Literature for Flight Simulator (Motion) Requirements Research

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Preface

This is a snapshot of a working document. The public version of this document has been stripped of any notes reflecting subjective assessments of the reviewers. What remains is a collection, with abstracts and keywords, of the literature reviewed in connection with the on-going work on flight simulator fidelity requirements for effective airline pilot training and evaluation.[1] This work is conducted at the United States Department of Transportation's John A. Volpe National Transportation System Center. The research is supported by the Federal Aviation Administration's Human Factors Research and Engineering Group (ATOP-HF). We thank its Air Carrier Training Program manager Dr. Eleana Edens for her effective guidance and assistance. The need for this work was established by the Voluntary Safety Programs Branch of the FAA's Air Transportation Division (AFS-230). We thank its manager Dr. Thomas Longridge for his insights.

As much as possible, the original abstracts of the documents cited were used. We don't recommend quoting directly from this document, but recommend consulting the original documents. Obvious spelling errors were corrected, and some spellings were americanized. URLs at the time the documents were entered may have changed. Some documents listed as drafts may now be available in their final version. Any corrections and suggestions are very welcome and should be e-mailed to Judith.Burki-Cohen@volpe.dot.gov.

Many researchers, colleagues, and librarians have contributed to this document, by suggesting, finding, entering, summarizing and interpreting the pieces of literature. Above all, however, we would like to thank Andrea Sparko, Young Jin Jo, Mary J. Townsend, Julie Guinn, and Sarah Ulanet for the countless hours they have spent with all of the above as well as managing both the electronic data base and the hard copies in our archive.

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Program Manager
Volpe Center/FAA Flight Simulator Human Factors Program

[1] Most publications resulting from this work are available at http://www.volpe.dot.gov/opsad/pubs.html

Reference Type: Report
Author: Advani, S.K.
Year: 1991
Title: The basic research simulator programme and the industrial and aerospace community: Opportunities for cooperative research
City: Delft, The Netherlands
Institution: Faculty of Aerospace Engineering, Delft University of Technology
Date: October
Report Number: LR-662
Number of Pages: 72
Keywords: flight simulators, research projects, human factors engineering, flight simulation, degrees of freedom, computer systems hardware, computer systems programs, motion simulation, cockpit simulators, aircraft, foreign technology
Abstract: A new flight simulation facility is being developed as a system specifically designed to investigate certain issues related to vehicle simulation. The three specific areas of interest are: The dynamic behavior and control of motion platforms; the performance of vehicle simulations in a ground-based environment; and the human factors of vehicle operation. The report discusses the configuration of the Basic Research Simulator and outlines the proposed applications of the facility. The benefits to industry are emphasized throughout.

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Reference Type: Conference Proceedings
Author: Advani, S.K.
Year of Conference: 1993
Title: The development of SIMONA: A simulator facility for advanced research into simulation techniques, motion system control and navigation systems technologies
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 156-166
Date: August 9-11
Author's Affiliation and Title: Assistant Professor/SIMONA Project Leader, Member AIAA, Delft University of Technology, Faculty of Aerospace Engineering, The Netherlands
Number of Pages: 11
Keywords: SIMONA, simulation techniques, motion systems control, navigation systems technologies, six-degrees-of freedom, man-machines interfaces, fixed-wing aircraft, human motion perception research, human visual perception research, motion-drive algorithms, motion platform
Abstract: The design and development of a new technology six-degrees-of-freedom research simulator will incorporate an advanced hydraulic motion system and a light-weight moving platform for outstanding dynamic performance. The primary design goal is to set a new standard for the fidelity of motion simulation. The simulator will become the core of the new International Centre for Research in Simulation, Motion and Navigation Technologies, or "SIMONA." Fundamental research in the SIMONA facility will be aimed towards the development of simulation modeling techniques, for the refinement of motion systems control, and for investigations into pilot interactions and realistic navigation environments. This simulator, now under construction, can be configured to represent a wide variety of vehicles including fixed and rotary-wing aircraft as well as surface vehicles for land and sea operations. This results in a variety of multi-disciplinary research roles for the simulator.

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Reference Type: Appendix
Author: Advani, S.K.
Year: 1998
Title: Appendix B - Motion washout filter reference frames
Pages: 1-5
Number of Pages: 6
Abstract: In the development and application of motion drive laws, a number of reference frames are specified. The aircraft and simulator reference frames are shown below.

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Reference Type: Book
Author: Advani, S.K.
Year: 1998
Title: The kinematic design of flight simulator motion-bases
Series Title: Control and Simulation
City: Delft, The Netherlands
Publisher: Delft University Press
Volume: 4
Number of Volumes: 4
Number of Pages: 243
ISBN: 90-407-1671-4
Abstract: (From the back cover of the book) The primary kinematic goal of the flight simulator motion-base is to provide sufficient motion workspace, such that the transformed specific forces and angular accelerations of the aircraft can be presented, but without the actuators achieving their mechanical limits. The workspace is a function of the motion-base architecture, and can be tailored through optimization. In the approach presented here, the minimum required workspace is specified by first synthesizing the motions required by the simulator through the mapping of the six-dimensional trajectory of the predicted simulator motions onto fifteen planar surfaces. Then, the trajectory boundary is approximated by two-dimensional ellipses. These ellipses are composed into an objective function, in the form of a six-dimensional hyper-ellipsoid, representing the shape of the desired workspace. The mechanism is then optimized, by specifying its design variables and their constraints. The optimization, a Linearly-Constrained Quadratic Programming sub-problem, attempts then to fit the hyper-ellipsoid into the workspace of the mechanism while minimizing the actuator lengths. A minimum-dexterity inequality constraint of 0.2 is applied, which prevents the mechanism from approaching architectural or configuration singularities. Following the optimization, the leg clearance and minimum dexterity (with higher resolution than allowed by during the optimization) is checked for the candidate architectures.
It is found that optimizing the position of the gimbal attachment points of the lower frame yields the most significant improvement in the desired flight simulator workspace over current Stewart Platform architectures. In all cases, the minimum-dexterity constraint is active, and occurs at some combination of the actuators at either their minimum or maximum lengths. In addition to the constraining of the minimum dexterity, a dynamic analysis shows that the consideration of the actuator loads is also important in the selection of a particular motion-base.

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Reference Type: Conference Proceedings
Author: Advani, S.K.
Year of Conference: 2003
Title: Motion cueing - To move, or not to move
Conference Name: Flight Simulation Engineering and Maintenance Conference
Pages: P-46-P-57

Date: September 18
Author's Affiliation and Title: Director, Simulation & Training, Aircraft Development & System Engineering, b.v.
Number of Pages: 2
Abstract: (Executive Summary) The subject of motion cueing in flight simulation is one that has stirred many debates and raised several questions. This is because motion perception itself is not as easily understood as, say, the perception of visual information from the outside-world image, or from the instruments. In fact, the standards that apply to flight simulation contain no standards for the motion cueing. These guidelines are limited to the robotic behavior of the motion system mechanism. The presentation sheds light on motion cueing from a basic point-of-view, explaining some of its origins—and the reason for the huge level of subjectivity. It begins by explaining that motion plays characteristically different roles depending on the task at hand, whether be it a maneuvering task, or a disturbance rejection task. Furthermore, motion directly influences the pilot's skill-based control behavior.
Recent research, as reported in the paper, can now be harnessed in order to improve the quality of simulation, and to bring objectivity to the area of motion cueing. The importance of this stems from the significant variability between simulators. For example, the motion platforms of two B747-400 simulators, built by the same manufacturer, will often respond differently even though the aircraft model outputs driving the motion systems are the same. Subjective tuning of the motion system leads to these variations; however, the inner-loop motion perception and control process of humans is to a great extent sub-conscious. Is one better than another? In order to answer this, we need to develop criteria as well as an objective means of quantifying the motion cues. In fact, since the visual information works with the non-visual information (primarily the vestibular stimuli) to create our self-motion perception, we need a model that integrates these processes, just as our brain does when controlling an aircraft. The presentation also suggests such a model, and how it could be applied to a QTG process. Despite some advances in motion systems, the flight simulation community can benefit greatly by incorporating new knowledge in a practical, beneficial, and cost-saving way. Imagine the day when the motion tuning process becomes an objective one, alleviating the need for ten evaluation pilots—and eleven different opinions. The question "to move, or not to move" is not the relevant question. Understanding how we use motion in the real aircraft, and applying this knowledge cost-effectively in simulation is however the key.
Notes: This is a summary of a presentation.
URL: http://www.arinc.com/fsemc/reports/2003/presentations/motion_cueing_advani.pdf

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Reference Type: Conference Proceedings
Author: Advani, S.K., Baarspul, M.
Year of Conference: 1992
Title: Design philosophies of the basic research simulator
Conference Name: International Council of the Aeronautical Sciences (ICAS)
Conference Location: Beijing, China
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Volume: 2
Pages: 2134-2143
Date: September 20-25
Number of Pages: 10
Abstract: Principles applied to the design of the Basic Research Simulator are discussed and the simulator's hardware is described. Particular attention is given to the simulation of the motion system and of the flight-deck platform. The applications of the Basic Research Simulator facility include its use in the design of advanced hydraulic systems, in motion drive research, in studies related to the improvement of vehicle simulation models, in aircraft systems research, and in human factors research.

Reference Type: Journal Article
Author: Advani, S.K., Hosman, R.
Year: 2000
Title: The appliance of science
Journal: Journal for Civil Aviation Training
Volume: 2000
Issue: 9
Pages: 40-44
Number of Pages: 5

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Reference Type: Conference Proceedings
Author: Advani, S.K., Mulder, J.A.
Year of Conference: 1995
Title: Achieving high-fidelity motion cues in flight simulation
Conference Name: AGARD FVP Symposium on "Flight Simulation--Where are the Challenges?"
Conference Location: Braunschweig, Germany
Publisher: NASA Technical Reports
Pages: Section 6
Date: May 22-25
Author's Affiliation and Title: Delft University of Technology, SIMONA International Research Centre, Kluyverweg 1, 2629 HS Delft, The Netherlands
Number of Pages: 11
Keywords: cues, accuracy degrees of freedom, dynamic characteristics, flight simulation, flight simulators, motion simulation, motion simulators, robustness (mathematics)
Abstract: The simulation of high-bandwidth manual flight control tasks dictate the use of simulator motion systems for the reproduction of motion cues on the vestibular and neuromuscular-mechanical arm-manipulator system. The reproduction of these cues, with particular emphasis on the lowest possible time delay, is necessary in human perception research, experimental flight control system development studies, as well as in routine flight training. Perfect reproduction of motion cues with ground-based flight simulators is principally impossible due to kinematic limitations inherent to the motion system. Washout filters minimize these effects. The dynamic characteristics of the motion system however lead to two types of control errors: short term, due to finite oil stiffness and line dynamics, as well as limited control valve bandwidth, and long-term, due to complexity of the non-linear motion system dynamics, making compensation of unwanted parasitic errors difficult. This paper will review techniques which increase the performance of six-degrees-of-freedom hydraulic motion systems for flight simulators. Application of pressure-feedback actuator control increases the robustness of the motion system dynamics, hence decreasing the short-term errors. The long-term control errors are addressed by a (separate) robust, multi-variable motion system controller which provided control signals to the platform with knowledge of the system state and its inherent properties. The total mass and the vertical location of the centre of gravity of the platform influence the time delay (phase lag) and fidelity of the motion system. These properties also limit any such improvements due to design changes in software or hydraulic hardware. As a result of these studies, a fundamentally unique light-weight motion platform design is proposed, making extensive use of advanced composite materials. This is called the SIMONA Research Simulator. With the improvements made to motion cue quality, fundamental research into human perception processes in human perception research, and experimental flight control system development work, will not be influenced by parasitic motions.

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Reference Type: Journal Article
Author: Advani, S.K., Nahon, M.A., Haeck, N., Albronda, J.
Year: 1999
Title: Optimization of six-degrees-of-freedom motion systems for flight simulators
Journal: Journal of Aircraft
Volume: 36
Issue: 5
Pages: 819-826
Date: September-October
Number of Pages: 8
Abstract: The cueing capabilities of a synergistic flight-simulator motion system are limited primarily by the maximum translational and rotational travel allowed by the motion-base. This travel capability, also known as the workspace, is dictated by the kinematic layout of the motion system. Furthermore, the Jacobian matrix, which maps velocities from platform space to joint space, indicates the dexterity of the mechanism, or the mechanical effort needed by the actuators to move the platform. To systematically design unconventional motion bases, a methodology has been developed to analyze arbitrary six-degrees-of-freedom motion systems. The approach is based on an optimization program to determine the optimal layout of the motion system, given the workspace performance objectives and the design constraints. This allows the investigation of unconventional platform geometries and actuator attachment points, thus allowing the designer to tailor the workspace as required by the simulation task, to ensure that a satisfactory dexterity is maintained, and to guarantee that the actuator legs do not interfere mechanically. This paper describes the proposed methodology, and shows examples of its applications, first to generic workspaces, and then to the workspace required for the simulation of a large transport aircraft.

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Reference Type: Conference Proceedings
Author: Advani, S.K., van der Vaart, J.C., Rysdyk, R.T., Grosz, J.
Year of Conference: 1993
Title: What optical cues do pilots use to initiate the landing flare? Results of a piloted simulator experiment
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 81-89
Author's Affiliation and Title: Delft University of Technology, Faculty of Aerospace Engineering, Kluyverweg 1, 2629 HS, Delft, The Netherlands
Number of Pages: 9
Abstract: A piloted moving-base simulator study of the landing of a twin-engined executive jet airplane was conducted to find out if pilots also use an optical variable called the Time-To-Contact (TTC) or tau, to time their actions. By manipulating the approach-path angle and the visual speed of the visible runway outline, the influence of the perceived TTC on the initiation of the landing was assessed. Results suggest that pilots indeed use some kind of Tau-margin strategy, but rely on the judgment of absolute height as well. Further experiments are needed to rule out any influence of prior training on the timing of the flare. Recent work on timing and perception suggests that the amplitude or speed of control actions may be determined by a higher order variable, i.e. the perceived rate of chance of the Time-To-Contact, called Tau-dot. Possible implications of this for further work are mentioned.

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Reference Type: Journal Article

Author: Advani, S.K., Verbeek, R.J.
Year: 1994
Title: The influence of platform mass properties on simulator motion system performance
Journal: AIAA Flight Simulation Technologies Conference
Pages: 145-155
Date: August 1-3
Author's Affiliation and Title: Advani: Assistant Professor, SIMONA Project Leader, Member AIAA, SIMONA International Research Centre, Delft University of Technology, The Netherlands
Verbeek: Research Assistant, SIMONA International Research Centre, Delft University of Technology, The Netherlands
Number of Pages: 11
Keywords: platform mass properties, simulator motion system performance, mechanical system, hydraulic system, center of mass
Abstract: The dynamic performance of a simulator motion system is to a great extent determined by the mechanical qualities of the motion system hydraulics, the motion control system which provides signals to the actuator servo valves, and also the mass properties of the moving equipment of the simulator placed on the motion system. Quite commonly, in the case of training flight simulators, the center of gravity of the large moving payloads is located far above the motion systems upper gimbals. An investigation, using a complete dynamic model of payload hydraulic motion system, was carried out to quantify the effects of payload mass properties on motion system performance. This paper will review the results obtained from these studies. It is found that the total mass and vertical location of the center of gravity influence the time delays, phase, and parasitic noises of the motion system, and that these properties also limit and further improvements due to design changes in software or hydraulic hardware. By adapting these design considerations, a motion system with inherently higher performance will result. Therefore, a fundamentally new and yet practical light-weight motion platform design is being proposed. This configuration is being introduced in the multi-functional SIMONA Research Simulator of the Delft University of Technology.

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Reference Type: Conference Proceedings
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year of Conference: 1978
Title: Flight mechanics panel specialists' meeting on piloted aircraft environment simulation techniques
Conference Location: Brussels, Belgium
Date: April 24-27
Number of Pages: 316
Keywords: flight simulation, human factors engineering, aerial warfare, environment simulation, pilots (personnel), aircraft seats, aircraft, atmospheric models
Abstract: These proceedings consist of the papers presented at the FMP Specialists' Meeting on "Piloted Aircraft Environment Simulation Techniques." An extensive coverage of the subject is presented. The areas examined range from requirements and user experience, through simulation of the atmosphere--including atmospheric models--to assessments of a wide range of visual systems. Also covered are motion systems, 'g' seats and air combat simulators. A comprehensive Technical Evaluation of the meeting appears in AGARD Advisory Report No. 126.
Notes: Some of the individual papers from these proceedings have also been included in this reference list.
Contents:

Par Y. Hignard
Differences between Simulation and Real World at the LABG Air-to-Air Combat Simulator with a Wide Angle Visual System - 24
By E. Vogl
Manned Air Combat Simulation - A Tool for Design, Development and Evaluation of Modern Fighter Weapon Systems & Training of Aircrews - 25
By R. H. Mathews
Use of Piloted Simulation for Studies of Fighter Departure/Spin Susceptibility - 26
By W. P. Gilbert And L. T. Nguyen

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Reference Type: Report
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year: 1979
Title: Dynamic characteristics of flight simulator motion systems
City: Neuilly sur Seine, France
Institution: Advisory Group for Aerospace Research and Development (AGARD)
Date: September
Type: Advisory Report
Report Number: AGARD-AR-144
Number of Pages: 40
Keywords: flight simulators, flight simulation, performance, display devices, flight characteristics, flight maneuvers
Abstract: In the last five years, there has been a sharp rise in the number of simulation facilities employing multiple degree-of-freedom motion systems; however, until recently no substantive attempts have been made to measure the performance of these systems. Those measurements that have been made and published have not been made in a uniform way, so that it is difficult to compare different systems. While data on the gross excursions, velocities and accelerations of these systems have been generally available in the literature, dynamic response, noise and other imperfections were usually neither carefully measured nor was information on them widely distributed.
This Advisory Report specifies a uniform method of measuring and reporting motion performance characteristics, developed by a Working Group of the Flight Mechanics Panel of AGARD. Such a uniform method, in addition to aiding system comparison, can assist in system diagnosis and might be used in writing performance specifications. The definitive characteristics selected for system description are excursion limits, describing function, linearity and acceleration noise, hysteresis, and dynamic threshold, definitions and methods of measurement and display are given, illustrated by measurements on particular motion systems.
This Advisory Report was prepared under the sponsorship of the Flight Mechanics Panel of AGARD.

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Reference Type: Report
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year: 1980
Title: Fidelity of simulation for pilot training
City: Neuilly sur Seine, France
Institution: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 1-60
Date: December
Type: AGARD Advisory Report

Report Number: AGARD-AR-159
Author's Affiliation and Title: North Atlantic Treaty Organization, Advisory Group for Aerospace Research and Development
Recipient's Affiliation and Title: AGARD Aerospace Medical and Flight Mechanics Panels
Number of Pages: 61
Keywords: flight simulation, accuracy, pilot training, psychology, pilots (personnel)
Abstract: Technology is allowing the simulation of increasingly complex flight situations with more and more fidelity. High fidelity generally implies high cost, but high fidelity is not always necessary to obtain satisfactory training. This report addresses the subject of fidelity of simulation for pilot training and provides background to specialists in the multiple disciplines involved. Topics presented in detail are: the training psychologist's views on fidelity of simulation required to train, and methods of assessing this fidelity; the physiologist's survey of pilot cueing mechanisms, in particular those provided by motion or visually induced motion sensations; and the simulator technologist's assessment of existing motion, visual and aircraft mathematical model technology and the characteristics which could be expected to provide high perceptual fidelity.
In each of these disciplines deficiencies were identified in the current ability to relate simulator fidelity to the needs for pilot training and recommendations are made for structuring future efforts.

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Reference Type: Report
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year: 1981
Title: Characteristics of flight simulator visual systems
City: Neuilly sur Seine, France
Institution: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 90
Date: May
Type: Advisory Report
Report Number: AGARD-AR-164
Keywords: flight simulators, flight simulation, color vision, imagery, simulators, visual perception
Abstract: Out-of-the-window visual simulation is a formidable challenge because of the fantastic performance capabilities of the human eye, the impracticability of producing a simulation system matching this performance and the inadequate understanding of how a human uses the visual information in a simulator. There is a continuing task to define the design characteristics that may affect perception of physiological responses, to establish the relative importance of the corresponding visual and physiological effects, and to understand their relationships with the physical continuums of the displays that can now be generated.
This report addresses only a very small part of the total problem, by identifying and defining those physical parameters that characterise the simulator visual system and determine its fidelity. These characteristics are discussed in terms of the three basic categories of spatial, energy and temporal properties, and for each of the parameters there is a description of its effect, a definition of its appropriate units or descriptors, a discussion of methods of measurement and of its use or importance to image quality. There is also a presentation of the experience of the Working Group members regarding the importance of these parameters in accomplishing a given visual task under given conditions. The final chapters of this report present projections of future trends and recommendations for research.

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Reference Type: Conference Proceedings
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year of Conference: 1987

Title: Symposium on motion cues in flight simulation and simulator induced sickness
Conference Name: Aerospace Medical Panel
Conference Location: Brussels, Belgium
Date: September 29-October 1
Number of Pages: 204
Keywords: simulator sickness, motion sickness, simulator after-effects, simulator design trends, simulator training
Abstract: These proceedings include seventeen papers, ensuing discussions of the papers, and a Round Table Discussion from the Symposium sponsored by the AGARD Aerospace Medical Panel held in Brussels, Belgium, on September 28 to October 1, 1987.
The frequency of reports of undesirable effects associated with simulator training has increased as simulator usage has increased to offset the higher costs and risks of conducting training in the complex modern aircraft. Review of current and anticipated future trends in simulator design features suggests that additional problems will arise if research on the etiology of simulator-induced motion sickness and other unwanted simulator effects is insufficient to counteract problems before they arise. The objective of this symposium was to examine simulator-induced effects, their operational implications, and their etiology in order to develop ideas for reducing undesired effects. The papers in this symposium address present and anticipated trends in simulator design, a theoretical viewpoint underlying many of the studies of simulator effects, characteristics of simulators associated with undesired effects, surveys of simulator-induced effects, models for the design and evaluation of simulators, and perceptual and neurophysiological functions fundamental to the understanding of simulation. These papers and the accompanying discussion provide a summary of information obtained in recent years on simulation, and guidelines for direction of future research.
Notes: Some of the individual papers from these proceedings have also been included in this reference list.
Contents:

Manifestation of Visual/Vestibular Disruption in Simulators: Severity and Empirical Measurement of Symptomatology - 11
By J. G. Casali and L. H. Frank
Modelling Operator Control Performance and Well-Being as a Function of Simulator Visual and Motion System Transport Delays - 12
By L. H. Frank, J. G. Casali and W. W. Wierwille
Enquête Sur Le Mal Des Simulateurs De Vol Couplée A Une Etude Nystagmographique - 13
Par G. De Heyn, P. De Graff et P. Vandenbosch
Head-Mounted Spatial Instruments: Synthetic Reality or Impossible Dream - 14
By S. R. Ellis, A. Grunwald and M. Velger
Influence of Vection Axis and Body Posture on Visually-Induced Self-Rotation and Tilt -15
By I. P. Howard, B. Cheung And J. P. Landolt
Vection and the Spatial Disposition of Competing Moving Displays - 16
By I. P. Howard, M. Ohmi, W. Simpson, And J. P. Landolt
Session IV - Preventive Medical And Operational Management Of Simulator Induced After-Effects
Cues for Training Vertigo, Providing Suggestions for the Management of Simulator Sickness - 17
By M. E. Norré
Preadaption to the Stimulus Rearrangement of Weightlessness: Preliminary Studies and Concepts for Trainer Designs - 18
By D. E. Parker and M. F. Reschke
Round Table Discussion - RTD

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Reference Type: Book
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year: 1988
Title: Advances in flying qualities
Series Title: AGARD Lecture Series No. 157
City: Neuilly Sur Seine, France
Publisher: AGARD
Notes: Contents:
Theme
List of Speakers
Introduction and Overview (by I.L. Ashkenas)
Pilot Modeling (by D.T. McRuer)
Pilot Modeling Applications (by I.L. Ashkenas)
Low-Speed Longitudinal Flying Qualities of Modern Transport Aircraft (by H.A. Mooij)
A Second Look at Mil Prime Flying Qualities Requirements (by R.J. Woodcock)
The Optimal Control Pilot Model and Applications (by M. Innocenti)
The Role of Simulation in Flying Qualities and Flight Control System Related Development (by A.G. Barnes)
Bibliography

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Reference Type: Conference Proceedings
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year of Conference: 1988
Title: Motion cues in flight simulation and simulator induced sickness
Conference Location: Brussels, Belgium
Pages: 204
Date: June

Number of Pages: 204
Keywords: simulator sickness, fixed wing, rotary wing, motion, visual, motion sickness, simulator after-effects, simulator design trends, simulator training
Abstract: These proceedings include seventeen papers, ensuing discussions of the papers, and a Round Table Discussion from the Symposium sponsored by the AGARD Aerospace Medical panel held in Brussels, Belgium, on September 28 to October 2, 1987.
The frequency of reports of undesirable effects associated with simulator training has increased as simulator usage has increased to offset the higher costs and risks of conducting training in the complex modern aircraft. Review of current and anticipated future trends in simulator design features suggests that additional problems will arise if research on the etiology of simulator-induced motion sickness and other unwanted simulator effects is insufficient to counteract problems before they arise. The objective of this symposium was to examine simulator-induced effects, their operational implications, and their etiology in order to develop ideas for reducing undesired effects. The papers in this symposium address present and anticipated trends in simulator design, a theoretical viewpoint underlying many of the studies of simulator effects, characteristics of simulators associated with undesired effects, surveys of simulator-induced effects, models for the design and evaluation of simulators, and perceptual and neuropsychological functions fundamental to the understanding of simulation. These papers and the accompanying discussion provide a summary of information obtained in recent years on simulation, and guidelines for direction of future research.

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Reference Type: Conference Proceedings
Author: A'Harrah, R.C.
Year of Conference: 1965
Title: Flight simulation, past, present, and future
Conference Name: American Institute of Aeronautics and Astronautics (AIAA) Second Annual Meeting
Conference Location: San Francisco, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: AIAA Paper #65-480
Date: July 26-29
Keywords: flight simulation, history, overview, visual display, motion cues
Abstract: This paper presents an overview of flight simulation as used in support of today's aerospace research and development programs. The current practices in application of simulation technology in terms of computer support, visual display techniques, and motion provisions are indicated. Pictorial coverage is included for a representative cross section of flight simulation facilities throughout Germany, the United Kingdom, and the United States.

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Reference Type: Report
Author: Aircraft Certification Office (ASO)-205
Year: 1991
Title: Airplane simulator qualification
Institution: Federal Aviation Administration (FAA)
Date: July 29
Type: Advisory Circular
Report Number: 120-40B
Number of Pages: 74
Keywords: airplane simulator qualification, validation, National Simulator Program Manager, NSPM

Abstract: Lists one of the means of compliance with the Federal Aviation Regulations (FAR) regarding the evaluation and qualification of airplane simulators used in training programs
Notes: (Incomplete abstract)
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/5B732295 0DD10F6B862569BA006F60AA?OpenDocument&Highlight=120-40b

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Reference Type: Report
Author: Aircraft Certification Office (ASO)-205
Year: 1992
Title: Airplane flight training device qualification
City: Washington, DC
Institution: Federal Aviation Administration (FAA)
Date: February 5
Type: Advisory Circular Draft
Report Number: AC 120-45A
Recipient's Affiliation and Title: Federal Aviation Administration, 800 Independence Avenue, S.W., Washington, DC 20591
Keywords: airplane simulator, flight training device, approval of flight training device, approval test guide, cockpit, convertible flight training device, evaluation of flight training device, latency, National Simulator Program Manager, operator, qualification, replica, set of airplanes, simulation data, simulator evaluation specialist, snapshot statement of compliance, time history, transport delay, upgrade
Abstract: This Advisory Circular (AC) provides an acceptable means, but not the only means, of ensuring compliance with the Federal Aviation Regulations (FAR) regarding the evaluation and qualification of all training devices in which flight training, qualification, or certification of airmen under Title 14, Code of Federal Regulations is accomplished. These devices are referred to in this document and other documents published by the Federal Aviation Administration (FAA) as "flight training devices." This AC specifies the criteria to be used by the FAA when qualifying a device and determining what the qualification level should be. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the pertinent FAR. Mandatory terms used in this AC such as "shall" or "must" are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described herein is used. Applicable regulations must also be referenced to assure compliance with provisions herein. This AC does not change regulatory requirements or create additional ones, and does not authorize changes in, or deviations from, regulatory requirements. The provisions of the FAR are controlling. This document does not interpret the regulations. Interpretations are issued only under established agency training devices described in this paragraph and further defined in paragraph 6b. Guidance of the evaluation of simulators is published in AC120-40, Airplane Simulator Qualifications, as amended.
Notes: This document contains a relevant definition list for many terms associated with flight training and simulators. Also contains appendices on flight training device standards, flight training device validation tests, and functional and subjective tests.
Replaces 120-45.
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/2E57CFE 51107AFE6862569E00073603A?OpenDocument

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Reference Type: Report
Author: Aircraft Certification Office (ASO)-205
Year: 1995
Title: Airplane flight training device qualification
Institution: Federal Aviation Administration (FAA)
Date: August 28
Type: Advisory Circular Draft
Report Number: 120-45B
Label: Draft
Keywords: airplane flight training device qualifications, validation data
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/5B732295 0DD10F6B862569BA006F60AA?OpenDocument&Highlight=120-40b

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Reference Type: Report
Author: Aircraft Certification Office (ASO)
Year: 1991
Title: FAR 135 training program outline
Institution: Federal Aviation Administration (FAA)
Type: Advisory Circular Draft
Number of Pages: 16

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Reference Type: Electronic Source
Author: Aircraft Owners and Pilots Association, A.
Year: 1999
Title: PCATD
Access Year: 2006
Access Date: Sept. 6
Last Update Date: March 27, 2002
Type of Medium: Online article
Number of Pages: 18
URL: http://www.aopa.org/asf/publications/sa10.html

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Reference Type: Conference Proceedings
Author: Albery, W.B., Gum, D.R., Kron, G.J.
Year of Conference: 1978
Title: Motion and force cueing requirements and techniques for advanced tactical aircraft simulation
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 18-11-18-10
Date: April 24-27

Author's Affiliation and Title: Albery: Electronics Engineer, Simulation Techniques Branch, Air Force Human Resources Laboratory, Advanced Systems Division, AFHRL/ASM, Wright-Patterson AFB, OH 45433
Gum: Chief, Simulation Techniques Branch, Air Force Human Resources Laboratory, Advanced Systems Division, AFHRL/ASM, Wright-Patterson AFB, OH 45433
Kron: Senior Staff Engineer, Link Division, Dept 495, Singer Company, Binghamton, NY 13901
Number of Pages: 10
Keywords: motion and force cueing, advanced tactical aircraft simulation, motion sensory mechanism, time delays, g-seat, g-suit, g-cueing
Abstract: The approach being pursued by the US Air Force to advance motion and force cueing technology for tactical air flight simulators is twofold. The first part includes efforts directed toward building a data base on which to base motion and force cueing requirements. The second part includes efforts to improve the performance of existing devices that have been shown to be somewhat effective and to develop new devices and techniques as indicated by the data base efforts. The data base development involves looking at the pilot who receives motion and force cues and the aircraft and environment which impart the motion and force cues. Models of human motion and force sensory mechanisms (vestibular, tactile, visual, motion and nonvestibular proprioceptive) describing how motion is perceived have been developed and the motion and force environment for tactical aircraft performing various maneuvers is being characterized. The results of the environment for this are being used to define motion and force cueing requirements and concepts for new devices to impart the necessary cues. Cueing device development efforts include the development of the next generation g-cueing (g-seat, g-suit, and benefit) system with improved response and onset cueing capability; the techniques for myoelectric control of visual simulation system brightness and field-of-view as a function of the g-force environment and pilot physical action; and design for the systems such as arm, thigh, and head loading devices to provide for simulation of the extremely high-g flight environment.

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Reference Type: Journal Article
Author: Allen, J.A., Hays, R.T., Buffardi, L.C.
Year: 1986
Title: Maintenance training simulator fidelity and individual differences in transfer of training
Journal: Human Factors
Volume: 28
Issue: 5
Pages: 497-509
Author's Affiliation and Title: Allen: George Mason University, Fairfax, VA
Hays: U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA
Buffardi: George Mason University, Fairfax, VA
Number of Pages: 13
Keywords: training effectiveness, simulator, fidelity
Abstract: This study was undertaken to investigate the relationship between simulator fidelity and training effectiveness. Two aspects of simulator fidelity were manipulated, namely, the degree to which a training simulator "looked like" actual equipment (physical fidelity), and the extent to which it "acted like" real equipment (functional fidelity). A transfer of training design was used to assess learning. Performance on an electromechanical troubleshooting task was correlated with a number of individual difference variables. Results indicated that physical and functional fidelity were interdependent and that temporal measures were most sensitive to fidelity manipulations. Low functional fidelity was associated with longer problem solution and inter-response times. Persons with high analytic abilities took longer to solve problems, but required fewer troubleshooting tests and made fewer incorrect solutions.

Reference Type: Report
Author: Allen, W.R., DiMarco, R.J.
Year: 1984
Title: Effects of transport delays on manual control system performance
Institution: National Aeronautics and Space Administration (NASA)
Report Number: NASA CP-2341 Vol. 1
Keywords: transport delay, manual control system
Abstract: Throughput or transport delays in manual control systems can cause degraded performance and lead to potentially unstable operation. With the expanding use of digital processors, throughput delays can occur in manual control systems in a variety of ways such as in digital flight control systems in real aircraft, and in equation-of-motion computers and CGI's in simulators. Previous research has shown the degrading effect of throughput delays on subjective opinion and system performance and dynamic response. A generic manual control system model is used in this paper to provide a relatively simple analysis of and explanation for the effects of various types of delays. The consequences of throughput delays of some simple system architectures were also discussed.

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Reference Type: Audiovisual Material
Author: Allied Pilots Association (APA)
Year: 1998
Title: Highways in the sky: Aviation on the road ahead
Publisher: Entertainment Design Workshop
Type: Videotape

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Reference Type: Conference Proceedings
Author: Allsopp, W.J.
Year of Conference: 1978
Title: Proposed advancements in simulation of atmospheric phenomena for improved training
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 6-1 - 6-11
Date: April 24-27
Author's Affiliation and Title: Senior Engineering Test Pilot & Senior Instructor Pilot, The Boeing Company, P.O. Box 3707, Seattle, WA 98124
Number of Pages: 11
Keywords: simulation of atmospheric phenomena, visual systems
Abstract: Obviously, flight simulators are a major training vehicle and the desire to reduce in-airplane training is the driving force to obtain better flight simulator visual systems. As the result of both commercial and military applications, major advancements were made in simulator visual systems, resulting in commercial use of the various electronically generated visual systems. Improvements appear to be required in many areas, such as field of view, resolution, brightness, scene content, lights, visual/motion integration, simulated airplane short-period response, and atmospheric environment. The latter is the subject of this paper.

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Reference Type: Conference Proceedings
Author: American Institute of Aeronautics and Astronautics (AIAA)
Year of Conference: 1988
Title: Proceedings
Conference Name: Flight Simulation Technologies Conference

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Reference Type: Conference Proceedings
Author: American Institute of Aeronautics and Astronautics (AIAA)
Year of Conference: 1989
Title: Proceedings
Conference Name: Flight Simulation Technologies Conference

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Reference Type: Conference Proceedings
Author: American Institute of Aeronautics and Astronautics (AIAA)
Year of Conference: 2000
Title: Proceedings
Conference Name: Modeling and Simulation Technologies Conference & Exhibit
Conference Location: Denver, CO
Date: August 14-17

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Reference Type: Conference Proceedings
Author: American Institute of Aeronautics and Astronautics (AIAA)
Year of Conference: 2005
Title: Meeting papers on disk
Conference Name: Modeling and Simulation Technologies Conference
Abstract: Papers from:
AIAA Atmospheric Flight Mechanics Conference and Exhibit
AIAA Guidance, Navigation, and Control Conference and Exhibit
AIAA Modeling and Simulation Technologies Conference and Exhibit

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Reference Type: Conference Proceedings
Author: Amery, J.G., Streid, H.
Year of Conference: 1999
Title: Flight simulation visual requirements and a new display system
Editor: Hopper, D.G.
Conference Name: International Society for Optical Engineering (SPIE)
Volume: 3690
Pages: 356-367
Series Title: Cockpit Displays VI: Displays for Defense Applications
Date: April 7-9
Author's Affiliation and Title: John G. Amery: M/S S064 1481 Flight Simulation Technology
Harry Streid: M/S S106 4685 Aerospace Training & Support Systems

Keywords: simulation, out-the-window, flat panel display, COTS, continuous mosaic display, cost effective
Abstract: This paper reviews the technical requirements for Out The Window (OTW) visual systems. Requirements for different modes of training and/or simulation will be stated. A new type of visual display will be described that provides improved, cost effective implementation and performance.
URL: http://www.rickleephoto.com/mosaicfresnel.htm

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Reference Type: Conference Proceedings
Author: Anderson, G.R.
Year of Conference: 1985
Title: A method for aircraft simulation verification and validation developed at the United States Air Force Flight Simulation Facility
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 20-21 - 20-27
Date: September 30-October 3
Author's Affiliation and Title: 1LT, USAF, Simulation Engineer, 6520 Test Group, Air Force Flight Test Center, Edwards, CA 93523-5000
Number of Pages: 7
Keywords: verification, validation, USAF
Abstract: The flight simulators at the USAF Flight Test Center (AFFTC) Aircraft Flight Simulation Facility (AFSF) are primarily used for performance and flying qualities studies. These high-fidelity, real-time simulators are used as an engineering tool during the flight development of the new or modified aircraft. Emphasis is placed on fully developing, verifying and validating a simulation before the actual aircraft begins flight testing. The flexibility, accuracy and ease with which the facility's method of verification and validation can be learned and implemented are a few of its advantages. This is demonstrated by the number of simulators which have been developed using it. The F-15 A/B, B-1B, Shuttle, F-15 C/D, AFTI (Advanced Fighter Technology Integration), F-16, F-16 C/D and the T-46 are examples of simulations presently operational at the facility which were developed using the AFSF's method.
The Philosophy of developing a simulation before flight test allows the most to be learned about the aircraft before testing begins. The "test smarter" approach taken at the AFFTC requires that aircraft simulations be built quickly and be used to make flight testing more efficient and safer. The methods for verifying and validating simulations used at the AFSF assure that these requirements are fulfilled.
Notes: Published in September 1986.

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Reference Type: Journal Article
Author: Andreassi, J.L., Greco, J.R.
Year: 1975
Title: Effects of bisensory stimulation on reaction time and the evoked cortical potential
Journal: Physiological Psychology
Volume: 3
Issue: 2
Pages: 189-194
Author's Affiliation and Title: Baruch College, City University of New York, 155 East 24th Street, New York, NY 10010

Number of Pages: 6
Abstract: Reaction times and evoked cortical potentials to visual and auditory stimuli alone and to the two in combination (bisensory stimulation) were studied. It was found that bisensory stimulation resulted in significantly faster reaction times than those obtained with visual or auditory stimulation alone. Auditory reaction times were faster than visual. The amplitudes of evoked potentials were significantly higher at both recording times (O_2 and C_2) under conditions of bisensory as compared to unisensory stimulation. Evoked potential latencies were in the expected direction, i.e., all conditions using auditory stimulation resulted in shorter latencies than the visual stimulation alone condition. It was concluded that evidence for sensory interaction (facilitative) had been obtained in this experiment and that the amplitude increases with bisensory stimulation were reflected in faster reaction times. A definitive statement regarding the central nervous system locus of this sensory interaction is not yet possible.

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Reference Type: Book Section
Author: Anstis, S.M.
Year: 1986
Title: Visual-vestibular interactions: Effects on self-motion perception and postural control
Editor: Held, R., Leibowitz, H.W., Teuber, H.-L.
Book Title: Handbook of Sensory Physiology: Perception
City: New York
Publisher: Springer Verlag
Volume: 8

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Reference Type: Conference Proceedings
Author: Ashkenas, I.L.
Year of Conference: 1985
Title: Collected flight and simulation comparisons and considerations
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 26-21 - 26-34
Date: September 30 - October 3
Author's Affiliation and Title: Vice President, Systems Technology, Inc., 13766 S. Hawthorne Boulevard, Hawthorne, CA 90250
Number of Pages: 34
Keywords: fidelity, perceptual, motion, tracking, failure detection, field-of-view
Abstract: Government-sponsored research at Systems Technology, Inc. dealing with simulation fidelity and utility is reviewed, starting with some generic effects of motion and vision system characteristics and of computational artifacts. Diagnostic methods and tools useful in discovering and delineating significant qualitative and quantitative differences between simulation and flight are then exposed and illustrated. Finally examples of both fixed and moving simulation successes and shortcomings are reviewed and examined as to root causes of either. The research-simulator equipment involved in the above comparison ranges from modeling large-scale motion systems and computer-generated imagery to fixed-base with simple CRT-generated displays.
Notes: Published in September 1986.

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Reference Type: Report
Author: Ashworth, B.R., McKissick, B.T., Parrish, R.V.
Year: 1984
Title: Effects of motion base and g-seat cueing on simulator pilot performance
City: Hampton, VA
Institution: National Aeronautics and Space Administration (NASA), Langley Research Center
Date: March
Type: Technical Report
Report Number: NASA TP-2247
Keywords: motion cue, g-seat cue, simulation, tracking error
Abstract: In order to measure and analyze the effects of a motion plus g-seat cueing system, a manned-flight-simulation experiment was conducted utilizing a pursuit tracking task and an F-16 simulation model in the NASA Langley Visual/Motion Simulator. This experiment provided the information necessary to answer the primary question; do motion and g-seat cues have an additive effect on the performance of this task? With respect to the lateral tracking error and roll-control stick force, the answer is affirmative. In this paper it is shown that presenting the two cues simultaneously caused significant reductions in lateral tracking error and that using the g-seat and motion base separately provided essentially equal reductions in the pilot's lateral tracking error.

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-200
Year: 1991
Title: Crew qualification and pilot type rating requirements for transport category aircraft
Institution: Federal Aviation Administration (FAA)
Date: May 13
Type: Advisory Circular
Report Number: 120-53
Keywords: transport category aircraft, rating requirements, crew qualification
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/C9574229A4AAB7E9862569EA00695F04?OpenDocument&Highlight=120-53

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-205
Year: 1994
Title: Helicopter simulator qualification
Institution: Federal Aviation Administration (FAA)
Date: October 11
Type: Advisory Circular
Report Number: 120-63
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/B56F9F7D967AFFBB862569E000736080?OpenDocument&Highlight=120-63

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-205

Year: 1995
Title: Airplane simulator qualification
Institution: Federal Aviation Administration (FAA)
Date: July 1
Type: Advisory Circular Draft
Report Number: 120-40C
Label: Draft
Keywords: simulator data requirements, simulator standards, validation tests
Abstract: Contains numerous appendices for qualifications based on wind shear, validation tests, simulator standards, functions and subjective tests

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-210
Year: 1991
Title: Crewmember cabin safety training
Institution: Federal Aviation Administration (FAA)
Type: Advisory Circular Draft
Report Number: AC120-51A DRAFT
Number of Pages: 6
Notes: This version has been canceled and replaced.

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-210
Year: 1994
Title: Use of airplane flight training devices; Inflight checking and training for airman qualification and certification
Institution: Federal Aviation Administration (FAA)
Date: October 11
Type: Advisory Circular
Report Number: 120-46A
Number of Pages: 6
Keywords: use of airplane flight training devices, inflight training and checking for airman qualification and certification, authorizations, old vs. new training device and simulator qualification level terminology

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-210
Year: 1995
Title: Crew resource management training
Institution: Federal Aviation Administration (FAA)
Date: March 1
Type: Advisory Circular
Report Number: 120-51B
Number of Pages: 28
Notes: AC 120-51A, Crew Resource Management Training, dated 2/10/93, has been canceled.

Reference Type: Report
Author: Aviation Flight Standards (AFS)-210
Year: 2004
Title: Line operational simulation: Line-oriented flight training, special purpose operational training, line operational evaluation
Institution: Federal Aviation Administration (FAA)
Type: Advisory Circular
Report Number: AC 120-35C
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/B86DE77A355EA57B86256F25006D977A?OpenDocument&Highlight=ac%20120-35b

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-840
Year: 1997
Title: Qualification and approval of personal computer-based aviation training devices
Institution: Federal Aviation Administration (FAA)
Date: May 12
Type: FAA Advisory Circular
Report Number: AC 61-126
Number of Pages: 11
Abstract: This advisory circular (AC) provides information and guidance to potential training device manufacturers and aviation training consumers concerning a means, acceptable to the Administrator, by which personal computer-based aviation training devices (PCATD) may be qualified and approved for flight training toward satisfying the instrument rating training under the provisions of Title 14 of the Code of Federal Regulations (14 CFR) parts 61 and 141. While these guidelines are not mandatory, they are derived from extensive Federal Aviation Administration (FAA) and industry experience in determining compliance with the pertinent parts of 14 CFR. Mandatory terms used in this AC such as "shall" and "must" are used only in the sense of ensuring applicability of this method of compliance. PCATDs are distinct from flight training devices (FTD) qualified under AC 120-45, Airplane Flight Training Device Qualification, and flight simulators qualified under AC 120-40, Airplane Simulator Qualification. It also provides acceptable criteria under which the airplane of FTD flight-hour training time required for an instrument rating may be reduced by using PCATDs that have been determined to meet acceptable FAA standards. This AC details only one means of determining the acceptability of such devices for use in instrument training curricula.
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/D0D8CDA61E05EB90862569BA0052B8F6?OpenDocument&Highlight=ac%2061-126

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Reference Type: Electronic Source
Author: Aviation Flight Standards (AFS)
Year: 1996
Title: CFR 14 Parts 1 through 199: Index of FARs
Access Year: 2006
Access Date: Sept. 6
Abstract: FAR PART 1--DEFINITIONS AND ABBREVIATIONS
FAR PART 11--GENERAL RULE-MAKING PROCEDURES
FAR PART 13--INVESTIGATIVE AND ENFORCEMENT PROCEDURES

FAR PART 14--RULES IMPLEMENTING THE EQUAL ACCESS TO JUSTICE ACT OF 1980
FAR PART 15--ADMINISTRATIVE CLAIMS UNDER FEDERAL TORT CLAIMS ACT
FAR PART 21--CERTIFICATION PROCEDURES FOR PRODUCTS AND FAR PARTS
FAR PART 23--AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES
FAR PART 25--AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES
FAR PART 27--AIRWORTHINESS STANDARDS: NORMAL CATEGORY ROTORCRAFT
FAR PART 29--AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY ROTORCRAFT
FAR PART 31--AIRWORTHINESS STANDARDS: MANNED FREE BALLOONS
FAR PART 33--AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES
FAR PART 34--FUEL VENTING AND EXHAUST EMISSION REQUIREMENTS FOR TURBINE ENGINE POWERED AIRPLANES
FAR PART 35--AIRWORTHINESS STANDARDS: PROPELLERS
FAR PART 36--NOISE STANDARDS: AIRCRAFT TYPE AND AIRWORTHINESS CERTIFICATION
FAR PART 39--AIRWORTHINESS DIRECTIVES
FAR PART 43--MAINTENANCE, PREVENTIVE MAINTENANCE, REBUILDING, AND ALTERATION
FAR PART 45--IDENTIFICATION AND REGISTRATION MARKING
FAR PART 47--AIRCRAFT REGISTRATION
FAR PART 49--RECORDING OF AIRCRAFT TITLES AND SECURITY DOCUMENTS
FAR PART 61--CERTIFICATION: PILOTS AND FLIGHT INSTRUCTORS
FAR PART 63--CERTIFICATION: FLIGHT CREWMEMBERS OTHER THAN PILOTS
FAR PART 65--CERTIFICATION: AIRMEN OTHER THAN FLIGHT CREWMEMBERS
FAR PART 67--MEDICAL STANDARDS AND CERTIFICATION
FAR PART 71--DESIGNATION OF CLASS A, CLASS B, CLASS C, CLASS D, AND CLASS E AIRSPACE AREAS; AIRWAYS; ROUTES; AND REPORTING POINTS
FAR PART 73--SPECIAL USE AIRSPACE
FAR PART 77--OBJECTS AFFECTING NAVIGABLE AIRSPACE
FAR PART 91--GENERAL OPERATING AND FLIGHT RULES
FAR PART 93--SPECIAL AIR TRAFFIC RULES AND AIRPORT TRAFFIC PATTERNS
FAR PART 95--IFR ALTITUDES
FAR PART 97--STANDARD INSTRUMENT APPROACH PROCEDURES
FAR PART 99--SECURITY CONTROL OF AIR TRAFFIC
FAR PART 101--MOORED BALLOONS, KITES, UNMANNED ROCKETS AND UNMANNED FREE BALLOONS
FAR PART 103--ULTRALIGHT VEHICLES
FAR PART 105--PARACHUTE JUMPING
FAR PART 107--AIRPORT SECURITY
FAR PART 108--AIRPLANE OPERATOR SECURITY
FAR PART 109--INDIRECT AIR CARRIER SECURITY
FAR PART 119--CERTIFICATION: AIR CARRIERS AND COMMERCIAL OPERATORS
FAR PART 121--CERTIFICATION AND OPERATIONS: DOMESTIC, FLAG, AND SUPPLEMENTAL AIR CARRIERS AND COMMERCIAL OPERATORS OF LARGE AIRCRAFT
FAR PART 125--CERTIFICATION AND OPERATIONS: AIRPLANES HAVING A SEATING CAPACITY OF 20 OR MORE PASSENGERS OR A MAXIMUM PAYLOAD CAPACITY OF 6,000 POUNDS OR MORE
FAR PART 129--OPERATIONS: FOREIGN AIR CARRIERS AND FOREIGN OPERATORS OF U.S. REGISTERED AIRCRAFT ENGAGED IN COMMON CARRIAGE
FAR PART 133--ROTORCRAFT EXTERNAL-LOAD OPERATIONS
FAR PART 135--AIR TAXI OPERATORS AND COMMERCIAL OPERATORS
FAR PART 137--AGRICULTURAL AIRCRAFT OPERATIONS
FAR PART 139--CERTIFICATION AND OPERATIONS: LAND AIRPORTS SERVING CERTAIN AIR CARRIERS
FAR PART 141--PILOT SCHOOLS

FAR PART 142--TRAINING CENTERS
FAR PART 143--GROUND INSTRUCTORS
FAR PART 145--REPAIR STATIONS
FAR PART 147--AVIATION MAINTENANCE TECHNICIAN SCHOOLS
FAR PART 150--AIRPORT NOISE COMPATIBILITY PLANNING
FAR PART 151--FEDERAL AID TO AIRPORTS
FAR PART 152--AIRPORT AID PROGRAM
FAR PART 155--RELEASE OF AIRPORT PROPERTY FROM SURPLUS PROPERTY DISPOSAL RESTRICTIONS
FAR PART 156--STATE BLOCK GRANT PILOT PROGRAM
FAR PART 157--NOTICE OF CONSTRUCTION, ALTERATION, ACTIVATION, AND DEACTIVATION OF AIRPORTS
FAR PART 158--PASSENGER FACILITY CHARGES (PFC'S)
FAR PART 161--NOTICE AND APPROVAL OF AIRPORT NOISE AND ACCESS RESTRICTIONS
FAR PART 169--EXPENDITURE OF FEDERAL FUNDS FOR NONMILITARY AIRPORTS OR AIR NAVIGATION FACILITIES THEREON
FAR PART 170--ESTABLISHMENT AND DISCONTINUANCE CRITERIA FOR AIR TRAFFIC CONTROL SERVICES AND NAVIGATIONAL FACILITIES
FAR PART 171--NON-FEDERAL NAVIGATION FACILITIES
FAR PART 183--REPRESENTATIVES OF THE ADMINISTRATOR
FAR PART 185--TESTIMONY BY EMPLOYEES AND PRODUCTION OF RECORDS IN LEGAL PROCEEDINGS AND SERVICE OF LEGAL PROCESS AND PLEADINGS
FAR PART 187--FEES
FAR PART 189--USE OF FEDERAL AVIATION ADMINISTRATION COMMUNICATIONS SYSTEM
FAR PART 191--WITHHOLDING SECURITY INFORMATION FROM DISCLOSURE UNDER THE AIR TRANSPORTATION SECURITY ACT OF 1974
FAR PART 198--AVIATION INSURANCE
URL: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?&c=ecfr&tpl=/ecfrbrowse/Title14/14tab_02.tpl

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Reference Type: Electronic Source
Author: Aviation Flight Standards (AFS)
Year: 2006
Title: Flight standards advisory circular index
Access Year: 2006
Access Date: Sept. 6
Abstract: AC No: 20-62D
ELIGIBILITY, QUALITY, AND IDENTIFICATION OF AERONAUTICAL REPLACEMENT PART
This advisory circular (AC) provides information and guidance for use in determining the quality, eligibility, and traceability of aeronautical parts and materials intended for installation on U.S. certificated products and to enable compliance with the applicable regulations.
Special Issue AC No: 43-16
AFS-96-1, TRANSPORTATION OF OXYGEN GENERATORS (CHEMICAL)
The purpose of the special issue is to advise and provide guidance concerning the prohibition of transporting chemical oxygen generators as cargo on passenger-carrying aircraft.
AC No: 61-101, PRESOLO WRITTEN TEST
To provide guidance to flight instructors in developing a written test to administer to student pilots prior to solo flight.
AC No: 61-103, ANNOUNCEMENT OF AVAILABILITY: INDUSTRY-DEVELOPED TRANSITION TRAINING GUIDELINES FOR HIGH PERFORMANCE AIRCRAFT.

This advisory circular (AC) informs all Federal Aviation Administration (FAA) certificated pilots and flight instructors of the availability of industry-developed guidelines for pilots transitioning into high performance single and multiengine piston-powered small airplanes and single and multiengine turbopropeller small airplanes.
AC No: 61-107, OPERATIONS OF AIRCRAFT AT ALTITUDES ABOVE 25,000 FEET MSL AND/OR MACH NUMBERS (M sub mo) GREATER THAN .75
This advisory circular (AC) is issued to alert pilots transitioning to complex, high-performance aircraft which are capable of operating at high altitudes and high airspeeds of the need to be knowledgeable of the special physiological and aerodynamic considerations involved within this realm of operation.
AC No. 61-10A, REFRESHER COURSES FOR PRIVATE AND COMMERCIAL PILOTS
Interest of pilots in refresher courses and special training to upgrade their piloting skills is increasing significantly. Training courses are being held at "pilot clinics" sponsored by state aeronautics commissions and national aviation organizations, and by local agencies such as flying clubs and operators organizations. The number of pilots who are individually seeking advanced flight training is also increasing.
AC No. 61-12M, STUDENT PILOT GUIDE
The Federal Aviation Administration (FAA) is charged by Congress with the promotion, encouragement, and development of civil aeronautics. This guide seeks to encourage the development of civil aviation by providing guidance to novice pilots.
AC No: 60-22, AERONAUTICAL DECISION MAKING
This Advisory Circular (AC) provides introductory material, background information, and reference material on Aeronautical Decision Making (ADM). The material in this AC provides a systematic approach to risk assessment and stress management in aviation, illustrates how personal attitudes can influence decision making and how those attitudes can be modified.
AC No: 61-65C, CERTIFICATION: PILOTS AND FLIGHT INSTRUCTORS
This advisory circular (AC) provides guidance for pilots and flight instructors on the certification standards, written test procedures, and other requirements contained in Federal Aviation Regulations (FAR) Part 61.
AC No: 61-67B, STALL AND SPIN AWARENESS TRAINING
This advisory circular (AC) explains the stall and spin awareness training required under Part 61 of the Federal Aviation Regulations (FAR) and offers guidance to flight instructors who provide that training.
AC No: 61-83C, NATIONALLY SCHEDULED FEDERAL AVIATION ADMINISTRATION-APPROVED, INDUSTRY-CONDUCTED FLIGHT INSTRUCTOR CLINICS
This advisory circular (AC) provides guidance for the preparation and approval of a training course outline (TCO) for industry-conducted flight instructor refresher clinics (FIRC), and sets forth guidelines to assist qualified sponsors/organizations in obtaining approval for the use of a designated airman certification representative (ACR) employed solely by the FIRC sponsor.
AC No: 61-84B, ROLE OF PREFLIGHT PREPARATION
This advisory circular (AC) modifies and updates the flight information available to pilots as a result of changes in the basic Airmen Information Manual format.
AC No: 61-89D, PILOT CERTIFICATES: AIRCRAFT TYPE RATINGS
This Advisory Circular (AC) provides a generic type rating curriculum that may serve as a basis for schools to develop a training course outline (TCO) to
meet the type rating training requirements of the Federal Aviation Regulations (FAR) Parts 61 and 141.
AC No: 61-98A, CURRENCY AND ADDITIONAL QUALIFICATION REQUIREMENTS FOR CERTIFICATED PILOTS
This advisory circular (AC) provides information for certificated pilots and flight instructors to use in complying with the flight review required by Federal Aviation Regulations (FAR) Section 61.56, the recent flight experience requirements of FAR Section 61.57, and the general limitations contained in FAR Section 61.31(d), (e), and (g).
AC No: 90-23E, AIRCRAFT WAKE TURBULENCE

This advisory circular (AC) is intended to alert pilots to the hazards of aircraft wake turbulence and recommends related operational procedures.
AC No: 90-42F, TRAFFIC ADVISORY PRACTICES AT AIRPORTS WITHOUT OPERATING CONTROL TOWERS
This advisory circular (AC) contains good operating practices and procedures for use when approaching or departing airports without an operating control tower and airports that have control towers operating part time. This AC has been updated to include changes in radio frequencies and phraseology.
AC No: 90-66A, RECOMMENDED STANDARD TRAFFIC PATTERNS AND PRACTICES FOR AERONAUTICAL OPERATIONS AT AIRPORTS WITHOUT OPERATING CONTROL TOWERS
This advisory circular (AC) calls attention to regulatory requirements and recommended procedures for aeronautical operations at airports without operating control towers. It recommends traffic patterns and operational procedures for aircraft, lighter than air, glider, parachute, rotorcraft, and ultralight vehicle operations where such use is not in conflict with existing procedures in effect at those airports.
AC No: 90-89A, ULTRALIGHT FLIGHT TESTING HANDBOOK
This advisory circular (AC) sets forth suggestions and safety related recommendations to assist amateur and ultralight builders in developing individualized aircraft flight test plans.
AC No: 91.21-1, USE OF PORTABLE ELECTRONIC DEVICES ABOARD AIRCRAFT
This advisory circular (AC) provides aircraft operators with information and guidance for assistance in the compliance of Federal Aviation Regulations (FAR) Section 91.21.
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/MainFrame?OpenFrameSet

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Reference Type: Report
Author: Baarspul, M., Mulder, J.A.
Year: 1989
Title: Essays on stability and control
City: Delft, The Netherlands
Institution: Delft University of Technology
Report Number: Report LR-600

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Reference Type: Conference Proceedings
Author: Bachelder, E., McRuer, D., Hansman, R.J.
Year of Conference: 2002
Title: Experimental study of 3-D synthetic cues on rotorcraft hover performance
Conference Name: AIAA Atmospheric Flight Mechanics Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-14
Date: August 5-8
Author's Affiliation and Title: Edward Bachelder and Duane McRuer: Systems Technology, Inc., Hawthorne, CA
R.J. Hansman: Massachusetts Institute of Technology
Number of Pages: 15
Abstract: Helicopter flight using night vision devices (NVDs) is difficult to perform, as evidenced by the high accident rate associated with NVD flight compared to day operation. The approach proposed in this paper is to augment the NVD image with synthetic cueing, whereby the cues would emulate position and motion and appear to be actually occurring in the physical space on which they are overlaid. Synthetic cues allow for selective enhancement of perceptual state gains to match the task requirements.
A hover cue set was developed on an analogue of a physical target used in a flight handling qualities tracking task, a perceptual task analysis for hover, and fundamentals of human spatial perception. The display was implemented on a simulation environment, constructed using a virtual reality device, an ultrasound head-tracker, and a fixed-base helicopter simulator. Seven highly trained helicopter pilots were used as experimental subjects and tasked to maintain hover in the presence of aircraft position disturbances while viewing a synthesized NVD environment and the experimental hover cues. The simulation employed a number of unique techniques that enabled identification of visual perception and division-of-attention effects. Measures of hover performance and subjective ratings were collected, and frequency analysis was used to measure system (i.e. pilot/display/vehicle suite) stability and bandwidth.
Significant performance improvements in NVD flight were observed when using synthetic cue augmentation. Subjective ratings showed longitudinal control to be more difficult than in the other axes for both single and multi-axis control. This paper demonstrates that artificial magnification of perceptual states through synthetic cueing can be an effective method of improving night-vision helicopter hover operations.

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Reference Type: Report
Author: Bailey, R.E., Knotts, L.H., Horowitz, S.J., Malone, H.L.
Year: 1987
Title: Effect of time delay on manual flight control and flying qualities during in-flight and ground-based simulation
Institution: American Institute of Aeronautics and Astronautics (AIAA)

Date: August
Report Number: AIAA Paper No. 87-2370

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Reference Type: Journal Article
Author: Baillie, S.W.
Year: 1992
Title: Handling qualities research at the Flight Research Laboratory, IAR/NRC, 1980-1990 and beyond
Journal: Canadian Aeronautics and Space Journal
Volume: 38
Issue: 1
Pages: 9-15
Date: March
Author's Affiliation and Title: Flight Research Laboratory, IAR/NRC, Ottawa, Ontario, Canada
Number of Pages: 7
Keywords: flight research laboratory, IAR airborne simulator, rotorcraft, handling qualities requirements, useable cue environment, vertical axis, side arm controller
Abstract: A summary of the handling qualities research performed at the Flight Research Laboratory, Institute for Aerospace Research/National Research Council Canada (IRC/NRC) over the past 10 years is presented. Three major areas are discussed: the study of advanced military rotorcraft handling qualities requirements, the integration and development of 4-axis side-arm controllers for rotorcraft, and investigations regarding the expansion of rotorcraft IFR operations.

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Reference Type: Conference Proceedings
Author: Baillie, S.W., Hui, K., DeLeeuw, J.
Year of Conference: 1992
Title: The flight test and data analysis program for the development of a Boeing/De Havilland Dash 8 simulator model
Conference Name: The Flight Mechanics Symposium
Conference Location: Chania, Crete, Greece
Publisher: Advisory Panel for Aerospace Research and Development
Pages: 30-31 - 30-19
Date: May 11-14
Author's Affiliation and Title: Baillie, Hui: Flight Research Lab, IAR/NRC, Montreal Road, Ottawa, Ontario K1A 0R6, Canada
DeLeeuw: Ph.D., AERCOL
Number of Pages: 19
Keywords: flight tests, flight control, performance evaluation, integrated systems, test procedures, avionics, digital systems
Abstract: A joint program between CAE Electronics Ltd. Montreal, and Flight Research Laboratory, NRC, was conducted to develop high fidelity simulator models of Dash 8 Series 100 and 300 aircraft. This paper focuses primarily on the Series 100 program. The flight test portion of the program entailed a relatively limited set of instrumentation due to aircraft ownership and regulatory constraints. The primary measurements were the basic inertial quantities and flight path reconstruction techniques were used to generate the time histories of other required flight path parameters (such as angle of attack and sideslip). The major problem of flight test data was analyzed using Maximum Likelihood Estimation with reliance on trim condition data for initial model estimates. The final simulator model was validated using specifically designed maneuvers conducted solely for validation purposes.

Notes: Published in October 1992.

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Reference Type: Journal Article
Author: Ball, K., Sekuler, R.
Year: 1980
Title: Models of stimulus uncertainty in motion perception
Journal: Psychological Review
Volume: 87
Pages: 435-469
Number of Pages: 35
Abstract: A model is proposed to account for the loss in visibility of moving targets that occurs when an observer is uncertain about the target's direction of motion. The model's key features are an array of directionally selective visual mechanisms and a rule governing the mechanisms from which an observer will derive sensory data. In response to uncertainty about two possible directions of motion, the observer is assumed to use a mechanism whose peak sensitivity is to a direction midway between the two possible directions. Seven experiments, using both reaction time and forced-choice data, demonstrate the predictive advantages of this midway model over competing single-band and multiple-band models. Additionally, the experiments reveal several new properties of human motion perception: (a) direction and velocity information have orthogonal representations in the visual system; (b) although motion sensitivity does not vary with direction, the predictions with which small changes in direction can be recognized does, reflecting differential breadth of tuning for directionally selective mechanisms sensitive to various directions; and (c) motion-analyzing mechanisms are broadly tuned for direction as well as speed.
Notes: Referenced in Ruud Hosman's book, *Pilot's perception and control of aircraft motions* (1996).

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Reference Type: Conference Proceedings
Author: Baret, M.
Year of Conference: 1978
Title: Six degrees of freedom large motion system for flight simulators
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 22-21 - 22-28
Date: April 24-27
Author's Affiliation and Title: Le Matériel Téléphonique, Division Simulateurs et Systèmes Electroniques, 3 avenue Albert Einstein, 78192 Trappes Cedex, France
Number of Pages: 8
Keywords: six degrees of freedom, long-stroke, hydrostatic bearings, hollow-rod jack
Abstract: The special feature of the six degrees of freedom large motion system described in this document is the long-stroke, hollow-rod jack with hydrostatic bearings.
This technique provides an improved performance and considerably reduces the level of the unwanted accelerations normally generated by motion systems, while offering new possibilities in the study of control laws.

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Reference Type: Conference Proceedings
Author: Barnes, A.G.
Year of Conference: 1978
Title: Simulating the visual approach and landing
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 2-1 - 2-13
Date: April 24-27
Author's Affiliation and Title: Chief Simulation Engineer, British Aerospace, Aircraft Group, Warton Division, Warton Aerodrome, Lancashire, PR4 1AX, United Kingdom
Number of Pages: 13
Keywords: visual approach, landing, textural quality
Abstract: A general view is taken of the standards of simulation which are currently achieved in training and research simulators. The approach and landing is subdivided into separate phases; straight-in approach, curved approach, flare and ground roll. The piloting task is critically examined in each case with particular reference to the use of outside world visual cues. The merits and deficiencies of existing simulators, as a means of providing the equivalent information, are then discussed. Improvements to the overall simulation of the landing approach are more likely to emerge if a better understanding of the information which the pilot uses in each phase is available. This paper is an attempt to assemble some of the information pieces, and to relate them to the technology of simulation.

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Reference Type: Conference Proceedings
Author: Barnes, A.G.
Year of Conference: 1985
Title: Simulation of aircraft behavior on and close to the ground
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 6B-1 - 6B-4
Date: September 30 - October 3
Author's Affiliation and Title: British Aerospace plc, Warton Division, Preston, Lancs PR4 1AX, United Kingdom
Number of Pages: 4
Keywords: behavior, ground simulation
Notes: Published in September 1986.

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Reference Type: Journal Article
Author: Baron, S., Levison, W.H.
Year: 1977
Title: Display analysis with optimal control model of the human operator
Journal: Human Factors
Volume: 19
Issue: 5
Pages: 437-457
Date: October
Author's Affiliation and Title: Bolt Beranek and Newman, Inc., Cambridge, MA

Number of Pages: 21
Abstract: Application of the optimal control model of the human operator to problems in display analysis is discussed. Those aspects of the model pertaining to the operator-display interface and to operator processing are reviewed and discussed. The techniques are then applied to the analysis of advanced display/control systems for a Terminal Configured Vehicle. Model results are compared with those obtained in a large, fixed-based simulation.

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Reference Type: Journal Article
Author: Barrett, G.V., Thornton, C.L.
Year: 1968
Title: Relationship between perceptual style and simulator sickness
Journal: Journal of Applied Psychology
Volume: 52
Issue: 4
Pages: 304-308
Author's Affiliation and Title: Goodyear Aerospace Corporation, Akron, Ohio
Number of Pages: 5
Abstract: Simulator sickness was hypothesized to be caused by the conflict between the visual presentation of apparent motion and the lack of any corresponding body sensation of motion. The hypothesis was tested by correlating individual differences in scores on the Rod and Frame Test (RFT; which measures accuracy of adjustment of a rod to true vertical under conditions of visual-kinesthetic conflict) and degree of simulator sickness. The data for Series 3 of the RFT and the indexes of sickness were best represented by hyperbolic functions yielding correlations of .40-.52. Implications for simulation technology and for a general conflict of cue theory are discussed with emphasis on supporting evidence from several areas of investigation.

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Reference Type: Newspaper Article
Reporter: Bates, K.L.
Year: 1995
Title: Seasick in cyberspace
Newspaper: The Detroit News
Issue Date: December 11
Number of Pages: 3

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Reference Type: Conference Proceedings
Author: Baughn, J., Wolf, J.
Year of Conference: 1998
Title: Teaching aircraft flight performance in aeronautical engineering using PC-based flight simulation
Conference Name: World Aviation Conference
Conference Location: Anaheim, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: September 28-30
Number of Pages: 7
Abstract: This paper describes some ways in which PC-based flight simulation can be used to teach aircraft flight performance and flight testing to aeronautical engineering students. Two PC-

based flight stimulation programs are used here for this purpose; the Jeppesen FS200 PCATD and Microsoft Flight Simulator 98. Examples of student flight test assignments using these programs are given for cruise (straight and level, unaccelerated) flight, climbs, descents (power off glide), and for (level) maneuvering flight. Simulation flight test data from these assignments are presented and compared to theory. It is concluded that PC-based flight simulation can be a valuable tool for illustrating flight performance and flight testing to aeronautical engineering students and can be challenging, interesting and fun for students.

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Reference Type: Magazine Article
Author: Beaudan, E.
Year: 1991
Title: Flight simulation in the 90's
Magazine: Aviation and Aerospace
Volume: 64
Issue Number: 6
Pages: 18-20
Date: June
Number of Pages: 3
Abstract: Flight simulation, a $4 billion industry worldwide, is moving into the 1990s at an aggressive pace. With the introduction of such new aircraft as the Airbus A330/340, the Advanced Tactical Fighter, the C-17 airlifter and the US Army's LH light helicopter, the commercial and military market for simulators is growing at the rate of 20 per cent a year. The leading manufacturers of flight simulators--Canada's CAE Electronics Ltd. and its Link subsidiary in the US, Hughes Training and Support System Group and its British subsidiary Rediffusion, British Aerospace's Reflectone Inc., France's Thomson-CSF, and FlightSafety International of the U.S.--are capitalizing on this trend by introducing technology that will make flight simulation more realistic and affordable.

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Reference Type: Journal Article
Author: Bekey, G.A., Burnham, G.O., Seo, J.
Year: 1977
Title: Control theoretic models of human drivers in car following
Journal: Human Factors
Volume: 19
Issue: 4
Pages: 399-413
Date: August
Author's Affiliation and Title: Bekey: University of Southern California, Los Angeles, CA
Burnham: Jet Propulsion Laboratory, Pasadena, CA
Seo: Korean Institute of Science and Technology, Seoul, Korea
Number of Pages: 15
Abstract: This paper is concerned with mathematical models of the control behavior of human drivers while following another vehicle in single lane traffic. The emphasis is on the representation of the individual driver, rather than on such abstract parameters of multi-lane traffic as average density or average velocity. Three basic types of approaches to representing the driver's control strategy are reviewed. First is a classical control structure in which assumptions concerning the stimulus-response characteristics of the driver are included, and a form for his control strategy algorithm is assumed. The second class of models is based on optimal control theory. The major feature of this class of models is that an assumed performance index is explicitly included in the

formulation, so that the driver's control strategy arises as a result of his attempts to minimize this index or criterion. The third class of models reviewed in the paper are heuristic models, which arise from control theory. The first of these, termed the "look-ahead" model, is based on the assumption that the driver is capable of observing more than one car ahead of him, and that he adjusts his own strategy from an analysis of the behavior of a majority of the vehicles he perceives. The second of these heuristic models is a finite state structure which is developed from the hypothesis that the driver attempts at all times to maintain a velocity equal to that of the lead car along with a safe headway. The paper concludes with a brief discussion of some current areas of research and possible applications.

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Reference Type: Journal Article
Author: Bellenkes, A., Bason, R., Yacavone, M.
Year: 1992
Title: Spatial disorientation in naval aviation mishaps: A review of Class A incidents from 1980 through 1989
Journal: Aviation, Space and Environmental Medicine
Volume: 63
Pages: 128-131
Date: February
Abstract: Spatial Disorientation (SD) has long been a major aeromedical factor contributing to naval aviation mishaps. In the past, it has been viewed as a generalized phenomenon, described by its vertigo-related symptoms. More recently, however, three distinct types of SD have been identified, each based on whether the aviator recognizes and responds to its onset. In the current retrospective study, Flight Surgeon and Mishap Investigation Report narratives from 33 Class A mishaps occurring from 1980 through 1989 were reviewed. SD was determined to have been a causal factor in all cases. The mishaps were examined to categorize SD into the three descriptive types and to describe the relationship (if any) between SD and various mission-related factors. Aircraft type, phase of flight, time of day, pilot experience, and flight topography were all considered. The results indicate that Types I and II SD could be identified as causal factors in all 33 Class A mishaps. Further, most Type I SD was experienced primarily by helicopter pilots at night while most Type II SD incidents affected jet pilots during day missions.

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Reference Type: Conference Proceedings
Author: Benson, A.J.
Year of Conference: 1987
Title: Aetiological factors in simulator sickness
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 3-1 - 3-8
Date: September 29
Author's Affiliation and Title: Royal Air Force Institute of Aviation Medicine, Farnborough Hants GU14 6SZ, United Kingdom
Number of Pages: 8
Keywords: aetiological factors, motion sickness, visual display, cues, neural mismatch, simulator sickness
Abstract: The clinical features of simulator sickness are similar to the malaise induced by other motion stimuli. The essential aetiology of the condition is considered to be the same as in other

types of motion sickness, namely, the mismatch between the motion information provided by the body's sense organs and the brain’s internal model of 'expected' motion cues. The mismatch can be between concomitant inputs provided by the angular and linear acceleration transducers of the vestibular apparatus, or between visual and vestibular inputs. More significantly, in a fixed base simulator, it is the essence of 'expected' inertial cues when the ambient visual system is stimulated by the external world, visual display that engenders neural mismatch. Even when the simulator has a motion base, quantitative and temporal disparities between visual and inertial cues commonly occur and can contribute, along with visual distortions and other anomalies, to the induction of the motion sickness syndrome.

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Reference Type: Journal Article
Author: Benson, A.J., Spencer, M.B., Stott, J.R.
Year: 1986
Title: Thresholds for the detection of the direction of whole-body, linear movement in the horizontal plane
Journal: Aviation, Space, and Environmental Medicine
Volume: 57
Issue: November
Pages: 1088-1096
Date: November
Author's Affiliation and Title: Royal Air Force Institute of Aviation Medicine, Farnborough, Hampshire, U.K.
Number of Pages: 9
Keywords: translational threshold, whole-body motion
Abstract: Thresholds for the detection (at p=0.67 correct) of the direction of discrete linear movements in the horizontal plane, having a cosine bell velocity trajectory and duration of 3 s, were determined in 24 subjects. Thresholds in the Z body axis (mean 0.154 m/s^2) were significantly higher than thresholds for movement in the X (mean 0.063 m/s^2) and Y (mean 0.057 m/s^2) body axes. In 8 subjects, X axis acceleration threshold was found to increase as a monotonic function of stimulus duration over the range of 0.98 to 6.96 s and exhibited similar frequency-dependent characteristics to thresholds for the detection of continuous oscillatory stimuli. This finding implies that the sensory system mediating the transduction and perception of liminal, whole-body linear movement is sensitive to a combination of the acceleration and rate change of acceleration (jerk) of the motion stimulus, and has similar dynamics to the "irregular" sensory receptors of the otolith organs.

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Reference Type: Journal Article
Author: Benson, J.
Year: 1998
Title: Conversations with Richard Christiansen
Journal: Aerospace America
Volume: May
Pages: 14-16
Date: May
Number of Pages: 3
Notes: RC = acting associate administrator for NASA’s Aeronautics and Space Transportation Technology Enterprise

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Reference Type: Conference Proceedings
Author: Bergeron, H.P.
Year of Conference: 1980
Title: The effects of motion cues on compensatory tracking tasks
Conference Name: Visual and Motion Simulation Technology Conference
Conference Location: Cape Canaveral, FL
Date: March 18

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Reference Type: Report
Author: Beringer, D.B.
Year: 1996
Title: Use of off-the-shelf PC-based flight simulators for aviation human factors research
Date: April
Type: Technical Report
Report Number: DOT/FAA/AM-96/15
Author's Affiliation and Title: Civil Aeromedical Institute, Federal Aviation Administration, Oklahoma City, OK 73125
Number of Pages: 16
Keywords: personal computer-based aviation flight simulation, simulator research, instrument flight psychology, applied psychology
Abstract: Flight simulation has historically been an expensive proposition, particularly if out-of-window views were desired. Advances in computer technology have allowed a modular, off-the-shelf flight simulation (based on 80486 processors or Pentiums) to be assembled that has been adapted, with minimal modification, for conducting general aviation research. This simulation includes variable flight instrumentation, forward, 45 and 90 degree left external world views, and a map display. Control inputs are provided by high-fidelity analog controls (e.g., damped and self-centering yoke, high-performance throttle quadrant, gear, flap, and trim controls; and navigation radio frequency select). The simulation is based upon two commercially available flight simulation software packages, one originally designed as an instrument flight trainer and the other as a "game"-type flight simulation. The provisions of these packages are discussed highlighting their particular research capabilities, as well as their limitations. The comparatively low cost and ease of assembly/integration allow multiple "standardized" systems to be distributed for cooperative inter-laboratory studies. The approach appears to have utility for both research and training.

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Reference Type: Journal Article
Author: Berry, D.T.
Year: 1982
Title: Flying qualities: A costly lapse in flight control design
Journal: Astronautics and Aeronautics
Pages: 54-57
Date: April
Author's Affiliation and Title: NASA Ames Research Center, Dryden Flight Research Facility
Number of Pages: 4

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Reference Type: Journal Article
Author: Birch, S.
Year: 2002
Title: CFM powers Airbus
Journal: Aerospace Engineering
Pages: 9-10
Date: October
Number of Pages: 2

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Reference Type: Electronic Source
Author: Bles, W.
Year: 2005
Title: Desdemona: Advanced disorientation trainer
Access Year: 2006
Access Date: Sept. 6
URL: www.amst.co.at/publics/desdemona_pub.htm

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Reference Type: Report
Author: Blickenderfer, B., Liu, D., Hernandez, A.
Year: 2005
Title: Simulation-based training: Applying lessons learned in aviation to surface transportation modes
Institution: Embry Riddle Aeronautical University
Date: June 30
Author's Affiliation and Title: Embry Riddle Aeronautical University
Recipient's Affiliation and Title: Center for Advanced Transportation Systems Simulation (CATSS)
Abstract: (Executive Summary) After reviewing the literature regarding simulation for aviation training and reviewing the literature on use of simulation in surface transportation, a number of lessons learned become apparent.
Lesson Learned 1: Simulation has been proven to be an effective educational and instructional tool. In tests of flight simulator training effectiveness, trainees develop knowledge and skills in simulated systems as well as they do in the actual systems (Hays, Jacobs, Prince, & Salas, 1992). The simulator is an excellent classroom, as the learner is able to make mistakes and learn from them (Duncan & Feterle, 2000). The instructor is allowed to focus on teaching and not operating the vehicle. Additionally, many simulators have the capability to collect performance measures during the training scenarios that can help assess competencies and deficiencies. Not as much research has occurred regarding the effectiveness of training via simulation in the surface transportation domain compared to the aviation field, yet considerable research support has appeared. It is likely that the results regarding simulator effectiveness for aviation training will generalize to the surface transportation domain, but simulation must be used wisely. Users should consider the competencies needed to perform the task and the capabilities of the simulator. Not all simulators are appropriate for training all competencies. Furthermore, not all competencies require simulation for effective training.
Lesson Learned 2: Simulators increase safety and reduce training costs. As noted in our review of the aviation literature, two main benefits of using simulation for training are increased safety during training and reduced training costs.
In terms of safety, using simulators for training enables individuals to practice in conditions that would be too dangerous to train in actual situations (for example, aircraft engine failures,

accidents, and other emergencies). This is also true when training driving and will likely be a major benefit of using simulation in surface transportation training.

Regarding cost, aviation simulation saves aircraft fuel, aircraft maintenance costs, and keeps aircraft available for revenue producing activities. In the case of automobiles, buses, and trucks, although training via simulation would conserve fuel, the cost savings are most likely not as great as they are in aviation. Indeed, considerable driving training can occur in the actual vehicles at low cost. Training train operators, on the other hand, may benefit from significant cost savings as well as benefiting from the simpler logistics of training via simulators rather than actual trains.

A benefit related to both safety and cost is that simulation can be used to give trainees experiences with unusual events. Unusual events are just that—unusual. Despite their rare occurrences, they can prove deadly in aviation as well as in surface transportation. Simulation offers the opportunity for drivers to experience these and learn how to perform effectively in these unusual situations (Down, Petford, & McHale, 1982). Consider driver training. Driving around in the real world, the driver may not encounter many, if any, hazardous or emergency situations. Using simulation, the scenario can be scripted to include a variety of hazards and emergencies. Thus, not only will simulation training give driver trainees the opportunity to master the knowledge and skills necessary to perform effectively in hazardous situations, but also it will do so in a safe environment.

Lesson Learned 3: Simulation alone does not equal training. Simulation is a tool for trainers to use (Salas, Bowers, & Rhodenizer, 1998). Simply experiencing a simulated environment is not effective training (Salas et al., 1998). Simulation must be used in a thoughtful, well-planned manner that includes identification of training needs, proper design of scenarios, appropriate performance measurement, and feedback to the learner (Oser et al., 1999). The same principles apply in surface transportation as well (Uhr et al., 2003).

Lesson Learned 4: Simulation is one variable in the “big picture” of training effectiveness. Training effectiveness is a complex problem (Cannon-Bowers et al., 1995, Colquitt et al., 2000, Baldwin and Ford, 1998). Training method (e.g., use of simulation) is one variable involved. Numerous other variables also exist including trainee characteristics, work environment characteristics, and the transfer environment. Simulation training will not solve every training challenge for any domain.

Lesson Learned 5: The Scenario Based Training model (Oser et al., 1999) is one method to ensure simulation is used appropriately. Aviation training researchers advocate using the scenario based training model to use simulation effectively. While a few papers have appeared in the surface transportation training literature regarding effective use of simulation (Uhr et al. 2003; Nagata & Kuriyama, 1983; Walker & Bailey, 2002; Down et al. 1982), limited advice exists regarding the use of simulation effectively in this domain. Fortunately, the basic principles of the Oser et al (1999) model apply to surface transportation and, if advocated in the surface field, can help instructors to use driving simulator systems most effectively. The Oser et al. approach is based on basic principles of learning. This approach guides training designers to 1) identify the task/mission and the knowledge, skills, and abilities involved; 2) design scenarios to include events which allow the trainee to develop and practice the specific knowledge, skills, and abilities identified; 3) design performance measures to enable the trainer to assess performance; and 4) ensure specific feedback is given to the trainee.

Lesson Learned 6: Effective human performance measurement is crucial both for simulation validation and assessing skill development. As new simulators are developed, validation must occur. Validation should occur not only from the engineering/system performance standpoint but also from the human performance perspective (Hays & Singer, 1989). For example, when examining whether performance in a simulator equals performance in the real-world task, accurate, reliable human performance measures are essential to understand the human interactions with the system. Without such measures, it will be impossible to quantify training transfer. Both objective and subjective measurement approaches exist. Careful time and attention should be paid to developing and selecting the appropriate measures to ensure a well-rounded assessment of skills.

Lesson Learned 7: Simulation fidelity is an important concept that needs to be understood. Simulation fidelity is the degree to which a device can replicate the actual environment or how “real” the simulation appears and feels (Alessi, 1998; Gross et al., 1999). Simulation fidelity is composed of a number of dimensions including psychological and cognitive factors as well as the more obvious physical factors (e.g., visual, auditory, motion, etc.). Numerous researchers are devoted to studying fidelity issues regarding aviation training such as how to define fidelity, fidelity dimensions, measuring fidelity, and the relationship between fidelity and training effectiveness, yet questions still remain. In terms of surface transportation, limited study exists on the relationship between fidelity and performance in surface transportation tasks. For comparable skills (e.g., control vs. perceptual vs. decision making), it is expected that the findings from fidelity research in aviation should generalize to surface transportation. However, surface transportation researchers should use these findings as a springboard for their own domain specific research.

Lesson Learned 8: The relationship between simulation fidelity and training effectiveness is not a positive, linear relationship. The simulation industry pushes for higher and higher levels of physical fidelity. Indeed, as simulation technology continues to evolve, simulations come ever closer to being exact replicas of the real world environment. At the current time, high fidelity translates as high financial cost, and many questions remain regarding the cost-benefit trade-offs of using high physical fidelity simulations for aviation training. Research indicates that high fidelity is not necessary to train certain skills (Jentsch & Bowers, 1998; Koonce & Bramble, 1998). In terms of surface vehicle driver training, training control tasks such as braking will require a high level of physical fidelity. On the other hand, it is likely that for other skills (e.g., risk assessment training), a lower level of physical fidelity will be adequate (Fisher et al., 2002). Thus, an expensive, high fidelity simulator is not always required to fulfill training needs. However, more research is needed to identify the exact relationship between fidelity and training effectiveness.

Lesson Learned 9: Motion fidelity is not always necessary. Motion fidelity is the extent to which a simulator replicates the motion cues actually felt during flight (Kaiser & Schroeder, 2003). In terms of aviation, motion appears to provide very little to training effectiveness (Garrison, 1985; Ray, 1996). While it is likely that these results generalize to surface transportation to some degree, the knowledge and skills required for effective driving differ somewhat from aviation (e.g., consider driving a vehicle over bumpy terrain), and motion is likely needed to train certain skills. Thus, additional domain specific research is needed.

Lesson Learned 10: Establishing a standard classification system for different types of simulations can facilitate collaboration within the simulation industry. In aviation, levels of simulation are specifically defined with certifications and regulations regarding necessary fidelity for training certain skills (e.g., level A, level B, and level C). Using a classification system of this nature has provided industry and academia with common terminology to use in simulation design and evaluation (i.e., everyone is using the same terminology to refer to the same concepts). In comparing the current simulation work in aviation to that of surface transportation, aviation has specific standards, but a simulation classification schema is not apparent in the surface transportation industry.

Lesson Learned 11: Many opportunities to use simulation exist—be creative! The aviation industry has moved beyond using simulation only for pilot training to also using it to train air traffic controllers. In addition, simulations are helping to design airport layouts, assess traffic problems, and teach ground workers airport navigation. In surface transportation, researchers have begun to use simulation to assess road design (Godley et al., 1997). Indeed, use of simulation seems limited only by our imagination.

As is the case in aviation training, the surface simulation industry is facing great challenges and also opportunities to make the roads safer, more efficient and enjoyable. With the development of technology, many driving operations become easier and require less effort. Unfortunately, these same technologies can introduce new opportunities for human error. The simulation industry must stay abreast of technological advances to produce up-to-date, effective training in a cost efficient manner. Many of the questions we posed in this report cannot be answered in a simple sentence, nor will the answers occur overnight. Instead, continued, fundamental research remains the key to understanding the human interaction with the vehicle.

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Reference Type: Thesis
Author: Boer, E.R.
Year: 1995
Title: Identification of time varying systems with applications to adaptive human control
Academic Department: Electrical Engineering and Computer Science
City: Chicago, IL
University: University of Illinois
Thesis Type: Doctor of Philosophy
Author's Affiliation and Title: Ir. Twente University, Enschede, The Netherlands, 1990
Abstract: In pursuit to identify an adapting human operator, five contributions resulted: 1) the Recursive Delay-time Identifier (RDI) capable of tracking time varying delay simultaneously with linear model coefficients, 2) an identifiable discrete-time Look Ahead Predictive Error Correcting (LAPEC) Human Operator Model (HOM) for pursuit and preview tracking, 3) new insights in human operator adaptation to the time varying experimental parameters (EPs), i.e. preview length (PV), reference signal bandwidth (BW) and control plant cutoff frequency (COF), 4) a set of performance measures that break the standard root mean squared error up into a shape match and a time shift component, 5) a set of experimental human operator tracking data collected under a wide variety of static and time varying conditions.
Application of the RDI to the data obtained under time varying conditions produced new insights into human operator adaptation. Humans respond differently to increasing and decreasing experimental parameters; a hysteresis type response is observed. Detectability differences plus performance driven adaptations are thought to cause the observed hysteresis in the sense that the degree to which subjects perceive a gradual change in the experimental parameter settings depends on whether it forces them to alter control to maintain a constant performance level or not. They tend to act on a performance decreasing change more acutely than one that allows them to maintain similar strategy without being penalized by a performance drop. This means that a decrease in preview, an increase in track bandwidth and an increase in control plant lag are adapted to quickest. These results could not have been obtained without the availability of the RDI.
The RDI was compared and contrasted with the following four other delay time tracking methods on simulated and experimental data: segmented cross correlations, peak to peak delay time estimation, segmented recursive least squares, and the multiple model approach. In all cases, the RDI performed equally well or better.
The RDI is based on the extended Kalman filter plus the Rauch-Tung-Striebel optimal smoother. The human delay time is treated as a non-linear operator which under the constraint of differentiability of the input and output signals (i.e. bandlimited signals) can be identified recursively. Applicability is also constrained by the rate at which delay time changes. Differentiability is imposed because the input signal is interpolated with a bicubic interpolation scheme to obtain fractional delay time estimates. This constraint is weak in the sense that the RDI shows good performance on stochastic bandlimited data. A significant advantage of the RDI over other static delay time identification methods is the fact that the delay time estimated are not limited to integer multiples of the sampling interval. One of its strong points is that it estimates delay time based on data sampled at the maximum available sampling frequency while the linear model coefficients can be identified on a decimated version of the same data sets to eliminate discrete time identification problems associated with high sampling frequencies.
The bicubic interpolation scheme proved superior in estimating subsample magnitudes and slopes of the track when compared with the truncated Whittacker interpolation, the third order Taylor expansion, the bicubic interpolation method, the biquadruple method, linear interpolation and the second and third order polynomial interpolation methods.
LAPEC- HOM was developed to provide a classical control based intuitive framework in which all results could be explained. It characterizes manual pursuit and preview tracking and consists of the following functional components: 1) visual reference signal processing delay, 2) visual reference signal filter/predictor, 3) error signal processing in terms of three different feed back loops, 4) internal model of control plant, 5) internal processing delay, 7) internal model of the neuro-muscular dynamics and 8) colored execution noise. LAPEC- HOM bypasses the

identifyability problems associated with Optimal Control Models (OCMs) and is more flexible than existing classical HOMs. The predictor/filter component is based on the finding that humans apply prediction during short preview and visual filtering during long preview. It is also shown that human's equalize the control plant's lag if sufficient preview is available thus suggesting in internal models of the control plant and neuromuscular dynamics. Sufficient preview is a function of the human's internal processing delay, the track bandwidth and the control plant dynamics.
The 2D preview tracking experiments were conducted with a fixed vertical drag velocity, which means that the subjects had no control over the perceived bandwidth of the track. Tracking was performed in a dark sound-proof room, whereby the six subjects sat comfortably on a chair 30 inches away from the 19 inch screen holding the springless joy stick manipulator in the dominant hand with the lower arm supported in the horizontal position. Stick movement, sampled at 60 Hz, was congruent with the lateral movement of the cross on the screen, which indicated the output of the control plant. The reference signal (track) was represented by a vertical curved line. Part of the experimental design consisted of developing methods to construct smoothly varying preview, track bandwidth and control plant dynamics. Twelve different settings of the EPs were used for statics experiments (PV=0,167,700ms, BW=1.0,0.5Hz, COF=0.75,2.5Hz) and twenty three combinations of one or two time varying EPs were selected for the time varying experiments (PV=0-700ms, BW@1.0-0.25Hz, COF=0.5- 2.5Hz).
To compare the findings with those in the literature, several batch analyses were performed on the static experiment data. A new performance measure (RMSSE) was introduced that is defined as the Root Mean Square (RMS) of the error (RMSE) between the plant output and a realization of the reference signal that is shifted by the lag (LAG) at which maximum correlation (XCOR) between the track and the plant output occurs. It is a true measure of the shape mismatch between the system input and output. Application of the RMSSE revealed that high bandwidth tracking (BW=l.0Hz) for zero and 167 ms preview caused a significant increase in RMSE when the plant's lag increases while RMSSE showed no significant change. The lag did increase significantly indicating that the observed increase in RMSE was mainly due to an increase lag between the track and the plant output. This means that a short preview provided the subjects with enough information to match the reference signal shape very well but were not able to null the tracking lag. Longer preview allowed for zero tracking delay for either COF setting.
The principal findings based on the batch analysis are: 1) regardless of the preview length, a 1.0 Hz track is never tracked as accurately as a 0.5 Hz one as indicated by the fact that all four measures (RMSE, RMSSE, LAG, XCOR) show a performance decrease for such a change in track bandwidth, 2) performance increased always when preview changed from 0 to 167 ms while a further increase to 700 ms caused a performance decrease in two of the less consistent subjects which was a result of anticipation as well as a decrease in shape match between the track and the control plant output while performance remained steady for the other four subjects and 3) a 167 ms preview provides enough look ahead time and information for further prediction to assure lag-free tracking except when the control plant introduces a significant lag; in that case, humans need more preview to equalize this lag (700 ms is sufficient). These findings were explained from the point of view that the HO acts as a predictor in his attempt to null his inherent delay time and equalize the control plant's lag.
The Fourier transform obtained bode plots showed good agreement with the identified ARMAX(2,2,2) model. Humans were found to induce substantially less noise when preview increased which is expected to be due to a better trade off between applying control and letting the tracking error temporarily increase. Furthermore, the cutoff frequencies associated with the AR portion of the model showed a dramatic decrease as preview increases resulting in a lower high frequencies gain which supports the finding that humans apply predictive tracking during low preview and visual filtering during high preview tracking.

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Reference Type: Edited Book
Editor: Boff, K., Kaufman, L., Thomas, J.

Year: 1986
Title: Handbook of perception and human performance
City: New York
Publisher: John Wiley and Sons
Volume: 1
Number of Volumes: 2
Edition: 1st
ISBN: 0-471-88544-4(v.1)

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Reference Type: Book Section
Author: Boldovici, J.A.
Year: 1987
Title: Measuring transfer in military settings
Book Title: Transfer of learning: Contemporary research and applications
Pages: 239-260
Number of Pages: 22

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Reference Type: Report
Author: Boldovici, J.A.
Year: 1992
Title: Simulator motion
Date: September
Type: ARI technical report
Report Number: 961
Author's Affiliation and Title: U.S. Army Research Institute
Number of Pages: 37
Keywords: simulator motion, force motion cuing, test reliability, statistical power, testing unsafe tasks, validity of inferences
Abstract: This review analyzes the arguments for and against using various methods of force motion cuing in land-vehicle and aircraft simulators. Research literature was reviewed and opinions were solicited from 31 authorities, 24 of whom replied. Analysis of the literature and of the reasons given by the authorities for and against the use of force motion cuing indicated the following: 1) no transfer of training data support using motion-based rather than fixed-base simulators; 2) the absence of supporting data may be due to the unknown characteristics of motion used in transfer research, safety considerations that preclude conducting definitive transfer of training experiments, and deficiencies in experiments that lead to inadequate statistical power; and 3) objective examination of the effects of force motion cuing on transfer to land vehicles and aircraft requires developing and using reliable and safe tests for assessing the performance of tasks that cannot safely be performed in parent vehicles. In the absence of transfer data demonstrating the superiority of fixed-based or motion-based simulators, analyses to identify discriminative stimuli are recommended. The report presents algorithms for deciding for which tasks the use of force motion cuing in training is likely to facilitate transfer to parent vehicles and for deciding whether seat shakers, g-seats, or motion bases are sufficient to provide discriminative stimuli for task performance.

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Reference Type: Conference Proceedings

Author: Bolton, M.J.P.
Year of Conference: 1978
Title: A high resolution visual system for the simulation of in-flight refueling
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 14-11 - 14-14
Date: April 24-27
Author's Affiliation and Title: Research Engineer, Redifon Simulation Ltd., Gatwick Road, Crawley, West Sussex RH10 2RL, England
Number of Pages: 14
Keywords: simulation, in flight refueling
Abstract: This paper describes a unique visual system, developed for the simulation of the in-flight refueling task; it incorporates both wide bandwidth and computer generated image (CGI) techniques. After a brief review of the in-flight refueling task and the simulation requirements, Redifon's previous experience in this field is outlined and the overall design of the latest visual system is described.
Particular attention is paid to the problem of providing the essential visual information within the constraints of cost and available technology. An important part of this visual system is the "special effects unit," which provides all video processing and image generation functions under the control of an autonomous computer.

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Reference Type: Conference Proceedings
Author: Boothe, E.M.
Year of Conference: 1992
Title: A case for simulator motion standards
Conference Name: European Forum on Matching Technology to Training Requirements
Publisher: Royal Aeronautical Society (RAeS)
Date: May
Author's Affiliation and Title: Federal Aviation Administration, National Simulator Program, Atlanta, GA
Number of Pages: 9
Abstract: The Federal Aviation Administration, the Civil Aviation Authority of the United Kingdom, and other aviation authorities require that simulators used in pilot training and checking be equipped with a motion base. The purpose, of course, is to provide the needed onset cues during pilot licensing and performance assessment. There is data to support the concept that pilot performance is improved when motion cues are available versus pilot performance in fixed-based devices. Data that are available are often disputed. In fact, discussions intended to address standards and testing of simulator motion systems are usually terminated without conclusion. Such discussions seem to quickly degenerate into emotional arguments about the need or worth of motion at all. Opinion seems to be about 50 percent for and 50 percent against motion. Proponents of airborne or in-flight simulation, however, cite the adverse influence that lack of motion has on pilot performance as a justification for in-flight simulation. Likely, such arguments will continue. The regulatory authorities have, however, taken the conservative position of "motion required." It is important, therefore, to properly specify the motion system characteristics so as to provide the appropriate cues and minimize any false cues.

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Reference Type: Conference Proceedings

Author: Boothe, E.M.
Year of Conference: 1992
Title: Simulation realism, cost and benefits
Conference Name: Information Technology Exposition and Conference (ITEC)
Date: April 8
Author's Affiliation and Title: Manager, Federal Aviation Administration, National Simulator Program
Number of Pages: 8

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Reference Type: Report
Author: Boothe, E.M.
Year: 1993
Title: The requirement for high quality data for flight simulators
City: Stone Mountain, GA
Institution: Flight Simulation and Training
Date: May
Author's Affiliation and Title: Consultant, Flight Simulation and Training, Stone Mountain, GA
Number of Pages: 9
Abstract: There are several categories of data required for flight simulator modeling and validation including aerodynamic, flight control engine, aircraft systems, terrain and, of course, dimensional. Each is important, each contributes to the quality of simulation and none can be neglected. The Federal Aviation Administration (FAA) in the *Advanced Simulation Plan*, however, emphasized the aerodynamic data and reiterated the emphasis in Advisory Circular (AC) 120-40B. The new international standards published by The Royal Aeronautical Society also emphasize aerodynamic data. In fact, all except aerodynamic data are hardly mentioned in these documents or are simply required by inference in statements such as "a full scale replica of the airplane simulated" or "systems must simulate the applicable airplane systems operation." The International Air Transport Association design and performance data requirements reflect the same aerodynamic data importance. This emphasis has stimulated the acquisition of much higher quality data for simulator aerodynamic modeling and validation.
The emphasis on aerodynamic data and simulator validation is well justified based on the permitted use of flight simulators. Total pilot training and certification, requiring no additional training in an airplane, is permitted and has become common practice among airlines. This practice demands that a simulator provoke proper pilot responses which in turn demands a continuous mathematical model and quality data to describe the airplane and its systems.

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Reference Type: Appendix
Author: Boothe, E.M.
Year: 1996
Title: Appendix 7: Level B motion and aerodynamics tests requirements
Date: November 11
Number of Pages: 15
Notes: Appendix to FAA/Industry Symposium on Aeromodel Transcript, Bürki-Cohen (ed.) (1996). See http://www.volpe.dot.gov/opsad/pubs.html

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Reference Type: Report

Author: Borah, J., Young, L., Curry, R.
Year: 1978
Title: Sensory mechanism modeling
City: Ohio
Institution: Advanced Systems Division, Wright-Patterson Airforce Base
Date: October
Type: Final Report
Report Number: AFHRL-TR-78-83
Author's Affiliation and Title: Gulf + Western, Applied Science Laboratories, 335 Bear Hill Road, Waltham, MA 02154
Number of Pages: 85
Keywords: flight simulation, motion perception, orientation perception, optimal estimation, sensory system modeling, neural sensory receptors, vestibular sensors, tactile sensors, proprioceptive sensors, visual effects, motion effects, linearvection, circularvection
Abstract: Pilots use information from a variety of sensory mechanisms to determine their estimate of orientation and motion. An understanding of this process and quantitative model are essential for the development of effective simulator motion cueing devices. A multisensory model for dynamic spatial orientation is being developed for this purpose.

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Reference Type: Report
Author: Borah, J., Young, L.R., Curry, R.E.
Year: 1979
Title: Sensory mechanism modeling
Institution: Air Force Human Systems Laboratory
Pages: 1-85
Date: February
Type: Final Report
Report Number: AFHRL-TR-77-70
Number of Pages: 86
Keywords: flight simulation, motion perception, orientation perception, optimal estimation, sensory system modeling, neural sensory receptors, vestibular sensors, tactile sensors, proprioceptive sensors, visual effects, motion effects, linearvection, circularvection
Abstract: Pilots use information from a variety of sensory mechanisms to determine their estimate of orientation and motion. An understanding of this process and a quantitative model are essential for development of effective simulator motion cueing devices. A multisensory model for dynamic spatial orientation is being developed for this purpose. Aircraft or simulator motion is translated into stimuli which are processed by dynamic models of the appropriate sensors (visual, vestibular, tactile, and proprioceptive), and are then fed to a central estimator which has been modeled as a linear optimal estimator, specifically a steady state Kalman Filter. In addition to the linear estimation process, some non-linear effects, such as the well documented delay in onset of visually induced motion, require non-linear additions to the model. Such additions have been kept to a minimum so as to retain the uniqueness and conceptual appeal of a linear optimization algorithm.
The model has been implemented as a computer program and has predicted some of the important qualitative characteristics of human dynamic spatial orientation under combined wide field visual motion and platform motion. Several types of special tactile and proprioceptive cues are also being considered but have not been validated.
The modeling effort has underscored the need for additional data in some areas and several experiments have been suggested to help fill these gaps.

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Reference Type: Journal Article
Author: Bos, J.E., Bles, W.
Year: 1998
Title: Modeling motion sickness and subjective vertical mismatch detailed for vertical motions
Journal: Brain Research Bulletin
Volume: 47
Issue: 5
Pages: 537-542
Date: January 24
Number of Pages: 6
Abstract: In an attempt to predict the amount of motion sickness given any kind of motion stimulus, we describe a model using explicit knowledge of the vestibular system. First, the generally accepted conflict theory is restated in terms of a conflict between a vertical as perceived by the sense organs like the vestibular system and the subjective vertical as determined on the basis of previous experience. Second, this concept is integrated with optimal estimation theory by the use of an internal model. If detailed for vertical motions only, the model does predict typical observed motion sickness characteristics, irrespective the parameter setting. By adjusting the nonvestibular parameters, the model can also quantitatively be adapted to seasickness data from the literature. With this concept, sickness severity hypothetically can also be predicted for other motions, irrespective of their origin and complexity.

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Reference Type: Magazine Article
Author: Bradley, P.
Year: 1996
Title: Advanced CRM: A trial program attempts to go a step further to help all pilots fly like the best pilots
Magazine: Business & Commercial Aviation
Pages: 62-66
Date: June
Number of Pages: 5
Keywords: CRM, ACRM, ACA, NTSB

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Reference Type: Journal Article
Author: Braithwaite, M.G., Durnford, S.J., Rosado, N.R.
Year: 1998
Title: Spatial disorientation in U.S Army rotary-wing operations
Journal: Aviation, Space and Environmental Medicine
Volume: 69
Pages: 1031-1037
Date: November
Abstract: This paper describes two surveys concerning spatial disorientation (SO) in U.S. Army rotary-wing operations that sought to assess the hazard and to identify recommendations to control it. One survey was of accident records, and the other was of aircrew experiences. Both surveys highlighted the magnitude of the problem. The accident survey showed that 30% of class A to C accidents involved SO as a significant factor, while the aircrew survey showed that 78% of aircrews have been disoriented (8% to the extent that flight safety was threatened). Both surveys showed a significant increase in SO associated with combat operations. Several differences between the two surveys were noted: 90% of the reviewed accidents were thought to involve type I (unrecognized) SO compared with only 43% of the reported incidents; both pilots in a particular

aircraft were considered to have been disoriented in at least 59% of accidents compared with 23% of incidents; sudden loss of visual cues ("brownout," "whiteout," or inadvertent entry to instrument meteorological conditions) accounted for 25% of SO accidents compared with 13% of incidents; and 62% of the accidents occurred at night compared with only 36% of incidents. Neither survey showed any association between SO and fatigue or other human factors. The results of both surveys suggested that crew coordination, alerting devices (e.g., audio warnings on the radar altimeter), flight information displays, and autopilot functions would be good targets for improvement.

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Reference Type: Journal Article
Author: Brandt, T., Dichgans, J., Koenig, E.
Year: 1973
Title: Differential effects of central versus peripheral vision on egocentric and exocentric motion perception
Journal: Experimental Brain Research
Volume: 16
Pages: 476-491
Number of Pages: 16

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Reference Type: Conference Proceedings
Author: Brauser, K., Seifert, R.
Year of Conference: 1985
Title: Computer simulation studies on human control reliability
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 10-11 - 10-19
Date: September 30 - October 3
Author's Affiliation and Title: Messerschmitt-Bölkow-Blohm GmbH, Ergonomics and Cockpit System LKE 301, Postfach 80 11 60, D-8000 München 80
Number of Pages: 10-1 - 10-19
Keywords: human control reliability, task taxonomy
Abstract: Pilot Induced Oscillations usually are defined as a sensitive indication of bad handling qualities. In the view of human performance reliability, PIOs are related to input errors with respect to the control characteristics of the controlled system. It has been learnt that this is a special aspect to the general rule that man will make errors while performing an arbitrary task under the influence of possible "performance shaping factors" (PSFs).
A recently developed "Task Taxonomy Method" is used as a tool for assessment of Human Error Probabilities (HEP) depending quantitatively on the effects of performance shaping factors (PSF) like task dimensions and characteristics, operator characteristics, system characteristics and environment factors. Using this Task Taxonomy procedure, HEP values for manual aircraft control tasks have been calculated. HEP values are drastically increased (0.5 - 0.9) by the influence of bad handling qualities while good handling qualities only reduce the HEP value to 0.1, because other PSFs may remain active. Therefore PIO incidents remain possible, even in aircraft with good handling qualities. This has been demonstrated by means of SAINT computer simulations using appropriate HEP values.
Notes: Published in September 1986.

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Reference Type: Report
Author: Bray, R.S.
Year: 1972
Title: Initial operating experience with an aircraft simulator having extensive lateral motion
Institution: NASA
Pages: 1-21
Date: May
Type: Technical Memorandum
Report Number: NASA TM X-62,155
Author's Affiliation and Title: Ames Research Center, Moffett Field, CA
Number of Pages: 22
Abstract: Late in 1969, a new research flight simulation facility, termed the Flight Simulator for Advanced Aircraft, was put into operation at Ames Research Center. This facility features an extensive cockpit motion system, emphasizing lateral motion for the simulation of lateral-directional control tasks. This paper describes briefly the motion capabilities of the simulator, and describes in some detail the logic with which the motion drives are controlled to provide the most effective approximations of the motion of flight. Preliminary assessments of the effectiveness of these motions, in the simulation of large transport aircraft, are discussed.

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Reference Type: Conference Proceedings
Author: Bray, R.S.
Year of Conference: 1985
Title: Visual and motion cueing in helicopter simulation
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 1-1 - 1-16
Date: September 30-October 3
Author's Affiliation and Title: NASA Ames Research Center, Moffett Field, CA 94035
Number of Pages: 16
Keywords: visual and motion cueing, helicopter simulation, fidelity, cockpit motion, washout
Abstract: For the past decade, helicopter handling qualities have been the subject of piloted-simulator programs at Ames Research Center. Early experience in fixed-cockpit simulators, with limited field of view, demonstrated the basic difficulties of simulating helicopter flight at the level of subjective fidelity required for confident evaluation of the vehicle characteristics. More recent programs utilizing large-amplitude cockpit motion and a multiwindow visual-simulation system have received a much higher degree of pilot acceptance. However, none of these simulations has presented critical visual-flight tasks that have been accepted by pilots as the full equivalent of flight. In this paper, the visual cues presented in the simulator are compared with those of flight in an attempt to identify deficiencies that may contribute significantly to these assessments. It is suggested that a non-optimum distribution of field-of-view elements, coupled with a severe lack of near-field detail, compromises the pilots sensing of transitional rates relative to nearby terrain or landing surface. For the low-amplitude maneuvering tasks normally associated with the hover mode, the unique motion capabilities of the Vertical Motion Simulator (VMS) at Ames Research Center permit nearly a full representation of vehicle motion. Especially appreciated in these tasks are the vertical-acceleration responses to collective control. For larger-amplitude maneuvering, motion fidelity must suffer diminution through direct attenuation or through high-pass filtering "washout" of the computer cockpit accelerations or both. Experiments were conducted in an attempt to determine the effects of these distortions on pilot performance of height-control tasks.

Results revealed that in holding position in the presence of vertical disturbances, pilot control-gain and resultant open-loop crossover frequency were significantly depressed as the fidelity of vertical motion was reduced. In height-tracking of a moving reference, gain and crossover were not greatly affected, but phase margin and tracking performance improved with motion fidelity. Pilot-opinion ratings of varied vertical-response characteristics were significantly modified by changes in motion-cue fidelity.
Notes: Published in September 1986.

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Reference Type: Conference Proceedings
Author: Bresee, J.S., O'Neal, A.F., Jennings, J.S.
Year of Conference: 1998
Title: Establishing relationships between flight data parameter values and instructor evaluations of performance for selected advanced qualification program qualification standards
Conference Name: Ninth International Training & Education Conference (ITEC '98)
Conference Location: Lausanne, Switzerland
Series Title: International Training & Education Conference
Date: April 28-30
Number of Pages: 10
Keywords: Flight Operations Quality Assurance (FOQA), Automated Performance Management System (APMS), Advanced Qualification Program (APQ)

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Reference Type: Conference Proceedings
Author: Breuhaus, W.O., Harper, R.P.
Year of Conference: 1970
Title: The selection of tasks and subjects of flight simulation experiments
Conference Name: Simulation
Conference Location: Ames Research Center, Moffett Field, CA
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 7-1 - 7-15
Date: March
Author's Affiliation and Title: Breuhaus: Aerosciences Division Director, Cornell Aeronautical Laboratory, Inc., Buffalo, NY 14221
Harper: Assistant Head, Flight Research Department, Cornell Aeronautical Laboratory, Inc., Buffalo, NY 14221
Number of Pages: 15
Keywords: flight simulation, task selection
Abstract: The fundamental, underlying purpose of flight simulation experiments is to estimate the results of a real-world evaluation of the flight problem that is being simulated. Many factors are important in the design of the simulation experiment, and it is essential that these factors be identified and dealt with. This paper considers two important areas: the selection of the simulation tasks, and the selection and preparation of the evaluation subjects.
The limitations of various simulators directly affect the simulation tasks which can be performed and, hence, affect the validity of the evaluation results obtained. The ability of simulator pilots to produce valid and repeatable evaluations which are applicable to the real-world situation can be no better than the accuracy with which the simulator tasks represent the essential characteristics of the real world. Unfortunately, this paper does not propose to set forth these sought-for necessities--it is beyond the knowledge of the authors to do so. Instead, certain considerations in the selection of simulator tasks are discussed, and problems are set forth which should be considered explicitly in the design of simulation experiments.

The selection and preparation of evaluation pilots are discussed in terms of the factors which appear to have substantial effects upon the program results. Experience in the real-world mission is one of several key elements which greatly enhances the evaluation results, and is discussed as an aid in bridging the gap to the real world. The discussion of the preparation of subjects considers the importance and nature of communication between the subject pilot and the analyst, and participation of the subjects in the experimental design.
Notes: Lead discussion by A. Filisetti and A. D. Brown. Also contains an open discussion.

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Reference Type: Report
Author: Brock, J.F., Jacobs, C., Van Cott, H., McCauley, M., Norstrom, D.M.
Year: 2001
Title: Simulators and bus safety: Guidelines for acquiring and using transit bus operator driving simulators
City: Washington, D.C.
Institution: Transit Cooperative Research Program
Transportation Research Board - National Research Council
Report Number: TCRP Report 72
Number of Pages: 29+appendix+glossary

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Reference Type: Conference Proceedings
Author: Brown, C.D.
Year of Conference: 1978
Title: Current deficiencies in simulation for training
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 1-1 - 1-7
Date: April 24-27
Author's Affiliation and Title: Colonel, United States Air Force, Tactical Air Warfare Center (USAFTAWC)
Number of Pages: 7
Keywords: flight simulation, deficiencies

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Reference Type: Report
Author: Brown, Y.J., Cardullo, F.M., McMillan, G.R., Riccio, G.E., Sinacori, J.B.
Year: 1991
Title: New approaches to motion cuing in flight simulators
City: Wright-Patterson Air Force Base, OH
Date: September
Type: Final Report
Report Number: AL-TR-1991-0139
Author's Affiliation and Title: Brown, Cardullo, McMillan, Riccio: Cardullo, Brown, & Associates, State University of New York
Sinacori: John B. Sinacori Associates, University of Illinois

Recipient's Affiliation and Title: Armstrong Laboratory, Crew Systems Directorate, Human Engineering Division, Human Systems Center, Air Force Systems Command, Wright-Patterson AFB, OH 45433-7022
Keywords: motion cuing
Abstract: A study was conducted to investigate new approaches in motion simulation. The study developed a conceptual model of pilot control of an aircraft. This model was subsequently used in a "need-based" analysis of motion cuing devices. This analysis technique involved a frequency domain representation of aircraft maneuvers, pilot perception of these maneuvers, and pilot perception of the cues from various simulator cuing devices. The analysis led to an assessment founded upon principles of pilot perception and behavior. An analysis task was performed on a pop-up attack in an F-4 aircraft to generate the aircraft maneuver time histories and pilot cue matrix. The results were used in a frequency domain analysis to determine the value of cuing devices for particular portions of the maneuver. The study investigated various cuing techniques beginning with proposed optimization of existing devices and proceeding to discuss several new techniques such as vibromyesthetic stimulation and direct electrical stimulation of nerves and muscles. The report concludes with recommendations for (1) future work employing the newly developed analytical technique and (2) experimentation with selected new devices to determine their cuing value.

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Reference Type: Conference Proceedings
Author: Brown, Y.J., Cardullo, F.M., Sinacori, J.B.
Year of Conference: 1989
Title: Need-based evaluation of simulator force and motion cuing devices
Conference Name: Flight Simulation Technologies Conference
Conference Location: Boston, MA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 78-85
Author's Affiliation and Title: Brown: Member of AIAA, Cardullo, Brown and Associates, Binghamton, NY
Cardullo: Member of AIAA, State University of New York, Binghamton, NY
Sinacori: Member of AIAA, John B. Sinacori Associates, Pebble Beach, CA
Number of Pages: 8
Keywords: pilot sensation of motion cues, force and motion cueing, mission profile, aircraft response, pilot sensory system response, and simulator cuing device performance
Abstract: Since aircraft--and particularly military aircraft--can produce sustained periods of significant acceleration, whereas ground based simulators cannot, the technical problem of providing faithful force and motion cues in a simulator is particularly difficult. Many force and motion cuing strategies and devices have been proposed, and many have been tested, but opinion remains divided as to the effectiveness of, or even the need for, such equipment. We have developed a method for analyzing the dynamic properties of force and motion cuing in terms of the relationship between the pilot sensation of motion cues involved in typical aircraft maneuvers and the pilot sensation of the corresponding synthetic cues produced by a simulator equipped with force and motion cuing devices. This analytic method will serve to characterize the applicability of available devices, indicate areas of fruitful development of new technologies, and guide research aimed at resolving applicability and usefulness issues. The analytic technique involves identifying the motions typical of operational flight maneuvers and then characterizing the pilot’s sensory response to the resulting accelerations and forces in the frequency domain. When a corresponding spectrum for the sensation of synthetic stimuli is overlaid, quantitative comparisons may be made. The analysis effectively integrates the relevant effects of mission profile, aircraft response, pilot sensory system response, and simulator cuing device performance into a unified graphical presentation.

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Reference Type: Conference Proceedings
Author: Brunt, M.A.
Year of Conference: 1985
Title: Use of VDU's by flight simulator instructors
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 7-1 - 7-6
Date: September 30 - October 3
Author's Affiliation and Title: Human Factors Consultant, Research & Development Department, Rediffusion Simulation Limited, Gatwick Road, Crawley, RH10 2RL, United Kingdom
Number of Pages: 6
Keywords: VDU, flight simulator instructors
Abstract: This paper compares the development of VDU-based simulator instructor stations with some Ergonomics rules, and provides a discussion around design aims and practical experience. Further rules are developed to establish a baseline for designers, procurers and users of instructor stations.
Notes: Published in September 1986.

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Reference Type: Report
Author: Bryant, R.B., Douglass, D.S., Ewart, R., Slutz, J.G.
Year: 1992
Title: Dynamic latency measurement using the Simulator Network Analysis Project (SNAP)
City: Wright-Patterson Air Force Base, OH
Institution: Wright-Patterson Air Force Base
Author's Affiliation and Title: Bryant, Douglass, Ewart: WL/FIGD, 2180 8th St., WPAFB, OH 45433
Slutz: EAI Services, Division of Halifax Corporation, 2180 8th St., WPAFB, OH 45433
Number of Pages: 9
Keywords: SNAP, simulator network analysis project, network latencies, simulation accuracy, protocol data units, network delays, EVDAS, electronic visual display altitude sensor, distributed interactive simulation
Abstract: This document outlines the SNAP project, its goals, its requirements, hardware and software, the verification and the experiments involved.

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Reference Type: Conference Proceedings
Author: Buffett, A.R.
Year of Conference: 1986
Title: Visual cueing requirements in flight simulation
Conference Name: Royal Aeronautical Society Conference on Advances in Flight Simulation - Visual and Motion Systems
Volume: Paper #8610

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Reference Type: Report
Author: Bull, J., Mah, R., Davis, G., Conley, J., Hardy, G., Gibson, J., Blake, M., Bryant, D., Williams, D.
Year: 1995
Title: Piloted simulation tests of propulsion control as backup to loss of primary flight controls for a mid-size jet transport
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA)
Date: December
Type: NASA Technical Memorandum
Report Number: NASA TM-110374
Author's Affiliation and Title: Bull - CAELUM Research Corporation
Mah, Davis, Conley, Hardy, Blake - NASA Ames Research Center
Gibson - Recom Technologies
Bryant, Williams - ManTech/NSI Technology Services Corporation
Number of Pages: 32
Keywords: propulsion control, jet transport, piloted simulation
Abstract: Failures of aircraft primary flight-control systems to aircraft during flight have led to catastrophic accidents with subsequent loss of lives (e.g., DC-10 crash, B-747 crash, C-5 crash, B-52 crash, and others). Dryden Flight Research Center (DFRC) investigated the use of engine thrust for emergency flight control of several airplanes, including the B-720, Lear 24, F-15, C-402, and B-747. A series of three piloted simulation tests have been conducted at Ames Research Center to investigate propulsion control for safely landing a medium size jet transport which has experienced a total primary flight-control failure. The first series of tests was completed in July 1992 and defined the best interface for the pilot commands to drive the engines. The second series of tests was completed in August 1994 and investigated propulsion controlled aircraft (PCA) display requirements and various command modes. The third series of tests was completed in May 1995 and investigated PCA full-flight envelope capabilities. This report describes the concept of a PCA, discusses pilot controls, displays, and procedures; and presents the results of piloted simulation evaluations of the concept by a cross-section of air transport pilots.

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Reference Type: Report
Author: Burcham, F.W.J., Maine, T.A.
Year: 1998
Title: Using engine thrust for emergency flight control: MD-11 and B-747 results
City: Edwards, CA
Institution: National Aeronautics and Space Administration (NASA)
Date: May
Report Number: NASA/TM-1998-206552
Number of Pages: 27
Abstract: With modern digital control systems, using engine thrust for emergency flight control to supplement or replace failed aircraft normal flight controls has become a practical consideration. The NASA Dryden Flight Research Center has developed a propulsion-controlled aircraft (PCA) system in which computer-controlled engine thrust provides emergency flight control. An F-15 and an MD-11 airplane have been landed without using any flight control surfaces. Preliminary studies have also been conducted that show that engines on only one wing can provide some flight control capability if the lateral center of gravity can be shifted toward the side of the airplane that has the operating engine(s). Simulator tests of several airplanes with no flight control surfaces operating and all engines out on the left wing have all shown positive control capability within the available range of lateral center-of-gravity offset. Propulsion-controlled aircraft systems that can operate without modifications to engine control systems, thus allowing PCA technology

to be installed on less capable airplanes or at low cost, are also desirable. Further studies have examined simplified "PCA Lite" and "PCA Ultralite" concepts in which thrust control is provided by existing systems such as autothrottles or a combination of existing systems and manual pilot control.

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Reference Type: Report
Author: Bürki-Cohen, J.
Year: 1995
Title: An analysis of tower (ground) controller - Pilot voice communications
City: Washington, DC
Report Number: DOT/FAA/AR-96/19

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Reference Type: Conference Proceedings
Author: Bürki-Cohen, J.
Year of Conference: 1995
Title: Say again? How complexity and format of air traffic control instructions affect pilot recall
Conference Name: 40th Annual Air Traffic Control Association
Pages: 225-229
Date: September

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Reference Type: Book Section
Author: Bürki-Cohen, J.
Year: 1996
Title: How to say it and how much: The effect of format and complexity on pilot recall of air traffic control clearances
Editor: Kanki, B.G., Prinzo, V.O.
Book Title: Methods and Metrics of Voice Communications
Volume: DOT/FAA/AM-96/10

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Reference Type: Conference Proceedings
Author: Bürki-Cohen, J.
Year of Conference: 2003
Title: Evidence for the need of realistic radio communications for airline pilot simulator training and evaluation
Conference Name: International Conference on Simulation of the Environment
Conference Location: London, UK
Publisher: Royal Aeronautical Society
Date: November 5-6
Abstract: This paper presents arguments in favor of realistic representation of radio communications during training and evaluation of airline pilots in the simulator. A survey of airlines showed that radio communications are mainly role-played by Instructor/Evaluators (I/Es), which increases I/E workload but reduces pilot workload. Opinions gathered from I/Es and the

literature indicate that this may lead to inadequate preparation of pilots to handle the complex radio-communications environment encountered in the air. A look at incidents during Initial Operating Experience (IOE) in revenue service via a review of the Aviation Safety Reporting System (ASRS) give additional support to this hypothesis. The paper concludes with a discussion of industry and airline efforts to find alternative means to provide realistic radio communications.

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Reference Type: Conference Proceedings
Author: Bürki-Cohen, J., Go, T.H.
Year of Conference: 2005
Title: The effect of simulator motion cues on initial training of airline pilots
Conference Name: American Institute of Aeronautics and Astronautics Modeling and Simulation Technologies Conference
Conference Location: San Francisco, CA
Date: August 15-18
Abstract: Two earlier studies conducted in the framework of the Federal Aviation Administration/Volpe Flight Simulator Human Factors Program examining the effect of simulator motion on recurrent training and evaluation of airline pilots have found that in the presence of a state-of-the-art visual systems, motion provided by a six-degree-of-freedom platform-motion system only minimally affected evaluation, and did not benefit training, of pilots that were familiar with the airplane. This paper gives preliminary results of a study on the effect of simulator platform motion on initial training of airline pilots that have never flown the simulated airplane.
Notes
First, the study confirmed the small but statistically significant alerting effect of motion found in the recurrent study with enhanced motion,16,17 although for initial training, the effect was only marginally significant. Even forewarned of an engine failure, pilots without motion cues remained unable to respond to an engine failure on take-off as fast as pilots with motion cues. It also showed, however, that like experienced pilots, pilots unfamiliar with the motion cues encountered in the airplane were able to catch up immediately once they receive motion cues, in other words, they did not have to be trained with motion to recognize the cues signaling an engine failure on takeoff. During the transfer portion of the study, all pilots responded equally fast for the V1 cut, regardless of the simulator configuration employed during training. With platform motion, the no-motion trained pilots improved significantly in response time, presumably because the motion cues alerted them to the engine failure.
Second, for the V1 cut only, motion appeared to help pilots to keep the column steady, which in turn helped them with airspeed—but not pitch angle—control. Recurrent pilots in the simulator with enhanced motion had controlled pitch angle better with motion, but only during the very first exposure to the V1 cut. Already with the second V1 cut, which was still flown without motion by the no-motion group, the difference between groups was gone. For both studies, the effects were small, and their operational relevance will need to be assessed by the operators themselves.
Third, although both groups improved on many variables for the ILS approach between training and transfer of training, the only group effect found was steadier pedal control for the no-motion group throughout. The recurrent study with enhanced motion had also found an overall steadier control strategy for the no-motion group, but for the wheel, not for the pedal. Also, the improved flight precision without motion found for recurrent pilots was not replicated with initial pilots.
Fourth, participants' perceptions did not indicate a marked preference for either of the two conditions. Most importantly, again there was no evidence that the sensory conflict between eyes and vestibular apparatus induced discomfort in the no-motion condition.

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Reference Type: Conference Proceedings

Author: Bürki-Cohen, J., Go, T.H., Chung, W.W., Schroeder, J., Jacobs, S., Longridge, T.
Year of Conference: 2003
Title: Simulator fidelity requirements for airline pilot training and evaluation continued: An update on motion requirements research
Conference Name: International Symposium on Aviation Psychology
Conference Location: Dayton, OH
Date: April 14-17
Abstract: Preliminary results are presented on the effect of enhanced hexapod motion on airline pilot recurrent evaluation, training, and transfer of training to the simulator with motion as a stand-in for the airplane (quasi-transfer). A first study, which tested "as is" motion in an FAA qualified full flight simulator, had not found any effect of motion. Under the enhanced motion conditions of the present study many effects of motion emerged that have not been previously shown in the airline-pilot training and evaluation context, indicating that motion may be required at least for pilot evaluation purposes. The implications of the results for recurrent training are also discussed.

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Reference Type: Conference Proceedings
Author: Bürki-Cohen, J., Go, T.H., Longridge, T.
Year of Conference: 2001
Title: Flight simulator fidelity considerations for total airline pilot training and evaluation
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Montreal, Canada
Publisher: American Institute for Aeronautics and Astronautics
Date: August 6-9
Number of Pages: 9
Abstract: This paper presents the FAA/Volpe Center's Flight Simulator Fidelity Research Program, which is part of the Federal Aviation Administration's effort to promote effectiveness, availability and affordability of flight simulators. This initiative will become increasingly critical with the anticipated regulatory changes mandating the use of simulators in airline pilot training and evaluation, dramatically reduced pilot new-hire experience levels and growing operational complexity. Two research areas with high pay-off potential for this effort are radio communications and platform motion simulation. Initial results suggest that to be fully effective in training and evaluating the cognitive and workload skills associated with radio communications, significant improvements in radio communications realism are needed. Initial research on the training effectiveness of a fixed-base simulator with a wide field-of-view visual system compared to a like system having platform motion failed to find an operationally significant effect of motion. Follow-up work will examine whether this result was a function of the motion characteristics or the maneuvers tested. No changes in regulatory requirements can be expected without absolute confidence in the reliability and validity of the results, requiring considerable additional research in both areas.

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Reference Type: Journal Article
Author: Bürki-Cohen, J., Kendra, A.J.
Year: 2001
Title: Air traffic control in airline pilot simulator training and evaluation
Journal: Air Traffic Control Quarterly
Volume: 9
Issue: 3
Pages: 229-253

Reference Type: Report
Author: Bürki-Cohen, J., Kendra, A.J., Kanki, B.G., Lee, A.T.
Year: 2000
Title: Realistic radio communications in pilot simulator training
City: Washington, DC
Report Number: DOT/FAA/AR-00/13

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Reference Type: Conference Proceedings
Author: Bürki-Cohen, J., Soja, N.N., Longridge, T.
Year of Conference: 1998
Title: Simulator fidelity requirements: The case of platform motion
Conference Name: Ninth International Training & Education Conference (ITEC '98)
Conference Location: Lausanne, Switzerland
Publisher: Computer Multimedia Productions Corporation
Pages: 216-231
Date: April 28-30
Author's Affiliation and Title: Bürki-Cohen: Volpe National Transportation Systems Center, Cambridge, MA
Soja: Consultant, Brookline, MA
Longridge: Federal Aviation Administration, Washington, DC
Number of Pages: 16

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Reference Type: Journal Article
Author: Bürki-Cohen, J., Soja, N.N., Longridge, T.
Year: 1998
Title: Simulator platform motion--The need revisited
Journal: International Journal of Aviation Psychology
Volume: 8
Issue: 3
Pages: 293-317
Author's Affiliation and Title: Bürki-Cohen: U.S. Department of Transportation-Volpe CenterDTS-79,
Soja: Consultant
Longridge: Federal Aviation Administration (FAA)
Number of Pages: 25
Abstract: The need to provide increased access to flight simulator training for US regional airlines, which historically have been limited by cost considerations in the use of such equipment for pilot recurrent training, is discussed. In light of that need, that issue of whether more affordable fixed-base simulators, identical to full flight simulators in all respects except for absence of platform motion, might provide an equivalent level of safety when employed for recurrent training, is examined. Pertinent literature from the past two decades is reviewed. The paper observes that no definitive conclusion can be drawn that would warrant modification of current qualification requirements for platform motion in full flight simulators. The article concludes that this situation will remain unchanged unless new research is undertaken, which takes into account the lessons learned from past research, and the opportunities engendered by new technology. Broad guidelines for an appropriate research design are discussed.

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Reference Type: Magazine Article
Author: Burnham, F.
Year: 1987
Title: Flight simulation: Hindrance or help in teaching to fly?
Magazine: Airport Services Management
Pages: 47-48, 57-58, 60
Date: October
Number of Pages: 5
Keywords: flight simulation, enclosed cockpit environment, desk-top training devices
Abstract: Computers have enabled the development of an array of devices that simulate an aircraft in flight. While some of these offer students quality practice at a reasonable price, others are no more than toys.

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Reference Type: Report
Author: Bussolari, S.R., Lee, A.T.
Year: 1986
Title: The effects of flight simulator motion on pilot performance and simulator acceptability in transport category aircraft
Institution: Massachusetts Institute of Technology/NASA Ames Research Center
Number of Pages: 6
Abstract: A series of quantitative models for human spatial orientation have been developed and applied to the assessment of flight simulator motion fidelity. A study was conducted to determine the effects of alterations in flight simulator motion upon pilot performance and opinion. Eighteen airline pilots, currently flying the Boeing 727 were given a series of flight scenarios in a Phase II simulator of that aircraft under varying conditions of simulator motion. The scenarios were chosen to reflect the flight maneuvers that these pilots might encounter during a routine pilot proficiency check. Pilot performance was measured during the simulated flights and they were asked to evaluate the simulator fidelity in comparison with the actual aircraft. No significant differences in pilot performance or rating of simulator fidelity was observed, despite large differences in the amplitude of simulator platform motion. The lack of sensitivity to simulator motion is predicted by estimates of pilot motion sensation generated with the spatial orientation models.
Notes: There are also four other documents referenced in this library that contain information about this study:
A. T. Lee and S. R. Bussolari (1989). Flight simulator platform motion and air transport pilot training.
S. R. Bussolari, L. R. Young and A. T. Lee (Conference Year Not Found in Document, Published in 1989). The use of vestibular models for design and evaluation of flight simulator motion.
S. R. Bussolari, L. R. Young and A. T. Lee (1987). The use of vestibular models for design and evaluation of flight simulator motion.
S. R. Bussolari, R. B. Sullivan and L. R. Young (1986). Vestibular models for design and evaluation of flight simulator motion.
The 1986 Bussolari, Sullivan and Young reference is most similar to this report.

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Reference Type: Conference Proceedings
Author: Bussolari, S.R., Sullivan, R.B., Young, L.R.
Year of Conference: 1986
Title: Vestibular models for design and evaluation of flight simulator motion
Conference Name: Advances in Flight Simulation: Visual and Motion Systems

Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Author's Affiliation and Title: Massachusetts Institute of Technology, Man-Vehicle Laboratory, Cambridge, MA
Number of Pages: 11
Abstract: Quantitative models for the dynamics of the human vestibular system have been applied to the generation of flight simulator platform motion. An optimal simulator motion control algorithm has been generated to minimize the vector difference between perceived spatial orientation estimated in flight and in simulation. The motion controller has been implemented on the motion system of the Vertical Motion Simulator at NASA Ames Research Center and evaluated experimentally through measurement of pilot performance and subjective rating during a VTOL aircraft simulation. In general, pilot performance in a longitudinal tracking task (formation flight) did not appear to be sensitive to variations in platform motion condition as long as motion was present. However, pilot compensation required to perform the flight tasks, as reflected in Cooper-Harper ratings of vehicle handling qualities and the direct assessment of motion fidelity by means of a rating scale designed for this purpose, were sensitive to motion controller design. The experiments generally validate the use of spatial orientation models in the design and evaluation of control systems for motion-base flight simulators.
Notes: There are four other documents in this library that contain information about this study:
A. T. Lee and S. R. Bussolari (1989). Flight simulator platform motion and air transport pilot training.
S. R. Bussolari, L. R. Young and A. T. Lee (Conference Year Not Found in Document, Published in 1989). The use of vestibular models for design and evaluation of flight simulator motion.
S. R. Bussolari, L. R. Young and A. T. Lee (1987). The use of vestibular models for design and evaluation of flight simulator motion.
S. R. Bussolari and A. T. Lee (1986?). The effects of flight simulator motion on pilot performance and simulator acceptability in transport category aircraft.
The 1986? Bussolari and Lee document describes the study more tersely.

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Reference Type: Conference Proceedings
Author: Bussolari, S.R., Young, L.R., Lee, A.T.
Year of Conference: 1987
Title: The use of vestibular models for design and evaluation of flight simulator motion
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 9-1 - 9-11
Date: September 29
Author's Affiliation and Title: Bussolari: Ph.D., Massachusetts Institute of Technology, Man-Vehicle Laboratory, Room 37-219, Cambridge, MA
Young: Sc.D., Massachusetts Institute of Technology, Man-Vehicle Laboratory, Room 37-219, Cambridge, MA
Lee: Ph.D., MS 239-1, NASA Ames Research Center, Moffett Field, CA
Number of Pages: 11
Abstract: Quantitative models for the dynamics of the human vestibular system have been applied to the design and evaluation of flight simulator platform motion. An optimal simulator motion control algorithm has been generated to minimize the vector difference between perceived spatial orientation estimated in flight and in simulation. The motion controller has been implemented on the motion system of the Vertical Motion Simulator at NASA Ames Research Center and evaluated experimentally through measurement of pilot performance and subjective rating during VTOL aircraft simulation. In general, pilot performance in a longitudinal tracking

task (formation flight) did not appear to be sensitive to variations in platform motion condition as long as motion was present. However, pilot compensation required to perform the flight tasks, as reflected in Cooper-Harper ratings of vehicle handling qualities and the direct assessment of motion fidelity by means of a rating scale designed for this purpose, were sensitive to motion controller design. Platform motion generated with the optimal motion controller was found to be generally equivalent to that generated by conventional linear crossfeed washout.
The vestibular models have been used to evaluate the motion fidelity of transport category aircraft (Boeing 727) simulation in a pilot performance and simulator acceptability study at the Man-Vehicle Systems Research Facility at NASA Ames Research Center. Eighteen airline pilots, currently flying the B-727, were given a series of flight scenarios in the simulator under various conditions of simulator motion. The scenarios were chosen to reflect the flight maneuvers that these pilots might expect to be given during a routine pilot proficiency check. Pilot performance and subjective rating of simulator fidelity was relatively insensitive to motion condition, despite large differences in the amplitude of motion provided. This lack of sensitivity may be explained by means of the vestibular models, which predict little difference in the modeled motion sensations of the pilots when different motion conditions are imposed.
Notes: There are also four other documents referenced in this library that contain information about this study:
A. T. Lee and S. R. Bussolari (1989). Flight simulator platform motion and air transport pilot training.
S. R. Bussolari, L. R. Young and A. T. Lee (Conference Year Not Found in Document, Published in 1989). The use of vestibular models for design and evaluation of flight simulator motion.
S. R. Bussolari, R. B. Sullivan and L. R. Young (1986). Vestibular models for design and evaluation of flight simulator motion.
S. R. Bussolari and A. T. Lee (1986?). The effects of flight simulator motion on pilot performance and simulator acceptability in transport category aircraft.
The document that was published in 1989 by AIAA has the same title and authors, and a less detailed abstract.

Reference Type: Conference Proceedings
Author: Calhoun, G., Valencia, G., Furness III, T.A.
Year of Conference: 1987
Title: Three-dimensional auditory simulation for crew station design/evaluation
Conference Name: Human Factors Society 31st Annual Meeting
Pages: 1398-1402
Author's Affiliation and Title: Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Dayton, OH 45433-6573
Number of Pages: 5
Abstract: A three-dimensional (3-D) auditory display can increase the pilot's situational awareness without requiring visual fixation. When visual acquisition is required the directional sound can give the pilot a more rapid cue to aim the eyes or head. in order to determine the utility and performance of a 3-D auditory display for cockpit applications, a method for generating 3-D auditory cues is required for simulation. Two laboratory systems are described which create, from monaural stimuli, binaural stimuli which can be perceived as localized and stabilized in space, regardless of the listener's head position. Additionally, preliminary results of the localization performance with one approach are presented.

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Reference Type: Conference Proceedings
Author: Callantine, T.J., Palmer, E.A.
Year of Conference: 2003
Title: Fast-time simulation studies of terminal-area spacing and merging concepts
Conference Name: 22nd AIAA/IEEE Digital Avionics Systems Conference
Conference Location: Indianapolis, Indiana
Publisher: Institute of Electrical and Electronics Engineers (IEEE)
Volume: 1
Author's Affiliation and Title: Todd J. Callantine: San Jose State University
Everett A. Palmer: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 8
Keywords: Air-traffic-control; Air-transportation; Airport-operations; Aviation-; Flight-simulators; Human-factors-engineering; Merging-control; Monte-Carlo-method; Spacing
Abstract: This paper examines fast-time simulation that is designed to complement real time human-in-the-loop simulations. Presented is preliminary fast-time simulation as designed for TRACON spacing and merging concepts. These simulations allow a variety of experimental conditions to be varied via Monte Carlo method.

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Reference Type: Report
Author: Carbaugh, D., Rockliff, L.
Year: 2004
Title: Airplane upset recovery training aid
Institution: Boeing, Airbus
Pages: 1-185
Date: August
Type: Training Aid
Author's Affiliation and Title: Captain Dave Carbaugh: The Boeing Company, Co-Chair Upset Recovery Industry Team
Captain Larry Rockliff: Airbus, Co-chair Upset Recovery Industry Team
Number of Pages: 186
Keywords: upset recovery training, URT, Airbus, Boeing

URL:
http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs200/branches/afs210/training_aids/media/upsetrecoveryweb.pdf

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Reference Type: Report
Author: Cardosi, K.M., Bürki-Cohen, J., Boole, P.W., Hourihan, J., Mengert, P., DiSario, R.
Year: 1992
Title: Controller response to conflict resolution advisory
City: Washington, DC
Report Number: DOT/FAA/NA-92/2

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Reference Type: Conference Proceedings
Author: Cardullo, F.
Year of Conference: 1999
Title: Fundamentals of simulation
Conference Name: The Fifteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Pages: 1-18
Date: January 11-15
Author's Affiliation and Title: Professor, State University of New York at Binghamton
Number of Pages: 18

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Reference Type: Conference Proceedings
Author: Cardullo, F.
Year of Conference: 1999
Title: Motion and force cuing II
Conference Name: The Fifteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Pages: 1-23, 21-32, 21-35
Date: January 11-15
Author's Affiliation and Title: State University of New York at Binghamton
Number of Pages: 90
Abstract: Motion and Force Cuing, II deals with the utilization of devices, which provide motion cuing by other than platform motion systems. All of these classes of systems are employed to supplement or fill the void not addressed by platform motion systems or to be used in place of those devices. There are portions of the motion environment experienced by pilots of aircraft that are not reproduced by platform motion systems. Hence these systems were developed to attempt to, "fill in the gaps".
There were three major classes of these systems in the past: G-Seats, Vibration Systems and High-G Augmentation Devices. The G-Seat was designed originally to provide sustained acceleration cues since platform motion onset cues are usually sustained for no more than 0.3 of a second. Vibrations systems were developed to provide the higher frequency vibration environment (usually 3-20 Hz) which for various reasons are not provided through platform motion systems. High-G Augmentation devices also extend the cuing capability of the platform motion system. In this case, these systems attempt to provide some of the physical effects, which occur in high-g flight and cannot be induced by platform motion systems. Some of these effects

are a diminution of the visual field of view (tunnel vision), an increase in apparent weight of the head and extremities, etc. The current thinking goes beyond the above to include primary motion cuing by devices other than platform motion systems.

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Reference Type: Conference Proceedings
Author: Cardullo, F.M.
Year of Conference: 1991
Title: An assessment of the importance of motion cueing based on the relationship between simulated aircraft dynamics and pilot performance: A review of the literature
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 436-447
Author's Affiliation and Title: Associate Professor, Mechanical Engineering, Associate Fellow AIAA, State University of New York, Binghamton, NY
Number of Pages: 12
Keywords: motion cueing, simulated aircraft dynamics, pilot performance, visual system, categories of motion
Abstract: This paper reviews a method of assessing the need for motion cueing based on the simulated aircraft flight dynamics environment. The flight environment is reduced into four categories: maneuvers which are largely open loop and low gain, high gain and closed loop with good visual, high gain and closed loop with poor visual and aircraft which are unstable; and assesses motion cueing requirements on that basis. Also reviewed is the motion cueing literature including both the results of performance studies and the transfer of training studies with the intent of establishing a determination of the relationship between the necessity of motion cueing and the task performed in the simulator.

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Reference Type: Newspaper Article
Reporter: Carey, S.
Year: 1998
Title: Demand for pilots is soaring as old-timers take off
Newspaper: The Wall Street Journal
Pages: B1, B12
Issue Date: June 4
Author's Affiliation and Title: Staff Reporter of The Wall Street Journal
Number of Pages: 1

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Reference Type: Newspaper Article
Reporter: Carey, S., Michaels, D.
Year: 2002
Title: At some airlines, laptops replace pilots' 'brain bags'
Newspaper: The Wall Street Journal

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Reference Type: Newspaper Article

Reporter: Carley, W.M.
Year: 1999
Title: Pull up! United 747's near miss sparks a widespread review of pilot skills--Flight 863 skirted a mountain and buzzed residences in the San Francisco area--'They didn't do the basics'
Newspaper: The Wall Street Journal
Pages: A1, A8
Issue Date: March 19
Author's Affiliation and Title: Staff reporter of the Wall Street Journal
Number of Pages: 2

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Reference Type: Conference Proceedings
Author: Caro, P.
Year of Conference: 1977
Title: Platform motion and simulator training effectiveness
Conference Name: Tenth NTEC/Industry Conference
Pages: 93-98
Number of Pages: 6

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Reference Type: Report
Author: Caro, P.
Year: 1979
Title: Some factors influencing transfer of simulator training
Institution: Human Resources Research Organization

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Reference Type: Report
Author: Caro, P.W.
Year: 1977
Title: Some factors influencing Air Force simulator training effectiveness
Date: March
Type: Technical Report
Report Number: HumRRO-TR-77-2
Author's Affiliation and Title: Seville Research Corporation, 400 Plaza Building, Pensacola, FL 32505
Number of Pages: 104
Keywords: aircraft simulation, simulators, simulator training, training device, training effectiveness, experimental design, simulator effectiveness, motion, fidelity, visual display, trainee characteristics, attitude, expectation, training
Abstract: A study of US Air Force simulator training was conducted to identify factors that influence the effectiveness of such training and to learn how its effectiveness is being determined. The research consisted of a survey of ten representative Air Force simulator training programs and a review of the simulator training research literature. A number of suspected or potential factors influencing simulator training effectiveness were identified. These factors include simulator design for training, visual display fidelity, platform motion system fidelity, handling characteristics, training program features, trainee and instructor characteristics, and attitudes and expectations toward simulator training. The discussion of each factor reviews relevant literature and Air Force simulator design features and training practices. Ten simulator training effectiveness study design

models were identified. Efforts by the Air Force to validate the simulator training activities surveyed are described in relation to these ten models. It was found that the programs surveyed had not been subjected to formal evaluation studies that would establish their training effectiveness in quantitative terms. Therefore, the influence of factors identified during the survey upon such training could only be hypothesized. Recommendations were made concerning research and administrative action that could enhance future simulator training effectiveness.

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Reference Type: Journal Article
Author: Caro, P.W.
Year: 1979
Title: The relationship between flight simulator motion and training requirements
Journal: Human Factors
Volume: 21
Issue: 4
Pages: 493-501
Author's Affiliation and Title: Seville Research Corporation, Pensacola, FL
Number of Pages: 9
Abstract: Flight simulator motion has been demonstrated to affect performance in the simulator, but recent transfer of training studies have failed to demonstrate an effect upon in-flight performance. However, these transfer studies examined the effects of motion in experimental designs that did not permit a dependency relationship to be established between the characteristics of the motion simulated and the training objectives or the performance measured. Another investigator has suggested that motion cues which occur in flight can be dichotomized as maneuver and disturbance cues, i.e., as resulting from pilot control action or from external forces. This paper examines each type cue and relates it analytically to training requirements. The need to establish such relationships in simulator design is emphasized. Future transfer studies should examine specific training objectives that can be expected to be affected by motion.

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Reference Type: Conference Proceedings
Author: Caro, P.W.
Year of Conference: 1983
Title: Flight crew training technology--A review
Editor: Lee, A.T., Lauber, J.K.
Conference Name: Flight Training Technology for Regional/Commuter Airline Operation
Conference Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA)
Author's Affiliation and Title: Seville Training Systems
Recipient's Affiliation and Title: NASA Ames Research Center, Moffett Field, CA 94035

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Reference Type: Report
Author: Carr, P.C., McKissick, B.T.
Year: 1988
Title: Analysis procedures and subjective flight results of a simulator validation and cue fidelity experiment
Institution: NASA
Pages: 1-28

Date: July
Type: Technical Memorandum
Report Number: NASA-TM-88270
Author's Affiliation and Title: Peter C. Carr: Ames Research Center, Dryden Flight Research Facility, Edwards, CA
Recipient's Affiliation and Title: Burnell T. McKissick: Langley Research center, Hampton, VA
Number of Pages: 29
Keywords: cues, flight simulators, flight tests, pilot performance, proving
Abstract: A joint experiment to investigate simulator validation and cue fidelity was conducted by the Dryden Flight Research Facility of NASA Ames Research Center (Ames-Dryden) and NASA Langley Research Center. The primary objective was to validate the use of a closed-loop pilot-vehicle mathematical model as an analytical tool for optimizing the tradeoff between simulator fidelity requirements and simulator cost. The validation process includes comparing model predictions with simulation and flight test results to evaluate various hypotheses for differences in motion and visual cues and information transfer. A group of five pilots flew air-to-air tracking maneuvers in the Langley differential maneuvering simulator and visual motion simulator and in an F-14 aircraft at Ames-Dryden. The simulators used motion and visual cueing devices including a g-seat, a helmet loader, wide field-of-view horizon, and a motion base platform.
URL: http://www.nasa.gov/centers/dryden/pdf/88103main_H-1371.pdf

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Reference Type: Report
Author: Carretta, T.R., Dunlap, R.D.
Year: 1998
Title: Transfer of training effectiveness in flight simulation: 1986-1997
Institution: United States Air Force Research Laboratory
Date: September
Report Number: AFRL-HE-AZ-TR-1998-0078
Author's Affiliation and Title: Carretta: Training Effectiveness Branch, Warfighter Training Research Division, 7909 Lindbergh Drive, Brooks AFB, TX 78235-5352
Dunlap: Air Warrior Training Branch, Warfighter Training Research Division, 6001 South Power Road, Bldg. 558, Mesa AZ 85206-0904
Number of Pages: 17
Keywords: flight simulation, flight simulator, simulation-based training, simulator effectiveness, simulator transfer of training, training effectiveness, transfer of training
Abstract: The purpose of this report was to review recent studies regarding the effectiveness of flight simulators as augmentation for "hands-on" flying training. Simulation-based training has been proposed to reduce costs, extend aircraft life, maintain flying proficiency, and provide more effective training, especially in areas difficult to train in operational aircraft. A review of the literature from 1986 to 1997 identified 67 articles, conference papers, and technical reports regarding simulator flying training and transfer. Of these, only 13 were related directly to transfer of training from the simulator to the aircraft. Studies of simulator effectiveness for training landing skills constituted a majority of the transfer studies, although a few examined other flying skills such as radial bombing accuracy and instrument and flight control. Results indicate that simulators are useful for training landing skills, bombing accuracy, and instrument and flight control. Generally, as the number of simulated sorties increases, performance improves, but this gain levels off after approximately 25 missions. Further, several studies indicate that successful transfer may not require high-fidelity simulators or whole-task training, thus reducing simulator development costs. Evaluation of this literature is difficult for many reasons. Typically, researchers fail to report sufficient detail regarding research methods, training characteristics, and simulator fidelity. In addition to these methodological concerns, there is a lack of true simulator-to-aircraft transfer studies involving complex pilot skills. This may be due to problems

such as inadequate simulator design, cost, and availability, and access to simulators in operational flying units. Future directions in simulator transfer of training are discussed.

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Reference Type: Report
Author: Casali, J.G., Frank, L.H.
Year: 1986
Title: Perceptual distortion and its consequences in vehicular simulation: Basic theory and incidence of simulator sickness
City: Washington, D.C.
Institution: Transportation Research Board
Report Number: Transportation Research Record 1059
Author's Affiliation and Title: Human Factors Laboratory, Department of Industrial Engineering and Operations Research - Virginia Polytechnic Institute
Number of Pages: 9
Abstract: Simulator-induced sickness is a serious problem that can afflict the users of vehicular simulators including aircraft and driving devices. Operators and passengers in training and research simulators have experienced symptoms akin to those of motion sickness both during and following a simulator experience. In some cases, even several hours postexposure, aftereffects or flashbacks to the simulation environment may surface creating sudden disorientation in the individual. The simulator-sickness syndrome appears to be severe and frequent enough that it affects the utility of simulation and may create safety hazards for users. It has, therefore, recently received considerable attention by the human engineering community. This paper provides background information on the sickness problem; its theoretical underpinnings; and a brief, tabularized literature review specific to simulator sickness. All available articles, reports, technical memoranda, and papers directly dealing with the problem of operator discomfort in vehicular simulators were obtained and selectively reviewed.

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Reference Type: Conference Proceedings
Author: Casali, J.G., Frank, L.H.
Year of Conference: 1987
Title: Manifestation of visual/vestibular disruption in simulators: Severity and empirical measurement of symptomatology
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 11-11 - 11-18
Date: September 29
Author's Affiliation and Title: Casali: Ph.D., Virginia Polytechnic Institute and State University, Department of Industrial Engineering and Operations Research, Blacksburg, VA 24060
Frank: LCDR, MSC, USN, Ph.D., Human Factors and Operational Analysis Branch, Pacific Missile Test Center, Point Mugu, CA 93042-5000
Number of Pages: 18
Keywords: visual, vestibular disruption, simulator sickness, motion sickness, symptoms
Abstract: Reported incidence rates on vehicular simulator-induced sickness in operators is highly variable both within and between devices. Recent review of the literature indicates that documented incidence rates range from 0 to nearly 90% in flight devices and even higher in some driving devices. However, the severity of the simulator sickness problem is not adequately gauged by a simple count of those operators experiencing one or more physiologic symptoms.

Instead, a battery of metrics is useful in identifying and properly assessing an induced state of simulator sickness. This is of particular importance with the recent thrust in empirical research toward determination of the effects of simulator design parameters, such as control loop delays, on operator sickness and performance. This paper reviews the symptomatology experiences by operators of flight and driving simulators. Drawing upon this review, dependent measures are recommended for use in simulator-sickness research including self-report forms, specific physiologic indices, postural equilibrium tests, performance tests and susceptibility prediction instruments. A tabular documentation of published research studies concerning simulator sickness is also provided, as is a discussion of the ramifications of the problem.

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Reference Type: Electronic Source
Author: Chamberlain, H.D.
Year: 2001
Title: Qualified PC computer-based training devices take off
Access Year: 2006
Access Date: Sept. 6
Number of Pages: 4
URL: http://avstop.com/Stories/Training.htm

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Reference Type: Electronic Source
Author: Chamberlain, H.D.
Year: 2002
Title: Personal computer-based aviation training devices: Does yours meet FAA training requirements?
Access Year: 2006
Access Date: Sept. 6
Last Update Date: 4/30/2002
Type of Medium: Online article
Number of Pages: 8
URL: http://avstop.com/Technical/computer.html

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Reference Type: Conference Proceedings
Author: Chambers, W.S.
Year of Conference: 1999
Title: Visual simulation
Conference Name: The Fifteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Date: January 11-15
Author's Affiliation and Title: Consultant, Future Technology, Inc.
Number of Pages: 13
Keywords: visual simulation, perception

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Reference Type: Conference Proceedings
Author: Chappelow, J.W.
Year of Conference: 1987
Title: Simulator sickness in the Royal Airforce: A survey
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 6-1 - 6-11
Date: September 29
Author's Affiliation and Title: RAP Institute of Aviation Medicine, Farnborough, Hampshire GU14 6SZ
Number of Pages: 11
Keywords: motion cues, simulator sickness
Abstract: A questionnaire survey was undertaken of pilot with experience of two air combat simulators. Two hundred and seventy one respondents completed questionnaires, some up to two years retrospectively and other immediately after a simulator session. There were, thus, four separate studies. The questionnaire sought information on the incidence of disequilibrium and other symptoms experienced in the simulator and after leaving it. The proportion of those suffering at least one symptom in the simulator varied between 50% and more than 90% across studies (53.5% overall). However, not all the symptoms reported were unequivocally ascribable to disequilibrium. The proportion of each sample reporting delayed symptoms was between 10% and 50% (13% overall). The effect on the respondent's motivation to use the simulator was negligible.

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Reference Type: Conference Proceedings
Author: Chung, W., Bürki-Cohen, J., Go, T.H.
Year of Conference: 2004
Title: Task and vehicle dynamics based assessment of motion cueing requirements
Conference Name: American Institute of Aeronautics and Astronautics Modeling and Simulation Technologies Conference
Conference Location: Providence, RI
Date: August 16-19

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Reference Type: Conference Proceedings
Author: Chung, W., Gerdes, R., LaForce, S.
Year of Conference: 1996
Title: Phase response requirements between cross-coupled motion axes for handling qualities research simulators
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: San Diego, CA
Pages: 72-90
Date: July 29-31
Author's Affiliation and Title: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 19
Abstract: An experiment was designed to study the effect of discrepancies between cross-coupled motion axes responses and to determine if phase response requirements for motion simulators is necessary for handling qualities research. Since the pilot is generally not located at the rotational center of a motion platform, this can produce distorted cues in a motion based flight

simulator. For kinetically cross-coupled motion axes, such as roll and lateral, coordinated translational commands are required in order to compensate for induced linear accelerations caused by angular motion at the pilot station. The effect of phase response discrepancies between the roll and lateral cross-coupled motion axes was the focus of this experiment. A stability derivative model, which represents a fully decoupled aircraft response, was tailored to meet Level I rotorcraft handling qualities at low speed. The Vertical Motion Simulator, a gimbaled motion system at NASA Ames Research Center, provided the six degrees of freedom motion. The roll and lateral motion dynamics were modified to produce specific phase characteristics. This was required to study phase requirements between the roll angular acceleration and lateral specific force. Two low speed tasks, hover and side step, were used to evaluate the vehicle's handling qualities under three motion configurations and two visual delay configurations. The phase characteristics between the roll and lateral motion axes as well as the phase characteristics of the visual system were varied in the experiment. The test results indicated significant reduction in pilot workload and improved performance when the cross-coupled motion axes were in phase with each other and with the visual responses. A mismatch of phase response in the cross-coupled motion axes, up to 40 msec phase difference, led to increased pilot workload and poorer pilot handling qualities ratings in most instances. Due to a resulting large phase discrepancy between the visual and motion cues, the results also suggest that visual delay compensation had little or no effect on pilots' handling qualities ratings under the given test conditions.

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Reference Type: Journal Article
Author: Chung, W., Wang, W.Y.
Year: 1988
Title: Evaluation of simulator motion characteristics based on AGARD-AR-144 procedures
Journal: Aerospace Simulation 1988
Pages: 177-188
Author's Affiliation and Title: Department of Simulation Programs, SYRE, Post Office Box 81, Moffett Field, CA 94035
Number of Pages: 12
Abstract: This paper presents the results of applying a set of motion evaluation procedures based on performance criteria developed by the North Atlantic Treaty Organization (NATO) Advisory Group for Aerospace Research and Development (AGARD) on the Vertical Motion Simulator (VMS) at Ames Research Center. The criteria being evaluated includes the describing function, operational limits and acceleration noise. The procedures include the development of a real-time operating system to generate the motion system drive commands and collect the response. The data analysis reveals the describing function and operational envelopes of the six motion axes, and the cross coupling between the motion axes.

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Reference Type: Conference Proceedings
Author: Chung, W.W.
Year of Conference: 2000
Title: A review of approaches to determine the effectiveness of ground-based flight simulation
Conference Name: AIAA Modeling and Simulation Technology
Conference Location: Denver, CO
Publisher: AIAA
Pages: 10
Date: August 14-17
Keywords: flight simulation, motion cueing, visual cueing, man/machine interaction

Abstract: A review of the current understanding of how key simulation cueing elements affect ground-based flight simulation has been conducted. The objectives are to develop a broad assessment of current approaches in determining simulator effectiveness and to identify future research directions. The review covers the visual cues and human/machine related topics. For visual cueing related issues, the review focuses on visual transport delay, resolution, scene content, and field-of-view. For human/machine interaction issues, the review focuses on human psychophysical characteristics, pilot models, and motion cueing criteria. Results and suggested future work from past investigations are summarized. Additional recommendations are presented.

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Reference Type: Conference Proceedings
Author: Chung, W.W., Schroeder, J.A.
Year of Conference: 1997
Title: Visual and roll-lateral motion cueing synchronization requirements for motion-based flight simulations
Conference Name: The American Helicopter Society 53rd Annual Forum
Conference Location: Virginia Beach, VA
Date: April 29-May 1
Author's Affiliation and Title: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 13
Abstract: An investigation of flight simulation cueing synchronization requirements for the visual, roll motion, and lateral motion was conducted on the Vertical Motion Simulator (VMS) at NASA Ames Research Center. The unique displacement capability of the VMS was exploited by developing a piloted task such that the visual and motion cues matched closely for a baseline configuration. Pilots performed a lateral sidestep between two points 20 feet apart using a helicopter model designed to have satisfactory handling qualities. Since the VMS has in excess of 20 feet lateral travel, the task was simulated exactly. That is, the motion and visual cues had a one-to-one correspondence. Starting with the baseline simulation cueing configuration that had synchronous visual, roll, and lateral cues, time delays of 40 and 80 msec were introduced into the visual, roll, and lateral axes in a randomized matrix giving a total of 27 configurations. The baseline configuration was developed based on the current FAA helicopter simulator specifications for civil helicopter motion fidelity requirements, which has little objective data for its support. Six experienced test pilots from both government and industry rated all the configurations. Objective and subjective data were taken that included handling qualities ratings, motion fidelity ratings, and perceptions of synchronization. Initial analysis of the data indicate support for aspects of the current FAA specifications on civil helicopter motion fidelity requirements, with some additional preconditions. Based upon a statistical analysis of the data, recommendations are made for permissible cueing delays and asynchronization.

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Reference Type: Conference Proceedings
Author: Chung, W.W., Schroeder, J.A., Robinson, D.J.
Year of Conference: 1997
Title: An initial evaluation of the effects of motion platform and drive characteristics
Conference Name: American Institute of Aeronautics and Astronautics
Pages: 1-11
Author's Affiliation and Title: William W. Chung and Jeffery A. Schroeder: Aerospace Engineer, NASA Ames Research Center, Moffett Field, CA
Doug J. Robinson: Research and Development Engineer, Lockheed Martin Skunk Works, Palmdale, CA
Number of Pages: 12

Abstract: Six motion cueing configurations were developed to investigate facility dependent effects on simulation fidelity. These configurations were tested on a large-amplitude motion-based flight simulator and, when possible, on a small amplitude hexapod flight simulator. On the large amplitude device, one configuration had no motion attenuation, and it served as the truth-case motion reference. Five other configurations were developed to represent a continuum of motion fidelity from high to low. Results from this investigation indicate that only the one-to-one motion configuration consistently reflected the predicted handling qualities ratings based on an existing handling qualities specification. It was also noted that reductions in motion fidelity can falsely improve handling qualities ratings. Non-trivial differences were measured between the facilities, and those differences are currently being investigated.

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Reference Type: Conference Proceedings
Author: Chung, W.W., Sweet, B.T., Kaiser, M.K., Lewis, E.
Year of Conference: 2003
Title: Visual cueing effects investigation for a hover task
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Austin, Texas
Publisher: AIAA
Date: August 11-14
Call Number: AIAA Paper 2003-5524
Abstract: In simulation, as in actual aircraft, pilots conduct their missions according to perceived vehicle performance and spatial orientation from out-the-window (OTW) information. Ground-based flight simulations rely upon computer-generated OTW visual scenes. The realism and fidelity of a specific OTW simulation therefore has a significant impact on mission effectiveness. This study investigates effects of three visual parameters of the computer-generated image system (field-of-view, collimation, and resolution) on a disturbance-rejection hovering task. Pilots' performance and workload were studied under the following conditions: collimated optics vs. non-collimated optics, wide field-of-view (FOV) vs. narrow FOV, and higher resolution vs. lower resolution. Subjects were instructed to maintain a station-keeping position during disturbances while piloting an uncoupled four degrees-of-freedom (DOF) helicopter model, which had a satisfactory rate-command system in pitch and roll axes and ideal heading and altitude hold. Display collimation and FOV were found to have significant effects on pilots' performance and their subjective perception of visual cueing quality.

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Reference Type: Conference Proceedings
Author: Chung, W.W.Y., Schroeder, J.A., Johnson, W.W.
Year of Conference: 1997
Title: Effects of vehicle bandwidth and visual spatial-frequency on simulation cueing synchronization requirements
Conference Name: AIAA Atmospheric Flight Mechanics Conference
Conference Location: New Orleans, LA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 509-523
Author's Affiliation and Title: NASA Ames Research Center, Moffett, CA
Number of Pages: 15
Abstract: Results of a recent flight simulation study suggested criteria for visual and motion cueing synchronization, but only for one vehicle bandwidth and one visual scene. The purpose of the study reported here was to determine if those synchronization criteria may be generalized. In particular, a complete factorial design was used to examine the flight simulation effects of the

following five experimental factors: visual time delay, roll motion time delay, lateral motion time delay, vehicle bandwidth, and visual spatial frequency. Five experimental test pilots completed the full experimental matrix. The results show that the more limited set of synchronization criteria generalize for the variations examined. That is, regardless of the vehicle bandwidths or the visual cueing spatial frequencies examined, the same synchronization criteria are applicable for the visual, roll, and lateral cues. Thus, the results add further confidence to the recently suggested criteria, which suggested three guidelines. First, roll and lateral motion cues should be synchronized, but if they cannot be, the asynchronization should be no more than 40 msec. Second, the visual and roll motion cues should also be synchronized, but if they cannot be, the asynchronization should also be no more than 40 msec. The synchronized roll and lateral motion cues can be allowed to lag, but should not lead the visual cues.

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Reference Type: Conference Proceedings
Author: Cohen, E.
Year of Conference: 1971
Title: How much motion is really needed in flight simulators?
Conference Name: Fourth International Simulation and Training Conference
Conference Location: Atlanta, GA
Publisher: Society of Automotive Engineers, Inc.
Call Number: #710488
Author's Affiliation and Title: Link Div., The Singer Co.
Number of Pages: 6
Keywords: flight simulator, motion cues, degree-of-freedom
Abstract: Although the need for motion on flight simulators used for training is well accepted, there is a wide divergence of opinion on the kind and amount of motion required. This paper reviews the requirements for motion in each of the six degrees of freedom, and suggests the extent of motion desirable in each, as well as ways to exploit given motion system geometry.

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Reference Type: Book
Author: Cohen, J.
Year: 1988
Title: Statistical power analysis for the behavioral sciences
City: Hillsdale, NJ
Publisher: Erlbaum
Number of Pages: 1-552
Edition: 2
Original Publication: 1969
Reprint Edition: 1977

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Reference Type: Journal Article
Author: Colavita, F.B.
Year: 1974
Title: Human sensory dominance
Journal: Perception and Psychophysics
Volume: 16
Issue: 2

Pages: 409-412
Author's Affiliation and Title: University of Pittsburgh
Number of Pages: 4
Abstract: Human Ss matched an auditory and a visual stimulus for subjective magnitude. Then each stimulus was used as a cue in a reaction time task. On occasions when both stimuli were presented simultaneously, Ss' responding was seen to be dominated by the visual stimulus. Of further interest was the finding that on some occasions of simultaneous light-tone presentation Ss were unaware that the tone had been presented. This apparent prepotency of the visual over the auditory stimulus was seen to persist across a variety of experimental conditions, which included giving Ss verbal instructions to respond to the tone when both stimuli were presented simultaneously.

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Reference Type: Magazine Article
Author: Collins, M.P.
Year: 2000
Title: The buzz about haptics: Zero-G research could lead to an enhanced attitude reference
Magazine: AOPA Pilot
Pages: 117-124
Date: August
Keywords: haptics, zero-G, motion sickness, disorientation
Abstract: Kristy Stokke's long blond hair flows haphazardly and her feet slowly slide above her head. The Massachusetts Institute of Technology senior is struggling to conduct an experiment in zero-G conditions. But Stokke is far away from MIT's campus labs. Far above them, too, for that matter. She's working in NASA's KC-135 microgravity research aircraft, officially named Weightless Wonder but better known as "The Vomit Comet." High above the Gulf of Mexico, the pilots of the four-engine jet follow a precise parabolic flight path, making a series of 45-degree climbs and descents that alternately subject the aircraft, its passengers, and their equipment to zero and positive 2 Gs. Stokke is too busy to think about motion sickness, a condition to which many of her fellow student researchers have succumbed. Instead, she's focused on her search for the answer to one question: Are there haptics in your future? An enthusiastic private pilot, Stokke sought to combine her interest in general aviation with the thesis that she had to complete as part of her undergraduate degree in mechanical engineering. Concerned about how easily VFR pilots can become disoriented when visual references are diminished, she hypothesized that disorientation can be reduced--and flight safety increased--by replacing the missing sensory cues. The result was Aeronautical Orientation Research Through Haptics--Study of Tactile Attitude Recovery, dubbed Northstar.

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Reference Type: Conference Proceedings
Author: Computer Multimedia Productions Corporation
Year of Conference: 1998
Title: Proceedings and exhibits CD-Rom
Conference Name: 9th International Training & Education Conference (ITEC '98)
Conference Location: Lausanne, Switzerland
Date: April 28-30

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Reference Type: Magazine Article

Author: Condom, P.
Year: 1997
Title: Simulation and training on the move again
Magazine: Interavia
Date: April
Number of Pages: 4
Keywords: flight safety, Boeing
Abstract: The formation...of a new joint company by Boeing and FlightSafety International to offer world airlines full training services, coming after the acquisition of Reflectone by British Aerospace to offer reliable training services to its military customers - and especially to Hawk operators, are making observers think that things may once again be on the move.

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Reference Type: Report
Author: Conrad, B., Schmidt, S.F.
Year: 1971
Title: A study of techniques for calculating motion drive signals for flight simulators
Institution: Analytical Mechanics Associates, Inc.
Pages: 1-69
Report Number: NASA CR-114345
Author's Affiliation and Title: Analytical Mechanics Associates, Inc., Mountain View, CA
Recipient's Affiliation and Title: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 70
Abstract: (from INTRODUCTION)
One of the challenging and unsolved problems in applications of pilot-flight simulators is how the very restricted motion freedom of the translational and rotational drive systems can "best" be used to simulate realistic flying sensations. The problem is difficult to solve because the constraints of the motion drive systems (position limits, velocity limits, and acceleration limits) preclude duplication of the body rates and forces on the pilot of the real aircraft except in a few tasks like hovering, refueling, and formation flying. As a result, the "best" motion is a compromise which attempts to provide the simulator test pilot with those flight sensations and motion "cues" that he needs while staying within the constraint barriers of the motion drive systems. The lack of knowledge on pilot needs, and the lack of a fundamental understanding of how such compromises in motion fidelity degrade the usefulness of the simulation test results, make the problem even more difficult.
In a previous study effort (Ref. 1), a number of empirical "rule-of-thumb" solutions to the problem were reviewed and documented. Also, a "heuristic" mathematical approach was given which tended to "explain" the empirical solutions. This approach was used to develop two promising washout circuits for the Ames All-Axis Motion Simulator. In order to evaluate these circuits, a "formation-type" flying task was conceived. In this task, the motion quality could be varied for near-perfect reproduction of real flight to a fixed-base (no motion) solution. The previous study effort terminated with the completion of an experimental program in which several pilots flew the formation-flying task for three different aircraft lateral handling characteristics with one-to-one motion and fixed-based (no motion). The results of that program showed that the task and simulated aircraft were such that one-to-one motion was very important to the simulator test pilots. The effect of motion was readily measures by rms calculations based on the pilot's ability to hold a tight formation. Hence, it was believed that the effects of washout circuit parameter variations (which affect the quality of motion) could be measured and the parameters optimized in an experimental investigation which used the formation-flying task.
The objectives of the study effort described in this report were as follows:
1. Develop an experimental test plan using the formation-flying task for the validation and refinement of the washout circuits described in Reference 1. The details of this plan are given in Section 2.

2. Execute the test plan in conjugation with NASA scientists and test pilots on the Ames simulation facilities. Some of the experimental results obtained in these tests are given in Section 3.
3. Analyze the experimental data in conjunction with NASA scientists, using pilot model identification methods. Difficulties encountered with these procedures are given in Section 4, along with a few preliminary results.
4. Develop FORTRAN IV washout programs for applications on the Ames All-Axis Simulator. Two such programs are described in the Appendix. Section 5 describes the use of these circuits.
5. Develop a questionnaire-type log to assist NASA personnel in documenting the experience obtained with the application of washout circuits to operational simulations. This log is presented in Section 6.

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Reference Type: Conference Proceedings
Author: Conrad, B., Schmidt, S.F., Douvillier, J.G.
Year of Conference: 1973
Title: Washout circuit design for multi-degrees-of-freedom moving base simulators
Conference Name: AIAA Visual and Motion Simulation Conference
Conference Location: Palo Alto, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-9
Date: September 10-12
Author's Affiliation and Title: Bjorn Conrad and S. F. Schmidt: Analytical Mechanics Associates, Mountain View, CA
J. G. Douvillier: NASA Ames Research Center, Moffett Field, CA
Abstract: Piloted, moving-base simulators generally contain actuators and drive linkages with sever position, velocity, and/or acceleration limits. These limits prevent the motion drive trains from exactly reproducing the very general motion histories that may be solved for an aircraft computer simulation. this paper presents a mathematical framework for designing logic to accept motion-dependent parameters from a simulation, attenuating them ("washing them out"), and generating appropriately limited drive signals. This framework is sufficiently general to encompass six-degrees-of-freedom simulators with large motion capability. Emphasis is placed on preserving certain motion cue relations (such as those that would be observed in coordinated flight). Strategies for simulating side forces via tilts are shown. Finally, several specific circuits are shown. These circuits have proven to be readily adaptable to a variety of moving-base simulators.

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Reference Type: Conference Proceedings
Author: Cooper, G.E., Drinkwater, F.J., III
Year of Conference: 1970
Title: Pilot assessment aspects of simulation
Conference Name: Simulation
Conference Location: Ames Research Center, Moffett Field, CA
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 9-1 - 9-16
Date: March
Author's Affiliation and Title: NASA Ames Research Center, Moffett Field, CA 94035
Number of Pages: 16
Keywords: pilot assessment, simulation, validation, visual displays, pilot stress, motion
Abstract: This lead paper on the pilot assessment aspects of flight simulation discusses in greater detail some of the problems introduced in the AGARD Report 567, "The Use of Pilot

Rating in the Evaluation of Aircraft Handling Qualities" (1). The important function of a lead paper on pilot assessment is to introduce the critical questions raised by pilots so they can be examined and discussed with the aim of developing solutions and improved understanding. Some answers are proposed that may in themselves be controversial and stimulate further discussions.
One major difficulty in the application and utilization of pilot assessment in simulation is that there are no simple black and white answers for many of our problems, and continuing communication between pilots and engineers is essential. This is not so difficult to understand when we realize that with simulation we are seeking answers with only part of the tools for the job, and we are using the human element, namely the pilot, to bridge the gap between simulation on one hand, and the final flight application on the other. It is important, therefore, that we involve the pilot as early as possible in developing a piloted simulation program.
In order to bring out the pilot's viewpoint, we have reviewed common pilot gripes and complaints arising from simulation experiences and selected a number of questions or problems that we believe focus discussion on areas of maximum interest and concern. We consider first the apparent primary concern of pilots participating in simulation work, and next the questions related to the pilots' actual participation in the planning and conduct of experiments, the simulation situation in terms of the facility being used, and the analysis and reporting of results.
Notes: Lead discussion by J. Pinet and Lt. C. A. Wheal, RN. Open discussion also included.

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Reference Type: Report
Author: Cooper, G.E., Harper, R.P., Jr.
Year: 1969
Title: The use of pilot rating in the evaluation of aircraft handling qualities
City: Washington, DC
Institution: National Aeronautics and Space Administration (NASA)
Date: April
Type: Technical Note
Report Number: NASA TN D-5153
Author's Affiliation and Title: Cooper: NASA Ames Research Center
Harper: Cornell Aeronautical Laboratory
Number of Pages: 52
Abstract: Pilot rating scales and their use in assessing aircraft handling qualities are reviewed historically, and objections that have been raised to limitations of earlier scales are considered in the development of a revised scale. Terminology used in the evaluation of handling qualities is reviewed and new definitions are proposed to improve communication and international understanding. Of particular significance is the new definition of handling qualities, which emphasizes the importance of factors that influence the selection of a rating other than stability and control characteristics.
The experimental use of pilot rating is discussed in detail, with special attention devoted to (1) clarifying the difference between mission and task, (2) identifying what the rating applies to, (3) considering the pilot's assessment criteria, and (4) defining the simulation situation. The important elements of the report are then summarized in a suggested "Briefing Guide," designed for guidance in planning and executing handling qualities.
Notes: Some portions of this report:
*Summary--p. 1
*Introduction--pp. 1-2
*Early Rating Scales--pp. 7-8
*Revised Pilot Rating Scale--pp. 8-17
* Pilot Assessment Considerations--pp. 22-25
*Simulation Situation--pp. 25-29
*Appendix B: Briefing Guide and Rating Information for Handling Qualities Experiments--pp.34-39
*References--p. 52

Reference Type: Conference Proceedings
Author: Cooper, J.C., Rutherford, M.L., McKinnon, G.M.
Year of Conference: 1985
Title: Digital control loading and motion: The final word?
Conference Name: Interservice/Industry Training, Simulation & Education Conference
Conference Location: Montreal
Publisher: CAE Electronics Ltd.
Pages: 140-145
Author's Affiliation and Title: Cooper: Group Leader, Control Loading, CAE Electronics Ltd., Montreal, Canada
Rutherford: Manager, Systems Engineering, CAE Electronics Ltd., Montreal, Canada
McKinnon: Director, R & D, CAE Electronics Ltd., Montreal, Canada
Number of Pages: 6
Abstract: This paper reviews the essential elements in effective load unit design and introduces a novel approach to digital control loading and motion with extensive performance and logistics benefits. Performance of the digital system is superior to modern analog systems. A 3-KHz iteration rate provides the ability to model non-linear characteristics which are difficult to reproduce cost-effectively in an analog model. Maintenance and sparing of the digital controller is simplified by the use of a minimum number of different card types with built-in automated diagnostics which locate failures at the board level. Updates and maintenance adjustments are performed through user-friendly software utilities, with rigid configuration control of the system's state via software backups.

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Reference Type: Report
Author: Corwin, W.H., Sandry-Garza, D.L., Biferno, M.H., Boucek, G.P., Jr., Logan, A.L., Jonsson, J.E., Metalis, S.A.
Year: 1989
Title: Assessment of crew workload measurement methods, techniques and procedures. Volume I--Process, methods, and results
City: Dayton, OH
Institution: Cockpit Integration Directorate, Wright Research and Development Center, Air Force Systems Command, Wright-Patterson Air Force Base
Date: September
Type: Final Report
Report Number: WRDC-TR-89-7006 Volume I
Number of Pages: 237
Keywords: subjective measures, performance measures, physiological measures
Abstract: This report summarizes the work conducted as part of an FAA/U.S. Air Force sponsored contract (F33615-C-86-3600) "The Assessment of Crew Workload measurement Methods, Techniques, and Procedures." The primary goal of the contract was to identify assessment techniques which demonstrate evidence of validity and reliability and are suitable as measures of flightcrew workload for aircraft certification.
To use a workload assessment technique with confidence for the certification of an aircraft flightdeck, the validity and reliability of the technique must be well established. Validity is the capability of the assessment technique to measure the abstract construct it is proposed to measure. Reliability is the capability of the measure to produce the same results with repeated testing.
A comprehensive literature review was conducted to identify workload measures which have an empirical record of validity and reliability. All candidate workload assessment techniques had to be applicable for evaluating workload in an aircraft environment. Two workshops were conducted to bring together experts in the workload assessment field to determine candidate measures for simulation testing (aided by the literature search), and make recommendations for testing in a

high fidelity simulation. Two separate simulation tests were conducted at the Man Vehicle System Research Facility at NASA-Ames Research Center using a Phase II B-727 motion-base simulator.
The process by which this contract was conducted allows us to make factual statements regarding the validity and reliability of workload measures. The findings of validity and reliability for the workload measures tested are repeatable as demonstrated by the replication of results in the second simulation study. The method employed in this contract allows for an audit trail of the process by which an assessment technique is determined to be valid and reliable. A summary of the steps completed for this contract includes:
a. Literature review and Fact Matrices
b. Workshop to gather expert agreement
c. Simulation testing
Workload measures which demonstrated evidence of validity and reliability in simulation testing includes:
a. In-flight and Post-flight subjective ratings (SWAT, NASA-TLX, and Bedford rating scales)
b. Heart rate, as measured by R-to-R wave interbeat Interval
c. Control Input Activity for the wheel (aileron) and column (elevator) during manual flight path control

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Reference Type: Conference Proceedings
Author: Cowdrey, D.A.
Year of Conference: 1985
Title: Advanced visuals in mission simulators
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 3-1 - 3-10
Date: September 30-October 3
Author's Affiliation and Title: Group Leader - Visual Applications, Singer Link-Miles Ltd, Dept 060, Churchill Industrial Estate, Lancing, W. Sussex BN15 8UE, United Kingdom
Number of Pages: 10
Keywords: visual, mission simulator, image generator, display systems, heat-mounted display, eye-tracked AOI
Abstract: Modern sophisticated full mission flight systems trainers are capable of accurate representation of the actual aircraft in many areas including handling, controls, systems, etc. The major area of inadequacy to date has been the inability to produce a satisfactory visual representation of the outside works. To produce an image to match that of the pilot's field-of-view at the required resolution is beyond the capabilities of conventional visual system technology. This paper describes various alternative techniques developed at the Link Flight Simulation Division of the Singer Company, based on an eye-enslaved area-of-interest (AOI) concept
Notes: Published in September 1986.

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Reference Type: Report
Author: Cowings, P.S., Toscano, W.B., DeRoshia, C.
Year: 1998
Title: An evaluation of the frequency and severity of motion sickness incidences in personnel within the Command and Control Vehicle (C2V)
Date: January
Type: Technical Memorandum

Report Number: A-98-09480
Author's Affiliation and Title: Cowings, DeRoshia: NASA Ames Research Center, Moffett Field, CA
Toscano: University of California, Los Angeles, CA
Number of Pages: 28
Keywords: human performance, motion sickness, psychophysiology
Abstract: The purpose of this study was to assess the frequency and severity of motion sickness in personnel during a field exercise in the Command and Control Vehicle (C2V). This vehicle contains four workstations where military personnel are expected to perform command decisions in the field during combat conditions. Eight active duty military men (U.S. Army) at the Yuma Proving Grounds in Arizona participated in this study. All subjects were given baseline performance tests while their physiological responses were monitored on the first day. On the second day of their participation, subjects rode in the C2V while their physiological responses and performance measures were recorded. Self-reports of motion sickness were also recorded. Results showed that only one subject experienced two incidences of emesis. However, seven out of eight subjects reported other motion sickness symptoms; most predominant was the report of drowsiness, which occurred a total of 19 times. Changes in physiological responses were observed relative to motion sickness symptoms reported and the different environmental conditions (i.e., level, hills, gravel) during the field exercise. Performance data showed an overall decrement during the C2V exercise. These findings suggest that malaise and severe drowsiness can potentially impact the operational efficiency of the C2V crew. It was concluded that conflicting sensory information from the subject's visual displays and movements of the vehicle during the field exercise significantly contributed to motion sickness symptoms. It was recommended that a second study be conducted to further evaluate the impact of seat position or orientation and C2V experience on motion sickness susceptibility. Further, it was recommended that an investigation be performed on behavioral methods for improving crew alertness, motivation, and performance and for reducing malaise.
Notes: Sponsoring organization: NASA

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Reference Type: Report
Author: Criel, T.M., Wyatt, F.V.
Year: 1988
Title: Sandia National Laboratories: Flight simulation facilities
City: Albuquerque, NM
Institution: Sandia National Laboratories
Date: May
Report Number: SAND87-2034 . UC-13
Author's Affiliation and Title: Exploratory Systems Development Division, Wyatt, Aerospace Projects Division
Number of Pages: 14
Abstract: Flight simulation computer facilities and motion simulator facilities at Sandia National Laboratories include an AD-10, an AD-100 (both real time digital simulation computers), two AD-5s (analog computers), a VAX 11/780 (a digital mainframe), a PDP 11/60 (a digital computer), and a Carco S-450R-3/R three axis motion simulator. This report describes the current equipment.

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Reference Type: Report
Author: Cross, K.D.
Year: 1992

Title: Training effectiveness assessment: Methodological problems and issues
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: April
Report Number: NTIS No. N93-30684
Keywords: flight simulators, helicopters, pilot performance, pilot training, training evaluation, economic factors, effectiveness
Abstract: The US military uses a large number of simulators to train and sustain the flying skills of helicopter pilots. Despite the enormous resources required to purchase, maintain, and use these simulators, little effort has been expended in assessing their training effectiveness. One reason for this is the lack of an evaluation methodology that yields comprehensive and valid data at a practical cost. Some of these methodological problems and issues that arise in assessing simulator training effectiveness, as well as problems with the classical transfer-of-learning paradigm were discussed.
Notes: In NASA/FAA simulator workshop p. 77-90.

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Reference Type: Report
Author: Cross, K.D., Gainer, C.A.
Year: 1984-1985
Title: An enumeration of research to determine the optimal design and use of army flight training simulators
City: Fort Rucker, AL
Institution: Anacapa Sciences, Inc.
Date: October
Type: Final Report
Report Number: ARI Technical Report 763
(performing organization report number) ASI479-066-85
Author's Affiliation and Title: Anacapa Sciences, Inc, P.O. Box 489, Fort Rucker, AL 36362
Recipient's Affiliation and Title: U.S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, VA 22333
Keywords: army flight simulator research requirements, helicopter pilot training, transfer of training, backward transfer, flight simulator fidelity requirements, training device characteristics, flying skill acquisition, flying skill sustainment, training device requirements, training effectiveness assessment
Abstract: This document lists and describes research the authors judged necessary to determine the optimal design and use of Army flight training simulators. Two major lines of research are described; the first addresses the design fidelity issue. Specifically, research is described that is judged necessary to determine the most cost- and training-effective level of fidelity for four simulator components: the visual system, the motion systems, the math models that determine the handling qualities of the flight simulator, and the cockpit displays and controls. The purpose of the second line of research is to determine how best to use production simulators that have been or are soon to be acquired by the Army. This line of research focuses primarily on the use of production simulators for field unit aviators who have completed institutional training and have been assigned to an operational field unit. However, the second line of research addresses some issues associated with the use of flight simulators for institutional training at the U.S. Army Aviation Center received before the aviator’s first assignment to an operational unit.
This document was prepared to serve as a vehicle for initiating meaningful dialogue among the agencies and personnel who share responsibility for optimizing the benefits of the Army’s Synthetic Flight Training System (SFTS) program; it has not been officially endorsed by any Army agency.

Reference Type: Report
Author: Cross, K.D., Szabo, S.M. (Eds.)
Year: 1986
Title: Human factors research in aircrew performance and training: Final summary report
City: Fort Rucker, AL
Institution: ARI Field Unit
Date: November
Type: Final Summary Report
Report Number: ARI Research Note 86-94
Author's Affiliation and Title: Anacapa Sciences, Inc., P.O. Box 489, Fort Rucker, AL 36362
Number of Pages: 214
Keywords: Army aviator training requirements: active duty aviators, individual ready reserve aviators, National Guard aviators, reserve unit aviators, flight surgeons; Army retention/attrition: separation questionnaire, attrition causes, retention causes; retention of helicopter flying skills; maintenance of flying skills: flying time required, practice iteration required; Army aviator training: simulator, aircraft, time, night, team, unit; Army aviator selection test development/validation: aptitudes, abilities, task/ability analysis; Army aviator performance measurement/evaluation: in simulators, in aircraft, in training, in research, consensual decision making, aviation resource management survey; Army helicopter workstation design: mission analysis, task analysis, function allocation, workload prediction, workload measurement, computer models, anthropometrics; helicopter flight simulation: training, retraining, transfer of training, skill maintenance, visual system, motion system, training support features, design fidelity, workload validation; flight simulators for training: simulator sickness; aviator peer evaluation; aviator safety: accident prediction, flight proficiency; aviator training media: programs of instruction, simulators, interactive videotapes, interactive videodiscs, light attenuation filters, night vision goggles
Abstract: This report presents a summary of the work performed by Anacapa Sciences, Inc. (ASI) for ARIARDA at Fort Rucker, Alabama, under Contract No. MDA903-81-C-0504, "Human Factors Research in Aircrew Performance and Training." The report contains summary descriptions for each of 29 projects on which ASI personnel worked during the period 1 September 1982 to 31 December 1985. Each summary description contains (a) a background section that describes the rationale for the research and the research objectives, (b) a research rationale for the research and the research objectives, (c) a research approach section that describes the tasks and activities required to fulfill the project objectives, (d) a results section that describes the research findings, and (e) a project status section that describes the work completed and projections for future research, if any.

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Reference Type: Journal Article
Author: Davies, D.P.
Year: 1975
Title: Approval of flight simulator flying qualities
Journal: Aeronautical Journal
Volume: 79
Pages: 281-297
Date: July
Author's Affiliation and Title: Chief Test Pilot, CAA
Number of Pages: 17
Abstract: (taken from 1. INTRODUCTION) Flight Simulation has made good steady progress over the years, and is now being given significant credit for its ability to reproduce aircraft flying qualities in a device on the ground. However, the simulator flight world is tending to claim too much credit for its present level of achievement. This talk is an attempt to review the present state of the art against an accurate comparison with aircraft flying qualities, to highlight the deficiencies and to appeal to the users of simulators to consolidate their present gains before proceeding further. This paper deals only with civil fixed-wing transport aircraft above 20,000 kg maximum weight.
There are three parts:
(i) a brief statement of the approval procedures in the UK;
(ii) a review of the present level of simulator flying qualities;
(iii) some elementary advice to all involved in simulation.
In order to avoid my having to indulge in repeated supposition, let us assume that the readers are all applicants for the approval of a flight simulator so that I may enjoy the use of personal pronouns.
As my last introductory comment, I must admit that I know really very little about flight simulators: the vocabulary alone for example baffles me. However, this admission is not significant. I do know a good deal about the flying qualities of contemporary aeroplanes and as the accurate simulation of aircraft flying qualities is the target of the flight simulator world then who better to discuss the subject than a specialist in the end product? I sometimes feel that my ignorance is not a bad thing anyway: if I knew a lot more of your difficulties, for example, it might cause my natural sympathy and kindness to warp my judgment. A measure of kindness is necessary otherwise the number of simulators presently approved would be significantly lower. For the proof of this last point read on.

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Reference Type: Conference Proceedings
Author: Dearing, M., Schroeder, J., Sweet, B., Kaiser, M.
Year of Conference: 2001
Title: Effects of visual texture, grids, and platform motion on unpowered helicopter landings
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Montreal, Quebec, Canada
Pages: 1-10
Date: August 6-9
Author's Affiliation and Title: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 11
Abstract: A simulation experiment examined how a range of visual and platform motion characteristics affected a pilot's ability to perform precise landings after a steep unpowered decent in a helicopter. The visual characteristics were texture density and different sized rectangular grids. The platform motion levels ranged from fixed-base to extremely large motion. Seven experienced test pilots flew all 36 visual and motion combinations, and their objective performance and subjective opinions were collected. Texture affected all of the dependent measures; however, the finest texture did not perform the best, which debunks a common

misperception that more texture is better. In contrast, grids only affected pilot subjective opinion of speed and attitude cueing. As more platform motion was added, touchdown sink rate improved, along with pilot opinion of the motion fidelity.

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Reference Type: Conference Proceedings
Author: DeBerg, O.H., McFarland, B.P., Showalter, T.W.
Year of Conference: 1976
Title: The effect of simulator fidelity on engine failure training in the KC-135 aircraft
Conference Name: Visual and Motion Simulation Conference
Conference Location: Dayton, OH
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 83-87
Date: April 26-28
Author's Affiliation and Title: Aeronautical Systems Division, United States Air Force, Wright-Patterson AFB, OH 45433
Number of Pages: 5
Abstract: Because of the dangers associated with engine failures during takeoff of large multi-engine air-craft, flight simulators are usually used to train pilots to recover from this failure. An assessment of the effectiveness of this training was made using an engineering flight simulator with KC-135A aircraft commanders as test subjects. The available visual system and motion system cueing capabilities of the engineering simulator were restricted to produce four combinations representative of current training hardware: (a) visual system cues only, (b) motion system cues only, (c) visual system and motion system cues, and (d) no visual system and motion system cues. One subject group was trained to recover from engine failure in each of these cueing situations. All restrictions to the cueing of the engineering simulator were then removed, and training effectiveness of the four candidate systems was assessed by measuring pilot performance in the unrestricted engineering simulator. Results were analyzed by a factorial analysis of variance. Results indicate: (a) the superiority of training effectiveness with simulator visual systems, (b) the enhancement of training effectiveness by including a motion system in the training simulator, and (c) the synergistic improvement in training using both motion and visual systems together. This experiment is the first of a series that will investigate simulation cueing effectiveness.

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Reference Type: Report
Author: Dell, W.
Year: 2000
Title: The use of 3-D to improve auditory cues in aircraft
Pages: 1-101
Author's Affiliation and Title: Department of Computing Science, University of Glasgow, Lilybank Gardens, Glasgow, G12 8QQ
Number of Pages: 102
Abstract: Auditory alarms are being used in many safety critical environments such as hospitals, nuclear power stations and aircraft. At present, these auditory alarms rarely make use of the fact that sound can be processed to come from more than one direction. Looking at aviation in particular, it is common for pilots to wear headphones that support stereo sound, which means that taking advantage of this aspect of audio is certainly feasible. Additionally, a 3D virtual acoustic display was proposed by Wenzel [1] when there was insufficient technology to test her assertions. However, with the release of DirectX 5.0, it is now practical to design and prototype auditory alarms that make use of 3D audio. This project investigates the impact of using

spatialised alarms versus stereo and mono alarms. The effectiveness of the three types of alarm are analyzed in terms of reaction time, error rate, learnability, performance of primary task and workload measures. The results from this experiment indicate that the technology for supporting 3D audio is not sufficient to yield an advantage over its alternatives.

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Reference Type: Report
Author: Demuth, J., Helmreich, B., Lofaro, R., Smith, K.
Year: 1991
Title: Crew resource management (CRM)
Date: September 20
Type: Advisory Circular Draft
Report Number: 120-51 Draft 2.4
Author's Affiliation and Title: Demuth, Helmreich, Lofaro, Smith: CRM/Los Integration Subcommittee, ATA/AQP Working Group
Number of Pages: 22

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Reference Type: Appendix
Author: den Hollander, J.G., Baarspul, M.
Year: 1977
Title: Measurement of motion quality of a moving base flight simulator
Author's Affiliation and Title: den Hollander, Baarspul: Delft University of Technology, Faculty of Aerospace Engineering
Notes: Memorandum M-264. Referenced in Ruud Hosman's book, *Pilot's perception and control of aircraft motions* (1996).

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Reference Type: Report
Author: Denne, P.R.M.
Year: 1994
Title: Motion effects on driver training
Author's Affiliation and Title: Managing Director, Denne Developments Ltd. Bournemouth. England
Number of Pages: 4
Abstract: Driver training in a non-motion simulator does not teach all the skills which are critical in the real world, because nobody drives in direct response to visual feedback information. The fast-response loop on which all trained reactions are based is a haptic one which includes tactile feedback from the controls and from the sensations of vehicle movement caused by control actions or by the irregularities of the environment. It follows that no driver training simulator is complete without well-designed motion and control-loading systems. Recent developments allow these to be provided at an acceptable cost.
URL: http://www.advancedmotion.net/pdf/sim5.pdf

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Reference Type: Conference Proceedings

Author: Dennerlein, J.T., Martin, D.B., Hasser, C.
Year of Conference: 2000
Title: Force-feedback improves performance for steering and combined steering-targeting tasks
Conference Name: Conference on Human Factors in Computing Systems
Volume: 2
Pages: 423-429
Date: April 1-6
Author's Affiliation and Title: Jack Tigh Dennerlein: Harvard University, 665 Huntington Ave, Boston, MA
David B. Martin: Harvard University & Dartmouth College, Hanover, NH
Christopher Hasser: Stanford University & Immersion Corporation, 2158 Paragon Drive, San Jose, CA
Abstract: The introduction of a force-feedback mouse, which provides high fidelity tactile cues via force output, may represent a long-awaited technological breakthrough in pointing device designs. However, there have been few studies examining the benefits of force-feedback for the desktop computer human interface. Ten adults performed eighty steering tasks, where the participants moved the cursor through a small tunnel with varying indices of difficulty using a conventional and force-feedback mouse. For the force-feedback condition, the mouse displayed force that pulled the cursor to the center of the tunnel. The tasks required both horizontal and vertical screen movements of the cursor. Movement times were on average 52 percent faster during the force-feedback condition when compared to the conventional mouse. Furthermore, for the conventional mouse vertical movements required more time to complete than horizontal screen movements. Another ten adults completed a combined steering and targeting task, where the participants navigated through a tunnel and then clicked a small box at the end of the tunnel. Again, force-feedback improved times to complete the task. Although movement times were slower than the pure steering task, the steering index of difficulty dominated the steering-targeting relationship. These results further support that human computer interfaces benefit from the additional sensory input of tactile cues to the human user.

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Reference Type: Newspaper Article
Reporter: Der Bund (sda)
Year: 1998
Title: Das Vertrauen verloren
Newspaper: Der Bund
Issue Date: April 15
Keywords: F/A-18, disorientation
Notes: Swiss Army accident by older pilot.

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Reference Type: Book Section
Author: Dichgans, J., Brandt, T.
Year: 1978
Title: Visual-vestibular interactions: Effects on self-motion perception and postural control
Editor: Held, R., Leibowitz, H.W., Teuber, H.-L.
Book Title: Handbook of Sensory Physiology
City: Berlin
Publisher: Springer-Verlag
Volume: 8, Perception

Reference Type: Report
Author: Dieudonne, J.E., Parrish, R.V., Bardusch, R.E.
Year: 1972
Title: An actuator extension transformation for a motion simulator and an inverse transformation applying Newton-Raphson's method
City: Washington, D.C.
Institution: National Aeronautics and Space Administration
Date: November
Type: Technical Note
Report Number: NASA TN D-7067
Number of Pages: 20
Keywords: Motion simulator
Newton-Raphson method
Real-time simulation
Abstract: A set of equations which transform position and angular orientation of the centroid of the payload platform of the six-degree-of-freedom motion simulator at the Langley Research Center into extensions of the simulator's actuators has been derived and is based on a geometrical representation of the system. An iterative scheme, Newton-Raphson's method, has been successfully used in a real-time environment in the calculation of the position and angular orientation of the centroid of the payload platform when the magnitude of the actuator extensions is known. Sufficient accuracy is obtained by using only one Newton-Raphson iteration per integration step of the real-time environment.

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Reference Type: Report
Author: Dillard, A.E.
Year: 2002
Title: Validation of advanced flight simulators for human-factors operational evaluation and training programs
Pages: 1-87
Date: September 12
Type: Draft
Number of Pages: 88

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Reference Type: Journal Article
Author: Dixon, P., Gabrys, G.
Year: 1991
Title: Learning to operate complex devices: Effects of conceptual and operational similarity
Journal: Human Factors
Volume: 33
Issue: 1
Pages: 103-120
Author's Affiliation and Title: Dixon: University of Alberta at Edmonton
Gabrys: University of Pittsburgh, PA
Number of Pages: 17
Abstract: In two experiments we investigated the effect of prior knowledge of a given device on learning to operate a similar device. Two kinds of similarity were investigated: conceptual similarity, in which the underlying concepts of how the devices worked were the same, and operational similarity, in which the organization and structure of the operating system were the same. Experiment 1 used devices that were always physically the same, regardless of how they

were described and the procedure used to operate them. Experiment 2 used devices that were always physically different but required the same logical sequence of steps. In both experiments there were substantial effects of operational similarity, but no reliable effect of conceptual similarity. It was concluded that prior experience with similar devices often helps because similar devices have similar operating procedures, not because similar devices work similarly.

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Reference Type: Conference Proceedings
Author: Doll, T.J.
Year of Conference: 1986
Title: Synthesis of auditory localization cues for cockpit applications
Conference Name: Human Factors Society 30th Annual Meeting
Conference Location: Dayton, OH
Pages: 1172-1176
Date: September 29-October 3
Author's Affiliation and Title: Georgia Tech Research Institute, Atlanta, GA
Number of Pages: 5
Abstract: The long-term objective of this work is to develop techniques for conveying accurate spatial information via audio signals delivered to the listener through headphones. Specific objectives of the first phase included the design, fabrication, and evaluation of an apparatus for demonstrating simulated auditory localization (SAL). The design of the SAL facility is described. An experimental test of the psychological fidelity of the SAL facility is summarized. The results show that the facility produces a high-fidelity simulation of normal, unaided auditory localization.

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Reference Type: Report
Author: Douvillier, J.G., Jr., Turner, H.L., McLean, J.D., Heinle, D.R.
Year: 1960
Title: Effects of flight simulator motion on pilots' performance of tracking tasks
City: Washington, DC
Institution: National Aeronautics and Space Administration (NASA)
Date: February
Type: Technical Note
Report Number: NASA TN D-143
Author's Affiliation and Title: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 34
Abstract: The effect of motion of a flight simulator on pilots' performance of a tracking task has been investigated by comparing the air-to-air tracking performance of two pilots in flight, on a motionless flight simulator, and on a flight simulator free to roll and to pitch. Two different attack displays were used.
It was found in tracking a maneuvering target that: the results from the moving flight simulator resembled the results from flight much more than did those from the motionless simulator; and that in flight the conventional circle-dot display was superior to a drone display. For simpler tracking tasks it was not possible to detect these differences.

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Reference Type: Report
Author: Draper, M.
Year: 1996

Title: Can your eyes make you sick? Investigating the relationship between the vestibulo-ocular reflex and virtual reality
Date: April 29
Type: Technical report
URL: http://www.hitl.washington.edu/publications/r-96-3/

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Reference Type: Conference Proceedings
Author: Driskell, C.R.
Year of Conference: 1978
Title: Wide angle visual system developments
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 15-11 - 15-12
Date: April 24-27
Author's Affiliation and Title: Project Director, US Army Office of Project Manager for Training Devices, Naval Training Equipment Center, Orlando, FL 32813
Number of Pages: 12
Keywords: wide angle visual system, scanned laser visual system, focus, resolution, attitude control
Abstract: The US Army Project Manager for Training Devices has two competing development programs designed to provide high resolution tactical scenes over a wide field of view for pilot training. In the first system, a laser beam scans the portion of a terrain model board to be presented to the pilot. A matrix of light sensors collects the light reflected from the model board. A composite video signal from the light sensors modulates a laser beam in the display scanner which scans the scene onto a spherical viewing screen. In the second system, an optical probe picks up a 360-degree annular image of a terrain model board. The annular image is scanned onto a radial array of charged coupled devices which converts the annular display into video signals. The video signals modulate the laser beams into an annular laser projector which scans the scene through an annular projection lens onto a spherical viewing screen. Both visual systems provide continuous seamless visual scenes without color matching, edge matching or brightness matching problems that arise in multiple window display systems.

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Reference Type: Generic
Author: Dunlap, J.H., Mangold, S.J.
Year: 1998
Title: Leadership/followership: Recurrent training instructor manual
Date: February
Type of Work: Instructor Manual
Author's Affiliation and Title: Dunlap: Western Michigan University
Mangold: Battelle Memorial Institute

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Reference Type: Conference Proceedings
Author: Dusterberry, J.C.
Year of Conference: 1978

Title: Visual simulation requirements and hardware
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 10-11 - 10-17
Date: April 24-27
Author's Affiliation and Title: Research Assistant to the Director, NASA Ames Research Center, Moffett Field, CA 94035
Number of Pages: 7
Keywords: visual simulation requirements, hardware
Abstract: Requirements for any out-of-the-cockpit visual system can easily lead to a set of system specifications which are clearly beyond the visual scene that can be produced by current technology. Therefore, the requirements of any proposed system must be assessed in light of the expected simulated aircraft and missions, experiments on pilot response, and available image generation and display hardware. A review is made of some of the recent experiments, and the results are related to aircraft and missions with particular emphasis on research and development simulators. Recent visual simulation hardware is considered in light of extending the range of applications of piloted aircraft simulators, and a method of design approach is proposed.

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Reference Type: Conference Proceedings
Author: Dusterberry, J.C.
Year of Conference: 1985
Title: Manned flight simulation: Challenge and response
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, UK
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: K-1 - K-7
Date: September 30-October 3
Author's Affiliation and Title: Retired, NASA Ames Research Center, Moffett Field, CA 94035
Number of Pages: 7
Keywords: flight simulation, control simulation, pilot training
Abstract: Early AGARD papers on manned flight simulation describe the status of an emerging test technique and then offer suggestions of the problems that should be solved to advance the technique and predictions of the results obtained by its use. Later AGARD literature is examined to determine how these challenges have been met, both in ground-based and in-flight simulation and how AGARD has played an important role in advancing the technique so that it is now an integral part of the aerospace vehicle design process.
Notes: Published in September 1986

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Reference Type: Report
Author: Edens, E.
Year: 1998
Title: Air carrier training research review
Institution: Federal Aviation Administration (FAA)
Date: May
Number of Pages: 33
Notes: Contains the Volpe Center project entitled, "Pilot Training and Evaluation: Airplane Simulation Human Factors."

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Reference Type: Report
Author: Edens, E.
Year: 2000
Title: Air carrier training research review
Institution: Federal Aviation Administration (FAA)
Number of Pages: 53

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Reference Type: Journal Article
Author: Eklund, J.M., Korenberg, M.J.
Year: 2000
Title: Simulation of aircraft pilot flight controls using nonlinear system identification
Journal: Simulation
Volume: 75
Issue: 2
Pages: 72-81
Date: August
Author's Affiliation and Title: Department of Electrical and Computer Engineering at Queens University
Number of Pages: 10
Keywords: aerospace system simulation, flight control systems, full flight simulators, nonlinear system identification, parallel cascade identification
Abstract: This paper is concerned with modeling of the front end of an aircraft pilot flight control system's behavior using a nonlinear system identification technique known as parallel cascade identification. Using this technique, we are able to model a critical part of a pilot flight control system with sufficient accuracy to meet the objective test requirements of the U.S. Federal Aviation Administration for certifying full flight simulators. Traditional approaches to modeling such aircraft systems involve extensive analytical studies of the design of the system, lengthy and detailed empirical testing and recording of data from the physical system, and then considerable analysis to fit parametric models to the data. The approach presented in this paper virtually eliminates the need for analysis of the system in question, significantly reduces the number of signals that need to be recorded from the real aircraft flight control system, and provides an extremely fast method of identifying the mathematical model based on these data. Overall, the time and costs associated with building an effective model are greatly reduced.

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Reference Type: Report
Author: Emery, C., Robin, J., Knipling, R., Finn, R., Fieger, S.

Year: 1999
Title: Research design: Validation of simulation technology in the training, testing, and licensing of tractor-trailer drivers
Type: Final Report
Report Number: FHWA-MC-99-060
Author's Affiliation and Title: Science Applications International Corporation, Turner-Fairbank Highway Research Center, 6300 Georgetown Pike, McLean, VA 22101
Number of Pages: 113
Keywords: driving simulator, truck driver training, heavy trucks, commercial motor vehicles, tractor-trailers
Abstract: The Federal Highway Administration (FHWA), Office of Motor Carrier Highway Safety (OMCHS) is conducting research to validate the use of low-to mid-cost simulator for commercial driver training, testing and licensing. The primary purpose of the study is to examine how simulator technology, as compared to conventional methods, may facilitate and enhance tractor-trailer driver performance. This report details the proposed research design to conduct the empirical simulator validation study.
The research design consists of three distinct parts. Part 1 addresses the forward transfer of training for entry-level drivers. Part 2 is an assessment of the advanced capabilities of the test simulator. Part 3 is a longitudinal study of the drivers that have successfully completed either the truck-based or simulator-based driver training program and have gone onto earn their Commercial Drivers License.
A previous OMCHS report titled, "Commercial Motor Vehicle Simulation Technology To Improve Driver Training, Testing and Licensing Methods Final Report - April 1996," evaluated truck driving simulators in the United States and Europe. The report indicated that truck driving simulation was sufficiently mature and recommended that FHWA validate this technology. The Digitran SafeDrive 1000 was recommended as the test bed for the follow-on validation study. A copy of the report can be obtained by contacting the National Technical Information Service (703-605-6000 or 1-800-553-6847) and referencing NTIS Publication Number PB96-183405.
The validation study will commence in FY1999. It will start with a reassessment of the commercial marketplace to assure the simulator selected as the test bed for the study reflects the most up-to-date information and best meets the needs of OMCHS.

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Reference Type: Electronic Source
Author: Environmental Techtonics Corporation
Year: 2001
Title: Environmental Techtonics Corporation announces the development of a tactical flight simulation centrifuge
Producer: Environmental Techtonics Corporation
Access Year: 2006
Access Date: Sept. 6
Last Update Date: December 13, 2001
Type of Medium: Press Release
Abstract: Environmental Tectonics Corporation (Amex: ETC) today announced its Sustained G Tactical Flight Simulator, the G-FET II TFS
URL: http://www.etcusa.com/corp/pressreleases/NR121301.htm

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Reference Type: Electronic Source
Author: Erwin, S.I.
Year: 2000

Title: $65K flight simulator draws skepticism from military buyers
Producer: National Defense Magazine
Access Year: 2006
Access Date: Sept. 6
Last Update Date: November
Type of Medium: Online Magazine Article
Number of Pages: 3
Notes: On Sept 6, 2006 webpage was no longer available.
URL: https://www.nationaldefensemagazine.org/article.cfm?Id=354

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Reference Type: Electronic Source
Author: Erwin, S.I.
Year: 2000
Title: Navy fine-tuning acquisition strategy for flight simulators
Producer: National Defense Online Magazine
Access Year: 2006
Access Date: Sept. 6
Last Update Date: November 2000
Type of Medium: Online article
Number of Pages: 7
URL: http://www.nationaldefensemagazine.org/issues/2000/Nov/Navy_Fine-Tuning.htm

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Reference Type: Electronic Source
Author: Erwin, S.I.
Year: 2001
Title: Aviation enthusiasts ponder: How good are PC simulators?
Producer: National Defense Online Magazine
Access Year: 2006
Access Date: Sept. 6
Type of Medium: Online article
Number of Pages: 3
URL: http://www.nationaldefensemagazine.org/issues/2001/Nov/Aviation_Enthusiasts.htm

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Reference Type: Report
Author: Federal Aviation Administration (FAA)
Year: 1995
Title: Airline transport pilot and type rating practical test standards
Date: July
Report Number: FAA-S-8081-5B
Notes: Replaced by FAA-S-8081-5D
URL: http://www.faa.gov/education_research/testing/airmen/test_standards/pilot/media/FAA-S-8081-5D.pdf

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Reference Type: Book Section
Author: Federal Aviation Administration (FAA)
Year: 1995
Title: SFAR No. 58
Editor: Spanitz, J.
Book Title: FAR Flight Crew; Federal Aviation Regulations; Parts 25, 63 & 121
City: Renton, WA
Publisher: Aviation Supplies and Academics, Inc. (ASA)
Pages: 208-212
Call Number: ASA-95-FAR-FC
ISBN 1-56027-206-6
Number of Pages: 5

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Reference Type: Report
Author: Federal Aviation Administration (FAA)
Year: 1996
Title: Assessment of PC-based aviation training devices
Institution: Federal Aviation Administration (FAA), Civil Aeromedical Institute
Date: September
Type: FAA research report
Report Number: ARR161-6
Number of Pages: 6

• • • • •

Reference Type: Newspaper Article
Reporter: Federal Aviation Administration (FAA)
Year: 1997
Title: FAA one level of safety commuter rule deadline marks safety improvements, decline in accident rate
Newspaper: FAA News
City: Washington, DC
Issue Date: March 21
Number of Pages: 3
Keywords: commuter rule, safety standards

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Reference Type: Report
Author: Federal Aviation Administration (FAA)
Year: 1998
Title: Airline transport pilot and/or type rating: Practical test standards for airplane and helicopter
City: Washington, DC
Institution: United States Government Printing Office
Author's Affiliation and Title: Flight Standards Service, Washington DC 20591, FAA-S-8081-5B
Notes: Site has been updated.
URL: http://www.faa.gov/education_research/testing/airmen/test_standards/pilot/media/FAA-S-8081-20.pdf

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Reference Type: Report
Author: Federal Aviation Administration (FAA)
Year: 1998
Title: Authorization for use of personal computer-based aviation training devices under the provisions of Title 14 of the Code of Federal Regulations (14 CFR) Parts 61 and 141
Institution: FSGA
Date: May 26
Report Number: FSGA 98-02
Number of Pages: 3
URL:
http://www.faa.gov/safety/programs_initiatives/aircraft_aviation/nsp/flight_training/qualification_process/media/fsga9802.txt

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Reference Type: Federal Aviation Regulation
Author: Federal Aviation Administration (FAA)
Year: 2000
Title: FAR-121-Appendix H to Part 121: Advanced simulation plan
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgFAR.nsf/MainFrame?OpenFrameSet

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Reference Type: Report
Author: Federal Aviation Administration (FAA)
Year: 2001
Title: Airline transport pilot and/or type rating practical test standards
Date: February
Report Number: FAA-S-8081-5D
Number of Pages: 9
Keywords: practical test standards (PTS)
URL: http://www.faa.gov/education_research/testing/airmen/test_standards/pilot/media/FAA-S-8081-5D.pdf

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Reference Type: Electronic Source
Author: Federal Aviation Administration (FAA)
Year: 2002
Title: 14 CFR Part 1: Part 1--Definitions and abbreviations
Access Year: 2006
Access Date: Sept. 6
Last Update Date: January 1, 2002
Number of Pages: 18
URL: http://www.access.gpo.gov/nara/cfr/waisidx_02/14cfr1_02.html

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Reference Type: Report
Author: Federal Aviation Administration (FAA)
Year: 2003
Title: Alternate means for airplane simulator qualifications incorporating Revision 2 to the ICAO Manual of Criteria for the Qualification of Flight Simulators
Date: September 12
Type: FSTD Guidance Bulletin draft
URL:
http://www.faa.gov/safety/programs_initiatives/aircraft_aviation/nsp/flight_training/bulletins/media/03-13.doc

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Reference Type: Electronic Source
Author: Federal Aviation Administration (FAA)
Year: 2005
Title: FAA flight standards service (AFS)
Access Year: 2006
Access Date: Sept. 6
Last Update Date: October 19, 2005
Type of Medium: Home page
Abstract: <u>Flight Standards Service</u>
The Flight Standards Service promotes safe air transportation by setting the standards for certification and oversight of airmen, air operators, air agencies, and designees. We also promote safety of flight of civil aircraft and air commerce by:
Accomplishing certification, inspection, surveillance, investigation, and enforcement
Setting regulations and standards
Managing the system for registration of civil aircraft and all airmen records
Flight Standards District Offices (FSDO)
Overview Video
Customer Satisfaction Industry Survey (CSIS)
<u>Address</u>
Federal Aviation Administration
Flight Standards Service
Room 821
800 Independence Avenue, S.W.
Washington, DC 20591
Phone: (202) 267-8237

Fax: (202) 267-5230
URL: http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/

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Reference Type: Conference Proceedings
Author: Federal Aviation Administration (FAA)
Year of Conference: 2006
Title: The current status & future of voluntary flight safety programs
Conference Name: Shared Visions in Aviation Safety Conference
Conference Location: Denver, CO
Date: April 18-20
Abstract: Topics / Speakers/Presenters:
1. Threat & Error Management (TEM) and the Line Operations Safety Audit (LOSA) James Klinect, Ph.D. Univ. of Texas, The LOSA Collaborative
2. Using LOSA Data Capt. Dave Bair, Frontier Airlines
3. How Alaska Uses LOSA Data Robert Graves, Alaska Airlines
4. LOSA Capt. Bruce Tesmer, Continental Airlines
5. Aviation Safety Action Program (ASAP) 101 Kevin Kelley, Aviation Safety Inspector, Voluntary Safety Programs-AFS-230
6. United Parcel Service ASAP Capt. Brendan Fahy, ASAP Coordinator, UPS; Capt. Terry Kom, UPS Airlines; O. T. Blankenship, Aviation Safety Inspector, Kentucky FSDO
7. OSAP United Flight Attendant Safety Awareness Program Lessons Learned Jack O'Brien, Manager Flight Safety-Onboard, United Airlines
8. Flight Operations Quality Assurance (FOQA) - Program Overview and Technology Update Capt. Doug Diehl, Director, Flight Operations Safety, Frontier Airlines
9. Advanced Qualification Program (AQP) 101 Doug Farrow, Ph.D., Instructional Specialist, FAA; Ron Barry, Aviation Safety Inspector, FAA
10. AQP Document Templates for Airlines Transitioning to AQP Ron Barry, Aviation Safety Inspector, FAA Contact presenter directly for information on presentation.
11. Introduction to the Conference Tom Longridge, Ph.D., Manager, Voluntary Safety Programs-AFS-230, FAA
12. Aviation Safety Information Sharing Efforts Terry McVenes, Executive Air Safety Chairman, Air Line Pilot Association
13. FAA Shared Vision of Aviation Safety Mont Smith, Director, Safety, Air Transport Association
14. The Role of a Just Culture in Implementing Safety Management Systems David Marx, President, Outcome Engineering
15. Safety Management from the Field: A European Regulator Perspective about Old & New Developments Stéphane DEHARVENGT, Head of Human Factors Program and Safety Initiatives, DGAC-F/DAST/SEA
16. ASAP Event Risk Analysis and ATOS Integration Frank Raymond, Manager, ASAP Programs, Alaska Airlines
17. Distributed National Airline Safety Archives Update Capt. Robert E. Lynch, Director National Aviation Safety Archives, Battelle
18. LOSA-Based Line Check Program Capt Bob Steider, B777 Assistant Fleet Manager, Continental Airlines
19. Recreation of an ASAP/ASRS Event for use in AQP Line Oriented Evaluations Standardization and Crew Resource Management Facilitation Roger Coleman, Manager, Human Factors and Safety Training, American Airlines
20. SNL Top Gun video Roger Coleman, Manager, Human Factors and Safety Training, American Airlines
21. Threat and Error Management as a Framework for ASAP Data Collection Michelle Harper, University of Texas at Austin Human Factors Research Project

22. How to Train for Automation - Results from Research & Tips for Application in the Field Florian Jentsch, U. of Central Florida; Deborah Boehm-Davis, George Mason U.; Elizabeth Lyall, Research Integrations, Inc.
23. Steering Committee for Distance Learning - Draft AC and 8400.10 Handbook Recommendations OJ Treadway, Manager, Flight Training Development, American Airlines
24. IFQASys ASAP Overview and Demonstration David Neu, IFQASys Program Manager, UTRS, Inc.; Arend van der Veen, IFQASys Team Member, UTRS, Inc.
25. System Safety Integration with Voluntary Programs Jim Kent, System Safety Manager, UPS
26. An Integrated Model for Flight Operations Monitoring Capt. John Scully, Line Assistance Mgr/Training & Flt Ops, Airbus
27. FOQA - Examples of Good and Bad practice, from operators Large and Small Dave Jesse, President, Flight Data Services Inc.
28. ATS International Services to Airlines with a focus on Flight Data Monitoring Services and Operations Manuals Dominique LECOMTE, Business Development ATS International Groupe AEROCONSEIL 2
29. QIT Aviation Safety Audit Manager - An affordable program to help you implement IEP and LOSA audits Logan Luo, Senior Consultant, QIT Consulting, Inc.
30. The Need for Quality Aviation Safety Graduates: An Educational Challenge Thomas R. Weitzel, Ed.D., Associate Professor, Embry-Riddle Aeronautical University
31. Aviation Safety Reporting System (ASRS): An Update on Safety Contributions Linda Connell, Director, Aviation Safety Reporting System, NASA
32. FOQA Review Board (FRB) - A New Concept Using a Collective Approach to FDR Based Decision-Making Jean-Pierre Dagon, Director Corporate Safety, AirTran Airways
33. Web-based Voluntary Disclosure Reporting Program for Operators & FAA Inspectors Scott Crosier, Aviation Safety Inspector, FAA
34. System Safety: Industry Problems and Concerns Steven C. McNeely, Manager, Internal Evaluations/Safety/ISO, Jet Solutions, LLC
35. Safety Action Program in a Flight Attendant Environment Valerie Walker, MEC Safety Vice-Chair, United, Association of Flight Attendants-CWA; Helen Zienkievicz, Manager, Health, Safety and Security, United Airlines
36. Update on SMS and its Relationship to Voluntary Safety Programs Don Arendt, Manager, Flight Standards Safety and Analysis Center (FSAIC), FAA
37. Integrating Safety Programs for Safety Action Chris Glaeser, Director of Safety, Northwest Airlines
38. Integrated Analysis in FOQA, ASAP, & AQP at Jet Blue Airways Tim Tatem, FOQA Manager, JetBlue Airways
39. The Air Traffic Organization - A Partner in Safety Management Paul Erway, Air Traffic Organization, FAA
40. Closing Remarks Tom Longridge, Ph.D., Manager, Voluntary Safety Programs-AFS-230, FAA

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Reference Type: Electronic Source
Author: Federal Aviation Administration (FAA)
Year: 2006
Title: FAA industry training standards (FITS)
Access Year: 2006
Access Date: Sept. 6
Last Update Date: February 22, 2006
Type of Medium: Website
Abstract: (taken from Program Plan Executive Summary) The FITS program is under the Safer Skies program and compliant with Challenge 2000 and OMB Circular A-119, Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities. The FITS program is a collaboration of FAA, industry (manufacturers, training

providers, universities, insurance companies, trade associations, etc) and the General Aviation Center of Excellence which seeks an evolutionary approach to change that is responsive to the pace of development in the general aviation community. The FITS program will work to develop standards that comply with the flexibility of the current rules, and regulations.
URL: http://www.faa.gov/education_research/training/fits/

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Reference Type: Magazine Article
Author: Fiorino, F.
Year: 1997
Title: Primary training-time for a proficiency check
Magazine: Aviation Week and Space Technology
Volume: 22/29
Pages: 100
Date: December
Number of Pages: 1
Keywords: training, experience level, pilot demand

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Reference Type: Conference Proceedings
Author: Flach, J.M.
Year of Conference: 1995
Title: Maintaining situation awareness when stalking cognition in the wild
Conference Name: International Conference on Experimental Analysis and Measurement of Situation Awareness
Conference Location: Embry-Riddle Aeronautical University, Daytona, FL
Author's Affiliation and Title: Psychology Department, Wright State University, Dayton, OH
Number of Pages: 10
Keywords: situation awareness, confirmation bias, hindsight bias, unified field theory

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Reference Type: Report
Author: Flach, J.M.
Year: 1995
Title: Situation awareness: In search of meaning
Institution: Wright State University
Author's Affiliation and Title: Wright State University, jflach@desire.wright.edu
Number of Pages: 4
Keywords: situation awareness, context independent situation global assessment technique

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Reference Type: Journal Article
Author: Flach, J.M.
Year: 1995
Title: Situation awareness: Proceed with caution
Journal: Human Factors

Volume: 37
Issue: 1
Pages: 149-157
Author's Affiliation and Title: Wright State University, Dayton, Ohio
Number of Pages: 9
Keywords: situation awareness, phenomenon identification

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Reference Type: Journal Article
Author: Flach, J.M., Hagen, B.A., Larish, J.F.
Year: 1992
Title: Active regulation of altitude as a function of optical texture
Journal: Perception and Psychophysics
Volume: 51
Issue: 6
Pages: 557-568
Number of Pages: 12
Keywords: altitude, optical texture, optical splay
Abstract: Two empirical studies are reported that examine active regulation of altitude as a function of the type of ground texture. Three ground textures were examined: lines perpendicular to the direction of motion, lines parallel to the direction of motion, and the combination (i.e., square or checkerboard texture). Although subjects only controlled altitude, disturbances were introduced on three axes: vertical, lateral, and fore-aft. The results show a clear advantage for texture parallel to the direction of motion. However, in considering these results in the context of previous research on altitude control, the argument is made that there is no compelling evidence that suggests either parallel (splay) or perpendicular (density) texture is privileged with regard to altitude control. Rather, the most effective display for altitude control will be the one that best isolates the optical activity associated with the changing altitude for the optical activity arising from other sources of disturbance (such as forward locomotion). Such a display will make it easier for the observer to distinguish and respond specifically to the disturbances of altitude.

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Reference Type: Journal Article
Author: Flach, J.M., Riccio, G.E., McMillan, G.R., Warren, R.
Year: 1986
Title: Psychophysical methods for equating performance between alternative motion simulators
Journal: Ergonomics
Volume: 29
Issue: 11
Pages: 1423-1438
Author's Affiliation and Title: Flach: University of Illinois at Urbana-Champaign, Engineering Psychology Program
Riccio: Systems Research Laboratories, Inc., Dayton, OH
McMillan & Warren: Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, OH
Number of Pages: 16
Keywords: ALCOGS, RATS, motion simulators, roll-axis flight control tasks, whole-body motion, g-cueing, dynamic seat, psychophysical matching, magnitude estimation, tactile-kinesthetic cueing, motion, simulation
Abstract: Psychophysical matching techniques were employed to equate the subjective experience of motion on two roll-axis motion simulation devices: the RATS, a whole-body motion

environment, and the dynamic seat sub-system of the ALCOGS, presenting motion cues through a moving seat-pan. Two psychophysical techniques, cross-modality matching and magnitude estimation, yielded similar results. These results indicated that motion sensitivity increased with roll angular frequency for both simulators. However, the rate of increase at high frequencies was greater for the RATS than for the dynamic seat. These results were used to design a filter for the dynamic seat which enhanced high-frequency signal components. Tests in a roll-axis tracking task showed that performance in a dynamic seat using this filter was both quantitatively (in terms of r.m.s. error) and qualitatively (in terms of frequency characteristics) similar to performance in the whole-body motion environment.

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Reference Type: Journal Article
Author: Fleishman, E.A., Rich, S.
Year: 1963
Title: Role of kinesthetic and spatial-visual abilities in perceptual-motor learning
Journal: Journal of Experimental Psychology
Volume: 66
Issue: 1
Pages: 6-11
Author's Affiliation and Title: Yale University
Number of Pages: 6
Abstract: Ss were administered a spatial test and a new measure of "kinesthetic sensitivity," and then received extended practice on a Two-Hand Coordination (THC) task. The results confirm the hypothesis that sensitivity to proprioceptive cues are more important later in perceptual-motor learning while sensitivity to exteroceptive (spatial-visual) are more critical earlier in learning. The study extends previous work which showed that abilities which contribute to learning early in practice may be different from those which facilitate later learning.

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Reference Type: Magazine Article
Author: Flight International
Year: 1994
Title: J41 crash probe focuses on training
Magazine: Flight International
Pages: 9
Date: January 19-25
Number of Pages: 1

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Reference Type: Journal Article
Author: Folk, C.L., Remington, R.W.
Year: 1994
Title: The structure of attentional control: Contingent attentional control by apparent motion, abrupt onset, and color
Journal: Journal of Experimental Psychology
Volume: 20
Pages: 317-329
Author's Affiliation and Title: NASA Ames Research Center
Number of Pages: 19

Abstract: Five spatial cuing experiments tested two hypotheses regarding attentional capture: (a) that attentional capture is contingent on endogenous attentional control settings and (b) that attentional control settings are limited to the distinction between dynamic and static discontinuities (Folk, Remington, & Johnston, 1992). In Experiments 1 and 2, apparent-motion precues produced significant costs in performance for targets signaled by motion, but not for targets signaled by color or abrupt onset. Experiment 3 established that this pattern is not due to differences in the difficulty of target discrimination. Experiments 4 and 5 revealed asymmetric capture effects between abrupt onset and apparent motion related to stimulus salience. The results support the hypotheses of Folk, et al. (1992) and suggest that stimulus salience may also play a role in attentional capture.

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Reference Type: Journal Article
Author: Förstberg, J., Andersson, E., Ledin, T.
Year: 1998
Title: Influence of different conditions for tilt compensation on symptoms of motion sickness in tilting trains
Journal: Brain Research Bulletin
Volume: 47
Issue: 5
Pages: 525-535
Author's Affiliation and Title: Swedish National Road and Transport Research Institute, Railway Systems, Linköping, Sweden
Royal Institute of Technology, Railway Technology, Stockholm, Sweden
Departments of ENT, University Hospital, Linköping, Sweden
Abstract: Increased speeds of trains can be achieved by using tilting trains that decrease the lateral acceleration experienced by passengers on curves, thereby allowing trains to run typically 25-30% faster on existing curved track and maintaining good ride comfort. Unfortunately, motion sickness in tilting trains is a major problem for some passengers. To investigate the incidence of motion sickness and the extent to which different tilt compensation strategies influence its occurrence, tests were conducted with a tilting train on a track with a large number of curves. Eighty healthy volunteers were studied, selected partly for their susceptibility. Three different cars were evaluated during 3 test days, with each test ride lasting about 3 h. On four occasions per test ride, the subjects answered a questionnaire concerning activities during the ride, ride comfort, ability to work and read, vegetative symptoms, fatigue, sleepiness, nausea and well-being. Subjects' estimation of average ride comfort and ability to work and read was good in all conditions. However, 10% of the test subjects reported various symptoms of motion sickness (SMS). A 55% degree of tilt compensation of the lateral acceleration instead of the normal 70% reduced the symptoms of motion sickness incidence (SMSI) by 25-40%. SMSI correlated poorly with motion doses, which integrates vertical or lateral acceleration but correlated well with roll acceleration motion dose ($r2 = 0.43$, $p < 0.001$). For women, riding backward ($p < 0.001$) minimized SMSI, but men were insensitive to direction. Future railway design will have to optimize tilt systems by both minimizing motion sickness and avoiding excessive lateral acceleration or jerk.

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Reference Type: Conference Proceedings
Author: Foster, F., Randle, R.
Year of Conference: 1983
Title: Simulation
Editor: Lee, A.T.

Conference Name: Flight Training Technology for Regional/Commuter Airline Operation
Conference Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: September 28-30
Author's Affiliation and Title: Foster: Ransome Airlines
Randle: National Aeronautics and Space Administration (NASA)

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Reference Type: Journal Article
Author: Frank, L.H., Casali, J.G., Wierwille, W.W.
Year: 1988
Title: Effects of visual display and motion system delays on operator performance and uneasiness in a driving simulator
Journal: Human Factors
Volume: 30
Issue: 2
Pages: 201-217

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Reference Type: Conference Proceedings
Author: Frank, L.H., Casali, J.G., Wierwille, W.W.
Year of Conference: 1988
Title: Modeling operator control performance and well-being as a function of simulator visual and motion systems transport delays
Conference Name: Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 12-11 - 12-17
Date: September 29
Author's Affiliation and Title: Frank: LCDR, MSC, USN, Ph.D., Head, Human Factors and Operational Analysis Branch, Pacific Missile Test Center, Point Mugu, CA 93042-5000
Casali: Ph.D., Virginia Polytechnic Institute and State University, Department of Industrial Engineering and Operations Research, Blacksburg, VA 24061
Wierwille: Ph.D., P.E., Virginia Polytechnic Institute and State University, Department of Industrial Engineering and Operations Research, Blacksburg, VA 24061
Number of Pages: 7
Keywords: visual and motion system transport delays, update frequency, control performance, simulator sickness, visual lead
Abstract: The role of visual-motion coupling delays and cueing order in operator performance and uneasiness was assessed in a driving simulator by means of a response surface methodology central-composite design. The most salient finding of the study was that visual delay appears to be more disruptive to an individuals control performance and well-being than is motion delay. Empirical multiple regression models were derived to predict 10 reliable measures of simulator operator driving performance and comfort. Principal components analysis of these 10 models decomposed the dependent measures into two significant models which were labeled vestibular disruption and degraded performance. Examination of the empirical models revealed that, for asynchronous delay conditions, better performance and well-being were achieved when visual system led the motion system. A secondary analysis of the tools of subject gender and perceptual style on susceptibility to simulator sickness revealed that neither of these independent variables was a significant source of variance.

Reference Type: Electronic Source
Author: Frasca International
Year: 1997
Title: Frasca tells congress new flight training device may be unsafe
Access Year: 2006
Access Date: Sept. 6
Last Update Date: November 10th, 1997
Type of Medium: Frasca Press Release
Number of Pages: 3
URL: http://www.avweb.com/other/fras9746.html

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Reference Type: Magazine Article
Author: Frasca, R.
Year: 1998 (?)
Title: PCATDs counterpoint
Magazine: Airport Business
Date: March
Number of Pages: 3

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Reference Type: Conference Proceedings
Author: Frasca, R.A.
Year of Conference: 1998
Title: PCATDs - A case for concern?
Conference Name: Royal Aeronautical Society's Simulation Symposium
Conference Location: London
Publisher: Frasca International, Inc.
Date: May
Number of Pages: 19
Abstract: The intent of this paper is to increase the level of awareness within the industry about the concern of a significant number of aviation training professionals regarding the FAA's Advisory Circular AC 61-126 Qualification and Approval of Personal Computer-Based Aviation Training Devices. This advisory circular allows hour-for-hour flight time credit up to ten hours for the use of PCATDs in the training of pilots for the Instrument Rating - Airplane. The author indicates the FAA's decision to implement the advisory circular was based on special interests and that the cited research in fact does not justify the allowance of flight time credit.

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Reference Type: Report
Author: Freeman, J.S., Watson, G., Papelis, Y.E., Lin, T.C., Tayyab, A., Romano, R.A., Kuhl, J.G.
Year: 1995
Title: The Iowa driving simulator: An implementation and application overview
Institution: Society of Automotive Engineers (SAE)
Date: February
Type: SAE Technical Paper Series, No. 950174
Report Number: SAE Technical Paper Series, No. 950174

Author's Affiliation and Title: Center for Computer-Aided Design, 208 Engineering Research Facility, The University of Iowa, Iowa City, Iowa 52242-1000
Abstract: This paper presents an overview of the Iowa Driving Simulator (IDS), including its implementation and experimental applications. The Center for Computer–Aided Design (CCAD) at The University of Iowa began developing the IDS in 1990 with primary funding from the state of Iowa and the Advanced Research Projects Agency (ARPA). The simulator utilizes a recently developed real–time multibody dynamics formulation to create high fidelity, operator–in–the–loop vehicle simulations, a large six–degree–of–freedom hexapod motion base, wide field–of–view textured graphics with directional audio sources, and several interchangeable, instrumented cabs to provide realistic cueing feedback to the driver. Human factors issues currently being investigated by IDS researchers include experimental studies for the design and use of automated highway systems, usage of raised pavement markers for lane edge–line delineation, IVHS collision warning and roadway departure warning systems, advanced traveler information systems, performance assessment of challenged drivers, verification of driver performance in virtual environments, and more general issues of simulator fidelity and perceived realism. Two applications of the IDS are detailed: a study of Automated Highway Systems (AHS) and vehicle virtual prototyping on a virtual proving ground.

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Reference Type: Journal Article
Author: Frigon, J.-Y., Delorme, A.
Year: 1992
Title: Roll, pitch, longitudinal and yaw vection visually induced by optical flow in flight simulation conditions
Journal: Perceptual and Motor Skills
Volume: 74
Pages: 935-955
Author's Affiliation and Title: University of Montreal
Number of Pages: 21
Abstract: The present experiment was undertaken to study the effect of the addition of stimulation in the peripheral visual field on perceived self-motion (vection). The parameters were axes of motion, "Central + Peripheral" versus "Central" vision, frequencies of sinusoidal motion (0.2 Hz to 1.0Hz), and amplitudes. Vection generally increased with increased amplitudes and frequencies. In the "Central + Peripheral" condition, there was an interaction between frequencies and amplitudes. When stimuli were presented in "Central" vision only, vection was generally higher. It has been concluded that, for vection, the addition of visual stimulation in the periphery is more important at low sinusoidal frequencies and high amplitudes; at higher frequencies, this produces a decrease in vection probably attributable to an increase in object motion perception

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Reference Type: Conference Proceedings
Author: Furness III, T.A.
Year of Conference: 1986
Title: The super cockpit and its human factors challenges
Conference Name: Human Factors Society--30th Annual Meeting
Pages: 48-52
Author's Affiliation and Title: Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio 45433-6573
Number of Pages: 5
Abstract: A revolutionary virtual crew station concept titled the "Super Cockpit" is introduced with its applications and operational advantages. Unique aspects of the virtual information portrayal

and interactive medium of the super cockpit are discussed leading to a need for new areas of human factors research and engineering.
URL: http://www.hitl.washington.edu/publications/m-86-1/

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Reference Type: Journal Article
Author: Garrood, S., Reid, L.D.
Year: 1994
Title: Pilot evaluations of augmented flight simulator motion
Journal: Journal of Aircraft
Volume: 31
Issue: 4
Pages: 826-830
Date: July-August
Author's Affiliation and Title: Garrood: Graduate Student, University of Toronto Institute for Aerospace Studies, Toronto, Ontario M3H 5T6, Canada
Reid: Professor and Associate Director, Associate Fellow of AIAA, University of Toronto Institute for Aerospace Studies, Toronto, Ontario M3H 5T6, Canada
Number of Pages: 5
Keywords: flight simulator motion
Abstract: In an earlier paper it was proposed that the turbulence-induced motion of a flight simulator could be augmented without affecting the visual and instrument displays. This may be necessary if the simulator's washout filters severely restrict its motion response to atmospheric turbulence. The present study has implemented the proposed technique on the University of Toronto Institute for Aerospace Studies flight research simulator, and carried out pilot evaluations for both high-altitude and low-altitude operations in the presence of atmospheric turbulence in a manner that is acceptable to pilots. It was found that a simple second-order transfer function representation of the aircraft is sufficient within the motion augmentation channel. The resulting motions were judged to add to the realism of the simulation and to compare favorably with other training simulators.

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Reference Type: Report
Author: Gebman, J.R., Stanley, W.L., Barbour, A.A., Berg, R.T., Birkler, J.L., Chaloupka, M.G., Goeller, B.F., Jamison, L.M., Kaplan, R.J., Kirkwood, T.F., Batten, C.L.
Year: 1986
Title: Assessing the benefits and costs of motion for C-17 flight simulators
Institution: Rand Corporation
Date: June
Report Number: R-3276-AF
Keywords: flight simulator, motion, cost analysis, training
Abstract: A framework for assessing the benefits and costs of incorporating a motion system in C-17 simulators is described. Three alternatives of C-17 simulator type are considered: a no-motion system, a system using combined hydraulic/pneumatic g-seats, and a system using a six-degree-of-freedom (dof) motion platform. The report shows that the motion platform alternative promises a large advantage over the other alternatives in terms of the range of tasks it can train, and also enjoys an advantage in terms of safety benefits, subjective considerations such as crew and instructor confidence, and its potential to reduce the risk of simulator sickness. It is estimated in the report that the incremental cost associated with the procurement and operation of the motion platform for 25 years is about 4% of the initial cost of the simulators. The study concludes that the cost of the motion platform simulator appears warranted when measured against potential improvements in flight safety and warfighting capability that result from the much greater training capability of the simulator.

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Reference Type: Report

Author: General Accounting Office (GAO)
Year: 1997
Title: Human factors: FAA's guidance and oversight of pilot crew resource management training can be improved
City: Washington, D.C.
Institution: General Accounting Office
Date: November
Report Number: GAO/RCED-98-7
Number of Pages: 23
Abstract: Previous studies of aviation safety have found that pilot performance is a major contributor to airline accidents and incidents (events that affect or could affect a flight's safety). Therefore, training to improve pilots' performance has been a primary effort to improve airline safety. As a part of this effort, some airlines have provided training in crew resource management (CRM) since the early 1980s, and the Federal aviation Administration (FAA) will require all airlines to have implemented this training for pilots by March 1998. CRM is an approach to improving pilot performance that focuses on better coordination--among members of the cockpit crew as well as among the cockpit crew and flight attendants, dispatchers, and air traffic controllers--to handle routine and emergency situations.
Airlines can meet the CRM training requirement in one of two ways: (1) by following FAA's traditional requirements for training pilots and crew--specified in part 121 of the federal aviation regulations--or (2) by instituting the Advanced Qualification Program (AQP), which combines CRM training with technical training for pilots. Part 121 training requirements have been in place without significant modification since the 1970s, and until 1990, all airlines had to meet these requirements. Since 1990, FAA has offered airlines AQP training as well as an alternative to traditional part 121 training, and eight major airlines have chosen to train their pilots under AQP requirements.
This report responds to your request that we examine the role of airline pilots' performance in accidents and FAA's efforts to address any inadequate performance. Specifically, we agreed to address the following:
(1) What are the types and frequency of accidents in which an airline pilots' performance was cited as a contributing factor, including those in which failure to use CRM principles was identified, and
(2) how adequate is FAA's guidance for and oversight of the airlines' implementation of pilots' training for CRM? We limited our review to the accidents and incidents experienced and training implemented by the 10 major U.S. airlines--those generating $1 billion or more in revenues annually.

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Reference Type: Report
Author: General Accounting Office (GAO)
Year: 1999
Title: Aviation safety: Research supports limited use of personal computer aviation training devices for pilots
City: Washington, DC
Institution: United States General Accounting Office
Date: July 12
Report Number: GAO/RCED-99-143
Number of Pages: 46
Abstract: NO ABSTACT - Discusses research that has been conducted to support the use of personal computer training devices for pilots.

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Reference Type: Report
Author: George Mason University
Year: 1996
Title: Developing and evaluating CRM procedures for a regional air carrier: Phase I report
City: Washington, DC
Institution: Federal Aviation Administration (FAA), Office of the Chief Scientific and Technical Advisor for Human Factors
Date: May 30
Author's Affiliation and Title: George Mason University, 4400 University Drive, Fairfax, VA 22030-4444
Recipient's Affiliation and Title: Federal Aviation Administration, Office of the Chief Scientific and Technical Advisor for Human Factors, AAR-100, 800 Independence Avenue, S.W.
Keywords: crew resource management, CRM, advanced qualification program, AQP, line oriented evaluation, LOE, Atlantic Coast

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Reference Type: Report
Author: Gertner, I.C., Wolberg, G., Geri, G.A., Kelly, G.R., Pierce, B.J., Thomas, M., Martin, E.L.
Year: 1994
Title: A PC-based photographic-quality image generator for flight simulation
Author's Affiliation and Title: Gertner, Wolberg: City College of New York (CUNY), Department of Computer Science, New York, NY 10031
Geri, Kelly: University of Dayton, Research Institute, Higley, AZ 85236-2020
Pierce, Thomas, Martin: Air Force, Armstrong Laboratory, Mesa, AZ 85206
Number of Pages: 7
Keywords: PC-based, photographic-quality image generator, flight simulation, multiple instruction multiple data, MIMD, rendering, Gouraud shading, incremental texture mapping, filtering

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Reference Type: Conference Proceedings
Author: Gilbert, W.P., Nguyen, L.T.
Year of Conference: 1978
Title: Use of piloted simulation for studies of fighter departure/spin susceptibility
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 26-21 - 26-13
Date: April 24-27
Author's Affiliation and Title: Aeronautical Engineers, NASA Langley Research Center, Mail Stop 355, Hampton, VA 23665
Number of Pages: 13
Keywords: departure/spin susceptibility, stall
Abstract: The NASA-Langley Research Center has incorporated into its stall-spin research program on military airplanes the use of piloted, fixed-base simulation to complement the existing matrix of unique research testing techniques. The piloted simulations of fighter stall/departure flight dynamics are conducted at the Langley Differential Maneuvering Simulator (DMS). This paper reviews the objectives of the situation research, presents the rationale underlying the simulation methods and procedures used in the evaluation of airplane characteristics, and discusses in detail the evaluation steps used to assess fighter stall/departure characteristics. Simulation results are presented to illustrate the flight dynamics phenomena dealt with.

The considerable experience accumulated in the conduct of piloted stall/departure simulation indicates that simulation provides a realistic evaluation of an airplane's maneuverability at high angles of attack and an assessment of the departure and spin susceptibility of the airplane. This realism is obtained by providing the pilot a complete simulation of the airplane and control system which can be flown using a realistic cockpit and visual display in simulations of demanding air combat maneuvering tasks. The use of the piloted simulation methods and procedures described in the paper have been found very effective in identifying stability and control problem areas and in developing automatic control concepts to alleviate many of these problems. A good level of correlation between simulated flight dynamics and flight test results has been obtained over many fighter configurations studied in the simulator.

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Reference Type: Report
Author: Gillingham, K., Previc, F.
Year: 1993
Title: Spatial orientation in flight
Institution: Armstrong Laboratory, Crew Systems Directorate, Crew Technology Division
Date: November
Report Number: AL-TR-1993-0022
Author's Affiliation and Title: Crew Systems Directorate, Crew Technology Division, 2504 D Drive, Suit 1, Brooks Air Force Base, TX 78235-5104
Recipient's Affiliation and Title: Armstrong Laboratory, Crew Systems Directorate, Crew Technology Division, 2504 D Drive, Suite 1, Brooks Air Force Base, TX 78235-5104
Keywords: motion sickness, pilot vertigo, spatial disorientation, spatial orientation, vestibular function, visual orientation
Abstract: Human spatial orientational mechanisms, and how those mechanisms fail in flight, are discussed in detail in this comprehensive review. Specific topics include: mechanics and associated physiologic nomenclature; visual orientation; vestibular function and information processing; other orientational senses; spatial disorientation, including definitions, types, causes, examples, statistics, and methods of preventing spatial disorientation mishaps; and the significance, etiology, and therapy of motion sickness. Forty-four figures are included many illustrating vestibular anatomy physiology, and other depicting the more common visual and vestibular illusions in flight.

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Reference Type: Report
Author: Gilliom, D.C., Spears, W.D., Demuth, H.J., Eddy, P.P., Hanley, D.E., Holmbeck, G.E., Fishburne, R.P.
Year: 1985
Title: A systematic determination of skill and simulator requirements for airline transport pilot certification
City: Washington, DC
Institution: Office of Flight Operations
Date: March
Report Number: DOT-TSC-FAA-85-1
Author's Affiliation and Title: Planning Systems International, Inc., 200 Little Falls Street, Suite 104, Falls Church, VA 22406
Number of Pages: 254
Keywords: simulation requirements, pilot performance, cue analysis, skill analysis, visual simulation, motion simulation, aircraft systems simulation, pilot certification, FAA airman certification system

Abstract: This research report describes:
(1) the FAA's ATP airman certification system; (2) needs of the system regarding simulator use;
(3) a systematic methodology for meeting these needs;
(4) application of the methodology;
(5) results of the study; and
(6) conclusions.
The methodology developed is Airman Certification Systems Development, or ACSD. Application of ACSD entailed a systematic study of the airman certification process. The study produced behaviorally defined evaluation and training objectives; sensory cue and behavioral analyses to support these objectives; and a statement of media requirements based on the objectives and behavioral and cueing data. This report provides comprehensive documentation of the results of the ACSD methodology as a tool to analyze simulator use in FAA airline transport pilot certification.

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Reference Type: Electronic Source
Author: Gilmore, T.
Year: 2001
Title: Flying right seat on a PCATD
Access Year: 2006
Access Date: Sept. 6
Type of Medium: Online article
URL: http://fgatd.sourceforge.net/nafi-PCATD.html

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Reference Type: Magazine Article
Author: Gladwell, M.
Year: 2002
Title: The social life of paper
Magazine: The New Yorker
Pages: 92-96
Date: March 25
Number of Pages: 5

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Reference Type: Electronic Source
Author: Gleim
Year: 2006
Title: Advanced pilot training
Producer: Gleim
Access Year: 2006
Access Date: Sept 6.
Number of Pages: 12
Keywords: instrument rating, commercial pilot certificate, flight instructor certificate, ground instructor certificate, airline transport pilot certificate
Notes: As of Sept. 6, 2006 the original web page was no longer available.
URL: http:\\www.gleim.com/Aviation/AdvancedTraining.html

Reference Type: Conference Proceedings
Author: Go, T.H., Bürki-Cohen, J., Chung, W.W., Schroeder, J., Saillant, G., Jacobs, S., Longridge, T.
Year of Conference: 2003
Title: The effects of enhanced hexapod motion on airline pilot recurrent training and evaluation
Conference Name: AIAA Modeling and Simulation Technology Conference
Conference Location: Austin, TX
Publisher: AIAA
Pages: August 11-14
Abstract: A quasi-transfer experiment tested the effect of simulator motion on recurrent evaluation and training of airline pilots. Two groups of twenty B747-400 pilots were randomly assigned to a flight simulator with or without platform motion. In three phases, they flew four maneuvers designed to reveal differences due to motion. In the first phase, termed Evaluation, the two groups flew the maneuvers as they would in a check ride. In the second phase, termed Training, the two groups flew the maneuvers repetitively and were given feedback on their performance. In the third phase, termed Quasi-Transfer, both groups flew the tasks again, but both in the simulator with motion (quasitransferinstead of real transfer to the airplane). This was to determine whether or not their previous training with or without motion made any difference. Statistically significant effects of both motion and the phase of experiment were found for all four maneuvers. Platform motion was shown to make a difference in Evaluation, but was not found to be of benefit in Training. Results of this study and the previous hexapod motion research should assist the FAA in determining future research directions in the effort to develop motion requirements for today's airline evaluation and training needs.

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Reference Type: Conference Proceedings
Author: Go, T.H., Bürki-Cohen, J., Soja, N.N.
Year of Conference: 2000
Title: The effect of simulator motion on pilot vehicle training and evaluation
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Denver, CO
Volume: AIAA-2000-4296
Pages: 1-9
Date: August 14-17
Author's Affiliation and Title: Tiauw H. Go: Postdoctoral Associate, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA
Judith Burki-Cohen: Engineering Psychologist, Volpe Center, U.S. Department of Transportation, Cambridge, MA
Nancy N. Soja: Consultant, experimental psychology, Brookline, MA
Number of Pages: 10
Abstract: This study empirically examined the effect of simulator platform motion on airline pilot recurrent training and evaluation. it is driven by the need for sound scientific data on the relationship between certain key modern device features and their effect on the transfer of pilot performance and behavior to and from the respective airplane. The experiment utilized an FAA qualified Level C simulator with six-degree-of-freedom synergistic motion and a wide angle high quality visual system. Experienced airline pilots were evaluated and trained in the simulator, half of them with and the other half without motion. Then the transfer of skills acquired by both groups during this training was tested in the simulator with the motion system turned on as a stand-in for the airplane (quasi-transfer). Every effort was made to avoid deficiencies in the research design identified in a review of prior studies, by measuring pilot simulation *and* response, testing both maneuvers and pilots that are *diagnostic* of a need of motion, avoiding pilot and instructor *bias*, and ensuring sufficient statistical *power* to capture operationally relevant effects. The results of the analyses as well as their implications are presented in this paper.

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Reference Type: Journal Article
Author: Go, T.H., Ramnath, R.V.
Year: 2002
Title: Analysis of the two-degree-of-freedom wing rock in advanced aircraft
Journal: Journal of Guidance, Control, and Dynamics
Volume: 25
Issue: 2
Pages: 324-333
Date: March-April
Author's Affiliation and Title: Massachusetts Institute of Technology, Cambridge, MA 02139
Number of Pages: 10
Abstract: The dynamics of wing rock on rigid aircraft having two rotational degrees of freedom are analyzed. Nonlinear mathematical models of the aircraft are developed for the purpose of the analysis. The aerodynamic expressions contained in the models are built by putting the appropriate aerodynamic data into the model. The nonlinear dynamics are analyzed using a technique combining the multiple time scales method, center manifold reduction principle, and bifurcation theory. Analytical solutions are developed in parametric forms showing a separation of the fast and slow dynamics. Such solutions have an advantage over numerical solutions in that the important parameters and their effects on wing rock characteristics, such as amplitude and frequency, are easily seen in explicit functional relationships. An excellent agreement between the analytical results and the numerical simulations is demonstrated.

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Reference Type: Book Section
Author: Gotoh, T.
Year: 1982
Title: Can the acoustic head-related transfer function explain every phenomenon in sound localization?
Editor: Gatehouse, R.W.
Book Title: Localization of Sound: Theory and Applications
City: Groton, CT
Publisher: Amphora Press
Pages: 244-248
Author's Affiliation and Title: Acoustic Research Laboratory, Matsushita Electric Industrial Company, Limited, Osaka, Japan
Number of Pages: 5

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Reference Type: Conference Proceedings
Author: Gower, D.W., Kennedy, R.S., Lilienthal, M.G., Fowlkes, J.E.
Year of Conference: 1987
Title: Simulator sickness in U.S. Army and Navy fixed- and rotary-wing flight simulators
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 8-1 - 8-20
Date: September 29

Author's Affiliation and Title: Gower: MAJ, Director, Biodynamics Research Division, U.S. Army Aeromedical Research Laboratory, P.O. Box 577, Fort Rucker, AL 36362-5292
Kennedy: Ph.D., Facility Director, Essex Corporation, 1040 Woodcock Road, Orlando, FL 32803
Lilienthal: LCDR, Branch Head, Training & Development Branch, Human Factors Division, Naval Training Systems Center, Orlando, FL 32813-7100
Fowlkes: Ph.D., Staff Scientist, Essex Corporation, 1040 Woodcock Road, Orlando, FL 32803
Number of Pages: 20
Keywords: simulator sickness, fixed wing, rotary wing, motion, visual
Abstract: As technology has been developed to provide improved visual and motion systems in operational flight trainers and weapon tactics trainers there have been increasing reports of the occurrence of simulator sickness. Simulator sickness here refers to one or more symptoms which can occur while in a simulator, immediately postexposure, or at some time later following exposure. Flight instructors have complained that these symptoms interfere with simulator usage. Some pilots have reports when driving following postexposure, they have had to pull off the road and wait for symptoms to subside. Instructor-operators have reported experiencing "the room spinning" when they went to bed. More critical is the potential for inflight problems due to prolonged physiological effects. As a result, flight activities after simulator flight have been limited by some commands.
The U.S. Army Aeromedical Research Laboratory at Fort Rucker, Alabama and the Naval Training Systems Center at Orlando, Florida have conducted field surveys to document the extent of the simulator sickness problems at operational fixed- and rotary-wing simulator sites. Data are pooled from 10 different Navy flight simulators and the Army's AH-64 flight simulator. The total number of surveys is approximately 1500, with the number of subjects in each simulator type ranging from 28 to 280. The simulator sickness incidence rates and the relative frequency of specific symptoms are presented and correlation factors such as flight experience, simulator experience, and flight mode are also represented. Difficulties in assessing the duration of simulator sickness effects are noted, and attempts are made to present the symptom duration for the Army's AH-64 combat mission simulator (CMS). Unique to this CMS is its use of the helmet display unit (HDU) in conjunction with other visuals in the simulator.
The combined Army and Navy simulator sickness database is an ongoing attempt to relate symptoms to specific equipment features, simulator instructional techniques, training procedures, and trainee characteristics. The study reinforces the need for continued research related to system design, training methods, and crew rest guidelines between simulator and actual flight.

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Reference Type: Journal Article
Author: Grant, P.R., Reid, L.D.
Year: 1995
Title: Motion washout filter tuning: Rules and requirements
Journal: Journal of Aircraft
Volume: 34
Issue: 2
Pages: 145-151
Date: March-April
Author's Affiliation and Title: University of Toronto
Number of Pages: 7
Abstract: Current motion-drive algorithms have a number of coefficients that are selected to tune the motion of the simulator. Little attention has been given to the process of selecting the most appropriate coefficient values. Final tuning is best accomplished using experienced evaluation pilots to provide feedback to a washout filter expert who adjusts the coefficients in an attempt to satisfy the pilot. This paper presents the development of a tuning paradigm and the capturing of such within an expert system. The focus of this development is the University of Toronto classical algorithm, but the results are relevant to alternative classical and similarly structured adaptive

algorithms. This paper provides the groundwork required to develop the tuning paradigm. The necessity of this subjective tuning process is defended. Motion cueing error sources within the classical algorithm are revealed, and coefficient adjustments that reduce the errors are presented.

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Reference Type: Report
Author: Grantham, W.D.
Year: 1989
Title: Comparison of flying qualities derived from in-flight and ground-based simulators for a jet-transport airplane for the approach and landing pilot tasks
City: Hampton, VA
Institution: National Aeronautics and Space Administration (NASA), Langley Research Center
Date: December
Type: Technical Report
Report Number: NASA TP-2962
Author's Affiliation and Title: Langley Research Center, Hampton, VA
Number of Pages: 31
Keywords: flying qualities, in-flight simulators, ground-based simulators, pilot performance, approach and landing
Abstract: The primary objective of this paper was to provide information to the flight controls/flying qualities engineer that will assist him in determining the incremental flying qualities and/or pilot-performance differences that may be expected between results obtained via ground-based simulation (and, in particular, the six-degree-of-freedom Langley Visual/Motion Simulator (VMS)) and flight tests. Pilot opinion and performance parameters derived from a ground-based simulator and an in-flight simulator are compared for a jet-transport airplane having 31 different longitudinal dynamic response characteristics. The primary pilot tasks were the approach and landing tasks with emphasis on the landing-flare task. The results indicate that, in general, flying qualities results obtained from the ground-based simulator may be considered conservative--especially when the pilot task requires tight pilot control as during the landing flare. The one exception to this, according to the present study, was that the pilots were more tolerant of large time delays in the airplane response on the ground-based simulator. The results also indicated that the ground-based simulator (particularly the Langley VMS) is not adequate for assessing pilot/vehicle performance capabilities (i.e., the sink rate performance for the landing-flare task when the pilot has little depth/height perception from the outside scene presentation).

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Reference Type: Report
Author: Griffin, M.J.
Year: 1991
Title: Physical characteristics of stimuli provoking motion sickness
Pages: 3-1 - 3-32
Type: Paper from AGARD Lecture Series 175
Author's Affiliation and Title: Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, Southampton, S09 5NH England
Number of Pages: 33
Abstract: The physical characteristics of motion stimuli responsible for motion sickness are reviewed un two parts. The provocative stimuli are categorized and their nauseogenic properties discussed qualitatively in terms of the sensory conflict theory of motion sickness. Quantitative information available from experimental studies with specific types of motion is then summarized. The motions of the body considered in this review include translational oscillation, swing motions,

rotation about a vertical axis, rotation about an off-vertical axis, rotational oscillation and cross-coupled (i.e. coriolis) stimulation. Conditions producing visually-induced motion sickness are also summarized.

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Reference Type: Thesis
Author: Groen, E.
Year: 1997
Title: Orientation to gravity: Oculomotor and perceptual responses in man
City: Utrecht, The Netherlands
University: Utrecht University
Thesis Type: Ph.D.
Keywords: human perception, spatial orientation
Abstract: This thesis concerns aspects of human spatial orientation, in particular the orientation with respect to gravity.
Summary
Chapter 1: In this chapter a new and automatic method was described to determine ocular torsion (OT) from digitized video images (Video-oculography). We developed this method based on the tracking of iris patterns. Instead of quantifying OT by means of cross-correlation of circular iris samples, which is commonly applied, this new method automatically selects and recovers a set of 36 significant patterns in the iris by a technique of template matching. Each relocated landmark results in a single estimate of the torsion angle. A robust algorithm estimates OT from this total set of individually determined torsion angles, thereby largely correcting for errors which may arise as due to misjudgments of the rotation center. In a prepared set of images of an artificial eye the new method reproduced OT with an accuracy of 0.1º. In a sample of 256 images of human eyes, a practical reliability of 0.25º was achieved.
Chapter 2: The objective of this experiment was to assess evidence for vestibular adaptation to prolonged hypergravity in human subjects as to substantiate previously described effects, such as postural imbalance and motion sickness (Sickness Induced by Centrifugation, SIC). We measured the ocular torsion response in eleven subjects during static and dynamic body tilt, once before and once after an one-hour centrifuge run of +3Gx. The OT response to static tilt (in the range of 0 to 57º to either side) showed a 10% decrease, suggesting a reduced otolith gain. The otolith-canal interaction was examined by comparing the dynamic OT response to sinusoidal body roll (frequency of 0.25 Hz and amplitude of 25º) about an earth-horizontal rotation axis (stimulation of both otoliths and canals) and about an earth-vertical rotation axis (stimulation of canals). After centrifugation, the gain of the slow component velocity increased in both conditions in all but four subjects, who showed a decrease in the supine condition (but not in the upright condition). These four subjects developed symptoms of SIC, so that the different behavior of their SCV gain was likely due to a declined state of alertness which specifically may have occurred in the supine condition. In addition to the OT data, the horizontal VOR was measured in response to a velocity step rotation about the vertical yaw axis. The mean gain of the horizontal VOR was unaffected by centrifugation, but the dominant time constant was significantly reduced. Because the time constant of the horizontal VOR is centrally controlled by the velocity storage mechanism, this result provides evidence for vestibular adaptation at a central level.
Chapter 3: In the experiment of Chapter 2 the dynamic OT response (or torsional VOR) was measured to study possible effects of centrifugation on the canal-otolith interaction. However, the response did not show a clear otolith contribution. Supposedly, the stimulus frequency of 0.25 Hz had been too high to reveal an otolith component. The response was therefore studied in more detail at a wider frequency range. The ocular torsion response was examined during passive sinusoidal body roll in five human subjects. To separate the otolith organ and semicircular canal contributions, again the axis of rotation was varied between earth-horizontal and earth-vertical. At a fixed amplitude of 25°, the stimulus frequency was varied from 0.05 to 0.4 Hz. Additionally, at a fixed frequency of 0.2 Hz, the response was also measured at the amplitudes of 12.5° and 50°.

The results showed that the gain and phase of the slow component velocity (SCV) did not depend on stimulus amplitude, indicating a linear response. Contribution of the otoliths affected the ocular torsion response in three different ways. First, the gain of the SCV was slightly but consistently higher during earth-horizontal rotation than during earth-vertical rotation. In the supine orientation the average gain increased from 0.10 to 0.26. In the upright orientation the average gain increased from 0.14 to 0.37. Second and more substantially, modulation of the otolith inputs improved the response dynamics by reducing the phase lead at frequencies up to 0.2 Hz. Third, the nystagmus showed considerably less anti-compensatory saccades in upright conditions than in supine conditions, even though the SCV gain was lower in the latter. As a consequence, the average excursion of torsional eye position was highest during earth-horizontal rotation. This effect was observed in the entire frequency range. Thus, the otoliths did not only control the torsional VOR at low stimulus frequencies by keeping the slow component in phase with head motion, but also in a wider frequency range by modulating the saccadic behavior as to increase the excursion range of torsional eye position. We conclude that, during head tilt, the primary concern of the otolith-oculomotor system is to stabilize eye position in space, rather than to prevent retinal blur. This confirms that tilt otolith-induced ocular responses subserve spatial orientation.
Chapter 4: This chapter describes a study on the effectiveness of a highly polarized visual environment to induce sensations of self-motion and self-tilt in a stationary observer. The subjects were immersed in an 8 foot cubic room which could be fully rotated about an earth-horizontal axis. The interior of the room was filled with common visual features such as a door, a window, and a great variety of objects which indicated up and down (visual polarity). When the room was tilted about the roll axis of an erect observer it produced illusory self-tilt by virtue of its visual polarity alone. Although the effect was larger than is known from the literature, the experienced self-tilt did not linearly increase with room tilt. At higher angles of room tilt (80 and 120º) the judgment of verticality became more variable and depended less on the visual scene. The room induced complete self-rotation in more than 80% of the cases when it was rotated at constant velocity about a stationary subject in various body positions. This strong effect was attributed to both its motion and its visual po**larity.**
Chapter 5: This chapter describes a study on the visual-vestibular interaction in the judgment of the body orientation relative to gravity. Illusory self-tilt and self-motion (vection) produced by rotation of a full-field non-polarized visual scene about the subject's roll axis was measured as a function of the presence or absence of actual rotation of the subject during visual acceleration. Subject rotation was at two levels of acceleration and with or without a delay between initial rotation and subsequent return (washout) to the vertical position. In one set of conditions, visual motion and self-motion were in opposite directions (concordant) and in another set they were in the same direction (discordant). For concordant motion the main effect of body rotation was to reduce the time taken by the subject to indicate self-rotation. The magnitude of self-tilt was increased by actual body tilt as could be expected from addition of the perceived actual body tilt and illusory body tilt induced by visual rotation. This effect of augmented body tilt did not persist after the body was returned to the vertical. The magnitude of vection was not influenced by body rotation and washout. For discordant motion of the body and the visual scene, subjects were confused and their responses were very variable. This suggests a non-linear visual-vestibular interaction, in which perceived self-tilt and self-motion are strongly determined by visual inputs, except for discordant accelerations of the body and the visual surroundings. Then the perception is determined by the vestibular inputs.
Notes: In book form
URL: http://www.desc.med.vu.nl/Publications/Thesis/Groen/Groen.htm

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Reference Type: Report
Author: Groen, E.L., Bles, W.
Year: 1999

Title: Pitch tilt as motion cue for the simulation of linear horizontal acceleration
City: Soesterberg, The Netherlands
Institution: TNO Human Factors Research Institute
Date: April 26
Type: TNO-report
Report Number: TM-99-B005
Number of Pages: 25
Abstract: In the present study we examined to which extent pitch motion may be used as motion cue to passive linear fore aft motion. In total, 15 subjects had to judge the simulation of sinusoidal motion profiles at four different frequencies between 0.04 and 0.33 Hz, and at three different amplitudes of visual acceleration (0.44, 0.88 and 1.76 m/s^2). Psychometric curves were calculated in order to determine: 1) at which minimum tilt amplitude the simulation was perceived as veridical in more than 50% of the cases, and 2) the maximum tilt amplitude at which tilting was perceived as rotation in more than 50% of the cases. The results show that at all frequencies proprioceptive stimulation improved the motion sensation. The minimally required pitch amplitude showed a negative relationship with the log stimulus frequency and depended on the visually simulated displacement. In addition, the detection threshold for rotation depended on the tilt rate, and was remarkably increased by the linear visual stimulus. As a consequence, the optimum tilt range narrowed toward higher frequencies. In conclusion, pitch tilt can be used effectively as motion cue to simulated fore aft motion.

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Reference Type: Journal Article
Author: Groen, E.L., Clari, M.S.V.V., Hosman, R.J.A.W.
Year: 2001
Title: Evaluation of perceived motion during a simulated takeoff run
Journal: Journal of Aircraft
Volume: 38
Issue: 4
Pages: 600-606
Author's Affiliation and Title: TNO Human Factors, 3769 ZG Soesterberg, The Netherlands
Number of Pages: 7
Abstract: The range of motion stimuli that produce realistic sensations of longitudinal acceleration during a simulated takeoff run in a research simulator are presented. In all conditions, the visually simulated motion profile consisted of a step acceleration of 0.35g. The gain of the translational (surge) and tilt-coordination channel (pitch) were systematically varied. The linear travel of the motion platform was kept constant by covarying the bandwidth with the gain of the high-pass surge filter. Rate and acceleration limit of tilt coordination were fixed at 0.052 rad/s and 0.052 rad/s^2, respectively. Using a two-alternative-forced-choice paradigm, seven experienced pilots judged their motion perception as pilots non-flying. Based on their subjective response, psychometric curves were constructed. Pilots' judgments were negatively influenced by any perceived discontinuity between the initial surge stimulus and the sustained pitch stimulus. The range of realistic motion parameters was centered around a gain of 0.2 and natural frequency of 0.73 rad/s for the surge filter and a gain of 0.6 for the low-pass pitch filter. Remarkably, unity gains were rejected as too powerful. Therefore, it is concluded that, for the typical hexapod platform, the takeoff maneuver can be more effectively simulated by providing less than the full mathematical model acceleration.

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Reference Type: Conference Proceedings
Author: Groen, E.L., Hosman, R.J.A.W., Dominicus, J.W.

Year of Conference: 2003
Title: Motion fidelity during a simulated takeoff
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Austin, Texas
Pages: 1-10
Date: August 11-14
Number of Pages: 11

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Reference Type: Journal Article
Author: Guckenberger, D., Guckenberger, L., Luongo, F., Stanney, K., Sepulveda, J.
Year: 1995
Title: Above-real-time training and the hyper-time algorithm
Journal: Dr. Dobb's Journal
Pages: 52-60
Date: April
Author's Affiliation and Title: D. Guckenberger: Senior Software Engineer, ECC International
L. Guckenberger: Research Associate, University of Central Florida
Stanney, Sepulveda: Associate Professors, University of Central Florida, Industrial Engineering Department
Luongo: Software Engineer, ECC International
Number of Pages: 5

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Reference Type: Conference Proceedings
Author: Guedry, F.E.J.
Year of Conference: 1987
Title: Technical evaluation report
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 0-7 - 0-14 (vii-xiv)
Date: September 29
Author's Affiliation and Title: M.S., Ph.D., Chief Scientist, Naval Aerospace Medical Research Laboratory, Pensacola, FL
Number of Pages: 8
Keywords: simulator sickness, motion sickness, simulator training
Abstract: The Aerospace Medical Panel Symposium on "Motion Cues in Flight Simulation and Simulator Induced Sickness" held in Brussels, Belgium from 29 September through 1 October 1987. The AGARD Conference Proceedings presented here consist of seventeen individual papers followed at the end of the proceedings by a round table discussion. Authors from six NATO countries presented papers.

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Reference Type: Journal Article
Author: Gum, D.R., Albery, W.B.
Year: 1976

Title: Time-delay problems encountered in integrating the advanced simulator for undergraduate pilot training
Journal: Journal of Aircraft
Volume: 14
Issue: 4
Pages: 327-332
Author's Affiliation and Title: Gum and Albery: Air Force Human Resources Laboratory, Wright-Patterson Air Force Base
Number of Pages: 6
Abstract: An advanced Computer Image Generation (CIG) visual system has been integrated with an advanced Flight Training Research Simulator. The integration design was the first developed for integrating a CIG visual system with a sophisticated flight simulator. There was much concern for the unique CIG system transport delay, and techniques were developed which proved to be quite successful in compensating for the majority of this delay. However, not enough concern was given to previously unrecognized and unreported excessive motion system delays which were encountered during final integrated system tests. The integration scheme and the impact of iteration rates, visual and motion system delays, and delay compensation on visual and motion cue coordination as perceived by pilots are presented.

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Reference Type: Conference Proceedings
Author: Gundry, J.
Year of Conference: 1976
Title: Man and motion cues
Conference Name: Third Flight Simulation Symposium
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Pages: 1-19
Date: April
Author's Affiliation and Title: R.A.F. Institute of Aviation Medicine, Farnborough, Hants.
Number of Pages: 20

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Reference Type: Conference Proceedings
Author: Guo, L., Cardullo, F.M., Telban, R.J., Houck, J.A., Kelley, L.C.
Year of Conference: 2003
Title: The results of a simulator study to determine the effects on pilot performance of two different motion cueing algorithms and various delays, compensated and uncompensated
Conference Name: AIAA Modeling and simulation Technologies Conference and Exhibit
Conference Location: Austin, TX
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-11
Date: August 11-14
Author's Affiliation and Title: Liwen Guo, Frank M. Cardullo, Robert J. Telban: Department of Mechanical Engineering, State University of New York, Binghamton, NY
Jacob A. Houck: Manager, Cockpit Motion Facility, Associate Fellow, NASA Langley Research Center, Hampton, VA
Lon C. Kelly: Unisys Corp., Hampton, VA
Number of Pages: 12
Abstract: A study was conducted employing the Visual Motion Simulator (VMS) at the NASA Langley Research Center, Hampton, Virginia. This study compared two motion cueing algorithms,

the NASA adaptive algorithm and a new optimal control based algorithm. Also, the study included the effects of transport delays and the compensation thereof. The delay compensation algorithm employed is one developed by Richard McFarland at NASA Ames Research Center. This paper reports on the analyses of the results of analyzing the experimental data collected from preliminary simulation tests. This series of tests was conducted to evaluate the protocols and the methodology of data analysis in preparation for more comprehensive tests which will be conducted during the spring of 2003. Therefore only three pilots were used. Nevertheless some useful results were obtained.
The experimental conditions involved three maneuvers; a straight-in approach with a rotating wind vector, an offset approach with turbulence and gust, and a takeoff with and without an engine failure shortly after liftoff. For each of the maneuvers the two motion conditions were combined with four delay conditions (0, 50, 100 & 200 ms), with and without compensation. Discrete time domain data of different variables were recorded and the Cooper-Harper Ratings (CHR) of simulator handling qualities were logged from the debriefing of the pilots who “flew” the simulator for the experiments. These two categories of data, allow both objective and quasi-objective evaluation, of the human controllers’ performance. Power Spectral Density (PSD), an approach in the frequency domain was adopted for the analysis of the objective data. The PSD of the operator control behavior is an excellent indicator of operator workload. Among the analyses employing the PSD are the integral of the PSD over selected intervals and the analysis determining the frequency at which the peaks of the PSD occur.
From the analyses of the power spectral density, the total PSD of roll stick and pitch stick control in the 0 to 1 Hz range is slightly smaller when the optimal motion cueing algorithm is used in the straight-in approach and the offset approach. There is no noticeable difference of the total PSD of the pedal between the adaptive and the optimal motion cueing algorithms. When time delay is inserted, the total PSD of the roll stick, pitch stick and pedal control increases in the 0 to 1 Hz range, and increases significantly in the 0.17 to 0.4 Hz portion of the spectrum. Time delay also moves the highest peak of the PSD of the roll stick to a higher frequency area. Compensation reduces the total PSD, increased by the time delay, especially in the 0 to 0.4 Hz range. It also shifts the highest peak of PSD back to relatively lower frequencies. The paper will present details of the analysis including graphical representations of the results.
From the analyses of Cooper-Harper ratings, the optimal motion cueing algorithm shows better performance over the adaptive algorithm. The CHR does not increase when a time delay of up to 100 ms is presented. The mean CHR across all pilots in the straight-in approach and offset approach increases when compensation is applied, and the handling qualities rating becomes worse with compensation as delay increases. The compensation brings the mean CHR down only in the takeoff maneuver.
The paper describes the motion cueing algorithms used as well as the details of the manner in which the delays were inserted. The McFarland compensation algorithm will also be described.
URL: http://library-dspace.larc.nasa.gov/dspace/jsp/bitstream/2002/12425/1/NASA-aiaa-2003-5676.pdf

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Reference Type: Conference Proceedings
Author: Hall, J.R.
Year of Conference: 1978
Title: Motion versus visual cues in piloted flight simulation
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 17-11 - 17-13
Date: April 24-27
Author's Affiliation and Title: Flight Systems Department, Royal Aircraft Establishment, Bedford, Bedfordshire, UK
Number of Pages: 13
Keywords: motion, vision cues, roll, surge, peripheral
Abstract: In the ground based simulation of piloted flight the provision of "adequate" cues to the pilot is essential for both training and the successful evaluation of handling and ride qualities. Realistic motion cues are particularly difficult to provide and attempts to justify other techniques are frequently made in order to provide the pilot with, subjectively at least, a realistic handling task. This paper presents two examples to show that motion cues can be vital even when "adequate" alternative visual cues are available. The first shows that practical, low gain, roll motion cues are better than nominally perfect peripheral vision cues for controlling a vehicle with an unstable dutch roll mode and the second that motion can be vital even for developing items such as head-up displays for which it might not at first sight seem necessary.
This paper concludes that for the prediction and evaluation of handling qualities using a piloted flight simulator it is not always sufficient for the pilot to achieve a similar performance in the simulator as in flight; it is also necessary that he should adopt the same control strategy. To achieve this it is often essential to provide the pilot with motion cues as no substitute in these circumstances has yet been found.

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Reference Type: Report
Author: Hall, J.R.
Year: 1989
Title: The need for platform motion in modern piloted flight training simulators
City: Bedford, UK
Institution: Royal Aerospace Establishment
Date: October
Type: Technical Memorandum
Report Number: Tech Memo FM 35
Number of Pages: 16
Keywords: platform motion, motion cueing, training simulators, (flight simulators, human factors engineering, flight simulations, Great Britain)
Abstract: This paper discusses motion cueing in piloted flight training simulators, and presents the factors that must be taken into account when assessing the need for, and benefits of, a motion platform so that informed decisions can be taken as to its training value. These factors include the role of the simulator, the handling qualities of the vehicle concerned, the tasks the pilot is required to fly, the performance he is expected to achieve and whether training considerations require him to use a similar control strategy and control activity in the simulator as in the aircraft.

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Reference Type: Conference Proceedings
Author: Hamann, S., Waldraff, W., Finsterwalder, R.
Year of Conference: 2004
Title: Development of a simulator audio system based on COTS sound synthesis software
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Providence, RI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-9
Date: August 16-19
Author's Affiliation and Title: University of the Federal Armed Forces Munich, 85577 Neubiberg, Germany
Number of Pages: 10
Abstract: Early 2003 started the development of a simulator audio system as part of the project "MASTER" at the "University of the Federal Armed Forces Munich", Germany. The primary objective of this project is the realization of a modular vehicle simulator for educational and research purposes. In literature it has been shown, that there is a need for realistic communication simulations in aircrew training. Therefore, apart from the simulation of typical aircraft related noises, realistic communication simulation was taken as a requirement for the audio system development. Investigations have shown that only a few specialized software products for simulator audio systems are available on the market. A view beyond the simulator market indicates that all the required functionality it also covered by COTS sound sampling and synthesis software used in the music industry. The advantage of this market is that it has more users, which results in further developed software products and lower software prices. Based on a list of requirements, the COTS software "REAKTOR 4" from Native Instruments was selected to be the basis of the audio system development. With this software it is possible to set up large audio models by hierarchical block diagrams. Therefore, a variety of function blocks is provided by a block library. These functions include audio/control inputs and outputs, frequency and amplitude controlled samplers, oscillators, filters, shapers and mixers, as well as basic mathematical operators and event handling. In order to control the audio system application at a high control ate and with low latency the standardized OSC interface is used. Latency problems were avoided by using ASIO 2.0 standard for interfacing audio software and audio hardware. This enables the usage of COTS audio hardware. The described approach was used to realize a simulator audio system that meets all requirements for a professional training simulator.

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Reference Type: Report
Author: Hamilton, K., Kantor, L., Heslegrave, R., Magee, L., Hendy, K.
Year: 1989
Title: Simulator induced sickness in the CP-140 (Aurora) Flight Deck Simulator
City: Downsview, Ontario
Institution: Defence and Civil Institute of Environmental Medicine
Date: May
Type: Research Report
Report Number: DCIEM No 89-RR-32
Number of Pages: 20
Keywords: simulator sickness, ataxia, postural control, workload
Abstract: Training on modern flight simulators can lead to a condition referred to as simulator induced sickness (SIS) which is characterized by nausea, dizziness and postural instability. It is believed that SIS results from exposure to conflicting sensory information. The present report examined the incidence, severity and duration of SIS as a function of flight experience and aircrew position (pilot/copilot) in 16 aircrew following training on the CP-140 (Aurora) Flight Deck Simulator at Canadian Forces Base Greenwood. The dependent measures included symptomatology and postural stability. In addition, measures of workload were taken to examine

the contribution of the high task demands generally associated with simulator training to the development of SIS symptomatology. The results indicated that over 50% of tested aircrew experienced increases in symptom frequency following simulator training with the most commonly reported symptoms being mild mental fatigue, physical fatigue, eye strain and after sensations of motion. This increase in symptom frequency was unaffected by either flight experience or aircrew position and symptoms dissipated, for the most part, after a few hours. No changes in postural stability were observed. The workload results confirmed that the simulator imposed high task demands on the aircrew. Furthermore, the workload results were consistent with the pattern of symptoms observed, suggesting that factors other than sensory conflict may be involved in the development of symptomatology following simulator exposure. Future investigations should attempt to identify these factors so that SIS can be managed more effectively.

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Reference Type: Conference Proceedings
Author: Hampton, S., Gibb, G.D., Kirton, T., Phipps, J., Wise, J.
Year of Conference: 1995
Title: An evaluation of reduced motion-based simulator use during initial training for MD-88 crews
Conference Name: The Eighth International Aviation Psychology Symposium
Conference Location: Columbus, OH
Pages: 1-6
Date: April 24-27
Author's Affiliation and Title: Embry-Riddle Aeronautical University, Daytona Beach, FL 32114-3900
Number of Pages: 6
Keywords: MD-88, motion-based simulator
Abstract: To evaluate the training capabilities of a level 6 flight training device twenty-four pilots from Embry-Riddle were trained at Delta Airlines. Twelve of the pilots received the same flight training, except that the first five periods of training were flown in a level 6 flight training device with a visual system. No significant differences were noted in the performance of the pilots during a flight check conducted by APDs, and observed by independent check pilots from Embry-Riddle. It is hoped that the results from the study will be used in part to justify further investigation into the capabilities of flight training devices, and whether or not they can be more effectively used during pilot training by both major, and regional airline operators. Because both the initial, and the operating costs of a full flight simulator are significantly higher than that of a flight training device, considerable savings may be possible to operators.

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Reference Type: Journal Article
Author: Hanson, T.
Year: 1998
Title: FOQA and ASAP
Journal: Safety Mind
Volume: 47
Pages: 5, 47-48
Number of Pages: 3

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Reference Type: Report
Author: Harper, R., Cooper, G.

Year: 1984
Title: Handling qualities and pilot evaluation

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Reference Type: Journal Article
Author: Harris, L.R., Jenkin, M., Zikovitz, D., Redlick, F., Jaekl, P., Jasiobedzka, U., Jenkin, H., Allison, R.S.
Year: 2002
Title: Simulating self motion I: Cues for the perception of motion
Journal: Virtual Reality
Volume: 6
Pages: 75-85
Author's Affiliation and Title: York University, 4700 Keele St., Toronto, Ontario, Canada M3J 1P3
L.R. Harris: Departments of Psychology and Biology
M. Jenkin, U. Jasiobedzka, and R.S. Allison: Department of Computer Science
D. Zikovitz and F. Redlick: Department of Biology
P. Jaekl and H. Jenkin: Department of Psychology
Number of Pages: 11
Abstract: When people move there are many visual and non-visual cues that can inform them about their movement. Simulating self motion in a virtual-reality environment thus needs to take these non-visual cues into account in addition to the normal high-quality visual display. Here we examine the contribution of visual and non-visual cues to our perception of self-motion. The perceived distance of self motion can be estimated from the visual flow field, physical forces or the act of moving. On its own, passive visual motion is a very effective cue to self motion, and evokes a perception of self motion that is related to the actual motion in a way that varies with acceleration. Passive physical motion turns out to be a particularly potent self motion cue: not only does it evoke an exaggerated sensation of motion, but it also tends to dominate other cues.
URL:
http://www.cse.yorku.ca/~jenkin/papers/2002/vr1.pdf#search=%22Simulating%20self%20motion%20I%3A%20Cues%20for%20the%20perception%20of%20motion%22

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Reference Type: Report
Author: Hart, D.C., Mitchell, D.G.
Year: 1996
Title: A simulation investigation of motion cueing and visual time delay effects on two helicopter tasks
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA)
Date: April
Type: NASA Technical Memorandum
Report Number: 110385
Author's Affiliation and Title: Hart: Aeroflightdynamics Directorate, U.S. Army Aviation and Troop Command
Mitchell: Hoh Aeronautics Inc., Lomita California
Number of Pages: 76
Keywords: simulation, simulation fidelity, visual delay, motion cueing, helicopter, handling qualities, simulator validation
Abstract: A piloted simulation study was performed on the NASA Ames Research Center's Vertical Motion Simulator to investigate motion and visual cueing fidelity for helicopter handling

qualities research. A stability derivative mathematical model represented the helicopter dynamics. The piloting tasks were a precision hover and a sidestep. The first objective was to define a rationale for configuring the motion high-pass filters to yield the most realistic results for handling qualities experiments. Two principal quantities were varied: (1) the gain between the math model acceleration and commanded motion acceleration, and (2) the high-pass filter natural frequency motion configuration in the sidestep task over a high gain/high natural frequency motion configuration. The second objective was to investigate the effects of reducing the visual time delay. Compensation of the visual delays was preferred in a majority of the hover cases, but no consensus resulted in the sidestep task.

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Reference Type: Book Section
Author: Hart, S.G., Staveland, L.E.
Year: 1988
Title: Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research
Editor: Hancock, P., Meshkati, N.
Book Title: Human Mental Workload
City: North Holland B.V.
Pages: 139-183
Author's Affiliation and Title: Hart: Aerospace Human Factors Research Division, NASA-Ames Research Center, Moffett Field, CA
Staveland: San Jose State University, San Jose, CA
Number of Pages: 45
Abstract: The results of a multi-year research program to identify the factors associated with variations in subjective workload within and between different types of tasks are reviewed. Subjective evaluations of 10 workload-related factors were obtained from 16 different experiments. The experimental tasks included simple cognitive and manual control tasks, complex laboratory and supervisory control tasks, and aircraft simulation. Task-, behavior-, and subject-related correlates of subjective workload experiences varied as a function of difficulty manipulations within experiments, different sources of workload between experiments, and individual differences in workload definitions. A multi-dimensional rating scale is proposed in which information about the magnitude and sources of six workload-related factors are combined to derive a sensitive and reliable estimate of workload.

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Reference Type: Report
Author: Heffley, R.K., Clement, W.F., Ringland, R.F., Jewell, W.F., Jex, H.R., McRuer, D.T.
Year: 1981
Title: Determination of motion and visual system requirements for flight training simulators
City: Fort Rucker, AL
Institution: Systems Technology, Inc.
Date: August
Type: Technical Report
Report Number: 546
Recipient's Affiliation and Title: Department of the Army
Keywords: training simulators, pilot training, transfer of training, flight training, flight simulation, training devices, simulation, simulator fidelity, army aircraft, army training, visual perception, motion perception
Abstract: Fidelity requirements for Army flight training simulators are explored using a manual control theory approach. The first step is to define "simulator fidelity" in operational terms which

provide a basis for each of the subsequent steps. This definition is accompanied by a taxonomy of measurable fidelity parameters. The next step, also of a preparatory nature, is the analysis of Army flight training missions. It describes how specific flight tasks and piloting techniques can be cast in terms compatible with feedback control theory. Pilot modeling techniques are then discussed, first in terms of pilot control and then in terms of pilot perception. Next, armed with compatible descriptions of fidelity, the training context, and pilot behavior, a procedure is described for studying visual and motion stimuli. It is found, however, that there are serious gaps in the experimental data base; and this precludes the systematic execution of this procedure. Because of the lack of data, it is not possible to accomplish fully the original objectives and, therefore, a formal bookkeeping scheme is outlined to guide the investigation of fidelity requirements. Conclusions and recommendations are then drawn. As aids to the reader, an executive summary and glossary of terms are provided.

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Reference Type: Journal Article
Author: Helmreich, R.L., Merritt, A.C., Wilhelm, J.A.
Year: 1999
Title: The evolution of crew resource management training in commercial aviation
Journal: The International Journal of Aviation Psychology
Volume: 9
Issue: 1
Pages: 19-32
Author's Affiliation and Title: The University of Texas at Austin, Department of Psychology, Aerospace Crew Research Project
Number of Pages: 14
Keywords: crew resource management training, commercial aviation, cockpit, error management approach
Abstract: In this study, we describe changes in the nature of Crew Resource Management (CRM) training in commercial aviation, including its shift from cockpit to crew resource management. Validation of the impact of CRM is discussed. Limitations of CRM, including lack of cross-cultural generality are considered. An overarching framework that stresses error management to increase acceptance of CRM concepts is presented. The error management approach defines behavioral strategies taught in CRM as error countermeasures that are employed to avoid error, to trap errors committed, and to mitigate the consequences of error.

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Reference Type: Conference Proceedings
Author: Henderson, S., Donderi, D.C.
Year of Conference: 2005
Title: Older drivers' reported perceptual loss correlates with a decrease in peripheral motion sensitivity
Conference Name: 3rd International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design
Author's Affiliation and Title: Steven Henderson: Transportation Safety Board of Canada, Hull, Quebec
Don C. Donderi: McGill University, Montreal, Quebec
Number of Pages: 8
Abstract: Eighteen older drivers (66 to 88 years old) and their passengers both reported on the drivers' performance using questionnaires that elicited responses related to attention and to speed and accuracy of object motion perception. The measure of reported perceptual loss was an equally weighted combination of standardized responses from the 17-item driver questionnaire

and the 11-item passenger questionnaire. Peripheral stationary and drifting contrast sensitivity was determined for 0.4 cycles per degree sine wave gratings at fifteen degrees eccentricity. The temporal two-alternative forced choice staircase procedure consisted of randomly interleaved left and right visual field presentations.
The correlation between $\log_{10}$ motion contrast sensitivity and reported perceptual loss was -.63 ($p<.01$), between age and perceptual loss was .56 ($p<.05$), and between age and $\log_{10}$ motion contrast sensitivity was -.54 ($p<.05$). The partial correlation between $\log_{10}$ motion sensitivity and reported perceptual loss, independent of age, was -.47 ($p=.054$. We concluded that some age-related driving performance deficits are associated with reduced sensitivity in the visual periphery. Peripheral motion contrast sensitivity was discussed in relation to "useful field of view" (UFOV) measures of visual function, and offered as a primary deficit of high risk drivers with Alzheimer's disease.
This research was conducted at McGill University in partial fulfillment of the doctoral thesis requirement of the first author. Please note also that road safety is outside the mandate of the Transportation Safety Board of Canada.
URL: http://ppc.uiowa.edu/driving-assessment/2005/final/papers/07_SteveHendersonformat.pdf

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Reference Type: Conference Proceedings
Author: Hendy, K.C.
Year of Conference: 1995
Title: Situation awareness and workload: Birds of a feather?
Conference Name: Situation Awareness: Limitations and Enhancements in the Aviation Environment
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 21-21 - 21-27
Date: April 24-28
Author's Affiliation and Title: Defence and Civil Institute of Environmental Medicine, PO Box 2000, North York, Ontario, Canada
Number of Pages: 7
Keywords: situation awareness, workload, situation awareness metric, performance, internal representation, mental model, perceptual control theory, measurement of workload, cognitive compatibility
Abstract: In this paper it is argued that an hierarchical information processing model, with a basis in perceptual control theory, provides the necessary framework for interpreting a large, unfocused empirical literature on the topics of workload and situation(al) awareness (SA). The fundamental importance of situation awareness will emerge in considering the role of the mental model in providing the reference signal for a closed loop perceptual control system. It will be asserted that those aspects of the mental model generally covered by the SA rubric result from high level information processing activity that requires spare capacity to service. Increasing time pressure (workload) reduced the capacity available for this activity. An experiment in the application of a workload scale (NASA TLX) and a situation awareness metric (SART) to a simulated air traffic control environment is cited. It will be shown that the situation awareness scale taps largely into the workload side of the equation rather than the SA side. Implications for the measurement of SA will be drawn.

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Reference Type: Journal Article
Author: Hess, R.A.
Year: 1977

Title: Prediction of pilot opinion ratings using an optimal pilot model
Journal: Human Factors
Volume: 19
Issue: 5
Pages: 459-475
Date: October
Author's Affiliation and Title: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 17
Abstract: A brief review of some of the more pertinent applications of analytical pilot models to the prediction of aircraft handling qualities is undertaken. The relative ease with which multiloop piloting tasks can be modeled via the optimal control formulation makes the use of optimal pilot models particularly attractive for handling qualities research. To this end, a rating hypothesis is introduced which relates the numerical pilot opinion rating assigned to a particular vehicle and task to the numerical value of the index of performance resulting from an optimal pilot modeling procedure as applied to that vehicle and task. This hypothesis is tested using data from piloted simulation and is shown to be reasonable. An example concerning a helicopter landing approach is introduced to outline the predictive capability of the rating hypothesis in multiaxis piloting tasks.

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Reference Type: Journal Article
Author: Hess, R.A.
Year: 1989
Title: Theory for aircraft handling qualities based upon a structural pilot model
Journal: Journal of Guidance, Control, and Dynamics
Volume: 12
Issue: 6
Pages: 792-797
Date: November
Author's Affiliation and Title: University of California, Davis
Number of Pages: 6
Abstract: A theory for describing the manner in which aircraft dynamic characteristics determine pilot opinion ratings of aircraft handling qualities is discussed. The theory centers upon the role of pilot rate feedback in continuous tracking. A structural model of the human pilot is used to quantify the amount of rate feedback the pilot is required to use in the control of an aircraft in a specific task. Using the model, 35 vehicle configurations that have been evaluated in manned simulation are analyzed. The tasks range from simple single axis, single-loop pitch attitude tracking to precision hover and landing approach, in which control of both vehicle position and attitude are required. The manner in which control system sensitivity affect pilot opinion rating is also investigated. The rate feedback theory is supported by the results of the model-based analyses, where it is shown that the mean square value of the rate feedback signal in the model correlates with the pilot opinion ratings obtained from the experiment.

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Reference Type: Journal Article
Author: Hess, R.A.
Year: 1990
Title: Model for human use of motion cues in vehicular control
Journal: Journal of Guidance, Control, and Dynamics
Volume: 13
Issue: 3
Pages: 476-482

Date: May
Author's Affiliation and Title: University of California, Davis
Number of Pages: 7
Abstract: A feedback model for human use of motion cues in tracking and regulation tasks is offered. The motion cue model is developed as a single extension of a structural model of the human pilot, although other equivalent dynamic representations of the pilot could be used in place of the structural model. In the structural model, it is hypothesized that proprioceptive cues and an internal representation of the vehicle dynamics allow the human to create compensation characteristics that are appropriate for the dynamics of the particular vehicle being controlled. It is shown that an additional loop closure involving motion feedback can improve pilot/vehicle dynamics by decreasing high-frequency phase lags in the effective open-loop system transfer function. Data from a roll-attitude tracking/regulation task conducted on a moving base simulator are used to verify the modeling approach.

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Reference Type: Journal Article
Author: Hess, R.A.
Year: 1995
Title: Modeling the effects of display quality upon human pilot dynamics and perceived vehicle handling qualities
Journal: IEEE Transactions on Systems, Man, and Cybernetics
Volume: 25
Issue: 2
Pages: 338-344
Date: February
Number of Pages: 7
Keywords: display quality, human pilot dynamics, perceived vehicle handling qualities, closed loop systems, visual scene quality, minimum separable acuity, VCR, visual cue ratio, closed loop tracking with degraded displays, model parameters
Abstract: A model-based technique addressing the effect of display or visual scene quality upon human pilot dynamics is introduced. The technique builds upon a methodology proposed for the preliminary assessment of flight simulator fidelity which uses a structural model of the human pilot. This model is incorporated in what is termed the primary control loop(s) for the task at hand. It is shown that the measured effects of degradations in display quality upon human pilot dynamics can be modeled by simple reductions in the gains associated with error and proprioceptive signals in the structural model. A control theoretic rationale for these gain reductions is presented. The effect of display quality upon perceived handling qualities is discussed and demonstrated in a simple example. Although the research had its genesis in flight simulator fidelity studies, the modeling procedure is applicable to any continuous control task involving degraded visual conditions.

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Reference Type: Journal Article
Author: Hess, R.A.
Year: 1997
Title: Unified theory for aircraft handling qualities and adverse aircraft-pilot coupling
Journal: Journal of Guidance, Control, and Dynamics
Volume: 20
Issue: 6
Pages: 1141-1148
Date: November

Author's Affiliation and Title: University of California, Davis
Number of Pages: 8
Abstract: A unified theory for aircraft handling qualities and adverse aircraft-pilot coupling or pilot-induced oscillations is introduced. The theory is based on a structural model of the human pilot. A methodology is presented for the prediction of 1) handling qualities levels, 2) pilot-induced oscillation rating levels, and 3) a frequency range in which pilot-induced oscillations are likely to occur. Although the dynamics of the force-feel system of the cockpit inceptor is included, the methodology will not account for effects attributable to control sensitivity and is limited to single-axis tasks and, at present, to linear vehicle models. The theory is derived from the feedback topology of the structural model and an examination of flight test results for 32 aircraft configurations simulated by the U.S. Air Force/CALSPAN NT-33A and Total In-Flight Simulator variable stability aircraft. An extension to nonlinear vehicle dynamics such as that encountered with actuator saturation is discussed.

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Reference Type: Book Section
Author: Hess, R.A.
Year: 2002
Title: Aircraft dynamics and control
Editor: Webster, J.
Book Title: Wiley Encyclopedia of Electrical and Electronics Engineering
Publisher: John Wiley and Sons, Inc.
Pages: 1-29
Number of Pages: 30
Abstract: *Aircraft dynamics* refers to the equations that describe how an aircraft responds to the forces and moments that act upon it. *Aircraft control* refers to the availability to move an aircraft along a desired trajectory in three-dimensional space at some desired speed. The subject is approached here in three parts. First, the equations that describe the motion of a rigid aircraft in a moving (nonquiescent) air mass are presented and discussed. Second, the applicability of these equations is demonstrated, and the topic of control synthesis is introduced through a simple control design example. The example requires only control synthesis techniques covered in a typical undergraduate engineering course on the subject and represents what has been termed a *classical* approach to aircraft control. Implementation of the resulting control system on a digital computer is discussed, and a simulation of the flight control system is presented. Third, *modern* control design approaches are discussed that involve control synthesis techniques more advanced than that of the design example. Pertinent concepts and definitions are introduced throughout.

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Reference Type: Journal Article
Author: Hess, R.A., Malsbury, T., Atencio, A.J.
Year: 1993
Title: Flight simulator fidelity assessment in a rotorcraft lateral translation maneuver
Journal: Journal of Guidance, Control, and Dynamics
Volume: 16
Issue: 1
Pages: 79-85
Date: January-February
Author's Affiliation and Title: Hess and Malsbury: University of California
Atencio: NASA Ames Research Center
Number of Pages: 7

Abstract: A model-based methodology for assessing flight simulator fidelity in closed-loop fashion is exercised in analyzing a rotorcraft low-altitude maneuver for which flight test and simulation results were available. The addition of a handling qualities sensitivity function to a previously developed model-based assessment criteria allows an analytical comparison of both performance and handling qualities between simulation and flight test. Model predictions regarding the existence of simulator fidelity problems are corroborated by experiment. The modeling approach is used to assess analytically the effects of modifying simulator characteristics on simulator fidelity.

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Reference Type: Journal Article
Author: Hess, R.A., Siwakosit, W.
Year: 2001
Title: Assessment of flight simulator fidelity in multiaxis tasks including visual cue quality
Journal: Journal of Aircraft
Volume: 38
Issue: 4
Pages: 607-614
Date: July-August
Author's Affiliation and Title: University of California, Davis
Number of Pages: 8
Abstract: A technique for analytical assessment of flight simulator fidelity is presented as an extension of a methodology previously introduced in the literature. The assessment is based on a computer simulation of the pilot and vehicle and is inherently task dependent. A simple model of visual cue quality is introduced that is based on the classical concept of human operator visual remnant. The complete assessment procedure now includes proprioceptive, vestibular, and visual cue modeling. Inverse dynamic analysis is employed that allows the use of compensatory models of the human pilot in multiaxis tasks. The methodology is exercised by considering a simple rotorcraft lateral and vertical repositioning task in which visual and motion cue quality is varied.

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Reference Type: Electronic Source
Author: Heusmann, J.
Year: 1995
Title: Glossary of modeling and simulation (M&S) terms
Producer: Department of Defense
United States of America
Access Year: 2006
Access Date: Sept. 6
Last Update Date: August 29, 1995
Type of Medium: Draft
Author's Affiliation and Title: DMSO POC
Number of Pages: 82
URL: http://home.earthlink.net/~gwhite2/glossary.html

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Reference Type: Report
Author: Hinson, D.R.
Year: 1996

Title: Draft B-737 recommendations
City: Washington, DC
Institution: Federal Aviation Administration (FAA)
Date: October 15
Type: NTSB Press Release
Recipient's Affiliation and Title: Federal Aviation Administration, Washington, DC 20591
National Transportation Safety Board
Notes: From the October 15, 1995 Public Meeting on B-737 Safety Recommendations

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Reference Type: Conference Proceedings
Author: Hodgkinson, J., Rossitto, K.F., Kendall, E.R.
Year of Conference: 1991
Title: The use and effectiveness of piloted simulation in transport aircraft research and development
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation Effectiveness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 27-21 - 27-28
Date: October 14
Author's Affiliation and Title: Douglas Aircraft Company, 3855 Lakewood Boulevard, Long Beach, CA 90846
Number of Pages: 8
Keywords: transport aircraft, motion
Abstract: Simulation requirements for military and for commercial transport aircraft are contrasted. The special problems introduced by active control are discussed with reference to earlier fighter data. Transport simulator experiments to explore these problems are described.
Notes: Published in February 1992

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Reference Type: Report
Author: Hoh, R.H., Baillie, S.W., Morgan, J.M.
Year: 1987
Title: Flight investigation of the tradeoffs between augmentation and displays for NOE flight in low visibility
City: Cherry Hill, NJ
Institution: American Helicopter Society
Date: October 13
Report Number: 414
Author's Affiliation and Title: Hoh: Systems Technology, Inc., Hawthorne, CA
Baillie, Morgan: National Aeronautical Establishment, Ottawa, Ontario, Canada
Number of Pages: 15
Keywords: NOE flight, visual cues, nap-of-the-earth, field of view, Cooper-Harper ratings
Abstract: The missions proposed for the next generation helicopter involve requirements to operate in essentially zero visibility in the nap-of-the-earth (NOE) environment. Such operations will require the use of pilot vision aids, which gives rise to the question of the interaction of such displays and the required aircraft handling qualities. This research was conducted to: 1) investigate the required visual cueing for low speed and hover, and 2) determine if an increase in stabilization can effectively be used to compensate for the loss of essential cues. Two flight tests experiments were conducted using a conventional helicopter, and a variable stability helicopter, as well as electronically fogged lenses and night vision goggles with daylight training filters. The

primary conclusion regarding the essential cues for hover was that fine-grained texture (microtexture) was more important than large discrete objects (macrotexture) or field of view. The use of attitude was a way to make up for display deficiencies. However, a corresponding loss of agility occurred with the tested attitude command/attitude hold system resulting in unfavorable pilot comments. Hence, the favorable control display tradeoff must be interpreted in the context that the best solution would be to improve the vision aid. Such an improvement would require an increase in the visible microtexture, an advancement in display technology which is unlikely to be available in the foreseeable future. Therefore, a criterion was developed to systematically evaluate display quality and the associated upgrade in required stabilization as a function of increasingly degraded visual cues.
Notes: National Specialists' Meeting on Flight Controls and Avionics.

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Reference Type: Report
Author: Holt, R.W., Boehm-Davis, D.A., Ikomi, P.A., Hansberger, J.T., Beaubien, J.M., Incalcaterra, K.A., Seamster, T.L., Hamman, W., Schultz, K.
Year: 1998
Title: CRM procedures and crew performance--Executive summary of advanced crew resource management (ACRM) evaluation
Author's Affiliation and Title: Holt, Boehm-Davis, Ikomi, Hansberger, Beaubien, Incalcaterra: George Mason University
Seamster: Cognitive & Human Factors
Hamman: Captain, United Airlines
Schultz: Captain, Atlantic Coast Airlines
Number of Pages: 12
Keywords: CRM procedures, crew performance
Abstract: A three-year research effort to determine the effectiveness of a proceduralized Crew Resource Management system (ACRM). George Mason University worked with a regional and a major carrier in determining that this approach to CRM does enhance crew performance and, by inference, increases safe operations.

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Reference Type: Report
Author: Horattas, C.G.
Year: 1981
Title: Gravitational-cueing system: An enhancement of aircraft flight simulation
City: Washington, DC
Institution: Transportation Research Board
Report Number: 803
Number of Pages: 5
Keywords: gravitational-cueing system, aircraft flight simulation
Abstract: This paper describes a man-machine interface that is used in aircraft trainers to create artificial acceleration cues, which are perceived by the pilot as the cues produced by real environmental effects. This interface, designated as the gravitational cueing (g-cueing) system, translates acceleration components generated in an aerodynamic math model into cues that creates sensations experienced in a real aircraft. The g-cueing system is a microprocessor controlled, hydraulically and pneumatically actuated, stand-alone system that can enhance the realism of the simulated flight environment.

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Reference Type: Conference Proceedings
Author: Hosman, R.
Year of Conference: 1999
Title: Are criteria for motion cueing and time delays possible?
Conference Name: American Institute of Aeronautics and Astronautics (AIAA)
Volume: AIAA-99-4028
Author's Affiliation and Title: Director, Aerospace Man-Machine Systems Consulting, Wielengahof 46, 2625 LK Delft, The Netherlands
Number of Pages: 10
Abstract: In spite of a continuing development of flight simulation over the past thirty years, there are still some areas where flight simulation is not a one to one replacement of real flight and can not completely fulfill the reasonable and objective requirements. To fulfill these needs, the proper feedback of effective motion cues seem to encounter two significant shortcomings, resulting from a lack of full understanding of (a) the impact of motion cueing on the pilot's behavior and (b) the requirements for motion cueing in the specific training application.
During the past twenty years, research projects on pilot motion perception and manual control have been performed in the Netherlands at the Delft University of Technology, the National Aerospace Laboratory, NLR, and the TNO Institute for Human Factors. The results have not only improved the knowledge on pilot's aircraft motion perception and control, but also initiated a reconsideration of motion feedback in flight simulation. Full flight simulation is meant to integrate the pilot's skill-based, rule-based and knowledge-based behavior in his control of the total aircraft system. Distinguishing the contribution of motion feedback to these three levels of behavior provides the tool to discriminate the impact of motion feedback on these levels of the resulting pilot behavior. Based on this discrimination, a review of motion system requirements, and washout filter design and optimization, subject to the training goal, becomes possible. The paper reviews the major results of the motion perception research, explains the discrimination of motion cues based on the three levels of behavior, and shows the impact on motion-base drive algorithm design. The significance of simulation-induced delays on compensatory manual control is shown, underscoring the value of such research in objectively defining future simulator requirements.

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Reference Type: Conference Proceedings
Author: Hosman, R., Advani, S., Haeck, N.
Year of Conference: 2002
Title: Integrated design of flight simulator motion cueing systems
Editor: Royal Aeronautical Society (RAeS)
Conference Name: Developments in Simulator Systems - Integration and Effectiveness
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Pages: 16-11 - 16-12
Date: May 8-9
Author's Affiliation and Title: Ruud Hosman: Director, Aerospace Man-Machine Systems Consulting, Deft, The Netherlands
Sunjoo Advani: Director, Simulation & Training, Aircraft development & Systems Engineering B.V., Hoofdorp, The Netherlands
Nils Haeck: Mathematics and Motion Control Specialist, Hellevoetsluis, The Netherlands
Number of Pages: 12
Abstract: A forward design process applicable to the specification of flight simulator cueing systems is presented in this paper. This process is based on the analysis of the pilot-vehicle control loop by using a pilot model incorporating both visual and vestibular feedback, and the aircraft dynamics. After substituting the model for the simulated aircraft, the analysis tools are used to adjust the washout filter parameters with the goal of restoring pilot control behaviour. This process allows the specification of the motion cueing algorithm. Then, based on flight files

representative for the operational flight envelope, the required motion system space is determined. The motion-base geometry is established based on practical limitations as well as criteria for the stability of the platform with respected to singular conditions. With this process the characteristics of the aircraft, the tasks to be simulated, and the missions themselves are taken into account in defining the simulator motion cueing system.
URL:
http://www.simdesign.nl/pubs/integrated_design_of_flight_simulator_motion_cueing_system.pdf

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Reference Type: Conference Proceedings
Author: Hosman, R., Lehman, C., Pelchat, Y., Schroeder, J.
Year of Conference: 2001
Title: Summary of the panel discussion on motion cueing requirements
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Montreal, Quebec
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-8
Date: August 6-9
Author's Affiliation and Title: Hosman - AMS Consult
Hamman - United Airlines
Lehman - Civil Aviation Training Magazine
Pelchat - CAE Electronics Ltd.
Schroeder - NASA Ames Research Center
Number of Pages: 9
Abstract: During the 2000 AIAA Modeling and Simulation Technologies Conference a panel discussion on motion cueing requirements was held. Representatives from the airline industry, the simulator manufacturers, and the research community introduced the discussion topic by expressing their point of view. The audience of around 40 attendees actively took part in the discussion. When talking about motion cueing criteria the main question is not if motion cueing is necessary for simulation. Although motion cueing is required for full flight simulators, this question was still an open question during the panel discussion. Looking back at the session, the more fundamental questions when and why motion feedback is necessary were not raised and answered directly. The aim of pilot training is to assure proficiency, and proficiency is more than the manual skill to handle the aircraft. To what extent motion contributes to a pilot's training and his proficiency is more complex than long has been understood. Motion contributes to a pilot's control behavior and his visual-vestibular perception of the aircraft's motion. The aircraft's handling characteristics, the particular maneuvers and pilot's skill-based manual control behavior determine if the motion feedback is essential in simulator training. The requirements for full simulators primarily ask for physical characteristics of the motion system and a subjective judgment of the motion cues. Both the manufacturers and the research community ask for more decisive requirements for motion cueing in the future. A more integrated approach to the requirements for the motion system and the motion cueing algorithms, both in relation to the simulation objective, seem more effective. The paper reviews the introductions and the discussion. Although the approach from the airline industry, the simulator manufacturers, and the research community representatives were quite different, the summary of the session gives a broad view of what the different disciplines and the audience considered important.

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Reference Type: Book
Author: Hosman, R.J.A.W.
Year: 1996

Title: Pilot's perception and control of aircraft motions
City: Delft, The Netherlands
Publisher: Delftse Universitaire Pers.
ISBN: ISBN: 90-407-1384-7
NUGI: 841
Author's Affiliation and Title: Delft University of Technology
Keywords: motion perception, simulation, control behavior

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Reference Type: Conference Proceedings
Author: Hosman, R.J.A.W., Mulder, M., Theunissen, E.
Year of Conference: 1995
Title: Perception of flight information from EFIS displays
Conference Name: IFAC Symposium on Analysis, Design and Evaluation of Man-Machine Systems
Conference Location: Massachusetts Institute of Technology, Cambridge, MA
Author's Affiliation and Title: Delft University of Technology, Faculty of Aerospace Engineering, P.O. Box 5058, 2600GB Delft, The Netherlands
Theunissen: Delft University of Technology, Faculty of Electrical Engineering, P.O. Box 5031, 2600 GA Delft, The Netherlands
Number of Pages: 6
Keywords: displays, man/machine interface, human factors, cognitive systems
Abstract: Pilot's perception of variables presented on the Electronic Flight Instrument System, EFIS, has been investigated. A stimulus response technique has been used to determine the accuracy and speed of the perception process. By varying the exposure time of the stimuli, it has been shown that the perception of the variable magnitude is faster and more accurate than the perception of the first derivative or rate of that variable. Results of experiments on roll and pitch attitude perception, the influence of scale division, and the perception of the indicated airspeed are shown.

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Reference Type: Conference Proceedings
Author: Hosman, R.J.A.W., Roggekamp, R.P.G.M., Van der Vaart, J.C.
Year of Conference: 1988
Title: Contribution of vestibular system output to motion perception
Conference Name: Twenty-Third Annual Conference on Manual Control
Conference Location: Massachusetts Institute of Technology, Cambridge, MA
Author's Affiliation and Title: Delft University of Technology, Faculty of Aerospace Engineering
Number of Pages: 20
Abstract: The influence of motion cues on pilot's control behaviour in actual and simulated flight has been studied for many years Results of these studies show that under certain conditions addition of cockpit motion improves pilot's tracking performance.
At the Faculty of Aerospace Engineering of the Delft University of Technology pilot's perception of the aircraft motion from visual and vestibular motion cues has been investigated in more detail. The results of an experiment using a second order system step response as a roll input to the subjects showed a much faster subject response when presented to the subject using simulator cockpit motion compared to the presentation of the stimulus on the artificial horizon.
To analyze the background of this faster response a more detailed analysis of the influence of the vestibular system dynamics on its output compared to the stimulus was necessary. In the literature the vestibular system output due to input angular acceleration is normally related to input angular rate. Such a comparison showed that the vestibular output also leads the stimulus

roll rate which seemed to confirm the experimental findings. It turned out that the lead time of the vestibular output relative to the angular rate is strongly dependent on the bandwidth of the input stimulus. With decreasing stimulus bandwidth the lead of the vestibular output increases.
A stimulus response experiment was performed using a second order step response as input signal. Three values of the own frequency ω_0 (0.65, 1 and 2 rad/sec) of the second order system were used. The difference in subject's response time due to the vestibular and visual stimulation increased as was expected with decreasing own frequency ω_0 of the stimulus generating second order system. It is concluded that the vestibular system decreases the time needed to perceive the aircraft motion by 150 msec or more which has a beneficial effect on pilot's performance and control behaviour.

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Reference Type: Conference Proceedings
Author: Hosman, R.J.A.W., Van der Steen, H.F.A.M.
Year of Conference: 1993
Title: False cue detection thresholds in flight simulation
Conference Name: Flight Simulation Technologies Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 193-201
Date: August 9-11
Author's Affiliation and Title: Delft University of Technology, Faculty of Aerospace Engineering, Delft, The Netherlands
Number of Pages: 9
Abstract: In this paper a new experimental method is presented for the design of motion filters, based on simple concepts using a multi sensory perception model.
We will present the results of recent research on the perception thresholds for differences in the visual and vestibular cues as determined by using a sled as well as a research flight simulator for linear motions (surge and heave). These differences will be called *false cues.* Peripheral visual cues are modulated relative to the vestibular cues to determine the threshold values. The thresholds turn out to be dependent on velocity magnitude. The no-motion ranges turn out to be so large that they are useful in simulation.

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Reference Type: Report
Author: Hosman, R.J.A.W., Van der Vaart, J.C.
Year: 1978
Title: Vestibular models and threshold of motion perception: Results of a test in a flight simulator
City: Delft, The Netherlands
Institution: Department of Aerospace Engineering, Delft University
Report Number: LR-265

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Reference Type: Conference Proceedings
Author: Hosman, R.J.A.W., Van der Vaart, J.C.
Year of Conference: 1981
Title: Effects of vestibular and visual motion perception on control task performance
Conference Name: First Annual Conference on Manual Control and Decision-Making

Conference Location: Delft, The Netherlands
Author's Affiliation and Title: Delft University of Technology, Department of Aerospace Engineering
Number of Pages: 27
Abstract: The influence of visual and vestibular motion perception on pilot's behaviour in a control task has aroused many discussions during the last decades which have not yet come to an end. This influence is of direct relevance to the modeling of pilot control behaviour and to flight simulation.
Results of experiments in this field as reported in the literature appeared to be somewhat different format the experience gained in the research flight simulator of the Department of Aerospace Engineering of the Delft University of Technology. The aim of the experiment described in the present paper was to obtain a data base on pilot's behaviour using central and peripheral visual and motion cues.
In a following task (or compensatory tracking task) and in a disturbance task (both roll tasks) using a double integrator as the controlled element, all possible combinations of central visual, peripheral visual and vestibular motion cues were presented to the subjects.
The results show significant influence of the peripheral visual and vestibular cues on subject's performance and dynamic behaviour in both control tasks.
Notes: Same as Acta Psychologica article from same year.

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Reference Type: Journal Article
Author: Hosman, R.J.A.W., Van der Vaart, J.C.
Year: 1981
Title: Effects of vestibular and visual motion perception on task performance
Journal: Acta Psychologica
Issue: 48
Pages: 271-287
Author's Affiliation and Title: Delft University of Technology, The Netherlands
Number of Pages: 17
Keywords: vestibular, visual motion perception, task performance, motion base simulator
Abstract: The effects of foveal and peripheral visual as well as vestibular cues on performance and control behavior of subjects in two different roll control tasks were studied in a moving base flight simulator with low noise motion characteristics.
Two different roll control tasks were used, one being a following task (or compensatory tracking task) where a displayed random signal was to be tracked, the other being a disturbance task in which a random signal perturbed the controlled system and the roll angle was kept at zero. Consistent improvement in controller performance was found after adding visual peripheral or vestibular (motion) cues to the basic configuration consisting of a central CRT display. Control behavior, as expressed by controller transfer functions, was also markedly influenced by the addition of these extra motion cues, the changes in control behavior being dependent on the types of control task. Some possible causes for this dependence are also discussed.

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Reference Type: Conference Proceedings
Author: Hosman, R.J.A.W., Van der Vaart, J.C.
Year of Conference: 1982
Title: Accuracy of visually perceived roll angle and roll rate using an artificial horizon and peripheral displays
Conference Name: Second European Conference on Manual Control and Decision-Making
Conference Location: Bonn

Date: June 2-4
Author's Affiliation and Title: Delft University of Technology, Department of Aerospace Engineering, Kluyverweg 1, 2629 HS, Delft, The Netherlands
Number of Pages: 18
Abstract: In a series of computer-controlled tests, subjects were required to make accurate and fast estimates of roll attitude or roll rate presented at short intervals on a central CRT-display (artificial horizon). The influence of exposure time and, in the case of the roll rate perception task, the influence of the presence of displays in the peripheral field of vision, were investigated.
It appeared that roll attitude perception is more accurate and can be accomplished at much shorter exposure times than roll rate perception. Moreover the reaction time for roll attitude perception is about 0.1 sec shorter than for roll rate perception using the central display. Peripheral displays showed to improve roll rate perception and to decrease reaction time.

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Reference Type: Conference Proceedings
Author: Hosman, R.J.A.W., Van der Vaart, J.C.
Year of Conference: 1983
Title: Perception of roll rate from an artificial horizon and peripheral displays
Conference Name: Nineteenth Annual Conference on Manual Control
Conference Location: Massachusetts Institute of Technology, Cambridge, MA
Date: May 23-25
Author's Affiliation and Title: Delft University of Technology, Department of Aerospace Engineering
Number of Pages: 23
Abstract: It was shown earlier that peripheral side displays can help to improve the performance of subjects in tracking tasks. The work reported in the present report was undertaken to find out whether this improvement was due to an increase in 'arousal level', a more accurate or a faster perception of roll rate.
The experiment described investigates the perception accuracy of roll rate by subjects from a central CRT-display (simulated artificial horizon), peripheral side displays (moving checkerboard pattern) and both displays combined. Discrete values of roll rate were presented to the subjects during exposure times between 0.1 and 0.8 second.
Immediately after stimulus exposure the displays were either plainly blanked or masked by a dithering line on the central display or dithering of the checkerboard pattern on the peripheral displays.
Results show that the roll rate perception process from peripheral displays is more accurate and up to 0.1 second faster than from the central display. Masking shows to have a different influence on the central visual perception than on the peripheral visual perception.

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Reference Type: Conference Proceedings
Author: Hosman, R.J.A.W., Van der Vaart, J.C.
Year of Conference: 1984
Title: Accuracy of system step response roll magnitude estimation from central and peripheral visual displays and simulator cockpit motion
Conference Name: Twentieth Annual Conference on Manual Control
Conference Location: NASA Ames Research Center, Moffett Field, CA
Date: June 12-14
Author's Affiliation and Title: Delft University of Technology, Department of Aerospace Engineering, Kluyverweg 1 - 2629 HS, Delft, The Netherlands
Number of Pages: 15

Abstract: The present experiment is an extension of work done in previous years, at Delft University, on the accuracy and temporal properties of visual roll attitude and roll rate perception. In earlier perception tasks, discrete stimuli of roll attitude were presented on a central artificial horizon type display. Roll rate rests were done with the same display and with peripheral visual field displays showing moving checkerboard patterns.
From tracking tasks in a flight simulator it was found that cockpit motion improved tracking accuracy and the present experiment was designed to assess the improvements of perception due to cockpit motion.
As it is not possible to present and to manipulate discrete motion stimuli in a moving cockpit just as in the case of visual stimuli alone, a different setup had to be chosen in which dynamic system step responses of roll angle were the stimuli to be presented.
After the onset of the motion, subjects were to make accurate and quick estimates of the final magnitude of the roll angle step response by pressing the appropriate button of a keyboard device. The differing time-histories of roll angle, roll rate and roll acceleration caused by a step response will stimulate the different perception processes related the central visual field, peripheral visual field and vestibular organs in different, yet exactly known ways.
Experiments with either of the visual displays or cockpit motion and some combinations of these were run to assess the roles of the different perception processes.
Results show that the differences in response time are much more pronounced than the differences in perception accuracy.

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Reference Type: Conference Proceedings
Author: Hosman, R.J.A.W., Van der Vaart, J.C.
Year of Conference: 1988
Title: Visual-vestibular interaction in pilot's perception of aircraft or simulator motion
Conference Name: Flight Simulation Technologies Conference
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Author's Affiliation and Title: Delft University of Technology, Faculty of Aerospace Engineering, Delft, The Netherlands
Number of Pages: 11
Abstract: The importance of man's vestibular organs in perceiving cockpit motion in an aircraft or a simulator is nowadays hardly questioned, as witnessed by the present widespread us of six-degrees-of-freedom motion systems for flight simulators. Still more advantage could be gained from the use of moving base simulators.
In order to illustrate this, the paper reviews research on control behaviour and performance of subjects in target following and disturbance tasks. By using results of work by authors and others, the importance of peripheral visual and vestibular motion perception in tasks that require inner-loop stabilization, is emphasized. Results of stimulus response experiments, especially designed to gather insight in central and peripheral visual and vestibular perception of motion are summarized and used to explain findings of tracking experiments.
It is concluded that peripheral visual and cockpit motion cues are of paramount importance in actual or simulated manual aircraft control and that, in simulation, the compensation for simulator motion system dynamics, computing time-delays and motion control laws deserve much more attention.

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Reference Type: Book Section
Author: Hosman, R.J.A.W., Van der Vaart, J.C.
Year: 1989
Title: Visual-vestibular interaction in pilot's perception of aircraft or simulator motion

Editor: Baarspul, M., Mulder, J.A.
Book Title: Essays in Stability and Control
City: Delft, The Netherlands
Publisher: Delft University of Technology
Abstract: The importance of man's vestibular organs in perceiving cockpit motion in an aircraft or a simulator is nowadays hardly questioned, as witnessed by the present widespread use of six-degrees-of-freedom motion systems for flight simulators. Still more advantage could be gained from the use of moving base simulators.
In order to illustrate this, the paper reviews research on control behavior and performance of subjects in target following and disturbance tasks. By using results of work by the authors and by others, the importance of peripheral visual and vestibular motion perception in tasks that require inner loop stabilization, is emphasized. Results of stimulus response visual and vestibular perception of motion are summarized and used to explain findings of tracking experiments.
It is concluded that peripheral visual and cockpit motion cues are of paramount importance in actual or simulated manual aircraft control and that, in simulation, the compensation for simulator motion system dynamics, computing time-delays and motion control lows deserve much more attention.

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Reference Type: Book Section
Author: Howard, I.P.
Year: 1986
Title: The perception of posture, self motion, and the visual vertical
Editor: Boff, K., Kaufman, L., Thomas, J.
Book Title: Handbook of Perception and Human Performance: Sensory Processes and Perception
City: New York
Publisher: John Wiley and Sons
Volume: 1
Number of Volumes: 2
Pages: 18-27
Edition: 1
Original Publication: Human Spatial Orientation

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Reference Type: Book Section
Author: Howard, I.P., Cheung, B., Landolt, J.
Year: 1987
Title: Influence of vection axis and body posture on visually-induced self-rotation and tilt
Book Title: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
City: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 15-11 - 15-18
Author's Affiliation and Title: Howard, Cheung: York University, Institute for Space and Terrestrial Science, Human Performance Laboratory, North York, Ontario, Canada, M3J 1P3
Landolt: DCIEM, 1133 Sheppard Ave. North York, Ontario, Canada, M3M 3B9
Number of Pages: 8
Keywords: vection axis, motion cues, posture, visually induced tilt
Abstract: Yaw vection is induced by a scene rotating about the spinal axis (z axis), pitch vection by a scene rotating about an axis in the mid-frontal plane (y axis) and roll vection by a scene

rotating about an axis parallel to the line of sight (x-axis). Each of these axes can be vertical, horizontal, making six conditions in all, of which only four have been studied previously. We studied vection and illusory body tilt under all six conditions, with a dull rotating field, reduced somesthetic cues and in a situation in which is rotation could occur. Yaw vection around a vertical axis was strongest. Forward pitch vection was stronger than backward pitch vection. Contrary to previous reports, for most subjects, backward illusory tilt was much stronger than forward illusory tilt. Two subjects experienced 360° body rotation in the horizontal-pitch condition. The direction of pitch axis asymmetry was found to be consistent and not related to the asymmetry of vertical optokinetic nystagmus.

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Reference Type: Conference Proceedings
Author: Howard, I.P., Ohmi, M., Simpson, W., Landolt, J.P.
Year of Conference: 1987
Title: Vection and the spatial disposition of competing moving displays
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 16-11 - 16-18
Date: September 29
Author's Affiliation and Title: Howard, Ohmi, Simpson: York University, Institute of Space and Terrestrial Science, Human Performance Laboratory, North York, Ontario, Canada, M3J 1P3
Landolt: DCIEM, 1133 Sheppard Ave. North York, Ontario, Canada, M3M 3B9
Number of Pages: 8
Keywords: vection, moving displays, visual displays
Abstract: In Experiment 1, we investigated the relative effectiveness of two superimposed displays in generating circularvection as a function of (i) the separation in depth between them, (ii) their perceived relative differences, and (iii) which display was in the plane of focus. Circularvection was found to be governed by the display that was perceived more distant even when it was actually nearer. Vection was not affected by whether the near or far display was in the plane of focus, nor by which display was fixated or pursued by the eyes. In Experiment 2, we asked whether the generally held belief that vection is induced most effectively by peripheral stimuli is due to an artifactual effect of perceived distance. The experiment assessed the separate contributions of foreground-background and central-peripheral placement of competing displays. It was found that both factors contribute in an interactive way to the experience of vection. In Experiment 3, we investigated how linear forward vection induced by looming visual display is affected by the near-far relationships of competing displays.

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Reference Type: Journal Article
Author: Huang, J.K., Young, L.R.
Year: 1987
Title: Influence of visual and motion cues on manual lateral stabilization
Journal: Aviation, Space, and Environmental Medicine
Issue: December
Pages: 1197-1204
Date: December
Author's Affiliation and Title: Huang: Old Dominion University, Department of Mechanical Engineering and Mechanics, Norfolk, VA
Young: Massachusetts Institute of Technology, Man Vehicle Laboratory, Cambridge, MA

Number of Pages: 8
Keywords: visual and motion cues, manual lateral stabilization, visual influence
Abstract: The ability of humans to detect and control their own lateral acceleration was measured by means of a closed-loop nulling task. Wide-field moving visual cues enhanced the operator's performance in nulling self-motion, especially at lower frequencies. Even visual cues, fixed relative to the operator, resulted in performance improvement relative to self-motion nulling in the dark. Describing function (frequency response) data was obtained for random acceleration conditions consisting of the visual field fixed relative to the laboratory, fixed relative to the subject, and in the dark. The describing function data was corrected for the dynamics of operator manual control strategy. The resulting frequency responses were used to develop a linear model of self-motion detection which required a lead term of 1.5 rad·s^{-1} to be added to the existing model in order to match the higher sensitivity at higher frequencies.

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Reference Type: Journal Article
Author: Huddleston, H.F., Rolfe, J.S.
Year: 1971
Title: Behavioral factors influencing the use of flight simulators for training
Journal: Applied Ergonomics
Volume: 2
Issue: 3
Pages: 141-148
Number of Pages: 8
Abstract: The case for using flight simulators as a training aid is propounded, and the drawbacks of training entirely in flight are listed. Transfer of learning from the simulated to real-life situation is discussed with relevant examples. A diagram illustrating the relative cost of using different types of simulator is given, and recent research is discussed. Finally, the attitude and influence of the organisation to simulator, trainee and instructor is described.

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Reference Type: Magazine Article
Author: Hughes, D.
Year: 1999
Title: Airbus training center uses advanced techniques
Magazine: Aviation Week & Space Technology
Pages: 66-67
Date: July 26
Number of Pages: 2
Abstract: Airbus Industries continues to refine its automated cockpit training to take advantage of new technology and the latest crew resource management techniques.

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Reference Type: Magazine Article
Author: Hughes, D.
Year: 1999
Title: NASA glass cockpit study finds improved training
Magazine: Aviation Week & Space Technology
Pages: 63-65
Date: July 26

Number of Pages: 3
Abstract: A NASA study of Continental Airlines pilots' transition into glass cockpit aircraft show that training has been vastly improved for automated aircraft even though pilots continue to make programming and mode awareness errors in operating computer-driven systems.

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Reference Type: Electronic Source
Author: Human Performance Center (HPC)
Year: 2002
Title: Cockpit and Crew Resource Management (CRM): Trends and Research
Access Year: 2006
Access Date: Sept. 6
Keywords: crew resource management training
Abstract: Crew Resource Management (CRM) training addresses the interactions of aviation team members and how those interactions affect the safety and effectiveness of the aircrew's mission.
Notes: Links include: Hardware and Software Issues; Benefits, Risks, Costs; Development Issues; Applications; WWW Related Sites; References
URL: https://www.spider.hpc.navy.mil/index.cfm?RID=APP_OT_1000131

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Reference Type: Report
Author: Humlie, M., Naumann, L., Goldsmith, T.E., Johnson, P.J.
Year: 1998
Title: Some statistical considerations in assessing pre-training maneuver evaluations
Pages: 1-5
Date: July 30
Author's Affiliation and Title: Humlie, Naumann: Delta Air Lines
Goldsmith, Johnson: University of New Mexico
Number of Pages: 5
Keywords: pre-training maneuver

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Reference Type: Journal Article
Author: Iacobucci, D.
Year: 2005
Title: From the editor: On p-values
Journal: Journal of Consumer Research
Volume: 32
Issue: 1
Date: June
Number of Pages: 11
Keywords: null hypothesis testing, statistics
Abstract: Periodically, social scientists debate the strengths ands weaknesses of hypothesis testing (for which researchers pose the question, e.g., "Are my group means the same or different?") compared with effects estimation (motivated by the question, "How large is the difference between my group means?"). As is often the case, the extreme positions are clear but they approach ideology, and a moderate stance seems the more constructive prescription.
The testing of null hypotheses affords researchers many advantages (Abelson 1997; Cortina and Dunlap 1997; Frick 1996; Greenwald et al. 1996; Hagen 1997; Harris 1997; Mulaik, Raju, and Harshman 1997). Of primary importance, the test of a null hypothesis is conducted in the context of a simple decision rule and provides a dichotomous outcome (Greenwald et al. 1996, 177). While critics would argue that hypothesis tests provide less information compared to alternative techniques, supporters argue that the binary decisions nevertheless enable scholarly progress and theory testing, which "requires nothing more than a binary decision about the relation between two variables" (Chow 1988, 105; Wainer 1999).

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Reference Type: Report
Author: IATA Flight Simulator Working Group
Year: 2002
Title: Simulated air and ground traffic environment for flight training
Date: June
Type: Revision 2

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Reference Type: Book
Author: International Air Transport Association (IATA)
Year: 1993
Title: Flight simulator design and performance data requirements
City: Montreal
Edition: 4th
ISBN: ISBN 92-9035-532-8
Keywords: configuration and design data, simulation modeling data, flight test validation and proof of match data aerodynamics and flight controls
Abstract: Lists all specific data types which must be tested and collected in flight simulation, covering aerodynamics, propulsion, ground handling, weight and moments of inertia, fuel, electrical power, ECS, hydraulics, instruments, sound and vibration.

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Reference Type: Report
Author: International Civil Aviation Organization (ICAO)

Year: 1995
Title: Manual of criteria for the qualification of flight simulators
Institution: International Civil Aviation Organization (ICAO)
Report Number: 9625-AN/938
Number of Pages: 53
Keywords: levels of simulator qualification, international test guide, types of evaluations, evaluators handbook
Abstract: This manual establishes performance and documentation requirements for the evaluation of aeroplane flight simulators used for training and checking of flight crew members. These test standards and methods of compliance were derived from extensive experience of regulatory authorities and industry.
The manual is intended to provide the means for a State civil authority to qualify a flight simulator, subsequent to a request by an applicant, through initial and recurrent evaluations of the flight simulator. Further, the manual is intended to provide the means for the civil aviation authorities of other states to accept the qualifications granted by the state which conducted the initial and recurrent evaluation of the flight simulator, without repetitive reevaluations, when considering the approval of the use of that flight simulator from their own state.

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Reference Type: Book Section
Author: International Journal of Aviation Psychology (IJAP)
Year: 1998
Title: Special issue simulation and training in aviation
Editor: Salas, E., Bowers, C.A., Prince, C.
Volume: 8
Pages: 195-318

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Reference Type: Report
Author: Jacobs, J.W., Prince, C., Hays, R.T., Salas, E.
Year: 1990
Title: A meta-analysis of the flight simulation training research
City: Orlando, FL
Institution: Naval Training System Center
Date: August
Type: Final Report
Report Number: NAVTRASYSCEN TR-89-006
Recipient's Affiliation and Title: Office of Naval Technology
Keywords: meta-analysis, flight simulation, training effectiveness, training system design, motion
Abstract: A meta-analysis of flight simulation research was conducted to identify important characteristics associated with the effectiveness of simulator training. A total of 247 articles, research reports, and technical reports were located, of which 26 had sufficient information for statistical meta-analysis; 19 involved jet pilot training and 7 involved helicopter pilot training. The major finding was that use of simulators consistently produced improvements in training for jets (relative to aircraft training only). No conclusion about simulator effectiveness for helicopter training could be made due to the small number of experiments available for this analysis. Use of motion cueing added little to the training environments for jets, and may have even detracted from training for some tasks. For helicopters, the effects of motion cueing were not able to be analyzed because of an insufficient number of experiments. Conclusions concerning the benefits of motion cueing for both types of aircraft were considered highly tentative due to methods used when conducting motion-related experiments. In general, training outcomes appear to be influenced by the type of task and the amount and type of training. An agenda for future research is provided.

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Reference Type: Report
Author: Jacobs, R.S.
Year: 1976
Title: Simulator cockpit motion and the transfer of initial flight training
City: Urbana-Champaign, IL
Institution: Air Force Office of Scientific Research, Air Force Systems Command, United States Air Force
Date: June
Type: Technical Report
Report Number: ARL-76-8/AFOSR-76-4
Author's Affiliation and Title: University of Illinois at Urbana-Champaign, Aviation Research Laboratory, Institute of Aviation
Number of Pages: 79
Keywords: transfer of training, flight training, simulator motion, transfer effectiveness, cost effectiveness, flight simulators, human factors
Abstract: Transfer of flight training from a Singer-Link GAT-2 training simulator, modified to approximate a counterpart Piper Cherokee Arrow airplane, was measured for independent groups of nine flight-naive subjects, each trained in one of three simulator cockpit motion conditions: normal washout motion in bank with sustained pitch angles, washout banking motion in which the direction of motion relative to that of the simulated airplane was randomly reversed 50% of the time as the cab passed through a wings-level attitude, and a fixed-base condition. Subjects received predetermined fixed amounts of practice in the simulator on each of 11 flight maneuvers drawn from the Private Pilot flight curriculum. Transfer of performance measures, including flight time and trials to FAA performance criteria and total errors made in the process, showed reliable transfer for all groups with differential transfer effects and cost effectiveness implications depending upon the type of simulator motion. An aptitude estimator measure and the

analysis of covariance technique provided increased discrimination among groups in the presence of considerable individual variation in performance within treatment conditions.

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Reference Type: Journal Article
Author: Jagacinski, R.J.
Year: 1977
Title: A qualitative look at feedback control theory as a style of describing behavior
Journal: Human Factors
Volume: 19
Issue: 4
Pages: 331-347
Date: August
Author's Affiliation and Title: Ohio State University, Department of Psychology, Columbus, OH
Number of Pages: 17
Abstract: The present paper reviews several ways feedback control theory has been used to describe tracking behavior and several qualitative experimental techniques. These techniques require only ordinal-level measurement and may aid any researcher investigating behavior whose temporal patterning is critical and which involves fairly continuous changes over time. One possible application in the area of stuttering behavior is presented in detail to show how these techniques can provide useful insights and hypotheses. Other suggested areas of application include the behavior of human social groups, motivational behavior, and emotional behavior.

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Reference Type: Journal Article
Author: Jentsch, F., Bowers, C.A.
Year: 1998
Title: Evidence for the validity of PC-based simulations in studying aircrew coordination
Journal: International Journal of Aviation Psychology
Volume: 8
Issue: 3
Pages: 243-260
Author's Affiliation and Title: Department of Psychology, University of Central Florida, Orlando
Number of Pages: 18
Keywords: PC-based simulations, aircrew coordination, validity, physical validity, convergent validity, discriminate validity, and construct validity
Abstract: Recently, advances in computer technology have allowed the use of PC-based simulations for a variety of aviation training and research purposes. One area in particular where PC-based simulations have been used extensively is the study of aircrew coordination. Yet, there have always been lingering questions about the validity of these simulations. Critics have argued that most PC-based simulations are derived from video games and that gaming cannot substitute for actual work tasks. Also, the low physical fidelity of these devices has been cited as a potential threat to validity. By reviewing a number of aircrew studies conducted over the past 10 years and by presenting new experimental results, this article provides evidence for the validity of using PC-based simulations. Additionally, this article provides a set of guidelines that can be used by practitioners to increase the validity of their simulations.

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Reference Type: Journal Article

Author: Jentsch, F.G., Rehfeld, S.A., Harper, M.E.
Year: 2002
Title: Software: STATISTICA Power Analysis module
Journal: Ergonomics in Design
Volume: 10
Issue: 3
Pages: 28-30
Date: Summer
Number of Pages: 3
Abstract: In this review, we focus on a recently improved power analysis module in a popular statistical application, the STATISTICA Power Analysis module. After providing basic information about the program, we focus on the utility and usability of the module. We conclude with a brief example from the literature and the Power Analysis module.

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Reference Type: Book
Author: Jeppesen
Year: 1991
Title: Aviation fundamentals
Publisher: Jeppesen Aviation Training Products

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Reference Type: Report
Author: Jex, H.R., Jewell, W.F., Megdaleno, R.E.
Year: 1979
Title: Effects of various lateral-beam washouts on pilot tracking and opinion in the "Lamar" simulator
City: Hawthorne, CA
Institution: Systems Technology, Inc
Pages: 244-266
Type: Air Force Flight Dynamics Laboratory Technical Report
Report Number: AFFDL-TR-79-3134
Abstract: A series of moving-base flight simulator experiments was performed using roll and sway motions of the Large Amplitude Multimode Aerospace Research Simulator (LAMARS) of Flight Dynamics Lab WPAFB, OH. The objectives were to:
a) Tie in the roll-only results of the 4 experienced pilots used here with previous results (Ref.1) for 4 well-trained nonpilot subjects.
b) Investigate effects of various lateral-beam-motion "was-out" filters designed to keep the lateral sway within the +- 10ft or LAMARS travel.
The high-pass washouts on lateral beam travel (y beam) were of the general form:
(See report for formula)
The basic task was to follow an evasive (randomly rolling) target while suppressing gust disturbances (Ref.1). A two-independent-input technique produced behavioral data (describing functions) and performance data (error and control scores), which revealed how pilots used the visual and motion cues. Subjective data was also gathered on the tracking task as well as on limited "sidestep" maneuvers.
The main results show: excellent tie-in with prior roll-only experiments with non-pilot subjects; most tracking performance and behavioral parameters were not significantly affected by various degree of sway washout: pilot commentary became more consistent and adverse as the spurious side-force peaks exceeded about 0.1 G y; specific problems were mapped vs. y and Ky.

Reference Type: Report
Author: JIL Information Systems
Year: 1999
Title: Aviation performance measurement system: Flight crew training and management support function
City: Washington, D.C.
Institution: JIL Information Systems, Inc.
Date: September 30
Number of Pages: 103

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Reference Type: Report
Author: JISC Technologies Applications Programme (JTAP)
Year: 2000
Title: JTAP Project 305 Human factors aspects of virtual design environments in education
Institution: JISC Technologies Applications Programme (JTAP)
Pages: 1-151
Date: February
Type: Final Report
Author's Affiliation and Title: Advanced VR Research Center, Loughborough University
Abstract: (taken from 1. Executive Summary)
1.1 Introductory Remarks
This project has concentrated on the human factors issues of interactive virtual design environments. As more and more use is made of 3D design systems (covering CAD and Virtual Design Environments) in higher education establishments there has been an urgent need to understand the complex human-computer aspects of these systems. Apart from the human factors in the use of these tools there is a requirement to understand the implications that may arise when these systems are used in teaching or educational contexts. The results from the study will be extremely important to anyone intending to use these systems for supporting education. Virtual design environments have evolved considerably during the life-span of the project and will revolutionise engineering design by enabling virtual prototyping to be undertaken earlier in the design process. Depending upon the application, immersive or non-immersive VR technologies may be employed. In educational terms, the advantage with virtual prototyping lies with the ability to interact with complex high fidelity 3D engineering data. In this context, the major feature is the ability of the student or designer to interact with the data in an intuitive manner. However, this presents a number of human factors issues that need to be resolved such as required fidelity of representation. Current interaction devices have been devised for 2D interaction and do not lend themselves to 3D applications. This can create additional difficulties when teaching students the use of 3D tools. The student should be able to interact with the virtual environment in a natural manner. Beyond this the student should be able to enter, view and manipulate their virtual designs as though they were in a real design environment, which would otherwise prove difficult or costly and yet is a requisite part of their learning. The ability to do this will profoundly enhance the educational methods and learning experience of such experimentation. The primary objective of the project has been to determine the key human factors aspects of these virtual design environments. Guidance on optimal human factors design principles has been reported in the context of virtual design environments for educational purposes.
URL: http://www.jisc.ac.uk/uploaded_documents/jtap-048.pdf

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Reference Type: Conference Proceedings

Author: Johnson, C.W., Dell, W.
Year of Conference: 2003
Title: Limitations of 3D audio to improve auditory cues in aircraft cockpits
Conference Name: International Systems Safety Conference
Author's Affiliation and Title: Department of Computing Science, University of Glasgow, Scotland, G12 9QQ
Keywords: accident reporting, media, causal Analysis, accident investigation
Abstract: Several organizations, including the FAA and NASA, have sponsored research projects into the use of spatialised audio as a means of improving warnings in commercial aircraft. Other research groups, including the Australian Defence Science and Technology Organisation, have explored the use of these techniques within military aviation. A common factor across all of this work is an apparent enthusiasm for the potential benefits of this technology. In contrast, this paper describes the problems that were encountered when attempting to derive empirical evidence for the benefits of 3D auditory cues in aircraft cockpits. Benefits were identified for the stereo presentation of auditory information but it was far harder to demonstrate any additional support for the use of more sophisticated techniques. The second half of this paper extends our investigation beyond the laboratory to examine pragmatic barriers that frustrate the introduction of this technology. These range from the problems of integrating cockpit warning systems through to an apparent confusion in the recommended practices for headphone use in Europe and North America.
URL: http://www.dcs.gla.ac.uk/~johnson/papers/ISSC2003/3daudio.pdf

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Reference Type: Conference Proceedings
Author: Johnson, D.
Year of Conference: 1978
Title: Visibility modeling for a landing simulator with special reference to low visibility
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 9-1 - 9-10
Date: April 24-27
Author's Affiliation and Title: Royal Aircraft Establishment, Farnborough, Hampshire, England
Number of Pages: 10
Keywords: landing simulator, visual simulation
Abstract: When a simulator is used to demonstrate or investigate the effects of restricted visibility on a pilot's ability to land an aircraft it is important that the visual sequence displayed is as realistic as possible.
In this paper the characteristics of the visual world by day and by night are described. In particular the topics of contrast, the apparent horizon and the perception of the lights are considered.
A brief account is also given of the characteristics of some of the more commonly encountered fogs whose effects could usefully be represented in simulating low visibility conditions. These include shallow fogs and those with marked vertical density gradients.
Various ways of simulating the outside world in general are briefly described and discussed in relation to fog and vision.

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Reference Type: Report
Author: Johnson, D.M., Stewart, J.E.I.
Year: 2002

Title: Utility of a Personal Computer Aviation Training Device for Helicopter Flight Training
Institution: U.S. Army Research Institute for the Behavioral and Social Sciences
Date: February
Type: Research Report
Report Number: 1787
Number of Pages: 47
Keywords: flight training, simulation, aircrew training programs, helicopter training
Abstract: Personal Computer Aviation Training Devices (PCATDs) have recently been shown to support beginning flight training both in the private sector and the military. These positive results are for fixed-wing aircraft only. The purpose of this research was to investigate which tasks from Initial Entry Rotary Wing (IERW) training could be supported by PCATD. A utility evaluation was performed. Sixteen aviators, representing both highly experienced and student helicopter pilots, evaluated the ability of a commercial PCATD to support IERW. Seventy-one tasks were selected from Primary and Instrument Flight Training. Aviators performed each task one or more times in the PCATD before rating it on a four-point scale. Additional data were also collected. Results showed remarkable agreement between the experienced aviators and the students. The device was judged as best able to support Instrument Flight Training, especially tasks involving radio navigation. Tasks from Primary Flight Training, especially tasks requiring hovering, were judged as less well supported. The most frequently stated positive comment was that the device would be of value in supporting the training of instrument procedures. The three most frequently cited criticisms of the device concerned narrow field of view, poor visual cues to depth, and inability to hover.

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Reference Type: Electronic Source
Author: Johnson, G.
Year: 1999
Title: Near miss spurs new pilot training
Producer: Mercury News
Access Year: 2006
Access Date: Sept. 6
Number of Pages: 3
Abstract: As Flight 863 lifted off the runway for its 14-hour, 25-minute journey, it was hit with one of the most practiced airplane emergencies, a failed engine. The plane's right inboard engine, one of four mounted on the wings, stalled. The co-pilot, who was flying the plane, correctly responded by shutting it down. Because it was overpowered on the left, the plane started to turn to the right. The correct response would have been stepping on the left rudder pedal, which would straighten the nose. Instead the pilot turned the control wheel to the left. That deployed panels on the plane's wing, reducing its lift, which led the plane towards San Bruno Mountain. Fortunately, the plane did clear the mountain.
Notes: On September 6, 2006 the original web page was no longer accessible.
URL: http://forums.sjmercury.com/nation/nationwire/docs/2569731.htm

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Reference Type: Report
Author: Johnson, P.J., Goldsmith, T.E.
Year: 1998
Title: The importance of quality data in evaluating aircrew performance
Institution: Federal Aviation Administration (FAA)
Pages: 1-37
Date: May

Type: Technical Report
Number of Pages: 37
Abstract: The primary goal of this chapter is to describe a set of methods and procedures that will enhance the quality of the data to assess aircrew performance. The two fundamental properties of quality data are reliability and validity. This section begins with a formal discussion of these two ideas, including a description of the statistics used to estimate reliability. After giving a formal treatment of reliability and validity we next discuss these concepts in the context of aircrew performance assessment. Here our discussion will be concerned with the three primary factors that influence the overall quality of data. The first is the observer or evaluator who must make the judgments or ratings of the observed performance. The second is the measuring instrument (e.g., a Line-Oriented Evaluation [LOE] grade sheet) that is used to collect data. The third factor is the host of parameters that comprise the assessment situation (e.g., a calibration session). As a brief aside it is important to understand that the assessment situation is often not the same situation under which assessments are normally conducted. For example, in a calibration session the evaluators will observe and judge a video of a crew flying an LOE as opposed to judging an LOE simulated flight. This is necessary because in order to estimate reliability every evaluator must observe the identical crew performance. The video is necessary because it would pose some obvious logistical problems to arrange for 20 or more evaluators to observe an actual LOE in the simulator. Returning to the central point of discussion, when we refer to the parameters of the assessment situation, it must be understood that they are not always the same as the conditions under which these types of observations are normally made.

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Reference Type: Conference Proceedings
Author: Johnson, W.W., Kaiser, M.K.
Year of Conference: 1995
Title: Perspective imagery in synthetic scenes used to control and guide aircraft during landing and taxi: Some issues and concerns
Conference Name: SPIE Conference on Synthetic Vision for Vehicle Guidance and Control
Conference Location: Orlando, FL
Publisher: International Society for Optical Engineering (SPIE)
Volume: 2463
Pages: 194-205
Author's Affiliation and Title: NASA Ames research center, Flight Management and Human Factors Division, Moffett Field, CA 94035
Number of Pages: 11
Keywords: synthetic vision, cockpit displays, perspective displays, display conformality, human factors
Abstract: Perspective synthetic displays that supplement, or supplant, the optical windows traditionally used for guidance and control of aircraft are accompanied by potentially significant human factors problems related to the optical geometric conformality of the display. Such geometric conformality is broken when optical features are not in the location they would be if directly viewed through a window. This often occurs when the scene is relayed or generated from a location different from the pilot's eyepoint. However, assuming no large visual/vestibular effects, a pilot can often learn to use such a display very effectively. Important problems may arise, however, when display accuracy or consistency is compromised, and this can usually be related to geometrical discrepancies between how the synthetic visual scene behaves and how the visual scene through a window behaves. In addition to these issues, this paper examines the potentially critical problem of the disorientation that can arise when both a synthetic display and a real window are present in a flight deck, and no consistent visual interpretation is available.

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Reference Type: Conference Proceedings
Author: Johnson, W.W., Schroeder, J.A.
Year of Conference: 1995
Title: Visual-motion cueing in the control of altitude
Conference Name: 1995 IEEE International Conference on Systems, Man, and Cybernetics
Conference Location: Vancouver, British Columbia, Canada
Pages: 2676-2681
Date: October
Author's Affiliation and Title: NASA Ames Research Center, Mail Stop 262-3, Moffett Field, CA 94035-1000
Number of Pages: 6
Abstract: The Vertical Motion Simulator at the NASA Ames Research Center was used to examine how platform motion and visual level of detail (LOD) cueing affected altitude repositioning and vertical rate control in two tasks utilizing a simulated AH-64 Apache helicopter. The LOD manipulation caused optical density to change across altitudes by a small, moderate, or large amount. The platform motion manipulation resulted in platform motion being either present, and 1:1 (full), or totally absent. Both small optical density changes and platform motion improved altitude judgments in the altitude repositioning task, while platform motion improved performance in a vertical rate control task. These findings show that 1) vertical platform motion mitigates the tendency of pilots to mistake optical flow rate (angular visual speed) as proportional to vehicle speed during altitude change, and contributes to the perception of movement amplitude; and 2) maintaining nearly constant optical density across altitudes improves altitude judgments.

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Reference Type: Report
Author: Johnston, D.E., Aponso, B.L.
Year: 1988
Title: Design considerations of manipulator and feel system characteristics in roll tracking
Institution: National Aeronautics and Space Administration (NASA)
Pages: 1-227
Type: NASA Contractor Report
Report Number: NASA Contractor Report 4111
Author's Affiliation and Title: Systems Technology, Inc., Hawthorne, CA
Recipient's Affiliation and Title: Ames Research Center
Dryden Flight research Facility
Number of Pages: 228
Keywords: flying qualities, limb-manipulator dynamics, neuromuscular system, roll control
Abstract: A fixed-based simulation was performed to identify and quantify interactions between the pilot's hand/arm neuromuscular subsystems and such control system features of typical modern fighter aircraft roll rate command mechanizations as: (1) force versus displacement sensing side-stick type manipulator, (2) feel force/displacement gradient, (3) feel system versus command prefilter dynamic lag, and (4) flight control system effective time delay.
The experiment encompassed some 28 manipulator/filter/aircraft configurations summarized in Sections IV and VI. Section IV concentrates on the displacement side-stick experiment results and compares these with the previous force sidestick experiment results. Attention is focused on control bandwidth, excitement (peaking) of the neuromuscular mode, feel force/displacement gradient effects, time delay effects, etc. Section V is devoted to experiments with a center-stick in which force versus displacement sensing, feel system lag, and command prefilter lag influences on tracking performance and pilot performance are investigated. Results in these two sections are summarized in numerous plots which are intended to serve as guides in the design of future control systems. Section VI concentrates on extraction of dynamic models for the pilot and closed-loop arm/manipulator/feel systems from the describing function data obtained in the Section V experiments. Parameters suitable for detailed models and for the simple crossover

model are derived. Details concerning the manipulators, feel gradients, etc. along with run logs and data summaries are presented in the several appendixes.

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Reference Type: Report
Author: Johnston, N.
Year: 1995
Title: Simulation and training: Perspectives on theory and practice
City: Dublin, Ireland
Institution: Aerospace Psychology Research Group, Trinity College
Date: August
Number of Pages: 27
Abstract: Fundamental to the design of effective simulation and training is some understanding as to the nature of human learning. This paper suggest that the conventional simulation and pilot training wisdom is based upon deficient models of learning. The paper in two parts; part 1 broadly considers theory, while Part 2 looks to the implications for simulation and training. Given that the favoured approach to training is derived from a combination of newly developing training principles, philosophical and theoretical aspects are considered in Part 1. Ideas and perspectives from research into Naturalistic decision Making, Human Expertise, Cognitive Task Analysis, Situated Learning and Phenomenology are also reviewed. In Part 2 preliminary conclusions are drawn and implications for simulation and training practice are discussed, including criteria for "low fidelity" simulation techniques. The overall objective of the paper is to contribute to the task of building a new foundation for the design and implementation of training.

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Reference Type: Report
Author: Joint Safety Analysis Team (JSAT)
Year: 1999
Title: Approach and landing
Institution: JSAT
Date: September 10
Number of Pages: 188

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Reference Type: Book
Author: Jones, E.R., Hennessy, R.T.
Year: 1985
Title: Human factors aspects of simulation
City: Washington, DC
Publisher: National Academy Press
Translator: 147

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Reference Type: Conference Proceedings
Author: Junker, A.M., Price, D.
Year of Conference: 1976

Title: Comparison between a peripheral display and motion information on human tracking about the roll axis
Conference Name: Visual and Motion Simulation Conference
Conference Location: Dayton, OH
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 63-70
Date: April 26-28
Author's Affiliation and Title: Junker: Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, OH
Price: Air Force Institute of Technology, Wright-Patterson Air Force Base, OH
Number of Pages: 8
Abstract: A comparative study of the effects of peripheral display information and motion cue information on roll axis tracking was performed. It has been shown that similar motion information improves tracking performance for some roll axis tracking tasks. For the motion case the cues available consisted of angular acceleration or velocity and linear acceleration. The peripheral display was driven by plant roll rate giving the human operator angular velocity information only. The same input forcing function and plant dynamics were used for the motion case and the peripheral display case so that the comparison could be made. The tracking results indicate an equivalent improvement in performance for both cases suggesting that angular velocity information was the principal motion component used by the human controller. The results also suggest that peripheral displays can be used to enhance tracking in much the same way as motion cues for tracking performance.

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Reference Type: Conference Proceedings
Author: Kaempf, G.L.
Year of Conference: 1992
Title: Development of integrated measures of cockpit resource management and technical performance for the advanced qualification program
Date: June 1
Author's Affiliation and Title: Ph.D., Klein Associates Inc., Fairborn, OH
Keywords: Crew resource management, CRM, Advanced Qualification Program, AQP, performance measures, knowledge elicitation techniques

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Reference Type: Report
Author: Kaempf, G.L., Cross, K.D., Blackwell, J.N.
Year: 1989
Title: Backward transfer and skill acquisition in the AH-1 flight and weapons simulator
City: Fort Rucker, AL
Institution: Anacapa Sciences, Inc.
Date: August
Type: Interim
Report Number: ARI (monitoring organization) Research Report 1537
Anacapa Sciences (performing organization) 690-312-88
Author's Affiliation and Title: Kaempf, Cross: Anacapa Sciences, Inc., P.O. Box 489, Fort Rucker, AL 36362
Blackwell: U.S. Army Research Institute Aviation, Research and Development Activity
Recipient's Affiliation and Title: Army Research Institute Aviation Research and Development Activity, Fort Rucker, AL 36362
Number of Pages: 48+
Keywords: flight simulation, skill acquisition, aircrew training, helicopter, training effectiveness, pilot performance, backward transfer, transfer of training
Abstract: Two experiments were conducted, one to investigate the backward transfer of flight skills to the AH-1 Flight and Weapons Simulator (AH1FWS) and another to investigate the acquisition of flight skills in the AH1FWS on selected maneuvers. In the backward transfer research, 16 AH-1 instructor pilots (IPs) from the AH-1 Aircrew Qualification Course were administered checkrides in the AH1FWS and the AH-1f aircraft. Comparison of the performance data from the two checkrides indicates that, while proficient on the maneuvers in the AH-1F, all IPs performed poorly in the AH1FWS. The IPs attributed their difficulties in the AH1FWS to deficiencies in the visual system and the handling and response characteristics of the flight controls.
In the skill acquisition research, four groups of 10 operational aviators received training in the AH1FWS. Each group received training on a different set of five maneuvers. The raining comprised 10 practice trials for each maneuver. Subjects received no feedback on trials 1-3; IPs provided instruction on trials 4-10. Mean performance ratings did not reach a satisfactory level of proficiency within the 10 practice trials for 17 of the 20 maneuvers investigated. Furthermore, the backward transfer data obtained during the skill acquisition research were consistent with similar data collected in a previous study.
The authors conclude that AH1FWS deficiencies adversely affect pilot performance on selected maneuvers. However, the extent to which these simulator deficiencies may affect subsequent pilot performance in the aircraft AH-1F aircraft and the AH1RQS are not interchangeable training devices and that forward transfer of training research is required. In addition, the results support the utility of the backward transfer paradigm as a potentially useful means of estimating forward transfer of training and as a relatively inexpensive testbed for the development of experimental procedures.

Reference Type: Report
Author: Kaempf, G.L., Klinger, D.W.
Year: 1993
Title: Integrated measurement of crew resource management and technical flying skills
City: Fairborn, OH
Institution: Klein Associates
Date: August
Type: Final Report
Report Number: DOT/FAA/RD-93/26
DOT-VNTSC-FAA-93-6
Number of Pages: 113
Keywords: human factors, evaluation, cockpit resource management, CRM, line oriented flight training
Abstract: This report presents the findings of a study designed with two objectives: to produce a prototype performance measurement instrument (PMI) that integrates the assessment of Crew Resource Management (CRM) and technical flying skills and to investigate the suitability of the Critical Decision method (CDM) for eliciting expert information concerning performance measurement. The work was funded by the FAA in support of the Advanced Qualification Program (AQP) and conducted in cooperation with a major U.S. carrier. The researchers used CDM to identify critical components of performance assessment for specific flight tasks and developed a prototype PMI. The instrument contains two sections for each task. One section allows an evaluator to record significant pilot and crew behaviors observed; the second section allows the evaluator to provide a subjective assessment of pilot and crew proficiency. The researchers pretested the instrument and made revisions based on recommendations from experienced instructors. The researchers then evaluated the PMI with eight instructors observing a total of 16 different flight crews in recurrent training, performing a standard Line Oriented Flight Training (LOFT) scenario in a flight simulator. The instructors reliably and accurately employed the PMI to assess performance of the crew and the individual pilot. The authors recommended that AQP developers use Cognitive Task Analysis (CTA) techniques to develop training programs for cognitive and team tasks.

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Reference Type: Book Section
Author: Kaiser, M.K., Schroeder, J.A.
Year: 2003
Title: Flights of fancy: The art and science of flight simulation
Editor: Tsang, P., Vidulich, M.
Book Title: Principles and Practice of Aviation Psychology
City: Mahwah, NJ
Publisher: LEA
Author's Affiliation and Title: NASA Ames Research Center

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Reference Type: Audiovisual Material
Author: Kapralos, B., Zikovitz, D., Jenkin, M., Harris, L.R.
Year: 2003
Title: Auditory cues in the perception of self motion
Date: October 17
Type: PowerPoint presentation
Author's Affiliation and Title: York University, North York Ontario, Canada
Kapralos: Department of Computer Science, Center for Vision Research

Zikovitz: Department of Biology, Center for Vision Research
Jenkin: Department of Computer Science, Center for Vision Research
Harris: Department of Biology, Department of Psychology, Center for Vision Research

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Reference Type: Report
Author: Karlins, M., Koh, F., McCully, L., Chan, C.T.
Year: 1997
Title: Cockpit resource management videos
Institution: Federal Aviation Administration (FAA)
Author's Affiliation and Title: Karlins - Professor of Management, University of South Florida
Koh - Assistant Director of Flight Operations, Singapore Airlines
McCully - Assistant Director of Flight Operations, Singapore Airlines
Chan - Deputy of Chief Pilot, Singapore Airlines

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Reference Type: Conference Proceedings
Author: Kemeny, A.
Year of Conference: 1999
Title: Simulation and perception
Conference Name: Driving Simulation Conference
Conference Location: Paris, France
Pages: 13-28
Date: July
Abstract: (Taken from 1. Introduction) A driving simulator consists of a vehicle and an engine of sensory stimuli producing the virtual environment. This virtual environment acts onto the driver at both perceptional and cognitive levels. Perceptional cueing is mainly visual, auditory and kinesthetic. Cognitive processes allow the driver to better sense the environment, infrastructure (horizontal and vertical road signs) and traffic, by performing driving tasks using these information, both perceptional and cognitive. Due to the human sensibility to cueing incoherence and sensory conflicts, especially regarding the perception of motion, it is essential to respect the characteristics of human perception systems. In the following, we shall review the influence of visual, vestibular, muscular and musculo-articular receptors on the characteristics of visual and kinesthetic rendering systems to take into account.
URL: http://www.experts.renault.com/DSC99/papers/INTROVA.PDF
Author Address: andras.kemeny@renault.fr

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Reference Type: Conference Proceedings
Author: Kemmerling, P.T., Jr.
Year of Conference: 1978
Title: Dynamic characteristics of flight simulator motion systems
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 20-21 - 20-20
Date: April 24-27

Author's Affiliation and Title: Kemmerling: Lt. Col., USAF, Director, Equipment Engineering, Deputy for Engineering, Aeronautical Systems Division, Wright-Patterson AFB, OH 45433
Number of Pages: 20
Keywords: motion
Abstract: Recognition is made of the complete lack of substantive data on the quality of motion produced by multiple degree of freedom aircraft simulator motion systems, and efforts made to produced this way are discussed. Working Group #07 of the Flight Mechanics Panel of AGARD has been given the charter to identify and define the pertinent physical characteristics of flight simulator motion systems, establish procedures for their measurement and prepare a report of their findings. The seven main characteristics identified by the Group are outlined, and efforts by several of the members to appoint characteristic techniques in laboratory measurements are discussed. Acknowledgment is made of the difficulties in establishing universally workable definitions and techniques for cataloging motion characteristics, and alternatives are suggested. The conclusion is reached that a taxonomy of motion characteristics is a valuable asset in determining the optional use of currently available motion systems.

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Reference Type: Conference Proceedings
Author: Kennedy, R.S., Berbaum, G.O., Allgood, G.O., Lane, N.E., Lilienthal, M.G., Baltzley, D.R.
Year of Conference: 1987
Title: Etiological significance of equipment features and pilot history in simulator sickness
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 1-1 - 1-22
Date: September 29
Author's Affiliation and Title: Kennedy, Berbaum, Lane & Baltzley: Essex Corporation, 1040 Woodcock Road, Suite 227, Orlando, FL 32803
Allgood: Martin Marietta Energy Systems, Inc., P.O. Box X, Oak Ridge, TN 37831
Lilienthal: Naval Training Systems Center, Human Factors Division (711), Orlando, FL 32813-7100
Number of Pages: 22
Keywords: simulator sickness, etiological factors, visual, motion, vestibular
Abstract: The U.S. Navy has conducted a survey in 10 flight trainers where motion experience questionnaires and performance tests were administered to pilots before and after some 1200 separate exposures. From these measures on pilots, several findings emerge: a) specific histories of motion sickness were predictive of simulator sickness symptomology; b) postural equilibrium was degraded after hops in some simulators; c) self-reports of motion sickness symptomology revealed three major symptom clusters: gastrointestinal, visual and vestibular; d) certain pilot experiences in simulators and aircraft were related to severity of symptoms experienced; e) simulator sickness incident varied from 10-60%; f) substantial perceptual adaptation occurs over a series of hops; g) in two moving base flight trainers motion sickness incidence appeared to be related to the amount of acceleration (energy) experienced in frequency ranges around 0.2 Hz.
The findings are discussed in the context of sensory conflict theory and recommendations are made for simulator design criteria. Suggestions are made for how to relate simulator and equipment configuration to the separate symptom clusters as an aid to diagnosis of specific problems within particular simulators. We believe this holds promise in diagnosing simulator equipment problems (e.g. alignment, inertial motion profile, cue asynchrony) since different symptom clusters may be related to different equipment features.

Reference Type: Book Section
Author: Kennedy, R.S., Bernbaum, K.S., Lilienthal, M.G.
Year: 1992
Title: Human operator discomfort in virtual reality systems: Simulator sickness--causes and cures
Editor: Kumar, S.
Book Title: Advances in industrial ergonomics and safety
City: Washington, DC
Publisher: Taylor and Francis
Volume: IV
Pages: 1227 -1234
Number of Pages: 8

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Reference Type: Journal Article
Author: Kennedy, R.S., Fowlkes, J.E.
Year: 1992
Title: Simulator sickness is polygenic and polysymptomatic: Implications for research
Journal: International Journal of Aviation Psychology
Volume: 2
Issue: 1
Pages: 23-38
Number of Pages: 16
Keywords: simulator sickness, polygenic, polysymptomatic
Abstract: The usefulness of visually based flight simulators for training may be compromised by the phenomenon of simulator sickness. Although a significant problem, design specifications for alleviation of simulator sickness have not yet been produced. The problems researchers face in this area are multiple: (a) Simulator sickness is polygenic, rendering experimental isolation of variables ineffective; (b) simulator sickness is polysymptomatic, which must be reflected in measurements of the human response; and (c) there are statistical limitations including limited sample sizes, adaptation over flights, small effect sizes, and large individual differences. These problems render certain research and engineering strategies more effective than others. Our conclusions, based on analysis of a large data base and statistical power calculations, suggest that improved simulator-design criteria can best be studied in "field experiments" in which large sample sizes permit the relatively small effects of several different simulator-equipment features to be isolated, contrasted, and revealed.

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Reference Type: Conference Proceedings
Author: Kennedy, R.S., Jones, M.B., Lilienthal, M.G., Harm, D.L.
Year of Conference: 1993
Title: Profile analysis of after-effects experiences during exposure to several virtual reality environments
Conference Name: 76th Aerospace Medical Panel Meeting on Virtual Interfaces Research and Applications
Conference Location: Lisbon, Portugal

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Reference Type: Conference Proceedings
Author: Kennedy, R.S., Lilienthal, M.G., Fowlkes, J.E.

Year of Conference: 1991
Title: What needs doing about simulator sickness?
Conference Name: Flight Simulation Technologies Conference
Conference Location: New Orleans, LA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 489-495
Date: August
Author's Affiliation and Title: Kennedy: Essex Corporation, Orlando, FL
Lilienthal: Naval Air Systems Command, Washington, DC
Fowlkes: Essex Corporation, Orlando, FL (Dr. Fowlkes is now located at Engineering and Economics Research, Inc., Orlando, FL)
Number of Pages: 7
Keywords: simulator sickness, virtual environment technology
Abstract: The usefulness of simulators may be compromised by a phenomenon know as simulator sickness. Until research determines how to design simulators that produce no or acceptably low incidence of sickness, there are at least two issues which require attention: (1) simulator monitoring techniques to identify when simulation systems begin to produce unacceptably high levels of sickness, and (2) identification of crewmembers who are at risk for simulator-induced posteffects. This paper describes the development and implementation of a free-standing device that utilizes human output (i.e., symptomatology) to address two questions: (1) is the simulator sick? and (2) is the crewmember sick? The first question is a systems engineering question and pertains to quality assurance testing of simulators. The incidence of simulator sickness symptomology can be tracked over time for a given simulator using a "quality control" model to detect shifts in calibration or other gradually emerging problems. The second question pertains to biomedical evaluation; crewmembers who exhibit extreme reactions during simulator training are at risk for posteffects and need to be identified so they can be warned with regard to post-training activities. A fielded prototype system has demonstrated that such a system can have: (1) sensitivity to factors which may be expected to affect systems performance, (2) economy in terms of cost and crewmember time, (3) high reliability, and (4) good user acceptance. The profile of the symptomatology holds promise for identifying and targeting the equipment features which, when fixed, will alleviate the problem. A recommendation is made that a technical data base be assembled from a series of field experiments where "naturally occurring" changes to the equipment be monitored "pre," "per," and "post" modification in very large samples (>100) of pilot exposures.

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Reference Type: Journal Article
Author: Keselman, H.J., Algina, J., Kowalchuck, R.K.
Year: 2001
Title: The analysis of repeated measures designs: A review
Journal: British Journal of Mathematical and Statistical Psychology
Volume: 54
Pages: 1-20
Author's Affiliation and Title: H. J. Keselman: University of Manitoba, Canada
James Algina: University of Florida
Rhonda K. Kowalchuck: University of Manitoba, Canada
Number of Pages: 21
Abstract: Repeated measures ANOVA can refer to many different types of analysis. Specifically, this vague term can refer to conventional tests of significance, one of three univariate solutions with adjusted degrees of freedom, two different types of multivariate statistic, or approaches that combine univariate and multivariate tests. Accordingly, it is argued that, by only reporting probability values and referring to statistical analyses as repeated measures ANOVA, authors convey neither the type of analysis that was used nor the validity of the reported probability value,

since each of these approaches has its own strengths and weaknesses. The various approaches are presented with a discussion of their strengths and weaknesses, and recommendations are made regarding the 'best' choice of analysis. Additional topics discussed include analyses for missing data and tests of linear contrasts.

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Reference Type: Conference Proceedings
Author: Key, D.L., Odneal, B.L., Sinacori, J.B.
Year of Conference: 1978
Title: Mission environment simulation for Army rotorcraft development-requirements and capabilities
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 4-1 - 4-17
Date: April 24-27
Author's Affiliation and Title: Aeromechanics Laboratory, U.S. Army Aviation R&D Command, Ames Research Center, Moffett Field, CA 94035
Number of Pages: 17
Keywords: rotorcraft, vertical motion system, turbulence, ground effect, motion requirements, visual requirements

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Reference Type: Conference Proceedings
Author: Kiefer, D.A., Calvert, J.F.
Year of Conference: 1992
Title: Developmental evaluation of a centrifuge flight simulator as an enhanced maneuverability flying qualities tool
Conference Name: Flight Simulation Technologies Conference
Conference Location: Hilton Head Island, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 191-212
Date: August 24-26
Author's Affiliation and Title: Air Vehicle and Crew Systems Technology Department, Naval Air Warfare Center, Aircraft Division, Warminster, PA
Number of Pages: 22
Keywords: centrifuge flight simulator, flying qualities tool, dynamic flight simulator, ground-based, enhanced maneuverability, light weight cockpit, g-bias function, motion fidelity
Abstract: Significant improvements in high angle of attack aerodynamics, flight control systems and the use of thrust vectoring is providing current and anticipated aircraft with enhanced maneuverability. These aircraft generate unusual rates and accelerations which will severely affect pilot spatial orientation and situational awareness during air combat maneuvering. The developing technology of centrifuge flight simulation offers the prospect of ground-based flying qualities and human factors testing in this same environment.
Centrifuge flight simulation technology, as implemented on the Dynamic Flight Simulator, has shown its value with F-14 flat spin and mishap investigations, preliminary enhanced fighter maneuverability studies, and physiological investigations in a realistic flight environment. Recent and current efforts are to expand this role for potential use as an enhanced maneuverability simulation tool. Specifically targeted for evaluation is the ability to perform piloted analyses of critical displays during high angle of attack enhanced maneuvering tasks.

Improvements have been made to the Dynamic Flight Simulator motion base control and actuator quality, cockpit displays, data collection capability, and compatible tactical aircraft models. The evaluation involved analyzing improvements to motion fidelity and demonstrating the potential for addressing a broader class of aircraft research, development, test and evaluation issues. Limitations are separated into those inherent to the technology and those dependent on the Dynamic Flight Simulator implementation. Tradeoffs between control method and mission applications are shown.

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Reference Type: Journal Article
Author: Killgore, J.I.
Year: 1989
Title: The planes that never leave the ground
Journal: American Heritage of Invention and Technology
Volume: 4
Issue: 3
Pages: 56-63
Number of Pages: 8

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Reference Type: Report
Author: Kingston, P., Peters, T., Lehman, C., Boothe, E.M., Gibb, G.D., Hampton, S., Wise, J.A., Wolf, J.
Year: 1992
Title: The real training value of FTDs in an airline training program
Author's Affiliation and Title: Kingston: IVEX
Peters: Captain, Delta Airlines
Lehman: Atlantis Aerospace Corporation
Boothe: Consultant, Flight Simulation and Training
Gibb, Hampton, Wise, Wolf: Embry-Riddle Aeronautical University
Number of Pages: 8
Keywords: flight training devices, FTD, air carriers
Abstract: The use of Flight Training Devices (FTD) in air carrier and other approved training programs has not become widespread. Most air carrier operators still prefer simulator programs using Level C or D simulators. An analysis has indicated that the most cost effective program would utilize an FTD for a significant portion of a conventional airline training program. A demonstration project to validate the conclusion of the analysis was conducted at the Delta Air Lines Training Center. Groups of pilots from Delta Air Lines and from Embry-Riddle Aeronautical University were trained using both the conventional all simulator curriculum and a curriculum in which a Level 6 FTD with a visual system was substituted for a significant portion of the training. Performance measures were obtained using simulator generated data, evaluations conducted by Aircrew Program Designees (APDs) and independent check pilots from Embry-Riddle. The results from standard type-rating check rides indicate that comparatively few significant differences still exist between the two training curricula. The results indicate that FTDs properly integrated with a simulator in an approved training program can produce pilot performance similar to those obtained from an all-simulator program. Further efforts should be expended to investigate assignment of training tasks to the appropriate level device. Since the initial and operating costs of a full flight simulator are significantly higher than that of an FTD, these efforts would be warranted.

Reference Type: Journal Article
Author: Klauer, K.M.
Year: 1997
Title: Examining the concept of total fidelity flight simulation
Journal: CSERIAC Gateway
Volume: 8
Issue: 2
Pages: 13 -15
Number of Pages: 3

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Reference Type: Journal Article
Author: Klein, R.M., Posner, M.I.
Year: 1974
Title: Attention to visual and kinesthetic components of skills
Journal: Brain Research
Volume: 71
Pages: 401-411
Author's Affiliation and Title: University of Oregon, Psychology Department
Number of Pages: 12
Abstract: The performance of skilled movements gives rise to several sources of feedback. It is important to determine whether and at what level these cues are used. This article considers their use at the highest level of conscious control. Several experimental techniques are outlined to investigate the role of attention on the processing of visual and kinesthetic cues during the acquisition, initiation, and control of movements.
The mere presence of a visual pattern disrupts the acquisition, initiation and control of a kinesthetic pattern, while the presence of a kinesthetic pattern does not affect the acquisition of a visual pattern unless the subject is forced to attend the kinesthetic information. In the acquisition of simple movements, kinesthetic cues seem to be ignored when visual cues are present, even though this delays initiation. These results support the view that vision dominates kinesthesis at the level of central attention.
Attentional mechanisms are involved in the initiation and control of discreet movements. Within the context of a continuous tracking task anticipated corrections appear to demand more attention than those which are not anticipated.

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Reference Type: Journal Article
Author: Kleiss, J.
Year: 1995
Title: Visual scene properties relevant for simulating low-altitude flight: A Multidimensional scaling approach
Journal: Human Factors
Volume: 37
Issue: 4
Pages: 711-734
Author's Affiliation and Title: University of Dayton Research Institute, Dayton, OH
Number of Pages: 24
Abstract: In the present experiments I sought to identify the properties of visual scenes relevant for simulating low-altitude flight. The approach was first to identify the relevant properties of real-world scenes. The stimuli were videotape segments or still photographs of real-world scenes exhibiting a variety of scene properties. Ratings of similarity between stimulus pairs were

submitted to multidimensional scaling analyses. Results using videotape segments provided consistent evidence for two relevant scene properties: variation in terrain shape and variation in object size or spacing. Results using still photographs were less interpretable, supporting the argument that motion information is important. Results suggest that designers of flight simulator visual scenes should focus specifically on rendering elements of terrain shape and objects in scenes.

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Reference Type: Journal Article
Author: Kleiss, J.A., Hubbard, D.C.
Year: 1993
Title: Effects of three types of flight simulator visual scene detail on detection of altitude change
Journal: Human Factors
Volume: 35
Issue: 4
Pages: 653-671
Date: December
Author's Affiliation and Title: Kleiss & Hubbard: University of Dayton Research Institute
Number of Pages: 19
Abstract: The effects of three types of flight simulator visual scene detail on detection of altitude change were evaluated in three experiments. Across all experiments and with a variety of tasks and display conditions, speed and accuracy of detecting altitude change improved with increases in the density of vertical objects in scenes. Adding detail to individual objects to increase their natural appearance produced no consistent effects on performance. In experiment 3 complex texture distributed globally on terrain surfaces improved detection of altitude change but did not alleviate the need for high object density. These results indicate that available computer image generator processing capacity would be used more effectively by increasing the density of objects in scenes, rather than by increased in the complexity and detail of individual objects. Complex texture is used more effectively when distributed globally on terrain surfaces, rather than when allocated to individual objects.

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Reference Type: Book
Author: Kline, R.B.
Year: 2004
Title: Beyond significance testing: Reforming data analysis methods in behavioral research
City: Washington, DC
Publisher: American Psychological Association (APA)
Number of Pages: 325
Author's Affiliation and Title: Associate Professor of Psychology, Concordia University, Montreal, Canada

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Reference Type: Report
Author: Klyde, D.H., Mitchell, D.G.
Year: 1997
Title: Handling qualities demonstration maneuvers for fixed wing aircraft Vol. I: Maneuver development process
City: Hawthorne, CA

Institution: Systems Technology, Inc.
Pages: 1-193
Date: September
Type: Technical Report
Report Number: 1310-1
Author's Affiliation and Title: David H. Klyde: Systems Technology, Inc.
David G. Mitchell: Hoh Aeronautics, Inc.
Abstract: I. INTRODUCTION
This report documents the results of a Phase II Small Business Innovation Research (SBIR) contract to develop and evaluate a set of demonstration maneuvers for the evaluation of fixed wing aircraft handling qualities. Systems Technology, Inc. (STI) and principle subcontractor Hoh Aeronautics, Inc. (HAI) conducted the work for the Air Force Dynamics Directorate at Wright Laboratory. The significant aircraft handling qualities research of the past 25 to 30 years was reviewed and relevant flight test maneuvers were compiled and categorized. By applying a mission-oriented approach, the maneuvers were categorized by required levels of precision and aggressiveness. A preliminary demonstration maneuver set was assembled with existing, refined, and newly defined maneuvers. Flight test evaluations with experienced test pilots were then used to verify that a maneuver could be flown as intended, to revise maneuver descriptions and handling qualities performance requirements, and to assess operational relevance. Some maneuver evaluations were also conducted with ground-based simulators when relevant flight test opportunities did not exist. The results of these evaluations were used to assemble a final maneuver catalog. Maneuvers that were found to emphasize aircraft performance rather than handling qualities were removed from the final set. The resulting catalog is referred to as "final" only in relation to this research effort. Following in the footsteps of previous aircraft handling qualities research, the maneuver catalog is considered a living document and therefore further revisions and additions are expected as new research is conducted.
The overall program objective was to develop a catalog of demonstration maneuvers that may be used to evaluate:
-All aircraft types (military and civil) and mission tasks;
-Modern flight control systems;
-The effect of advanced displays and vision aids on handling qualities; and
-Multiple-axis handling qualities.
The maneuvers will provide a check of handling qualities beyond the quantitative criteria of the military flying qualities standard, MIL-STD-1797 (Ref. 1). A primary benefit of a formalized set of repeatable, measurable, and well-constrained demonstration maneuvers is that they may be used from the initial design stages to post-developmental testing of an aircraft. Because the demonstration maneuvers are mission-oriented, they provide an essential link between operational requirements and the design process. Background material is provided in Part II.
The first step of this program was to define a catalog of proposed demonstration maneuvers. During the SBIR Phase I effort (Appendix C of Ref. 2), potential maneuvers were identified from an extensive literature search of relevant handling qualities flight test and simulator evaluations. This effort along with the development of numerous new maneuvers was continued as the initial Phase II task. This process is documented in Part III.
The next step of this program was to evaluate as many of the maneuvers as possible in a flight test environment. Funding was provided by the USAF to evaluate the Standard Evaluation Maneuver Set (STEMS) on the NASA F/A-18 High Alpha Research Vehicle (HARV) as part of this program. McDonnell Douglass Aerospace had previously developed the STEMS (Ref. 3) for the USAF Flight Dynamics Directorate through piloted simulation. Details of the two-phase HARV flight test program are published in Ref. 4 and summarized herein. Unfortunately, further direct funding for flight test of other demonstration maneuvers was not available. Thus, efforts were made to evaluate additional maneuvers as part of existing USAF, NASA, and United States Navy (USN) flight test programs. In the end, 18 maneuvers of the 36 present in the final version of the maneuver catalog were evaluated in flight. Additional maneuver evaluations were conducted via piloted simulation. The results of these evaluations are presented in Part IV, while details of the individual flight test and simulator programs are provided in the appendices to this report.

The last step was to assemble the revised maneuvers into a final version of the maneuver catalog (Part V of this report). The authors, of course, anticipate and encourage refinements and additions to the catalog as new research is conducted. To facilitate the use of the catalog, Part V has been published as a separate report volume.
This volume of the report concludes in Part VI with a program summary and recommendations for further research.

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Reference Type: Report
Author: Klyde, D.H., Mitchell, D.G.
Year: 1997
Title: Handling qualities demonstration maneuvers for fixed wing aircraft Vol. II: Maneuver catalog
City: Hawthorne, CA
Institution: Systems Technology, Inc.
Pages: 1-95
Date: September
Type: Technical Report
Report Number: 1310-1
Author's Affiliation and Title: David H. Klyde: Systems Technology, Inc.
David G. Mitchell: Hoh Aeronautics, Inc.
Abstract: **A. Introduction**
This report documents the results of a Phase II Small Business Innovation Research (SBIR) contract to develop and evaluate a set of demonstration maneuvers for the evaluation of fixed wing aircraft handling qualities. Systems Technology, Inc. (STI) and principle subcontractor Hoh Aeronautics, Inc. (HAI) conducted the work for the Air Force Dynamics Directorate at Wright Laboratory. The significant aircraft handling qualities research of the past 25 to 30 years was reviewed and relevant flight test maneuvers were compiled and categorized. By applying a mission-oriented approach, the maneuvers were categorized by required levels of precision and aggressiveness. A preliminary demonstration maneuver set was assembled with existing, refined, and newly defined maneuvers. Flight test evaluations with experienced test pilots were then used to verify that a maneuver could be flown as intended, to revise maneuver descriptions and handling qualities performance requirements, and to assess operational relevance. Some maneuver evaluations were also conducted with ground-based simulators when relevant flight test opportunities did not exist. The results of these evaluations were used to assemble a final maneuver catalog. Maneuvers that were found to emphasize aircraft performance rather than handling qualities were removed from the final set. The resulting catalog is referred to as "final" only in relation to this research effort. Following in the footsteps of previous aircraft handling qualities research, the maneuver catalog is considered a living document and therefore further revisions and additions are expected as new research is conducted.
The overall program objective was to develop a catalog of demonstration maneuvers that may be used to evaluate:
-All aircraft types (military and civil) and mission tasks;
-Modern flight control systems;
-The effect of advanced displays and vision aids on handling qualities; and
-Multiple-axis handling qualities.
In addition the maneuvers will provide a check of handling qualities beyond the quantitative criteria of the military flying qualities standard, MIL-STD-1797A (Ref. 1). A primary benefit of a formalized set of repeatable, measurable, and well-constrained demonstration maneuvers is that they may be used from the initial design stages to post-developmental testing of an aircraft. Because the demonstration maneuvers are mission-oriented, they provide an essential link between operational requirements and the design process. Volume I of this report provides relevant background material, a discussion of the issues influencing the development of

candidate maneuvers, results of specific flight test and piloted simulation evaluations, and a program summary and recommendations.
This report volume presents a set of handling qualities demonstration maneuvers that were developed to be included in a future revision to MIL-STD-1797A. These are *handling qualities* evaluation maneuvers, and are not intended to dictate aircraft performance. Rather they should be adjusted to include the full performance range of the aircraft. They are also not specifically aimed toward assessment of susceptibility to pilot-induced oscillations (PIO); other work is currently ongoing for this purpose. This is why the familiar Handling Qualities During Tracking (HQDT) task, for example, that requires the pilot to track a target as tightly as possible, is not included. Other air-to-air tracking tasks with defined performance requirements, however, are included in this set of maneuvers.
The desired and adequate performance requirements of the demonstration maneuvers catalog presented herein were developed specifically for use with the familiar Cooper-Harper Handling Qualities Rating Scale (Ref. 2). In addition, the maneuvers were assembled with the expectation that PIO ratings would also be taken, or at the least PIO susceptibility would be included in the pilot evaluation process. For this reason explicit desired and adequate performance requirements regarding PIO and "bobble" were not included in the maneuver descriptions. The susceptibility of an aircraft configuration to undesired or divergent oscillations should, therefore, be considered implicit requirements and always be accounted for in the pilot's ratings and comments.

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Reference Type: Conference Proceedings
Author: Knotts, L.H., Bailey, R.E.
Year of Conference: 1988
Title: Ground simulator requirements based on in-flight simulation
Conference Name: Flight Simulation Technologies Conference
Conference Location: Atlanta, GA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 191-197
Date: September 7-9
Author's Affiliation and Title: Knotts: Principal Engineer, Member AIAA, Calspan Advanced Technology Center, Buffalo, NY
Bailey: Senior Engineer, Calspan Advanced Technology Center, Buffalo, NY
Number of Pages: 7
Keywords: ground simulator requirements, in-flight simulation, NT-33A, piloting tasking, pilot-induced oscillations, time delays
Abstract: Several recent NT-33A in-flight simulation projects have addressed issues relevant to ground simulator fidelity. During two of these studies a comparison was made of handling qualities for several aircraft configurations when flown in the NT-33A compared to the same configurations flown in a ground simulator. Piloting tasks consisted of visual landings and head-up display tracking tasks. During one of these studies systematic variation of added time delay was made for several generic types of aircraft in the flight as well as the ground simulator environment. Observations were made concerning the effects of piloting task, simulator motion, and time delay on aircraft handling qualities. A third study consisted of an in-flight investigation into the effects of feel system dynamics and time delay on lateral handling qualities. It was found that low frequency artificial feel systems can significantly degrade handling qualities. The findings of this study can be applied to control loader requirements for ground simulators. A common theme of the generic simulation studies performed in the NT-33A is that calibration and documentation is an essential step in the set-up of a simulation. This is true not only for simulation of aircraft dynamics, but also for other characteristics which may affect handling qualities such as time delay and control stick characteristics.

Reference Type: Magazine Article
Author: Kocks, K.
Year: 1998
Title: Training overview: Filling the 'Qualifications Gap'
Magazine: Aviation Today
Volume: December
Date: December
Number of Pages: 12
Abstract: Rotor & Wing's recent polling of the helicopter training industry reveals progress in training new commercial pilots, but some disturbing trends suggest that the industry faces serious challenges.

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Reference Type: Report
Author: Kolasinski, E.M.
Year: 1998
Title: Prediction of simulator sickness in a virtual environment
Number of Pages: 5
URL: http://www.hitl.washington.edu/research/knowledge_base/virtual-worlds/kolasinski/

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Reference Type: Report
Author: Kolasinski, E.M., Goldberg, S.L., Hiller, J.H.
Year: 1995
Title: Simulator sickness in virtual environments
City: Alexandria, VA
Institution: United States Army Research Institute for the Behavioral and Social Sciences
Date: May
Type: Technical Report
Report Number: Technical Report 1027
Author's Affiliation and Title: Kolasinski: U.S. Army Research Institute
Goldberg: Chief, Simulator Systems Research Unit
Hiller: Director, Training Systems Research Division
Recipient's Affiliation and Title: U.S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, VA 22333-5600
Number of Pages: 48
Abstract: Requirement
The Army has made a substantial commitment to Distributed Interactive Simulation (DIS) and the electronic battlefield for training, concept development, and test and evaluation. The current DIS training system--Simulation Networking (SIMNET)--and the next generation system--the Close Combat Tactical Trainer (CCTT)--provide effective training for soldiers fighting from vehicles, but are unable to do the same for individual dismounted soldiers. Virtual Environment (VE) technology has the potential to provide Individual Combat Simulations (ICS) for the electronic battlefield. However, initial research in the use of VE technology indicates that some participants experience simulator sickness--a pattern of symptoms including nausea, headaches, and disorientation. This has implications for both training effectiveness and safety. This report is the first step in the identification of ways to reduce the occurrence and severity of these symptoms.
Procedure
Since the research literature of simulator sickness in VEs is very limited, the literature on sickness in other types of simulators and, to a lesser extent, the literature on the related phenomenon of motion sickness were reviewed. The factors believed to affect the duration and severity of

simulator sickness were organized into three groups: simulator factors, task factors, and individual factors.

Findings

Although there is debate as to the exact cause or causes of simulator sickness, a primary suspected cause is inconsistent information about body orientation and motion received by the different senses, known as the cue conflict theory. For example, the visual system may perceive that the body is moving rapidly, while the vestibular system perceives that the body is stationary. Inconsistent, non-natural information within a single sense has also been prominent among suggested causes.

Although a large contingent of researchers believe the cue conflict theory explains simulator sickness, an alternative theory was reviewed as well. Forty factors shown or believed to influence the occurrence or severity of simulator sickness were identified. Future research is proposed.

Utilization of Findings

This literature search provides a framework that can be used to conduct future research to reduce the occurrence of simulator sickness in virtual environments. In addition, it has directly influenced the approach being used in technical advisory service provided to Headquarters, U.S. Army Training and Doctrine Command, to reduce simulator sickness in combat vehicle trainers.

Notes: As of 3/21/06 website was no longer available. URL provided has summary contact information.

URL: http://www.cyberedge.com/info_r_a+p05_ss-es.html

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Reference Type: Conference Proceedings
Author: Komoda, M., Kawahata, N., Tsukano, Y., Ono, T.
Year of Conference: 1988
Title: VSRA In-flight simulator--Its evaluation and applications
Conference Name: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 171-181
Author's Affiliation and Title: Komoda: Tokyo Metropolitan Institute of Technology, Tokyo, Japan
Kawahata: Nihon University, Chiba, Japan
Tsukano and Ono: National Aerospace Laboratory, Tokyo, Japan
Number of Pages: 11
Abstract: The paper describes an in-flight simulator named VSRA (Variable Stability and Response Airplane), in some detail. The VSRA system is designed based upon an explicit model following theory. Only linearized dynamics are assumed. Discussed are technical difficulties which are pertinent to the VSRA systems and have been overcome to achieve good model following capabilities. Two examples of VSRA's application to studying problems concerning to man-machine dynamic systems are included to show that the VSRA is a mandatory device to some classes of flight mechanical problem. The one is related to evaluating a newly proposed mode-decoupling (named Relaxed Static and Speed Stability - RSS^2) system, and the other is to investigate pilot's capability for detecting failures in control systems assuming an aircraft accident.

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Reference Type: Report
Author: Koonce, J.M.
Year: 1974
Title: Effects of ground-based aircraft simulator motion conditions upon prediction of pilot proficiency. Part II
City: Savoy, Illinois

Institution: University of Illinois
Date: April
Report Number: AFOSR-TR-74-1292
Author's Affiliation and Title: University of Illinois, Savoy, IL
Number of Pages: 213
Keywords: performance prediction, pilot training, flight simulator motion
Abstract: Three groups of thirty pilots with multi-engine and instrument ratings performed a simulated flight mission in a General Aviation Trainer - 2 (GAT-2) on each of two days. The experimental conditions for the groups differed in terms of GAT-2 motion (Group I--no motion; Group II--sustained linear, scaled-down analog motion; Group III--washout motion). Each group of pilots then flew the same mission in a light twin-engine aircraft representative of the class of aircraft simulated by the GAT-2. The experimental design was a two factor mixed design (groups by days) with repeated measures on one factor (groups).
The mission consisted of five maneuvers representative of those usually performed under instrument flight rules (IFR) without visual reference to the outside world and five maneuvers usually performed with outside visual contact under visual flight rules (VFR). In the simulator, all of the maneuvers were performed without outside visual reference.
Two trained observers, one of whom was also the safety pilot for the mission, recorded pilot performance on each mission in a specially designed booklet. The order of assignment of observers to the mission permitted recording of a pilot's performance on two successive missions by the same observer and two independent observers.
The results indicated that the proficiency of aircraft pilots can be predicted to a high degree from ground-based simulator performance measures. Of the three simulator motion conditions used greater prediction of operator performance from a simulator to flight can be obtained using sustained cockpit motion than by using washout motion or no motion. There was no significant difference between the predictive validities of performance with no motion and washout motion. The experiment demonstrated that very high observer-observer reliabilities (r = .771 to .971) on the same mission can be obtained by recording performance on scales that are well defined and easy to follow, descriptive of the maneuver and behavior being recorded, and not too demanding upon the person doing the recording of performance. The performance measures taken in the simulator tended to be more reliable than those taken in the aircraft because of the elimination of degrading environmental factors and the reduction of safety oriented duties frequently imposed upon safety observers.
Simulator motion tends to increase subject acceptability of the device, lower performance error scores, and reduce the workload on the subjects and observers through the aiding effects of the motion onset cues. But the differential effects of motion on two performance trials in the simulator do not transfer to performance in flight. In the prediction of operator performance in flight the magnitude of the error scores resulting with the use of one motion system as opposed to another is not as important as the stability of the subjects' performances from one day to the next. Increasing the fidelity of the simulator motion system may bring much of the variability of flight into the simulated environment which was used to escape the variability of the operational environment.
The recorded pilot performance measures correlated very highly with the observers' overall subjective ratings of the missions (r = .726 to .878). The observers' overall ratings correlated slightly higher with performance on instrument flight maneuvers than with performance on visual flight maneuvers. Other possible indices of pilot proficiency, such as the amount of multi-engine land, instrument or total flight time logged in the past six months, did not correlate very well with mission performance scores, in fact they correlated about as well as age.

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Reference Type: Journal Article
Author: Koonce, J.M., Bramble, W.J., Jr.
Year: 1998

Title: Personal computer-based flight training devices
Journal: The International Journal of Aviation Psychology
Volume: 8
Issue: 3
Pages: 277-292
Author's Affiliation and Title: Koonce: University of Central Florida, Center for Applied Human Factors in Aviation, Orlando
Bramble: Flight Safety International, Daytona Beach, Florida
Number of Pages: 16
Keywords: personal computer aviation training devices (PCATDs), aviation pilot training, flight simulator development, simulator training, fidelity
Abstract: This article reviews the role of personal computer aviation training devices in general aviation pilot training. A brief history of flight simulator development is provided, accompanied by a sampling of early research on the effectiveness of simulator training. PCATDs are described along with their more common interface devices. Next, an examination of the use of PC-based flight simulators in formal and informal flight training programs reveals some of the recent data validating their use. Special emphasis is paid to the use of PC-based flight simulators for the instruction of novices in how to fly and the training of pilots in the performance of instrument flight maneuvers. Then, the role fidelity plays in producing transfer from PC-based training devices is addressed. Finally, a case is made for researchers to provide the kind of data that regulatory agencies should use in determining the standards for certification of PCTADs in flight training programs. Finally, suggestions are made for improvement of future PC-based flight training devices.

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Reference Type: Conference Proceedings
Author: Korn, J., Kleinman, D.L.
Year of Conference: 1982
Title: Modeling lateral acceleration effects on pilot performance
Conference Name: Ames Research Center 16th Annual Conference on Manual Control
Conference Location: Storrs, CT
Publisher: University of Connecticut, Department of Electrical Engineering and Computer Science
Author's Affiliation and Title: University of Connecticut, Department of Electrical Engineering and Computer Science, Storrs, CT 06268
Number of Pages: 9
Abstract: Attendant to the direct side force maneuver of a Vectored Force Fighter us the transverse acceleration imposed in the pilot. This lateral acceleration(Gy), when combined with a positive Gz stress, is a potential source of pilot tracking performance impairment. A research effort to investigate these performance decrements includes experimental as well as analytical pilot performance modeling using the Optimal Control Model.

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Reference Type: Report
Author: Korteling, J.E., Sluimer, R.R.
Year: 1999
Title: A critical review of validation methods for the man-in-the-loop simulators
Institution: TNO Human Factors Research Institute
Pages: 1-31
Date: March 16
Type: TNO-report

Report Number: TNO-report TM-99-A023
Author's Affiliation and Title: TNO Human Factors Research Institute, Kampweg 5, 3769 DE Soesterberg
Number of Pages: 32
Abstract: This review examines the methodological concepts, paradigms and pitfalls related to validation- and fidelity studies of man-in-the-loop simulators. A distinction is made between validation methods for training simulators and for research simulators. Validation methods for training simulator are applied in experiments which assess effects of simulator variables (e.g. resolution of display, cue augmentation, moving base characteristics) on the effectiveness of a simulator as a training device. Validation methods for research simulators are applied in experiments which assess the effects of simulator variables on the effectiveness of a simulator as a research tool. The review is particularly focused on the various artefact that may affect the outcome of such validation experiments. The artefact are separately described for each single validation method. It will be demonstrate that validation of simulators is a very complicated matter and prone to various methodological flaws and confounding factors. After the discussion of the common methods including their advantages and disadvantages the following recommendations for future research are given:
1. Terminology in the field of simulator research is ambiguous. It is advised to standardize terms, which will lead to more comprehensible communication among researchers.
2. Validity is not a single, independent attribute. The term validity in simulator research only makes senses if related to functional aspects of simulators, such as the purpose of the simulator (training, research) and the tasks and training methods involved. This will reduce the amount of overgeneralizations that are now encountered too frequently.
3. Always take face validity into consideration. If people do not believe in the simulator they are not very likely to use it properly.
4. Apply more than one method in simulator validity study. Combination of e.g. objective with subjective methods reduces the risk of erroneous conclusions and combines the benefits of both kinds of methods.
5. Aim more research at creating task-specific formulas, which relate physical simulator variables to psycho-physical and human performance variables. This will reduce the need to measure human task performance in simulator validation studies.
6. Always allocate substantial effort to find a practical method that still compares simulator performance with on-the-job performance by subjects. A relatively simple and practical method is proposed to assess the effectiveness of a driving simulator training.

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Reference Type: Journal Article
Author: Kozac, J.J., Hancock, P.A., Arthur, E.J., Chrysler, S.T.
Year: 1993
Title: Transfer of training from virtual reality
Journal: Ergonomics
Volume: 36
Pages: 777-784

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Reference Type: Conference Proceedings
Author: Kraft, C.L., Shaffer, L.W.
Year of Conference: 1978
Title: Visual criteria for out of the cockpit visual scenes
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques

Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 3-1 - 3-18
Date: April 24-27
Author's Affiliation and Title: Kraft: Ph.D., Crew Systems, Boeing Aerospace Company, Seattle, WA
Shaffer: Systems Engineering, General Electric Company, Daytona Beach, FL
Number of Pages: 18
Keywords: visual resolution, cockpit visual scenes, field of view, virtual image display

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Reference Type: Conference Proceedings
Author: Kricke, K.D., Quellmann, W.
Year of Conference: 1991
Title: Use of a virtual cockpit for the development of a future transport aircraft
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation Effectiveness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 25-21 - 25-10
Date: October 14
Author's Affiliation and Title: Kricke: Dr-Ing., Deutsche Airbus, Kreetslag 10, P O Box 95 01 09, 2103 Hamburg 95, Germany
Quellmann: Dipl.-Ing., Deutsche Airbus, Kreetslag 10, P O Box 95 01 09, 2103 Hamburg 95, Germany
Number of Pages: 10
Keywords: virtual cockpit, transport aircraft
Abstract: This paper describes a development tool called "Virtual Cockpit" which is used at Deutsche Airbus.
The following aspects are discussed:
A comparison of civil and military transport aircraft developments shows a significant gap on the military tactical transport side during the last 30 years. Therefore, it seems beneficial to consider a "dual use" of well proven "civil technologies" for military applications.
Specific military transport missions require aircraft capabilities, some of which are quite new and therefore challenging for transport aircraft (e.g. low-level flight profiles in night and poor-visibility conditions). This demonstration of the feasibility and an evaluation of technical solutions imply the need for suitable development tools.
The Virtual Cockpit is explained in terms of its components (hardware/software), features and capabilities. A major field of investigation in this contest is the aircraft systems' central control and monitoring.
Notes: Published in February 1992.

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Reference Type: Conference Proceedings
Author: Krois, P., Ahlstrom, U., Bürki-Cohen, J., Jentsch, F., Kanki, B.G., Lyall, B., Manning, C., King, R.
Year of Conference: 2006
Title: Business case for civil aviation human factors
Editor: Human Factors and Ergonomics Society (HFES)
Conference Name: Human Factors and Ergonomics Society 50th Annual Meeting
Conference Location: San Francisco, CA
Date: October 16-20

Author's Affiliation and Title: Panel Organizer: Paul Krois, Federal Aviation Administration, Washington, D.C.
Panelists: Ulf Ahlstrom, FAA Technical Center, Atlantic City Airport, NJ; Judith Bürki-Cohen, Volpe National Transportation Systems Center, Cambridge, MA; Florian Jentsch, University of Central Florida, Orland, FL; Barbara Kanki, NASA Ames Research Center, Moffett Field, CA; Beth Lyall, Research Integrations, Inc., Tempe, AZ; Carol Manning and Ray King, FAA Civil Aerospace Medical Institute, Oklahoma City, OK
Number of Pages: 5
Abstract: We examined how human factors research and engineering in addressing flight deck and air traffic control issues improves safety and provides tangible cost savings and cost avoidance for Federal Aviation Administration sponsors and industry. The agency spends a limited percentage of its annual budget on research and prioritizes these investments to ensure the best return. This research cuts across a range of human factors considerations spanning selection of applicants for air traffic controller jobs, flight simulator fidelity, generation of scenarios used in pilot training, a new evaluation tool for flight deck certification, design of flight deck operating documents, and design of an air traffic controller information display aid.

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Reference Type: Conference Proceedings
Author: Kurts, D., Gainer, C.
Year of Conference: 1991
Title: The use of a dedicated testbed to evaluate simulator training effectiveness
Conference Name: Flight Mechanics Panel Symposium on Piloted Simulation Effectiveness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 11-11 - 11-19
Date: October 14
Author's Affiliation and Title: Kurts: Manager, Tactical Systems, CAE Electronics Ltd., Montreal, Quebec, Canada
Gainer: Chief, Army Research Institute, Aviation Research and Development Activity, Fort Rucker, AL
Number of Pages: 9
Keywords: testbed, training effectiveness, SCTB, visual
Abstract: The Simulator Complexity Test Bed (SCTB) is being produced for the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) at Fort Rucker, Alabama to specifically address the question of the level of simulation fidelity required to ensure adequate transfer of training in a tactical helicopter simulator environment. This paper presents the objectives of the SCTB, the hardware and software architecture designed to facilitate these goals and presents examples of some typical research that will be conducted. The simulator is based in the Apache AH-64A attack helicopter using aircraft parts and simulated avionics to provide a realistic replica of the pilot and copilot gunner stations.
Notes: Published in February 1992.

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Reference Type: Conference Proceedings
Author: Lahiri, A.
Year of Conference: 1996
Title: Importance of spatial sound cues in simulators
Conference Name: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 683-684
Call Number: AIAA-96-3551-CP
Author's Affiliation and Title: Staff Systems Engineer, NATCO, Eagan, MN
Number of Pages: 2
Abstract: Flight simulators attempt to replicate an environment conducive to aircrew training. The designated level of the simulation is a directly dependent on the resultant fidelity towards realism. This fidelity has been the key factor that has enabled progression in transfer of training both in procedures and methods. Amongst the many different cues available sound plays a very important role in a simulator training scenario. With upcoming regulations governing the fidelity of flight simulators, the status of simulated sound has been further elevated. Sufficient emphasis has, however, not been replaced on the spatial aspects and effects of sound. Sound cues, especially in the cockpit, does not only alert to a single or a series of events but also attempt to provide various information regarding the source(s). Use of modern sound recording techniques can be easily utilized along with multiple sound gathering elements to obtain the kind and quality of sound data needed. These sounds can then be duplicated in a multi-channel environment for closer spatial simulation. Testing would involve the use of similar setups, though in a much simpler form which would also ensure repeatability. Simpler setups would reduce cost and time involved as well. It is necessary to justify such fidelity which would ultimately ensure not only enhanced simulation to further training requirements but reasonable methods of maintaining the integrity of the standards of the sound as well.

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Reference Type: Report
Author: Lahiri, A.
Year: 2005
Title: Significance of a qualitative handing assessment approach towards motion system requirements for flight simulators
Institution: National Simulator Program (NSP), Federal Aviation Administration (FAA)
Date: July 18
Author's Affiliation and Title: National Simulator Program, Federal Aviation Administration (FAA), Atlanta, GA
Number of Pages: 5
Abstract: Progress drives regulation and regulation drives progress. The aircraft is a classic example where one aspect is constantly trying to push the other to be a step ahead.
URL:
http://www.faa.gov/safety/programs_initiatives/aircraft_aviation/nsp/research/media/Arnab_Lahiri.rtf

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Reference Type: Journal Article
Author: Lambo, R.
Year: 2001
Title: Panel to review relevance of flight crew licensing and training standards
Journal: ICAO Journal
Volume: 8
Author's Affiliation and Title: ICAO Secretariat

Reference Type: Electronic Source
Author: Landsberg, B.
Year: 2001
Title: Safety pilot: Meet the PCATD
Producer: Aircraft Owners and Pilots Association (AOPA)
Access Year: 2006
Access Date: Sept. 6
Number of Pages: 4
URL: http://www.aopa.org/asf/asfarticles/sp9707.html#bio

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Reference Type: Journal Article
Author: Larish, J.F., Flach, J.M.
Year: 1990
Title: Sources of optical information useful for perception of speed of rectilinear self-motion
Journal: Journal of Experimental Psychology
Volume: 16
Issue: 2
Pages: 295-302
Author's Affiliation and Title: University of Illinois at Urbana-Champaign
Number of Pages: 8
Keywords: optical information, rectilinear self-motion, optical edge rate, global optical flow rate
Abstract: Magnitude judgments of the speed of self-motion were examined. The principal independent variables were edge rate, global optical flow rate, and the type of texture (grid or dot). Results indicated that edge rate and global optical flow rate had additive effects on magnitude judgments, with edge rate accounting for a larger portion of the variance. Effects were independent of texture type. Secondary variables examined were viewing condition and task load. Attempts were made to control the availability of flatness cues. Evidence indicates that the effectiveness of global optical flow rate varied with the control of flatness cues. A secondary running auditory Sternberg task was used to prevent edge counting; the presence of this task did not reduce the effect of edge rate. These results replicate and extend previous work by D. H. Owen and colleagues.

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Reference Type: Conference Proceedings
Author: Larsen, W.E.
Year of Conference: 1991
Title: NASA/FAA helicopter simulator workshop
Conference Location: Biltmore Hotel, Santa Clara, California
Publisher: United States Department Of Commerce, National Technical Information Service
Date: April 23-26
Author's Affiliation and Title: Federal Aviation Administration, NASA Ames Research Center, Moffett Field, CA
Number of Pages: 192
Abstract: A workshop was convened by the FAA and NASA for the purpose of providing a forum at which leading designers, manufacturers, and users of helicopter simulators would initiate and participate in a development process that would facilitate the formulation of qualification standards by the regulator agency. Formal papers were presented, special topics were discussed in breakout sessions, and a draft FAA advisory circular defining specifications for helicopter simulators was presented and discussed. A working group of volunteers was formed to work with the National Simulator Program Office to develop a final version of the circular. The workshop

attracted 90 individuals from a constituency of simulator manufacturers, training organizations, the military, civil regulators, research scientists, and five foreign counties. A great amount of information was generated and recorded verbatim. This information is presented herein within the limits of accuracy inherent in recording, transcribing and editing spoken technical material.
Notes: U.S. Department Of Commerce, National Technical Information Service, Springfield, VA 22161

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Reference Type: Edited Book
Editor: Larsen, W.E., Randle, R.J., Popish, L.N.
Year: 1995
Title: Vertical flight training: An overview of training and flight simulator technology with emphasis on rotary-wing requirements
Series Editor: NASA
Volume: 1
Number of Volumes: 1
Edition: 1
Label: NASA Reference Publication 1373
DOT/FAA/CT-94/83
Keywords: vertical flight training, rotary-wing requirements, flight simulators, simulation validation, training schools, training requirements, cockpit motion, visual space perception
Notes: Contents:

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Reference Type: Report
Author: Latham, R.
Year: 1994
Title: Achieving consistent colors and textures in visual simulation

City: Mountain View, CA
Institution: Computer Graphics Systems Development Corporation
Author's Affiliation and Title: Computer Graphics Systems Development Corporation, Mountain View, CA 94043-2330
Number of Pages: 7
Keywords: color, texture, visual simulation, color cataloging
Notes: Regarding simulators in general.

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Reference Type: Conference Proceedings
Author: Laughery, K.R.
Year of Conference: 1984
Title: Human operator modeling: A new technology for addressing human factors during design
Conference Name: IEEE 1984 National Aerospace and Electronics Conference
Conference Location: Dayton, Ohio
Pages: 857-865
Date: May 21-25
Author's Affiliation and Title: Micro Analysis and Design, Boulder, CO
Number of Pages: 9
Abstract: Tools now exist which will allow human factors engineers to estimate human performance in systems early in system design. Human Factors engineers can now develop computer models and conduct experiments on human performance long before any type of prototype is available. This paper addresses four questions; 1) when should computer models of operator performance be used, 2) what are the available technologies, 3) what are some of the recent advancements in one of these technologies, and 4) what steps are involved in building a model of human operator performance in a system.

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Reference Type: Magazine Article
Author: Lavitt, M.O.
Year: 1997
Title: Mobile Beach 1900 simulator brings training to pilots
Magazine: Aviation Week and Space Technology
Date: October 27
Number of Pages: 3
Keywords: mobile simulator, Techniflite, Skyway Airlines, Paul Ray, portable simulator

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Reference Type: Journal Article
Author: Lawther, A., Griffin, M.J.
Year: 1988
Title: Motion sickness and motion characteristics of vessels at sea
Journal: Ergonomics
Volume: 31
Issue: 10
Pages: 1373-1394
Author's Affiliation and Title: Human Factors Research unit, Institute of Sound and Vibration Research, University of Southampton, Southampton, S09 5NH England
Number of Pages: 22

Keywords: seasickness, motion illness, vomiting, ship motion
Abstract: Measurements of vessel motion and consequent seasickness amongst passengers have been made on six ships, two hovercraft and a hydrofoil. Data are presented for 20029 passengers surveyed on 114 voyages involving 370 hours of motion recordings. Vomiting incidence and illness rating were found to be linearly related to the root-mean-square magnitude of the vertical z-axis acceleration. Sickness increased with increasing duration of exposure and a measure of motion "dose" is examined as a convenient way of combining the variables of stimulus magnitude and duration. High frequency motion in hovercraft at about 0 multiplied by 6 Hz was found to be less provoking of sickness than similar magnitudes at lower frequencies. Motion in axes other than the vertical correlated less highly with sickness, although there was some intercorrelation between axes. The results presented enable predictions to be made of seasickness occurrence in marine vessels and other forms of transport where low frequency vertical oscillations are encountered.

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Reference Type: Journal Article
Author: Lawther, A., Griffin, M.J.
Year: 1988
Title: A survey of the occurrence of motion sickness amongst passengers at sea
Journal: Aviation, Space & Environmental Medicine
Volume: 59
Issue: 5
Pages: 399-406
Date: May
Author's Affiliation and Title: Human Factors Research Unit, Institute of Sound and Vibration Research, The university, Southampton, England
Abstract: A questionnaire survey of motion sickness occurrence on board passenger ferries has been conducted. Data were collected from 20,029 passengers on 114 voyages on 9 vessels: 6 ships, 2 hovercraft, and 1 jetfoil. Information was obtained about feelings of illness, the occurrence of vomiting, the taking of anti-seasickness tablets, the consumption of alcoholic drinks, regularity of travel by sea, age, and sex. Overall, 7% of passengers reported vomiting at some time during the journey, 21% said they felt "slightly unwell," 4% felt "quite ill," and a further 4% felt "absolutely dreadful." Both vomiting incidence and illness rating were greater in females than in males, and there was a slight decrease in sickness occurrence with increasing age. The incidence of vomiting was related to the taking of tablets and the drinking of alcohol; there were also some interaction effects with other variables. Anecdotal information from passengers is reported and consideration is given to the effects of environmental variables.

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Reference Type: Conference Proceedings
Author: Lawver, J., Lee, A.T.
Year of Conference: 1983
Title: Low cost training aids and devices
Editor: Lee, A.T.
Conference Name: Flight Training Technology for Regional/Commuter Airline Operation
Conference Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: September 28-30
Author's Affiliation and Title: Lawver: Scientific Airlines
Lee: NASA

Reference Type: Conference Proceedings
Author: Lee, A.T.
Year of Conference: 1983
Title: Low-cost training technology
Editor: Lee, A.T., Lauber, J.K.
Conference Name: Flight Training Technology for Regional/Commuter Airline Operation
Conference Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: September 28-30
Author's Affiliation and Title: NASA Ames Research Center, Moffett Field, CA 94035

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Reference Type: Conference Proceedings
Author: Lee, A.T., Bussolari, S.R.
Year of Conference: 1986
Title: Flight simulator requirements for airline transport training: An evaluation of motion system design alternatives.
Conference Name: IEE Second International Conference on Simulators
Conference Location: University of Warwick, United Kingdom

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Reference Type: Journal Article
Author: Lee, A.T., Bussolari, S.R.
Year: 1989
Title: Flight simulator platform motion and air transport pilot training
Journal: Aviation Space and Environmental Medicine
Volume: 60
Issue: 2
Pages: 136-140
Date: February 1
Author's Affiliation and Title: Lee: M.A., Ph.D., NASA Ames Research Center
Bussolari: M.S., Ph.D., Massachusetts Institute of Technology
Number of Pages: 5
Keywords: (jbc) keywords-flight simulator, platform motion, air transport pilot, training
Abstract: The influence of flight simulator platform motion on pilot training and performance was examined in two studies utilizing a B-727-200 aircraft simulator. The simulator, located at Ames Research Center, is certified by the FAA for upgrade and transition training in air carrier operations. Subjective ratings and objective performance of experienced B-727 pilots did not reveal any reliable effects of wide variations in platform motion design. Motion platform variations did affect the control behavior of pilots with no prior heavy aircraft flying experience. The effect was limited, however, to pitch attitude control inputs during the early phase of landing training. Implications for the definition of platform motion requirements in air transport training are discussed.

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Reference Type: Conference Proceedings
Author: Lee, A.T., Lauber, J.K.
Year of Conference: 1983
Title: Regional airline association/NASA workshop proceedings

Conference Name: Flight Training Technology for Regional/Commuter Airline Operation
Conference Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: September 28-30
Number of Pages: 263

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Reference Type: Report
Author: Lee, W.-S., Kim, J.-H., Cho, J.-H.
Year: 1997
Title: Development of a driving simulator
Institution: Society of Automotive Engineers (SAE)
Author's Affiliation and Title: Department of Automotive Engineering, Kookmin University, 861-1 Chungnung-dong, Sungbuk-gu, Seoul, 136-702, Korea
Number of Pages: 6
Keywords: driving simulator, real-time vehicle simulation, visual/audio system, motion system, control force loading system, system integration
Abstract: Driving simulators are used effectively for vehicle system development, human factor study, and other purposes by enabling to reproduce actual driving conditions in a safe and tightly controlled environment. This paper describes a driving simulator developed for design and evaluation of full-scale driving simulators and for driver-vehicle interaction study. The simulator consists of a real-time vehicle simulation system, a visual and audio system, a motion system, a control force loading system, and an experiment console. The real-time vehicle simulation system supervises overall operation of the simulator and also simulates dynamic motion of realistic vehicle models in real-time. The economical visual system generates high fidelity driving scenes that are displayed on a screen by a projector. The motion system generates realistic motion cue using a six degree-of-freedom Stewart platform driven hydraulically. The control force loading system acts as an interface between a driver and the simulator. The experiment console monitors the status of the simulator in operation and also collects and manages experimental data.

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Reference Type: Conference Proceedings
Author: Leibowitz, H.W.
Year of Conference: 1986
Title: Recent advances in our understanding of peripheral vision and some implications
Conference Name: Human Factors Society 30th Annual Meeting
Pages: 605-607
Author's Affiliation and Title: Pennsylvania State university, University Park, PA
Number of Pages: 3
Abstract: The characteristics of peripheral vision and its relation to object recognition and spatial orientation functions are reviewed in the light of recent developments. implications of these findings and their relevance to some selected human engineering problems are discussed.

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Reference Type: Journal Article
Author: Levison, W., Baron, S., Kleinman, D.
Year: 1969
Title: A model for human controller remnant
Journal: IEEE Transactions on Man-Machine Systems

Volume: MMS-10
Issue: 4
Pages: 101-108
Date: December
Author's Affiliation and Title: IEEE Members
Number of Pages: 8
Abstract: A model for human controller remnant is postulated in which remnant is considered to arise from an equivalent observation noise vector whose components are linearly independent white noise processes. Extensive analysis of data obtained from simple manual control systems verifies that this model structure holds over a wide range of input amplitudes and bandwidths, vehicle dynamics, and display locations. When the display is viewed foveally, the component noise processes are proportional to the variances of the displayed quantities. This constant of proportionality is independent of input parameters and of vehicle dynamics.

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Reference Type: Report
Author: Levison, W.H.
Year: 1981
Title: Effects of whole-body motion simulation on flight skill development
City: Washington, DC
Institution: Bolling Air Force Base, Air Force Office of Scientific Research
Date: October
Type: Final Report
Report Number: AFOSR-TR-82-006
Author's Affiliation and Title: Bolt Beranek and Newman Inc., 10 Moulton Street, Cambridge, MA 02238
Keywords: human operator technology, human operator modeling, learning, optimal control model, parameter identification, motion cueing
Abstract: Progress was made toward the development of models for piloting skill acquisition. The following tasks were accomplished: (1) design of an experiment to study visual and motion cue integration in a multi-axis control tasks; (2) enhancement of the optimal control pilot model; (3) further development of a scheme for automatic identification and significance testing of "pilot-rated" model parameters; (4) analysis of control strategy development; (5) study of the relationship between task structure and pilot response limitations; (6) test of a multiplicative motor noise model; and (7) a brief literature search on adaptive control and identification algorithms for potential application to models for control-strategy development.

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Reference Type: Report
Author: Levison, W.H., Junker, A.M.
Year: 1977
Title: A model for the pilot's use of motion cues in roll-axis tracking tasks
City: Wright-Patterson Air Force Base, OH
Institution: Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force Systems Command
Date: June
Type: Interim Scientific Report
Report Number: AMRL-TR-77-40
Author's Affiliation and Title: Bolt Beranek and Newman Inc., Cambridge, MA 02138
Number of Pages: 76
Keywords: human operator technology, human operator modeling, motion, optimal control model

Abstract: An experimental and analytical study was undertaken jointly by the Aerospace Medical Research Laboratory and Bolt Beranek and Newman Inc. to test a model for the pilot's use of motion cues in roll-axis tracking tasks. Simulated target-following and disturbance-regulations tasks were explored with subjects using visual-only and combined visual and motion cues. The effects of motion cues on task performance and pilot response behavior were appreciably different for the two task configurations and were consistent with data reported in earlier studies for similar task configurations.
The "optimal-control" model for pilot/vehicle systems provided a task-independent framework for accounting for the pilot's use of motion cues. Specifically, the availability of motion cues was modeled by augmenting the set of perceptual variables to include position, rate, acceleration, and acceleration-rate of the motion simulator; and results were consistent with the hypothesis of attention-sharing between visual and motion variables. This straightforward informational model allowed accurate model predictions of the effects of motion cues on a variety of response measures for both the target-following and disturbance-regulation tasks.

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Reference Type: Conference Proceedings
Author: Liao, J., Milgram, P.
Year of Conference: 1991
Title: On validating human performance simulation models
Conference Name: Human Factors Society 35th Annual Meeting
Pages: 1260-1264
Author's Affiliation and Title: Department of Industrial Engineering, University of Toronto
Number of Pages: 5
Abstract: This paper addresses some of the difficult and elusive problems associated with validating human performance simulation models. Simulation validity can be subclassified into input and validity, structure validity and output validity. Of these, output validity is the most objective and also the most important, because it determines whether or not the purpose of the modeling effort can be met. In testing for output validity analysis of variance alone is not sufficient for validating human performance simulation models, as is often taken for granted by many researchers. A more systematic approach is proposed and its implications discussed. The approach is based on considering analysis of variance in terms of the power of the test and a predetermined level of acceptable differences between model and reality.

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Reference Type: Journal Article
Author: Lind, R., Brenner, M.
Year: 1998
Title: Incorporating flight data into a robust aeroelastic model
Journal: Journal of Aircraft
Volume: 35
Issue: 3
Pages: 470-477
Number of Pages: 8
Keywords: Aeroelastic Model
Abstract: Stability analysis and control synthesis for high-performance aircraft must account for errors in the aircraft model. This paper introduces a method to update a theoretical model using measured flight data. Variations between the flight data and model are represented as uncertainty operators in a robust stability framework. The structured singular value can directly account for these uncertainty operators to compute stability margins robust to the associated dynamical

variations. This procedure is used to formulate an uncertain model of an F/A-18 fighter aircraft and compute stability margins that indicated the worst-case flutter conditions.

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Reference Type: Journal Article
Author: Lintern, G.
Year: 1991
Title: An informational perspective on skill transfer in human-machine systems
Journal: Human Factors
Volume: 33
Issue: 3
Pages: 251-266
Author's Affiliation and Title: University of Illinois, Savoy, IL
Number of Pages: 16
Abstract: Differentiation of perceptual invariants is proposed as a theoretical approach to explain skill transfer for control at the human-machine interface. I propose that sensitivity to perceptual invariants is enhanced during learning and that this sensitivity forms the basis for transfer of skill from one task to another. The hypothesis implies that detection and discrimination of critical features, patterns, and dimensions of difference are important for learning and for transfer. This account goes beyond other similarity conceptions of transfer. To the extent that those conceptions are specific, they cannot account for effects in which performance is better following training on tasks that are less rather than more similar to the criterion task. In essence, this is a theory about the central role of low-dimensional informational patterns for control of behavior within a high-dimensional environment, and about the adjustment of an actor's sensitivity to changes in those low-dimensional patterns.

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Reference Type: Journal Article
Author: Lintern, G., Garrison, W.
Year: 1992
Title: Transfer effects of scene content and crosswind in landing instruction
Journal: International Journal of Aviation Psychology
Volume: 2
Issue: 3
Pages: 225-244
Author's Affiliation and Title: University of Illinois at Urbana-Champaign, Aviation Research Laboratory, Institute of Aviation
Number of Pages: 20
Abstract: Transfer of landing skills was tested from a high-detail pictorial, low-detail pictorial, or symbolic scene and from a zero, moderate, or high level of crosswind to a high-detail pictorial scene and a moderate level of crosswind. There were significant differential transfer effects as assessed by measures of accuracy and stability in lateral control. Training with pictorial scenes (whether of high or low detail) was superior to training with a symbolic scene, but there was no general transfer advantage from training with high versus low scene detail. Nor was there any general advantage of training with the transfer level of crosswind. In contrast to the prediction of a high-fidelity theory of transfer, the data show that values of crosswind higher or lower than the transfer value can be advantageous in certain circumstances.

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Reference Type: Conference Proceedings
Author: Lintern, G., Garrison, W.
Year of Conference: 1996
Title: Simulation for flight training
Conference Name: Twelfth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Pages: 1-28
Date: January 22-26
Author's Affiliation and Title: University of Illinois at Urbana-Champaign, Aviation Research Laboratory
Number of Pages: 28
Abstract: The modern flight-training simulator in intended to provide safe, economical and efficient instruction of flight control skills. At issue is how a flight simulator can be designed to ensure the satisfaction of those goals. One approach is to seek high fidelity; that is to design and tune the simulator so the it mimics to the closest possible extent the perceptual sensations of real flight. The pursuit of high-fidelity can, however be a costly exercise. A more rational design approach would be to ascertain what dimensions of a simulation impact training effectiveness. Such an approach might result in the design of systems that are less costly but equally effective. Cost effectiveness of simulators may be improved by eliminating simulator features that do not contribute to training effectiveness and by implementing special instructional strategies that speed learning. The evidence in support of both approaches is reviewed in these notes.

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Reference Type: Book Section
Author: Lintern, G., McMillan, G.
Year: 1990
Title: Transfer for flight simulation
Book Title: Aviation Instruction and Training
Pages: 130-162
Author's Affiliation and Title: Charles River Analytics
Number of Pages: 33
Keywords: transfer, transfer experiment, visual displays, proprioceptive motion cueing, system dynamics, skill transfer
Abstract: The modern flight-training simulator is intended to provide a vehicle for safe, economical and efficient instruction of flight control skills. At issue is how a flight simulator can be designed to ensure the satisfaction of those goals. The normal design approach is to seek high fidelity; that is to design and tune the simulator so that it mimics to the closest possible extent the perceptual sensations of real flight. The pursuit of high-fidelity can, however, be a costly exercise. A more rational design approach would be to evaluate what dimensions of these components impact training effectiveness. Such an approach should result in the design of systems that are less costly but equally effective.

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Reference Type: Journal Article
Author: Lintern, G., Roscoe, S.N., Koonce, J.M., Segal, L.D.
Year: 1990
Title: Transfer of landing skills in beginning flight training
Journal: Human Factors
Volume: 32
Issue: 3
Pages: 319-327

Author's Affiliation and Title: Lintern, Koonce and Segal: University of Illinois at Urbana-Champaign, Savoy, IL
Roscoe: Aviation Sciences, Las Cruces, NM
Number of Pages: 9
Abstract: Beginning flight students from the University of Illinois flight training program were given two sessions of landing practice in a simulator with a computer-animated contact landing display before they commenced intensive landing practice in the aircraft. For each experimental student there was a control student, paired with the same instructor, who received no landing practice in the simulator. Experimental students required significantly fewer presolo landings in the airplane than did the paired controls, representing a potential savings of about 1.5 presolo flight hours per student. These data show that pretraining with a moderately detailed, yet relatively inexpensive, computer-animated landing display can offer worthwhile savings in flight time. Some students were provided adaptive visual augmentation during their simulator training, and there was evidence of incremental transfer attributable to this instructional feature.

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Reference Type: Journal Article
Author: Lintern, G., Roscoe, S.N., Sivier, J.E.
Year: 1990
Title: Display principles, control dynamics, and environmental factors in pilot training and transfer
Journal: Human Factors
Volume: 32
Issue: 3
Pages: 299-317
Author's Affiliation and Title: Lintern, Sivier: University of Illinois at Urbana-Champaign, Savoy, IL
Roscoe: Aviation Sciences, Las Cruces, NM
Number of Pages: 19
Abstract: Sixty-four flight-naive men were tested in a fractional factorial, quasi-transfer experiment to examine the effects of four display factors, one control response factor, and one environmental factor on acquisition and transfer of aircraft landing skills. An additional 12 trainees served as experimental controls. Transfer was measured from each of 64 experimental training conditions to a criterion condition with a conventional inside-out pictorial contact display, normal simulator control dynamics, and a 5-knot crosswind. Transfer was better following training with pictorial displays than with symbolic displays, and with normal rather than reduced bank control order. Interactions of crosswind with predictive augmentation and with bank control order showed that for some conditions, transfer benefited from training with predictive augmentation and from training without crosswind.

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Reference Type: Journal Article
Author: Lintern, G., Taylor, H.L., Koonce, J.M., Kaiser, R.H., Morrison, G.A.
Year: 1997
Title: Transfer and quasi-transfer effects of scene detail and visual augmentation in landing training
Journal: The International Journal of Aviation Psychology
Volume: 7
Issue: 2
Pages: 149-169
Author's Affiliation and Title: Lintern, Taylor, Kaiser, and Morrison: University of Illinois, Institute of Aviation, Savoy, IL

Koonce: University of Central Florida, Orlando, Center for Applied Human Factors in Aviation, FL
Number of Pages: 21
Keywords: transfer, quasi-transfer, scene detail, visual augmentation, landing training
Abstract: Beginning flight students were taught landings in a flight simulator with a visual landing display to examine the effects of scene detail, visual augmented guidance, and number of landing training trials. Some students were trained in a control condition with no visual display. Transfer was assessed in the airplane in relation to the amount of landing training required prior to release for solo. Training with a low-detail scene was better for transfer than was training with a moderate-detail scene. An interaction between scene detail and augmented guidance showed that augmented guidance enhanced transfer when used in training with a low-detail scene but degraded transfer when used in training with a moderate-detail scene. The data also show that both visual and nonvisual training in the simulator build skills that enhance transfer.

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Reference Type: Conference Proceedings
Author: Longridge, T., Bürki-Cohen, J., Go, T.H., Kendra, A.J.
Year of Conference: 2001
Title: Simulator fidelity considerations for training and evaluation of today's airline pilots
Conference Name: The 11th International Symposium on Aviation Psychology
Conference Location: Columbus, OH
Pages: 8
Date: March 5-8
Number of Pages: 8
Abstract: Regulatory changes in response to today's airline pilot training and evaluation needs push the twin issues of effectiveness and affordability of flight simulators for use by U.S. airlines to the forefront. The Federal Aviation Administration (FAA) is sponsoring two research programs with high pay-off potential in this area, namely, platform motion and realistic radio communications. This paper describes the rationale and the initial results of this work.

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Reference Type: Conference Proceedings
Author: Longridge, T., Ray, P., Boothe, E., Bürki-Cohen, J.
Year of Conference: 1996
Title: Initiative towards more affordable flight simulators for U.S. commuter airline training
Conference Name: Training: Lowering the Cost, Maintaining the Fidelity
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Pages: 2.1-2.17
Date: May 15-16
Author's Affiliation and Title: Longridge: Manager, Advanced Qualification Program, Federal Aviation Administration (FAA), Washington, DC
Ray: Manager, National Simulator Program, Federal Aviation Administration (FAA), Washington, DC
Boothe: Consultant, Flight Simulation and Training, Atlanta, GA
Bürki-Cohen: Engineering Psychologist, Volpe National Transportation Systems Center, Department of Transportation, Cambridge, MA
Number of Pages: 17
Abstract: Recent regulatory action, coupled to a policy of encouraging commuter airlines to conduct all pilot training and checking activities in ground based equipment, has created an impetus to consider how best to ameliorate the conditions which have discouraged the use of such equipment for pilot recurrent training by commuter airlines in the United States. This paper

compares the relative merits of permitting additional recurrent training credit for enhanced flight training devices versus revising the qualification standards for Level B full flight simulators to achieve enhanced affordability. The current status of an ongoing Level B flight simulator qualification standards review, results to date, and future plans, including plans for the development of a comprehensive applied research program, are discussed.

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Reference Type: Conference Proceedings
Author: Longridge, T., Thomas, M., Fernie, A., Williams, T., Wetzel, P.
Year of Conference: 1989
Title: Design of an eye slaved area of interest system for the simulator complexity testbed
Conference Name: Interservice/Industry Training, Simulation & Education Conference
Pages: 275-283
Author's Affiliation and Title: Longridge: U.S. Army Research Institute, Aviation R&D Activity, Fort Rucker, AL
Thomas: U.S. Air Force Human Resources Lab, Operations Division, Williams AFB, AZ
Fernie, Williams: CAE Electronics, Ltd, Montreal, Canada
Wetzel: University of Dayton Research Institute, Higley, AZ
Number of Pages: 9
Abstract: The Simulator Complexity Testbed (SCTB) is a highly modular flight simulator for experimental research focused on US Army Aviation advanced rotary wing combat. A major component in the development of the helmet mounted fiber optic display media for this device is an eye slaved area-of-interest (AOI). In order to provide for an accurate, reliable, and robust helmet mounted eye tracker to support proper system operation, the engineering development of competing eye tracking designs was initiated under a cooperative US Army/US Air Force/Canadian cost shared development program. This paper describes the overall design of the SCTB eye slaved, servo driven optical system and discusses the issues involved in its development.

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Reference Type: Conference Proceedings
Author: Longridge, T.M.
Year of Conference: 1987
Title: Flight simulator training effectiveness research in U. S. Army aviation
Conference Name: The Acquisition and Use of Flight Simulation Technology in Aviation Training: International Three Day Conference
Conference Location: London?
Volume: 2
Pages: 356-390
Date: April 27-29
Author's Affiliation and Title: Army Research Institute, Aviation Research & Development Activity (ARIARDA), Fort Rucker, AL
Number of Pages: 35
Keywords: flight simulator training effectiveness, cost effectiveness

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Reference Type: Journal Article
Author: Lu, Z.-L., Sperling, G.
Year: 1996

Title: Contrast gain control in first- and second-order motion platform
Journal: Journal of the Operational Society of America
Volume: 13
Issue: 12
Pages: 2305-2318
Date: December
Author's Affiliation and Title: Zhong-Lin Lu: Department of Psychology, University of Southern California, Los Angeles, CA 90089
George Sperling: Human Informational Processing Laboratory, Department of Cognitive Sciences and Institute for Mathematical Behavioral Sciences, University of California, Irvine, CA 92697
Number of Pages: 14
Abstract: A novel pedestal-plus-test paradigm is used to determine the nonlinear gain-control properties for the first-order (luminance) and the second-order (texture-contrast) motion systems, that is, how these systems' responses to motion stimuli are reduced by pedestals and other masking stimuli. Motion-direction thresholds were measured for test stimuli consisting of drifting luminance and texture-contrast-modulation stimuli superimposed on pedestals of various amplitudes. (A pedestal is a static sine-wave grating of the same type and same spatial frequency as the moving test grating.) It was found that first-order motion-direction thresholds are unaffected by small pedestals, but at pedestal contrasts above 1-2% (5-10x pedestal threshold), motion thresholds increase proportionally to pedestal amplitude (a Weber law). For the first-order stimuli, pedestal masking is specific to the spatial frequency of the test. On the other hand, motion-direction thresholds for texture-contrast stimuli are independent of pedestal amplitude (no gain control whatever) throughout the accessible pedestal amplitude range (from 0 to 40%). However, when *baseline carrier* contrast increases (with constant *pedestal modulation* amplitude), motion thresholds increase, showing that gain control in second-order motion is determined not by the modulator (as in first-order motion) but by the carrier. Note that baseline contrast of the carrier is inherently independent of spatial frequency of the modulator. The drastically different gain-control properties of the two motion systems and prior observations of motion masking and motion saturation are all encompassed in a functional theory. The stimulus inputs to both first- and second-order motion process are normalized by feedforward, shunting gain control. The different properties arise because the modulator is used to control the first-order gain and the carrier is used to control the second-order gain.

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Reference Type: Conference Proceedings
Author: Luijt, R.S., Van de Moesdijk, G.A.J.
Year of Conference: 1992
Title: Some considerations for the definition of motion cue validation tests
Conference Name: European Forum on Matching Technology to Training Requirements
Publisher: Royal Aeronautical Society
Date: May

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Reference Type: Conference Proceedings
Author: Lusk, S.L., Martin, C.D., Whiteley, J.D., Johnson, W.V.
Year of Conference: 1990
Title: Time delay compensation using peripheral visual cues in an aircraft simulator
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Author's Affiliation and Title: Lusk : Logicon Technical Services Inc.
Martin : University of Dayton Research Institute
Whiteley : Armstrong Aerospace Medical Research Laboratory

Johnson : Systems Research Laboratories, Inc.
Number of Pages: 8
Abstract: The effects of simulator time delays on performance, control behavior and transfer of training were investigated using supplementary peripheral visual cueing. A disturbance-regulation task was used in which subjects were instructed to maintain a particular heading and altitude in the presence of pseudo-random wind gusts. The experiment took place in a fixed-base simulator with fighter-type dynamics. Delays used for the primary visual display were 67 and 300 ms. The peripheral horizon displays were either matched to the primary display mismatched, or not present at all. Respectively, the four combinations of primary and peripheral display delays investigated were: (1) 67 ms/ 67 ms, (2) 300 ms/ 67 ms, (3) 300 ms/ 300 ms, and (4) 300 ms/ no peripheral display. Subjects trained in one of these four conditions for 50 trials. At the end of training, subjects in the matched, minimal delay condition (67 ms/ 67 ms) maintained heading significantly better ($p<.05$) than subjects in each of the other three conditions. Thus, delayed primary cues did degrade performance. However, subjects with delayed primary cues and matched or mismatched peripheral cues (conditions 2 and 3) did not perform significantly better than subjects with delayed primary cues and no peripheral display (condition 4). This suggests that supplementary peripheral cueing, matched or mismatched, was not able to adequately compensate for the unresponsiveness of the simulated aircraft. There were no significant differences among the groups at transfer (trial 51).

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Reference Type: Book Section
Author: Mack, A.
Year: 1986
Title: Perceptual aspects of motion in the frontal plane
Editor: Boff, K., Kaufman, L., Thomas, J.
Book Title: Handbook of Perception and Human Performance: Sensory Processes and Perception
City: New York
Publisher: John Wiley and Sons
Volume: 1
Number of Volumes: 2
Pages: 117-126
Edition: 1

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Reference Type: Conference Proceedings
Author: Magee, L.E., Kantor, L., Sweeney, D.M.C.
Year of Conference: 1987
Title: Simulator induced sickness among Hercules aircrew
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 5-1 - 5-7
Date: September 29
Author's Affiliation and Title: Defence and Civil Institute of Environment Medicine, 1133 Sheppard Ave. West, Downsview, Ontario, M3M 3B9 Canada
Number of Pages: 7
Keywords: simulator induced sickness, Hercules aircrew, motion, vision, symptoms
Abstract: The purposes of this study were to investigate the incidence, severity and time course of simulator sickness amount pilots and flight engineers training on a C-130H(Hercules) flight simulator, and to assess the influence of flight experience on susceptibility. Evidence of simulator sickness was collected by questionnaire, tests of balance, and observation. The questionnaires were completed at the conclusion of a four-hour training session and 20 hours later. The balance tests were performed immediately prior and immediately following the training session. Overt signs of pallor, sweating, drowsiness and visual nystagmus were also recorded at these times. Thirty-five of the 42 aircrew (i.e. 83 %) tested reported characteristic symptoms of simulator sickness. The most prevalent were eyestrain, mental and physical fatigue, and after-sensations of motion. Some effects persisted following simulator training for many hours although most were not severe. Few had delayed onset. Although eleven subjects (26%) reported loss of balance at the end of the training session, performance on the balance tests improved; this suggests a practice effect which masks ataxia. With the exception of occasional nystagmus, no overt signs of simulator sickness were evident. The relationship between aircraft experience, both general and type-specific, and diagnostic scores based on symptoms were examined. There was no evidence to indicate that experience influenced susceptibility to simulator sickness.

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Reference Type: Conference Proceedings
Author: Manville, P., Whybray, E.D.
Year of Conference: 1978
Title: Low budget simulation in weapons aiming

Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 11-11 - 11-18
Date: April 24-27
Author's Affiliation and Title: Royal Aircraft Establishment
Number of Pages: 8
Keywords: low budget simulation, weapons aiming
Abstract: For a number of years Flight Systems Department at RAE Farnborough has been effectively operating and developing a low budget research simulator, designed to explore aiming sequences, accuracies and real time usage in air-to-ground weapon delivery from low altitude. Work completed has shown the value of this basic facility in providing fundamental data for assessment purposes and for the optimisation of pilots' tasks.
As a result, the simulator has been expanded to permit the aiming sequences of air-to-air combat and air-to-ground designators to be evaluated.
The description of the techniques and equipment employed illustrate how accuracy and fidelity can be achieved within modest resources.

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Reference Type: Conference Proceedings
Author: Martin, E.
Year of Conference: 1999
Title: Motion and force simulation systems I: Whole-body motion simulation
Conference Name: The Fifteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Pages: 1-14, 11-16, 11-20
Date: January 11-15
Author's Affiliation and Title: Wright-Patterson Air Force Base
Number of Pages: 50

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Reference Type: Thesis
Author: Martin, E.A.
Year: 1985
Title: The influence of tactual seat-motion cues on training and performance in a roll-axis compensatory tracking task setting
Academic Department: Department of Biomedical Engineering
University: Ohio State University
Thesis Type: Dissertation
Author's Affiliation and Title: B.S., M.S. (EE)
Keywords: seat-motion cues, roll-axis compensatory tracking

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Reference Type: Conference Proceedings
Author: Martin, E.A.
Year of Conference: 1985
Title: An investigation regarding the use of a dynamic seat-pan display for training and as a device for communicating roll-axis motion information

Conference Name: Third Symposium on Aviation Psychology
Conference Location: Aviation Psychology Laboratory, Ohio State University, Columbus
Date: April 22-25
Author's Affiliation and Title: U.S. Air Force, Aeronautical Systems Division, Wright-Patterson Air Force Base
Number of Pages: 8
Keywords: dynamic seat-pan, roll-axis motion, DSS, dynamic seat system, RATS, roll-axis tracking simulator
Abstract: This paper describes a research program conducted to determine the feasibility of providing useful angular onset-motion information via a broad-area tactual seat-pan display. The experiment was designed to permit the evaluation of the utility of the display as a training device as well as its efficacy for imparting motion information. The results indicate that--with proper attention given the drive law--the tactual display can elicit both performance and control behavior indistinguishable from that observed in a whole-body motion environment. Unfortunately, the training transfer results were not so encouraging. These indicated that the seat-pan display as used in this study was not adequate for training naive subjects to properly interpret and use the motion information available in a whole-body motion environment.

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Reference Type: Conference Proceedings
Author: Martin, E.A.
Year of Conference: 1996
Title: Motion and force simulation systems I: Whole-body motion simulators
Conference Name: Flight and Ground Simulation Update
Conference Location: State University of New York at Binghamton

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Reference Type: Conference Proceedings
Author: Martin, E.A., Brett, B.E., Hoagland, D.G.
Year of Conference: 1999
Title: Tools for including realistic representations of operator performance in DoD constructive simulations
Conference Name: AIAA Modeling And Simulation Technologies Conference And Exhibit
Conference Location: Portland, Oregon
Pages: 59-67
Date: August 9-11
Author's Affiliation and Title: Martin - Crew System Interface Division Airforce Research Laboratory
Brett - Science Application International Company
Hoagland - Crew System Interface Division Airforce Research Laboratory
Number of Pages: 9
Abstract: Military weapon systems are normally built to satisfy a set of requirements levied by the warfighter. All these weapon systems are manned in some sense, yet tools for quantifying the effectiveness with which a crewstation must support operator performance are lacking. Analysts and decision-makers need a means to readily model and understand the effects of human performance on total weapon system effectiveness when translating operational requirements into system requirements. This paper discusses the research and demonstration activities being conducted by the Combat Automation Requirements Testbed (CART) Program within the Air Force Research Laboratory / Human Effectiveness Directorate. CART will demonstrate how human-in-the-loop and constructive operator models and data can be integrated with Simulation-Based Acquisition activities for the purpose of defining crewstation requirements. Utilizing the

Army's IMPRINT human-performance modeling environment, CART will provide High Level Architecture (HLA) interfaces that enable human-performance models to interact with constructive models of systems. A second extension will incorporate the ability to represent the goal-oriented nature of human performance. Modelers and analysts will be able to define operator goal states and priorities that dynamically drive task network models based on changing states and events in simulated military
environments.

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Reference Type: Conference Proceedings
Author: Martin, E.A., Osgood, R.K., McMillan, G.R.
Year of Conference: 1987
Title: The dynamic seat as an onset cuing device
Conference Name: Flight Simulation Technologies Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-8
Date: August 17-19
Author's Affiliation and Title: Martin: Ph.D., ASD/ENETA, Wright-Patterson AFB, OH 45433-6503
Osgood: Ph.D., Systems Research Laboratories, Dayton, OH 45440
McMillan: Ph.D., AAMRL/HEF, Wright-Patterson AFB, OH 45433-6503
Number of Pages: 7
Keywords: dynamic seat, offset cueing device, g-seats, ALCOGS, RATS
Abstract: The research described in this paper deals with an evaluation of advanced dynamic seats as an alternative to platform motion simulation. The dynamic seat has been shown to be an effective device for providing task-critical onset motion information, provided that proper attention is given to the drive laws. Its value as a training device remains equivocal, however; additional research is required to address this training issue.
It is difficult to extrapolate the benefit derived from dynamic seat cuing in laboratory tracking tasks to the operational task environment. An evaluation of the dynamic seat within the context of a more operationally-realistic task environment is necessary. The task chosen for this evaluation is aerial refueling. This paper discusses a brief series of experiments initiated to develop the drive laws for additional angular and linear degrees-of-freedom that become necessary with a multi-axis control task like aerial refueling.

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Reference Type: Report
Author: Martin, E.L.
Year: 1981
Title: Training effectiveness of platform motion: Review of motion research involving the advanced simulator for pilot training and the simulator for air-to-air combat
City: Brooks Air Force Base, TX
Institution: Air Force Human Resources Laboratory
Date: February
Type: Final Report
Report Number: AFHRL-TR-79-51
Author's Affiliation and Title: Operations Training Division, Williams Air Force Base, AZ 85224
Recipient's Affiliation and Title: Air Force Human Resources Laboratory, Brooks Air Force Base, TX 78235
Number of Pages: 29

Keywords: platform motion, transfer of training, training effectiveness, flight simulator, flying training, Advanced Simulator for Pilot Training (ASPT), Simulator for Air-to-Air Combat (SAAC), motion simulation

Abstract: This report presents a summary review of the transfer-of-training studies conducted by the Operations Training Division of the Air Force Human Resources Laboratory investigating the training effectiveness of six-degrees-of-freedom platform motion cueing. A total of six studies are reviewed. Of the six studies, five were conducted on the Advanced Simulator for Pilot Training (ASPT) located at Williams AFB and one on the Simulator for Air-to-Air Combat (SAAC) located at Luke AFB. Tasks investigated included basic and advanced contact, instruments, basic fighter maneuvers, and conventional weapons delivery. The review of each study contains a statement of objectives, a summary of the method and results, a data excerpt representative of the findings, and a critique. The report also contains a description of the research strategy from which the studies were derived, a discussion of transfer-of-training methodology, and a discussion of the relationship between the results of these six studies and research findings from other agencies or facilities. Implications for future research are discussed.

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Reference Type: Conference Proceedings
Author: Mathews, R.H.
Year of Conference: 1978
Title: Manned air combat simulation: A tool for design, development and evaluation for modern fighter weapon systems and training of aircrews
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 25-21 - 25-26
Date: April 24-27
Author's Affiliation and Title: Chief, Flight Simulation, Flight Simulation Department, McDonnell Aircraft Company, A Division of McDonnell Douglas Corporation
Number of Pages: 6
Keywords: manned air combat, simulation, aircrew training

Abstract: Manned Aircraft combat simulation has matured into a major element in modern fighter aircraft design and development. The simulation fidelity now available allows meaningful training to be accomplished such that U.S. Government is now procuring an Air Combat Maneuvering Simulator (ACMS) for fighter tactics training. This paper describes the contributions of manned air combat simulation to the F-15 fighter weapon systems from design concept through successful introduction to squadron service. Specific examples are given of airframe avionics, and integrated systems simulation support in the design and development process. A comparison of flight simulation results in several test programs included in air combat maneuvering is presented. Additionally, a description is presented of the Air Combat Maneuvering Simulator (ACMS Device 2E6) being provided to the U.S. Navy for air combat training.

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Reference Type: Conference Proceedings
Author: Matthews, N.O., Martin, C.A.
Year of Conference: 1978
Title: The development and evaluation of a "g" seat for a high performance military aircraft training simulator
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques

Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 21-21 - 21-28
Date: April 24-27
Author's Affiliation and Title: Cranfield Institute of Technology, Cranfield, Bedford, England, MK43 OAL
Number of Pages: 8
Keywords: g -seats
Abstract: Early 'g' seats fitted in British Military training simulators had been unsatisfactory in that they produced incorrect and, in some cases, negative cues to the pilots and, in addition, were incapable of providing simulated steady 'g' cues.
The program of development work described in this paper will cover the examination of the original type of seat and attempts to improve its performance leading to the design of a completely new concept in simulator 'g' seats. The philosophy behind the changes in the design will be considered and the implementation of these in terms of hardware will be described.
Tests of the prototype model of the new seat have been carried out in conjunction with a 3-axis motion system of improved performance characteristics at Cranfield Institute of Technology and the results of evaluations by a number of service test pilots and pilots will be described.
The seat has now been accepted for installation in a service training simulator for the next generation of high performance aircraft.

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Reference Type: Conference Proceedings
Author: Matton, J.S.
Year of Conference: 1996
Title: Principles and technologies for reengineering pilot training
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: San Diego, CA
Pages: 453-462
Date: July 29-31
Number of Pages: 10
Abstract: Computer hardware and software technology has advanced far more rapidly than principles for guiding its application to aviation training. Technological capabilities will not increase the effectiveness or efficiency of training unless the structure and processes of current training programs are changed, and the specific potentialities of information technology are matched to student learning needs. Reengineering principles have been successful for increasing efficiency and productivity within business and industry and can be applied to the task of integrating new technologies within existing training programs. When combined with well-established findings of learning and training research, the reengineering of pilot training processes can successfully tap the power of new technologies to produce overall improvements in pilot training.
Computer hardware and software technology has advanced far more rapidly than principles for guiding its application to aviation training. For example, we are now able to simulate many types of flight environments with a great deal of accuracy and realism and record the actions, decisions, and behavior of pilots and aircrew in real time, but these new capabilities do not guarantee effective training. Part of the problem is due to older training models and strategies that were produced for a different type of economy with different constraints and limitations. Misconceptions and overgeneralizations of psychological principles of learning and educational research have also resulted in suboptimal training technology. Technologies, applied research, and reengineering principles should be combined to provide for a robust integration of technology rather than simply embellishing or automating parts of the existing training program.

Reference Type: Journal Article

Author: McCabe, M.D.
Year: 1997
Title: A low cost PC-based aviation training device for IFR flight simulation
Journal: American Institute of Aeronautics and Astronautics (AIAA)
Number of Pages: 7
Abstract: This paper describes the Jeppesen Sanderson FS-200 IFR Flight Training System. The FS-200 is an example of a new class of synthetic flight training device, the Personal Computer-Based Aviation Training Device (PCATD). Recent studies of PCATD training effectiveness show that these devices can aid teaching of instrument flight tasks at decreased cost. Qualification requirements for PCATDs and limits for authorized use of PCATDs are contained in FAA Advisory Circular (AC) 61-126. The qualification requirements of AC 61-126 and their influences on the FS-200 PCATD design are discussed.

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Reference Type: Edited Book
Editor: McCauley, M.E.
Year: 1984
Title: Research issues in simulator sickness
Series Title: McCauley, M.E. (Ed.), *Research Issues in Simulator Sickness: Proceedings of a Workshop*, Washington, DC: National Academy Press, 1984.
City: Naval Postgraduate School, Monterey, CA
Publisher: National Academy Press
Author's Affiliation and Title: Committee on Human Factors, Commission on Behavioral and Social Sciences and Education, National Research Council
Keywords: motion sickness, sensory conflict, human factors research, vestibular, vision
Abstract: Simulator sickness, with symptoms similar to motion sickness, occurs frequently in military and civilian flight trainers. Simulator sickness appears to be independent of whether a fixed base or moving base simulator is used. Methods for amelioration are described as well as recommendations for future research to develop countermeasures.

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Reference Type: Report
Author: McCauley, M.E., Hettinger, L.J., Sharkey, T.J., Sinacori, J.B.
Year: 1990
Title: The effects of simulator visual-motion asynchrony on simulator induced sickness
Institution: American Institute of Aeronautics and Astronautics (AIAA)
Author's Affiliation and Title: McCauley, Hettinger & Sharkey: Monterey Technologies, Inc., Carmel, CA
Sinacori: John B. Sinacori Associates, Pebble Beach, CA
Number of Pages: 8
Keywords: simulator visual-motion asynchrony, simulator induced sickness, vertical motion simulator
Abstract: A program of experimental research on simulator induced sickness is in progress at the Army Crew Station Branch and the Development Branch at NASA Ames Research Center. The first of a series of studies investigated the relationship between dynamics implied by the visual system and delivered by the motion base. Forty-eight Army rotorcraft pilots flew the NASA Vertical Motion Simulator (VMS) in four consecutive 10-minute segments of increasing maneuverability while assigned to one of four conditions of motion. Simulator sickness was found in all motion conditions. It increased with exposure time and maneuvering level. Differences between the four motion conditions were not statistically significant given the individual differences in susceptibility.

Reference Type: Journal Article
Author: McCauley, M.E., Sharkey, T.J.
Year: 1992
Title: Cybersickness: Perception of self-motion in virtual environments
Journal: Presence: Teleoperators and Virtual Environments
Volume: 1
Issue: 3
Pages: 311-318
Author's Affiliation and Title: Monterey technologies, Inc., Cay, North Carolina 27511
Number of Pages: 8
Abstract: Human perceptual systems have evolved to provide accurate information about orientation and movement through the environment. However, these systems have been challenged in the past century by modern transportation devices and will be further challenged by visual environments (VEs) and teleoperator systems. Illusory self-motion within a VE ("cyberspace") will be entertaining and instructive, but for many users it will result in motion sickness ("cybersickness"). Sensory conflict theory and the poison hypothesis provide an unproven theoretical foundation for understanding the phenomenon. Although no single solution is likely, the problem can be contained by a combination of engineering design, equipment calibration, and exposure management.

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Reference Type: Report
Author: McDaniel, W.C., Scott, P.G., Browning, R.F.
Year: 1983
Title: Contribution of platform motion simulation in SH-3 helicopter pilot training
City: Orlando, FL
Institution: Department of the Navy, Training Analysis and Evaluation Group
Report Number: Technical Report 153

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Reference Type: Conference Proceedings
Author: McGregor, D.M.
Year of Conference: 1970
Title: Some factors influencing the choice of a simulator
Conference Name: Simulation
Conference Location: Ames Research Center, Moffett Field, CA
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 6-1 - 6-31
Date: March
Author's Affiliation and Title: National Aeronautical Establishment, National Research Council of Canada
Number of Pages: 31
Keywords: hardware, pilot tasks, motion, field-of-view, visual illustration,
Abstract: This paper outlines some of the means by which the pilot derives motion information during flight and attempts to highlight some of the areas in which specific simulator characteristics are required to obtain valid results.
Discussions of several shortcomings of present hardware that must be overcome before specific tasks, such as low altitude, low speed maneuvering and the difficulties of achieving a thorough understanding of the man-machine system, necessary before the simulator with just the right degree of complexity can be selected with the conference, are presented.
Notes: Lead Discussion by J.T. Gallagher and open discussion.

Reference Type: Conference Proceedings
Author: McIntyre, H.M., Roberts, M.E.C.
Year of Conference: 1995
Title: Simulated visual scenes - Which are the critical cues?
Conference Name: AGARD FVP Symposium on "Flight Simulation--Where are the Challenges?"
Conference Location: Braunschweig, Germany
Publisher: NASA Technical reports
Pages: Section 2
Date: May 22-25
Author's Affiliation and Title: Thomson Training & Simulation Ltd, West Sussex, RH10 2RL, UK
Number of Pages: 7
Abstract: Research has shown that pilots can expect information from relatively impoverished visual scenes. However, performance of a variety of simulated flight tasks improves with greater scene complexity. Simulator visual systems cannot replicate the real world. Further, it is not possible to optimise visual system performance in all areas simultaneously. Some improvements in flight simulator visual cueing will come inevitably, as technology advances. Others present a research challenge, particularly where the likely effects of missing, contradictory or distorted information are not fully understood. These include:
The luminance dynamic range of the display; this is far less than that encountered in reality. Relative luminances between objects cannot be maintained. Luminance variations with range will therefore be distorted. Maintaining accurate colour ratios at low luminances is also difficult. By careful mapping, detection ranges could be adjusted to be nominally accurate under specific conditions but not continuously accurate. The implications need to be considered carefully.
The simulation of night scenes, with some illuminated areas may require the simultaneous mixing of 2 or 3 models in the same scene, creating unusual data base management demands. This requires further investigation.
Distance judgments may be observed to be inaccurate in the simulator. To prevent this leading to degraded simulator performance and deficiencies in training it may be possible to compensate for the absence of some cues by enhancing the effect of others. Further investigation is required to establish whether such compensation is truly possible, to what degree it enhances simulator effectiveness and to identify associated costs.

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Reference Type: Magazine Article
Author: McKenna, J.T.
Year: 1999
Title: United, Pratt target simulator shortfalls
Magazine: Aviation Wek & Space Technology
Pages: 64-65
Date: May 24
Number of Pages: 2
Abstract: Heeding a study's call for high priority action, the companies plan to improve simulator fidelity.
Simulators today do not portray engine malfunctions accurately.

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Reference Type: Journal Article
Author: McLane, R.C., Wierwille, W.W.
Year: 1975
Title: The influence of motion and audio cues on driver performance in an automobile simulator
Journal: Human Factors

Volume: 14
Issue: 5
Pages: 488-501
Author's Affiliation and Title: Virginia Polytechnic institute and State University, Blacksburg, VA
Number of Pages: 13
Abstract: A highway driving simulator with a computer-generated visual display, physical motion cues of roll, yaw, and lateral translation, and velocity-dependent sound/vibration cues was used to investigate the influence of these cues on driver performance.
Forty-eight student subjects were randomly allocated to six experimental groups. Each group of eight subjects experienced a unique combination of the motion and audio cues. The control group received a full simulation condition while each of the remaining five groups performed with certain combinations of motion and sound deleted. Each driver generated nine minutes of continuous data from which five performance measures were derived. Results indicate that the performance of yaw, lateral, and velocity deviation are significantly affected by the deletion of cues. In support of the hypothesis that driver performance is augmented by the addition of motion cues, statistically significant negative correlations were obtained between the number of motion cues present and the measures of yaw and lateral deviation. With respect to motion and audio cues, recommendations are made regarding simulator design criteria.

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Reference Type: Conference Proceedings
Author: McMillan, G.R., Cardullo, F.M.
Year of Conference: 1997
Title: System integration
Conference Name: Thirteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Publisher: Office of Continuing Education, Watson School of Engineering, State University of New York
Pages: Section 11
Date: January 13-17
Author's Affiliation and Title: McMillan: Armstrong Laboratory
Cardullo: State University of New York at Binghamton
Recipient's Affiliation and Title: Office of Continuing Education, Watson School of Engineering, State University of New York
Binghamton, New York, Phone: (607) 777-2154, Fax: (607) 777-4411
Number of Pages: 132
Abstract: These notes address the issues of cue integration and synchronization in terms of their effects on human sensation, perception and performance. Before exploring these issues, let us define a few terms. Sensation is usually defined as the process of converting or transducing physical energy into neural impulses. The energies being transformed may arise externally (e.g., light quanta) or from within the person (e.g., feedback from joint motion). Perception is typically defined as the organization of these stimuli into meaningful patterns. In the vast majority of cases the resulting percept is stable and in direct correspondence with the state of the observer and the environment. Perceptual theorists have argued that stability is maintained because the critical sensory elements do not vary from situation to situation.
This leads to the integration and synchronization problem. What happens when all of the critical elements are not present? What happens when the critical sensory elements are not presented in the correct temporal sequence? As suggested above, the stability of the perceptual process will be affected. The observed effects may range from a complete absence of the desired percept, to a delayed or weak percept, or in extreme cases to severe psychological and physical discomfort. This is not meant to imply that successful simulation requires reproduction of all the physical energies produced by actual flight. Rather most perceptual theorists maintain that the critical sensory events are some subset of the real-world stimuli, or are some higher-order pattern or

relationship among the stimuli. Regardless, the key elements must be included (integration) and the critical spatial and temporal relationships must be maintained (synchronization).
The term cue is more troublesome to define, because of its wide variety of uses. Some use the term to mean a stimulus or stimuli which elicit(s) a percept. Others us the term to mean a stimulus or stimuli which elicit(s) a specific action, or provides specific information. However, all of these uses are an attempt to name the critical stimulus elements or patterns that must be included in the simulation. While the precise definitions of the terms are not critical, the sensory and perceptual processes the terms describe are. Human perception is a highly tuned and integrated process that has evolved and developed to respond to specific patterns when certain events occur in the environment. When these relationships are violated, perception is degraded.
The remainder of this paper provides an overview of the integration and synchronization issues in flight simulation. Sources of integration and synchronization errors are identified. Typical effects of these errors on pilot training and performance are discussed. Finally, means available to minimize the errors are reviewed.

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Reference Type: Conference Proceedings
Author: McMillan, G.R., Cardullo, F.M.
Year of Conference: 1999
Title: Integration and synchronization as perceptual issues
Conference Name: The Fifteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Pages: 1-30, 31-26
Date: January 11-15
Author's Affiliation and Title: McMillan: Armstrong Laboratory
Cardullo: State University of New York at Binghamton
Number of Pages: 56

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Reference Type: Conference Proceedings
Author: McMillan, G.R., Martin, E.A., Flach, J.M., Riccio, G.E.
Year of Conference: 1985
Title: Advanced dynamic seats: An alternative to platform motion?
Conference Name: Seventh I/ITEC Conference
Conference Location: Orlando, FL
Pages: 153-163
Date: November
Author's Affiliation and Title: McMillan: Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, OH 45433
Martin: Aeronautical Systems Division, Wright-Patterson Air Force Base, OH 45433
Flach: University of Illinois at Urbana-Champaign, Aviation Research Laboratory, IL 61874
Riccio: Systems Research Laboratories, Inc., Dayton, OH 45440
Number of Pages: 11
Keywords: advanced dynamic seats, platform motion, g-seats, RATS, roll-axis training simulator, advanced low cost g-cueing system, ALCOGS
Abstract: The experiment program described in this paper is investigating advanced dynamic seats (g-seats) as an alternative to platform motion systems. The studies have quantified the effects of dynamic seat cueing on the performance of roll-axis turbulence regulation task, and on transfer of training to a whole-body motion simulator. The studies have clearly demonstrated that the dynamic seat can elicit tracking performance and manual control behavior equivalent to that observed in whole body motion. To date, significant transfer of training from the dynamic seat to

whole-body motion has only been observed with pilot subjects. Techniques to achieve the same training benefit with naive trainees are being pursued.

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Reference Type: Conference Proceedings
Author: McQuillan, F., Ure, R.
Year of Conference: 1992
Title: Use of simulation to prove military worth of advanced platform technologies
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 79-88
Author's Affiliation and Title: CAE Electronics Ltd., St. Laurent, Quebec, Canada
Number of Pages: 10
Keywords: advanced platform technologies, simulation, scenario analysis, database management
Abstract: Spiraling costs in the development and evaluation of new military aircraft are forcing many agencies to look to simulation as a mechanism for advanced platform evaluation.
This paper describes a simulation facility being developed at CAE Electronics Ltd. to support a study of advanced VTOL concepts being conducted by the US army.
The facility allows researchers and engineers to evaluate the effectiveness of aircraft in performing selected missions. It provides a user-definable, high fidelity threat environment with terrain interaction. The experimenter can specify all attributes of the various player and tactical scenario in a flexible and user-friendly manner. A data recording capability is available to log mission results for off-line analysis.
For the more promising airframes identified, a real-time piloted simulation is anticipated as the next phase of this project.
Notes: Published in 1992.

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Reference Type: Journal Article
Author: McRuer, D.
Year: 1980
Title: Human dynamics in man-machine systems
Journal: Automatica
Volume: 16
Pages: 237-253
Author's Affiliation and Title: Systems Technology, Inc., 13766 South Hawthorne Boulevard, Hawthorne, CA 90250, USA
Number of Pages: 17
Keywords: adaptive systems, bang-bang control, biocontrol, crossover model, human dynamics, man-machine systems, optimal systems, physiological models, structural isomorphic model
Abstract: The dynamic behavior of human operators in manual control systems has long served as a compelling target for control theory explanations. While many theoretical attempts have been found wanting, some classical and modern control theory concepts have proved useful in practice. In this paper some human dynamic properties are outlined to illustrate the variety of human behavior, and some suitable theoretical treatments are summarized. Time-optimal control theory is used to characterize one form of human behavior. Other behavioral aspects are quantified by the two predominant models in current use--a structurally isomorphic cause-effect model and an algorithmic model utilizing linear-quadratic-gaussian optimal control. Many of the procedures developed to achieve practical utility for these models have parallels useful for automatic control as well.

Reference Type: Report
Author: McRuer, D.T.
Year: 1988
Title: Pilot modeling
City: Hawthorne, CA
Institution: Systems Technology, Inc.
Pages: 2-1 - 2-30
Report Number: AGARD-LS-157
Author's Affiliation and Title: President, Systems Technology, Inc., 13766 S. Hawthorne Blvd., Hawthorne, CA 90250
Number of Pages: 31
Abstract: This paper begins with a description of pilot control behavior in general. This is followed by emphasizing the essential features of pilot dynamics for closed-loop control of aircraft. The crossover model is presented as the simplest and most useful model for structural-isomorphic form which accounts for some human subsystems as well as the total input-output behavior; and an algorithmic optimal control model which attempts to mimic the pilot's total response only. Both full and divided attention conditions are treated.

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Reference Type: Journal Article
Author: McRuer, D.T., Allen, R.W., Weir, D.H., Klein, R.H.
Year: 1977
Title: New results in driver steering control models
Journal: Human Factors
Volume: 19
Issue: 4
Pages: 381-397
Date: August
Author's Affiliation and Title: Systems Technology, Inc., Hawthorne, CA
Number of Pages: 17
Abstract: The dynamic control properties of drivers and driver/vehicle systems in steering operations have been widely investigated. This paper presents a short review of the combined compensatory, pursuit, and precognitive features needed to describe the total properties of the driver as a controller. Specific combinations of these features are associated with particular driving maneuvers. Some recent results are presented to confirm previous hypotheses and more completely quantify the models.
The driver-organized system structure for regulation control is reviewed with emphasis on the loops closed and adjustments made by the driver in compensating for vehicle dynamic changes. Pursuit structures are given which describe steering control with preview and as one explanation for lane change maneuvers. Precognitive behavior is then presented as the most skilled mode utilized in rapid lane changes and other well-practiced maneuvers including obstacle avoidance. For all three categories of control, full-scale or simulator data are presented as indications of model verification.

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Reference Type: Journal Article
Author: McRuer, D.T., Jex, H.R.
Year: 1967
Title: A review of quasi-linear pilot models
Journal: IEEE Transactions on Human Factors in Electronics
Volume: 8

Issue: 3
Pages: 231-249
Number of Pages: 19
Abstract: During the past several years, an analytical theory of manual control of vehicles has been in development and has emerged as a useful engineering tool for the explanation of past test results and prediction of new phenomena. An essential feature of this theory is the use of quasi-linear analytical models for the human pilot wherein the models' form and parameters are adapted to the task variables involved in the particular pilot-vehicle situation.
This paper summarizes the current sate of these models; experimental data and equations of describing function models for compensatory, pursuit, periodic, and multiloop control situations; the effects of task variables on some of the model parameters; some data on "remnant"; and the relationship of handling qualities ratings to the model parameters.

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Reference Type: Report
Author: McRuer, D.T., Krendel, E.S.
Year: 1974
Title: Mathematical models of human pilot behavior
City: France
Institution: NATO Advisory Group For Aerospace Research & Development
Date: January
Report Number: AGARDograph No. 188
Author's Affiliation and Title: McRuer: President and Technical Director, Systems Technology, Inc., Hawthorne, CA
Krendel: Professor of Operations Research, University of Pennsylvania, Philadelphia, PA
Number of Pages: 72
Keywords: human pilot behavior, stability, control, display system, flying qualities, quasi-linear models, single-loop system configuration, multi-loop system configuration, Successive Organization of Perception (SOP) theory
Abstract: The use of mathematical models of the human pilot in analyses of the pilot/vehicle system has brought a new dimension to the engineering treatment of flying qualities, stability and control, pilot/vehicle integration, and display system considerations. As an introduction to such models, elementary concepts and specific examples are used to set the stage for a step-by-step development of what is known about the human pilot as a dynamic control component. In the process, quasi-linear models for single-loop systems with visual stimuli and multiloop systems with visual stimuli are presented and then extended to cover multiloop, multi-modality situations. Empirical connections between the pilot dynamics and pilot ratings are also considered.
Some of the most important nonlinear features of human pilot behavior in adapting to changes in the character of the stimuli are described and tied to the quasi-linear models via the Successive Organization of Perception (SOP) theory, which is reviewed and elaborated. Dual-mode control models needed to describe the pilot's behavior in response to sudden transients are presented, along with pursuit and compensatory elements of the SOP continuum.
The current status of mathematical pilot models is shown to cover random, random-appearing, and transient inputs for single- and multi-loop system configurations. An extensive bibliography of applications and a summary of analysis problems which have been addressed is included, as is a short general status summary and critique of existing models in the form of a listing of shortcomings and problem areas.

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Reference Type: Magazine Article
Author: Mecham, M.

Year: 1994
Title: Cathay refines approach to simulator training
Magazine: Aviation Week and Space Technology
Pages: 35, 37
Date: January 17
Number of Pages: 2

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Reference Type: Magazine Article
Author: Mecham, M.
Year: 1994
Title: MD-11 introduction prompts JAL maintenance review
Magazine: Aviation Week and Space Technology
Pages: 36-37
Date: January 24
Number of Pages: 2

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Reference Type: Journal Article
Author: Merfeld, D.M., Young, L.R., Oman, C.M., Shelhamer, M.J.
Year: 1993
Title: A multidimensional model of the effect of gravity on the spatial orientation of the monkey
Journal: Journal of Vestibular Research
Volume: 3
Pages: 141-161
Author's Affiliation and Title: Merfeld, Young, Oman: Massachusetts Institute of Technology, Man-Vehicle Laboratory, Cambridge, MA
Shelhamer: Johns Hopkins University, School of Medicine, Baltimore, MD
Number of Pages: 21
Abstract: A "sensory conflict" model of spatial orientation was developed. This mathematical model was based on concepts derived from observer theory, optimal observer theory, and the mathematical properties of coordinate rotations. the primary hypothesis is that the central nervous system of the squirrel monkey incorporates information about body dynamics and sensory dynamics to develop an internal model. The output of this central model (expected sensory afference) is compared to the actual sensory afference, with the difference defined as "sensory conflict." The sensory conflict information is, in turn, used to drive central estimates of angular velocity ("velocity storage"), gravity ("gravity storage"), and linear acceleration ("acceleration storage"), toward more accurate values. The model successfully predicts "velocity storage" during rotation about an earth-vertical axis. The model also successfully predicts that the time constant of the horizontal vestibulo-ocular reflex is reduced and that the axis of eye rotation shifts toward alignment with gravity following postrotatory tilt. Finally, the model predicts the bias, modulation, and decay components that have been observed during off-vertical axis rotations (OVAR).

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Reference Type: Journal Article
Author: Merfeld, D.M., Zupan, L.H.
Title: Influence of rotational cues on the neural processing of gravito-inertial force
Journal: Levels of Perception

Pages: 1-40
Author's Affiliation and Title: Department of Otology and Laryngology, Harvard Medical School Jenks Vestibular Physiology Laboratory, Massachusetts Eye and Ear Infirmary
Number of Pages: 41
Abstract: Sensory systems often provide ambiguous information. For example, otolith organs measure gravito-inertial force (GIF), the sum of gravitational force and inertial force due to linear acceleration. According to Einstein's equivalence principle, no set of linear accelerometers alone can distinguish gravitational force (which changes with head orientation during head tilt) from inertial force (which changes with linear acceleration of the head). Therefore, the central nervous system (CNS) must use other sensory cues to distinguish tilt from translation. For example, the CNS can use rotational cues provided by the semicircular canals and vision. Much of this chapter provides a brief review of studies showing the influence of rotational cues on the neural processing of tilt and translation. However, we also include previously unpublished data. We begin by discussing the underlying physics (and associated neural processes) and neural representations. We then present studies that measure the influence of rotational cues on tilt responses before presenting studies of translation responses. We finish by reviewing modeling approaches to sensory integration for both tilt and translation responses.
URL: http://paperairplane.mit.edu/16.423J/Space/SBE/neurovestibular/NVChapter.doc

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Reference Type: Report
Author: Merriken, M.S., Johnson, W.V., Cress, J.D., Riccio, G.E.
Year: 1988
Title: Time delay communication using supplementary cues in aircraft simulator systems
Institution: American Institute of Aeronautics and Astronautics (AIAA)
Type: Experimental Report
Report Number: 88-4626-CP
Number of Pages: 9
Abstract: This study investigated the effects of providing real-world supplementary information to the visual and tactual modalities to reduce the deleterious effects of a delayed primary display on operator control performance. The supplementary visual and motion cues were presented at two different rates: (1) at the same rate as the primary display and (2) at a rate 133 ms faster. The results indicate that the conditions with the faster updating secondary cues had better performance in altitude control than the conditions with the cues at the same rate as the delayed primary display. There were no significant effects for heading control. When compared to a control condition with no supplementary cue there were no statistical differences but the trend of the faster updating secondary cue conditions having better performance scores was maintained for both altitude and heading control.

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Reference Type: Thesis
Author: Mesland, B.
Year: 1998
Title: About horizontal self-motion perception...
City: Utrecht, The Netherlands
University: Utrecht University
Thesis Type: Ph.D. Thesis
Keywords: self-motion, human perception, visual illusion
Abstract: This thesis discusses the technique for measuring perceived horizontal self-motion indirectly, using perceived object-motion. It also describes sensory interactions during the horizontal linear self-motion perception.

Reference Type: Report
Author: Mesland, B.S., Bles, W., Wertheim, A.H., Groen, E.L.
Year: 1998
Title: The influence of expectation on the perception of linear horizontal motion
City: Soesterberg, The Netherlands
Institution: TNO Human Factors Research Institute
Date: March 23
Type: TNO report
Report Number: TM-98-A010
Number of Pages: 23
Keywords: motion study, perception of movement, vestibular responses
Abstract: In normal situations the judgment of linear horizontal self-motion largely depends on visual information. In the absence of adequate visual feedback, however, the information provided the otolith organs and non-vestibular proprioceptors (together called linear proprioceptive sensors) becomes more important. the particular thing about these sensors is that they respond to linear acceleration, which may arise from translatory motion as well as from the gravitational acceleration. As a consequence it is difficult for these sensors to differential between linear translations and tilt with respect to gravity. This ambiguity may lead to the false percept of tilt during pure linear accelerations along a horizontal path. Still, it was our experience that these illusory percepts only seldomly occur when we oscillate subjects to and fro on a linear track (the ESA-sled). It was hypothesized that prior knowledge of subjects, who had seen the linear motion device before the experiment, may have biased the percept toward a vertical sensation of linear self-motion as opposed to an illusory sensation of self-tilt. In other words, their expectation may have influenced their perception of the stimulus. Therefore, two experiments were carried out in which this cognitive factor was controlled as an independent variable. In the first experiment, blindfolded subjects who were completely naive regarding the characteristics of the motion device were exposed to oscillatory linear motion at frequencies of 0.159 and 0.252 Hz. in the second experiment similar linear motion was applied, but this time in combination with various angles of actual tit of the subject's seat. The subjects in this experiment were informed beforehand that they would be exposed to various combinations of linear motion and tilt, so that they--although not completely naive--could not have any expectation about whether to perceive tilt or translation. In both experiments the dependent variable was the report about experienced self-motion and self-tilt. The results of both experiments unambiguously confirm that illusory self-tilt is sensed much more frequently when the subject has no precise expectation about the linear motion. Expressed in another way, the expectation of subjects who have seen the sled beforehand seems to enhance the threshold for perceiving self-tilt. It is concluded that expectation from prior knowledge and previous experience should be taken into account when modeling the perception of self-motion.
The experiments described in this report clearly demonstrate that the expectation, or mental state, of a subject has significant bearing on the judgment of linear horizontal self-motion. Clearly, the interpretation of sensory information about self-motion depends more on the transfer characteristics of the peripheral senses alone. As a consequence, one has to take cognitive factors, such as prior knowledge or previous experience, into account when investigating or modelling the perception of self-motion. From this point of view it will be more difficult to exactly predict or reconstruct the sensations of an aviator on the basis of the physical characteristics of a flight path. Seen from the positive side, the expectation of an experienced pilot is likely to be advantageous for the appreciation of simulated motion in a flight simulator.

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Reference Type: Magazine Article
Author: Mikula, J.
Year: 2004
Title: Modeling and simulation

Magazine: Aerospace America
Volume: 12
Pages: 80
Date: December
Number of Pages: 1

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Reference Type: Conference Proceedings
Author: Mikula, J., Chung, W.W.Y., Tran, D.
Year of Conference: 1999
Title: Motion fidelity criteria for roll-lateral translational tasks
Conference Name: Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 474-484
Date: August 9-11
Author's Affiliation and Title: Mikula: NASA Ames Research Center, Moffett Field, CA
Chung: Logicon Information Systems and Services, Moffett Field, CA
Tran: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 11
Abstract: A systematic effort investigating the motion cueing dependencies for coordinated roll-lateral tasks was designed for this study. Previous studies suggested a possible criterion to determine required motion fidelity. This experiment was expanded to confirm the previously suggested criteria by investigating a full range of rotational and translational motion attenuation and phase distortion. Two translational tasks were developed: (1) a helicopter making a 20-ft translation in hover, and (2) a fixed-wing jet making a 20-ft translation at a cruising speed of 250 knots. Both aircraft had desired handling qualities. Motion fidelity ratings and handlings qualities ratings were collected as the subjective data. The results were consistent with and extended the previously suggested fidelity criteria for coordinated roll-lateral tasks.

Reference Type: Conference Proceedings
Author: Miller, G.K., Jr., Riley, D.R.
Year of Conference: 1976
Title: The effect of visual-motion time delays on pilot performance in a pursuit tracking task
Conference Name: Visual and Motion Simulation Conference
Conference Location: Dayton, OH
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 55-57
Date: April 26-28
Author's Affiliation and Title: AIAA Members, NASA Langley Research Center, Hampton, VA 23665
Number of Pages: 3
Abstract: A study has been made to determine the effect of visual-motion time delays on pilot performance of a simulated pursuit tracking task. Three interrelated major effects have been identified: task difficulty, motion cues, and time delays. As task difficulty, as determined by airplane handling qualities or target frequency, increases, the amount of acceptable time delay decreases. However, when relatively complete motion cues are included in the simulation, the pilot can maintain his performance for considerable longer time delays. In addition, the number of degrees of freedom of motion employed is a significant factor.

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Reference Type: Report
Author: Miller, G.K.J., Riley, D.R.
Year: 1977
Title: The effect of visual-motion time delays on pilot performance in a simulated pursuit tracking task
City: Hampton, VA
Institution: National Aeronautics and Space Administration (NASA)
Date: March
Type: Technical Note
Report Number: NASA TN D-8364
Number of Pages: 97
Abstract: An experimental study has been made to determine the effect on pilot performance of time delays in the visual and motion feedback loops of a simulated pursuit tracking task. Three major interrelated factors were identified: task difficulty in the form of airplane handling qualities or target frequency, the amount and type of motion cues, and time delay itself. In general, the greater the task difficulty, the smaller the time delay that could exist without degrading pilot performance. Conversely, the greater the motion fidelity, the greater the time delay that could be tolerated. The effect of motion was, however, pilot dependent.

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Reference Type: Report
Author: Miller, J.C., Sharkey, T.J., Graham, G.A., McCauley, M.E.
Year: 1993
Title: Autonomic physiological data associated with simulator discomfort
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: February
Report Number: CONTRACT NAS2-12927
NASA_CR-177609
Author's Affiliation and Title: Monterey Technologies, Inc., P.O. Box 223699, Carmel, CA 93922
Number of Pages: 30
Keywords: simulator discomfort, simulation, helicopter, virtual reality, motion sickness, simulator sickness, heart period, heart rate, electrocardiogram, electrogastrogram
Abstract: We report here the development of a physiological monitoring capability for the Army's advanced helicopter simulator facility and some preliminary physiological data. Our objective was to demonstrate sensitivity of physiological measures in this simulator to self-reported simulator sickness. The data suggested that heart period, hypergastria, and skin conductance levels were more sensitive than were vagal tone and normal electrogastric activity.

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Reference Type: Journal Article
Author: Molloy, R., Parasuraman, R.
Year: 1996
Title: Monitoring an automated system for a single failure: Vigilance and task complexity effects
Journal: Human Factors
Volume: 38
Issue: 2
Pages: 311-322
Date: June
Number of Pages: 12

Abstract: The present study examined the effects of task complexity and time on task on the monitoring of a single automation failure during performance of a complex flight simulation task involving tracking, fuel management, and engine-status monitoring. Two groups of participants performed either all three flight simulation tasks simultaneously (multi-complex task) or the monitoring task alone (single-complex task); a third group performed a simple visual vigilance task (simple task). For the multi-complex task, monitoring for a single failure of automation control was poorer than when participants monitored engine malfunctions under manual control. Furthermore, more participants detected the automation failure in the first 10 min of a 30 min session than in the last 10 min of the session, for both the simple and the multi-complex task. Participants in the single-complex condition detected the automation failure equally well in both periods. The results support previous findings of inefficiency in monitoring automation and show that automation-related monitoring inefficiency occurs even when there is a single automation failure. Implications for theories of vigilance and automation design are discussed.

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Reference Type: Conference Proceedings
Author: Monfort, M.
Year of Conference: 1970
Title: Engineering analysis
Conference Name: Simulation
Conference Location: Ames Research Center, Moffett Field, CA
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 8-1 - 8-21
Date: March
Number of Pages: 21
Keywords: aircraft simulation, pilot workload, pilot rating
Notes: Lead discussion by D. R. Madill, W. R. Reynolds, I. L. Ashkenas and D. T. McRuer. Also includes an open discussion.

Reference Type: Conference Proceedings
Author: Mooij, H.A.
Year of Conference: 1987
Title: Technology involved in the simulation of motion cues: The current trend
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 2-1 - 2-15
Date: September 29
Author's Affiliation and Title: National Aerospace Laboratory NLR, Amsterdam, The Netherlands
Number of Pages: 15
Keywords: motion cues, simulator sickness, visual display, motion cue generation, current trend in visual and motion systems, basic cuing methodology in flight simulation, developments in image generation, image display, platform motion cue generation and motion hardware mechanisms, importance of maintenance and calibration of flight simulator installations
Abstract: The subject of motion cue generation is a topic that requires serious attention from all involved in the design, development and manufacture of flight simulators. The enhanced realism in the depiction of terrain, sky, and other aircraft available in current visual systems has been associated with an increasing number of instances of simulator sickness. This form of sickness is the constellation of symptoms which may be experienced by pilots as a result of flying a simulator.

As one of the introductory papers of the AGARD Aerospace Medical Panel Symposium on "Motion Cues in Flight Simulation and Simulator Induced Sickness," this paper presents observations concerning the current trend in visual and motion systems.
After an introduction of basic cueing methodology in flight simulation, the overview concentrates in developments in image generation, image display platform motion cue generation and motion hardware mechanisms. The paper concludes with some observations concerning the importance of maintenance and calibration of flight simulator installations.

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Reference Type: Conference Proceedings
Author: Moon, R.N.
Year of Conference: 1985
Title: Providing high performance visual simulation at low cost
Conference Name: Seventh I/TEC Conference
Conference Location: Orlando, FL
Pages: 100-105
Date: November
Author's Affiliation and Title: Evans & Sutherland Computer Corporation, 580 Arapeen Drive, Salt Lake City, UT 84108
Number of Pages: 6
Abstract: For years, the users of visual systems, in both the military and commercial worlds, have made a plea to the developers to significantly lower the costs of those visual systems. Then, in a second breath, they have continued to demand high visual fidelity. Not surprisingly, the trend among visual system developers has been to provide more capabilities for higher cost. This paper describes a system design where a serious and concerted effort has been made to lower costs, while still maintaining the features most essential and effective for training tasks. During the highly selective process of determining system features, some capabilities, such as smooth shading, color blending and transparencies, were seriously questioned. Other capabilities, such as texture, scene detail management, resolution, dynamic coordinate systems, and reasonable image quality, remain high on the list. The paper describes how the essential features were incorporated in a highly cost-effective design with surprising flexibility and modularity. Painstaking efforts were made to optimize the hardware efficiency, making use of custom, semicustom, and commercial VLSI. These latest technologies have made possible a parallel processor architecture in the geometric processor--a departure from capabilities ranging from low-cost, night-only operation to high-resolution, daylight scenes rivaling the current high-end systems. All of this can be contained in a single card cage per channel. The challenge of the visual users has been met.

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Reference Type: Journal Article
Author: Morgan, P.L.
Year: 2003
Title: Null hypothesis significance testing: Philosophical and practical considerations of a statistical controversy
Journal: Exceptionality
Volume: 11
Issue: 4
Pages: 209-221
Keywords: null hypothesis
Abstract: This article outlines underlying logic of null hypothesis testing and the philosophical and practical problems associated with using it to evaluate special education research.

Reference Type: Book Section
Author: Morimoto, M., Ando, Y.
Year: 1982
Title: On the simulation of sound localization
Editor: Gatehouse, R.W.
Book Title: Localization of Sound: Theory and Applications
City: Groton, CT
Publisher: Amphora Press
Pages: 85-97
Author's Affiliation and Title: Faculty of Engineering, Kobe University, Nada, Kobe 657, Japan
Number of Pages: 13

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Reference Type: Report
Author: Morrison, J.
Year: 1990
Title: Power analysis of gunnery performance measures: Differences between means of two independent groups
Institution: Human Resources Research Organization
Date: January
Report Number: Technical Report 871
Number of Pages: 25

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Reference Type: Report
Author: Muller, R.C., Allgood, C.O., Van Hoy, B.
Year: 1988
Title: Prototype data acquisition and analysis system for navy operational flight simulators
Report Number: DE88 014557
Author's Affiliation and Title: Oak Ridge National Laboratory, Oak Ridge, TN
Number of Pages: 5
Keywords: flight simulators, hardware, operating systems
Abstract: A problem of flight simulators has been the discomfort experienced by some pilots to the point of nausea. Likely explanations are a significant lack of synchronization between sight and movement as well as motion in the critical frequency magnitude region. A program to examine this problem has been undertaken at Oak Ridge National Laboratory, and the selection of appropriate computer hardware and software for analyzing motion and visual systems in real time is described. While requirements such as huge data acquisition rate and high rates operations have driven the selections, rapid advances in computer technologies guided system development toward easy upgrade at modest cost. Results for use and demonstration have been positive, especially in the areas of reliability and ease of use.

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Reference Type: Conference Proceedings
Author: Murray, P.M., Barber, B.
Year of Conference: 1985
Title: Visual display research tool
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom

Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 2-1 - 2-8
Date: September 30-October 3
Author's Affiliation and Title: Rediffusion Simulation Ltd, Gatwick Road, Crawley, W.Sussex RH10 2RL, United Kingdom
Number of Pages: 8
Keywords: visual display research tool, helmet mounted
Abstract: The simulation of the field of view seen by the pilot through the cockpit canopy where high detail over a wide field is required, as in low-level flight, navigation and target acquisition for example, remains a difficult and expensive problem. The Visual Display Research Tool (VDRT) is a new concept in visual displays which utilizes this 'area of interest' approach by matching its display parameters to those of the human eye.
Notes: Published in September 1986.

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Reference Type: Journal Article
Author: Nahon, M.A., Reid, L.D., Kirdeikis, J.
Year: 1992
Title: Adaptive simulator motion software with supervisory control
Journal: Journal of Guidance, Control, and Dynamics
Volume: 15
Issue: 2
Pages: 376-383
Author's Affiliation and Title: Nahon: Student Member of AIAA, University of Ontario, Institute for Aerospace Studies, Downsview, Ontario, Canada M3H 5T6
Reid: Associate Fellow of AIAA, University of Ontario, Institute for Aerospace Studies, Downsview, Ontario, Canada M3H 5T6
Number of Pages: 9
Keywords: adaptive simulator motion software, supervisory control, washout filters
Abstract: Concepts for flight simulator motion-drive algorithms range from the most basic to the relatively complex, with little to guide a choice between these, short of implementing them all and choosing the best. In order to avoid this lengthy process and put into practice the experience gained in a previous large-scale evaluation exercise, a flexible motion algorithm has been implemented. It can be run as a simple classical algorithm with few free parameters, and can be quickly adjusted to yield good motion performance. The more sophisticated adaptive features of the algorithm can then be brought in gradually to improve performance. Various forms of cost functions and adaptive features were investigated. These were tested on a synergistic 6 degrees-of-freedom motion-base simulator and promising features were identified. Finally, a supervisory code was included to ease motion adjustment, and to provide a safe interactive interface with the designer, as well as automatic motion adjustment to different flight conditions.

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Reference Type: Electronic Source
Author: NASA Ames Research Center
Year: 2005
Title: SimLab Vertical Motion Simulator
Producer: National Aeronautics and Space Administration (NASA)
Access Year: 2006
Access Date: Sept. 6
Last Update Date: April 25, 2005
Type of Medium: Website
Abstract: (taken from introductory paragraph) At NASA Ames research Center, in California's Silicon Valley, scientists conduct advanced research in a unique flight simulation complex. The facility provides researchers with exceptional tools to explore, define, and solve issues in both aircraft and spacecraft design. It offers fast and cost-effective solutions using real-time piloted simulation, realistic sensory cues, and the greatest motion range of any flight simulator in the world.
URL: http://www.simlabs.arc.nasa.gov/vms/vms.html

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Reference Type: Journal Article
Author: Nash, T.
Year: 1997
Title: A changing industry?
Journal: The Journal for Civil Aviation Training
Volume: 8

Issue: 4
Author's Affiliation and Title: Editor-in Chief, Journal for Civil Aviation Training
Number of Pages: 1
Keywords: US Advanced Qualification Program (AQP), Ro-Ro concept, FFS shell, FTD
Notes: "CAT comment" section of the journal.

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Reference Type: Report
Author: Nataupsky, M., Waag, W.L., Weyer, D.C., McFadden, R.W., McDowell, E.
Year: 1979
Title: Platform motion contributions to simulator training effectiveness: Study III--interaction of motion with field-of view
City: Williams Air Force Base, AZ
Institution: Flying Training Division, Air Force Human Resources Laboratory
Type: Final Report (Technical)
Report Number: AFHRL-TR-79-25
Recipient's Affiliation and Title: HQ Air Force Human Resources Laboratory (AFSC)
Keywords: field of view, motion simulation, platform motion, training effectiveness, transfer of training, visual simulation
Abstract: The objective was to determine the effects of platform motion cueing, visual field of view, and their interaction upon learning in the simulator and as subsequent transfer of training to the aircraft for basic contact maneuvers in the T-37 aircraft. A transfer-of training study design was used in which student pilots were initially trained in the Advanced Simulator for Pilot Training and subsequently evaluated on their first sortie in the T-37 aircraft. Each student received training under one of four simulator configurations: (a) full platform motion (six degrees of freedom), full FOV (300 horizontal by 150 vertical); (b) full platform motion, limited FOV (48 horizontal by 36 vertical); (c) no platform motion, full FOV; and (d) no platform motion, limited FOV. For the ASPT pretraining phase, scores from the automated performance measuring system and overall instructor pilot ratings were used for analysis. For the T-37 evaluation sorties, the overall instructor pilot ratings, as well as individually recorded flight parameters, were analyzed. These data provided no conclusive evidence of differential transfer effects resulting from platform motion cueing, size of the visual FOV, or their interaction. As such, these data provide support for previous findings that platform motion cueing does not significantly enhance the transfer of learning for basic contact tasks in the T-37 aircraft. It would seem that the impact of peripheral visual cues for initial acquisition is not critical. Furthermore, no convincing evidence was found indicating increased transfer using platform motion in conjunction with a narrow FOV visual scene. The major implication from these findings is that a fixed-base, limited FOV simulator configuration provides sufficient cueing for basic contact skills normally trained during Undergraduate Pilot Training.

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Reference Type: Electronic Source
Author: National Aeronautics and Space Administration (NASA)
Year: 2006
Title: FAA Regulations-Part 141
Producer: National Aeronautics and Space Administration (NASA),
Access Year: 2006
Access Date: Sept. 6
Last Update Date: August 7, 2006
Number of Pages: 5

URL: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=f4866fb822b1dbcc615562678afed80b&rgn=div5&view=text&node=14:3.0.1.1.2&idno=14

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Reference Type: Magazine Article
Author: National Aeronautics and Space Administration (NASA), A.S.R.S.
Year: 1998
Title: Blow off the cobwebs
Magazine: ASRS Callback; A Monthly Safety Bulletin from The Office of the NASA Aviation Safety Reporting System
Issue Number: 227
Date: May
Author's Affiliation and Title: P.O. Box 189, Moffett Field, CA 94035-0189
Abstract: Even highly-qualified pilots are prone to mistakes if they lack recent flight experience, as an air carrier First Officer learned on a flight with a company Flight Manager.
URL: http://asrs.arc.nasa.gov/callback_issues/cb_227.htm

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Reference Type: Electronic Source
Author: National Air Traffic Services (NATS)
Year: 2006
Title: New tower is virtually real for Heathrow air traffic control
Access Year: 2006
Access Date: Sept. 6
Last Update Date: May 5, 2006
Type of Medium: Website
Number of Pages: 2
Abstract: One of Europe's most realistic air traffic control (ATC) simulators has gone live, preparing controllers at Heathrow for life in their new tower, 87 meters above the runways of the world's busiest international airport.
URL: http://www.nats.co.uk/article/19/58/new_tower_is_virtually_real_for_heathrow_air_traffic_control_.html

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Reference Type: Book Section
Author: Naval Aerospace Medical Institute (NAMI)
Year: 1991
Title: Disorientation not attributable to strong vestibular stimuli-primacy of vision
Editor: Naval Aerospace Medical Institute (NAMI)
Book Title: U.S. Naval Flight Surgeon's Manual
Edition: 3rd
Number of Pages: 5
Abstract: (taken from introduction paragraph) Many of the disorienting conditions described in previous sections would be considerably ameliorated or overcome by good visual reference to the Earth's surface. The single most important cause of pilot disorientation is the absence of adequate visual reference to the Earth because of darkness or adverse weather conditions. Certain flying conditions can introduce visual information that may be either directly disorienting

or misinterpreted, but the crucial factor in the human response it that, without good visual reference to Earth's surface, the remaining sensory data on spatial disorientation are not sufficiently reliable to permit safe piloting of aircraft. This was nicely demonstrated by Krause (1959) who measured times from occlusion of pilots' visual reference until the aircraft assumed a condition requiring 10,000 feet for recovery. Following banks and turns, time were typically 20 to 30 seconds, but even after level flight, mean times were on the order of 60 seconds. Many instances of pilot disorientation are less attributable to some overwhelming misleading vestibular response than to some subtle perceptual inconsistency or even to perceptual insensitivity to the acceleration environment.

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Reference Type: Conference Proceedings
Author: Nelson, W.T., Bolia, R.S., McKinley, R.L.C., T. L., Tripp, L.D., Esken, R.L.
Year of Conference: 1998
Title: Localization of virtual auditory cues in high $+G_z$ environment
Conference Name: Human Factors and Ergonomics Society 42nd Annual Meeting
Pages: 79-101
Author's Affiliation and Title: Nelson, McKinley, Chelette, Esken: Air Force Research Laboratory, Wright-Patterson AFB, OH 45433
Bolia, Tripp: Veridian, 5200 Springfield Pike, Dayton OH 45431-1289
Number of Pages: 23
Abstract: The ability to localize a virtual auditory source was evaluated under varying levels of sustained (+Gz) acceleration. Participants were required to judge the locations of virtual auditory cues located along the horizontal plane (elevation 0°) during exposure to 1.0, 1.6, 2.5, 4.0, 5.6, and 7.0 +Gz. The experiment was conducted at the Air Force Research Laboratory's Dynamic Environment Simulator - a man-rated, three axes centrifuge. No significant increases in localization error were found between 1.0 and 5.6 +Gz; however, a significant increase did occur at the 7.0 +Gz level. In addition, the percentage of reversals did not vary as a function of +Gz level. Collectively, these results indicate that one's ability to localize virtual auditory cues is well maintained at various levels of sustained acceleration.
URL: http://www.hec.afrl.af.mil/Publications/Hfes98v3.pdf

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Reference Type: Conference Proceedings
Author: Neville, K.W.
Year of Conference: 1996
Title: More cost effective method for update and validation of simple derivative simulations
Conference Name: Training: Lowering the Cost, Maintaining the Fidelity
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Pages: 4.1-4.10
Date: May 15-16
Author's Affiliation and Title: Boeing Commercial Airplane Group, Seattle, WA
Number of Pages: 10
Abstract: Since the establishment of the FAA Advanced Simulation Plan in the early 1980's, qualification of high-level training simulators has required an extensive quantitative comparison of simulator and aircraft data. The requirement for direct comparison to flight data has played a major role in the greatly improved fidelity and increased training credit possible for high-level simulators. However, this improved fidelity has been accompanied by a substantial increase in the cost to the data provider for developing simulator data bases and software models. This paper will show that for a simple derivative airplane model where the only significant difference

relative to a new or major derivative model is a change in fuselage length, analytical methods may be used to supplement a reduced flight validation program to produce an equivalent flight-updated simulation, thus avoiding much of the cost associated with the full flight update and validation process. The primary source of validation data for a simple derivative model would be the aircraft manufacturer's engineering simulator.

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Reference Type: Electronic Source
Author: News, B.
Year: 2006
Title: Air traffic simulator introduced
Access Year: 2006
Access Date: Sept. 6
Last Update Date: May 5, 2006
Type of Medium: Website
Abstract: Air traffic control staff will use a £1.5m simulator to train to use a £50m control tower at Heathrow.
URL: http://news.bbc.co.uk/2/hi/uk_news/4975974.stm

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Reference Type: Journal Article
Author: Nickerson, R.S.
Year: 1973
Title: Intersensory facilitation of reaction time: Energy summation or preparation enhancement?
Journal: Psychological Review
Volume: 80
Issue: 6
Pages: 489-509
Date: November
Author's Affiliation and Title: Bolt Beranek and Newman Inc., Cambridge, MA
Number of Pages: 21
Abstract: Some recent studies of intersensory facilitation of reaction time are reviewed. The finding of interest is that reaction time to a primary (usually visual) stimulus can be shortened if an accessory (usually auditory) stimulus is presented at approximately the same time. This is true when the accessory stimulus is defined as irrelevant in the sense that the subject need not attend to it in order to perform the task, and he is not to respond to it when it occurs alone. Energy summation across modalities and preparation enhancement have been suggested as two factors that play roles in facilitation, and the position has been taken that both concepts are necessary to account for all the results. The argument is made in this article that it is not necessary to invoke both concepts because a preparation-enhancement hypothesis can account for all the findings that can be explained by an energy-summation hypothesis, and other findings as well.

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Reference Type: Conference Proceedings
Author: Noon, H., Murphy, M.
Year of Conference: 1983
Title: Innovative approaches to recurrent training
Editor: Lee, A.T.
Conference Name: Flight Training Technology for Regional/Commuter Airline Operation

Conference Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: September 28-30
Author's Affiliation and Title: Noon: Command Airways
Murphy: NASA

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Reference Type: Conference Proceedings
Author: Norré, M.E.
Year of Conference: 1987
Title: Cues for training vertigo, providing suggestions for the management of simulator sickness
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 17-11 - 17-14
Date: September 29
Author's Affiliation and Title: M.D., Ph.D., Department of Otoneurology & Equilibriometry, The University of Leuven Hospitals, Leuven, Belgium
Number of Pages: 4
Keywords: vertigo, simulator sickness, vestibular, sensory mismatch

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Reference Type: Book Section
Author: O'Hare, D., Roscoe, S.
Year: 1990
Title: Training environments: Instruction and simulation
Book Title: Flight Deck Performance: The Human Factor
City: Ames
Publisher: Iowa State University Press

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Reference Type: Book Section
Author: Oman, C.
Year: 1991
Title: Sensory conflict in motion sickness: An observer theory approach
Editor: Ellis, S.R., Kaiser, M.K., Grunwald, A.C.
Book Title: Pictorial communication in virtual and real environments
City: New York
Publisher: Taylor and Francis
Pages: 362-376
Number of Pages: 15
Keywords: motion sickness, observer theory, exogenous motion, sensory rearrangement, physiological basis, sensory conflict theory, Kalman filter, orientation brain, emertic brain
Abstract: "Motion Sickness " is the general term describing a group of common nausea syndromes originally attributed to motion-induced cerebral ischemia, stimulation of abdominal organ afferent, or overstimulation of the vestibular organs of the inner ear. Sea-, car- and airsickness are the most commonly experienced examples. However, the discovery of other variants such as Cinerama-, flight simulator-, spectacle- and space sickness in which the normal physical motion of the head and body are absent has led to a succession of "sensory conflict" theories which offer a more comprehensive etiologic perspective. Implicit in the conflict theory is the hypothesis that neural and/or humoral signals orient regions of the brain subserving spatial orientation, and that these signals somehow traverse to other centers mediating sickness symptoms. Unfortunately, our present understanding of the neurophysiological basis of motion sickness is far from complete. No sensory conflict neuron or process has yet been physiologically identified. To what extent can the existing theory be reconciled with current knowledge of the physiology and pharmacology of nausea and vomiting? This paper reviews the stimuli which cause sickness, synthesizes a contemporary observer theory view of the sensory conflict hypothesis, and presents a revised model for the dynamic coupling between the putative conflict signals and nausea magnitude estimates. The use of quantitative models for sensory conflict offers a possible new approach to improving the design of visual and motion systems for flight simulators and other "visual environment" display systems.

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Reference Type: Journal Article
Author: Oman, C.M.
Year: 1982
Title: A heuristic mathematical model for the dynamics of sensory conflict and motion sickness
Journal: Acta Oto-Laryngologica
Volume: 392
Author's Affiliation and Title: Massachusetts Institute of Technology, Man Vehicle Laboratory, Department of Aeronautics and Astronautics, Cambridge, MA 02139
Number of Pages: 44

Keywords: sensory conflict, motion sickness, vestibular, movement control, autonomic nervous system, mathematical models, biocybernetics

Abstract: The etiology of motion sickness is now usually explained in terms of a qualitatively formulated "sensory conflict" hypothesis. By consideration of the information processing task faced by the central nervous system in estimating body spatial orientation and in controlling active body movement using an "inertial model" references control strategy, a mathematical model for sensory generation is developed.
Further systematic efforts to experimentally refine and validate the model are indicated.

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Reference Type: Journal Article
Author: Oman, C.M., Kendra, A., Hayashi, M., Stearns, M., Bürki-Cohen, J.
Year: 2001
Title: Vertical navigation displays: Pilot performance and workload during simulated GPS constant angle of descent approaches
Journal: International Journal of Aviation Psychology
Volume: 11
Issue: 1
Pages: 15-31

Abstract: This study compared the effect of alternative graphic or numeric vertical navigation aircraft cockpit displays on horizontal and vertical flight technical error, workload, and subjective preference. Displays included (a) a moving map with altitude range arc; (b) the same format, supplemented with a push-to-see profile view, including a vector flight-path predictor; (c) an equivalent numeric display; and (d) a numeric nonvertical navigation display. Sixteen pilots each flew 4 different approaches with each format in a Frasca 242 simulator. Our vertical navigation displays reduced vertical flight technical error by as much as a factor of 2 without increasing workload. Relative advantages of the graphic formats are discussed.

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Reference Type: Conference Proceedings
Author: Orasanu, J., Fischer, U., McDonnell, L.K., Davison, J., Haars, K., Villeda, E., VanAken, C.
Year of Conference: 1998
Title: How do flight crews detect and prevent errors? Findings from a flight simulation study
Conference Name: Human Factors and Ergonomics Society, 42nd Annual Meeting
Pages: 191-195
Author's Affiliation and Title: Orasanu: NASA Ames Research Center, Moffett Field, CA
Fischer: Georgia Institute of Technology, Atlanta, GA
McDonnell, Davison, Haars, Villeda, VanAken: San Jose State University/NASA Ames Research Center, Moffett Field, CA
Number of Pages: 5

Abstract: In order for a team to maintain safety in a high-risk engineered environment, its members must monitor each other's behavior, as well as the situation. The advantage of a team structure is that members can support each other, catching errors and preventing problems from developing into serious situations. In its analysis of aviation accidents in which crew behavior played a role, the National Transportation Safety Board (1994) observed that most of those accidents involved "monitoring and challenging" errors. After an error occurred, the crew either failed to detect it or to communicate effectively in order to ameliorate the outcome.
This paper describes a simulator study that examined two factors thought to affect monitoring and challenging: (1) level of physical risk in a developing situation and (b) degree of face threat involved in a challenge. Events were scripted to present errors committed by a confederate pilot

(high face threat) or problems developing outside the flight deck (low face threat). Videotapes of performance showed that captains were more assertive and responded earlier than first officers, often preventing the problems from developing. This difference, however, was only evident in high-risk situations. First officers were more sensitive to face threat than captains, indicating a need for techniques to overcome limits to error mitigation in high-face threat situations.

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Reference Type: Report
Author: Orlansky, J., String, J.
Year: 1977
Title: Cost effectiveness of flight simulators for military training. Vol I: Use and effectiveness of flight simulators
City: Arlington, VA
Institution: Institute for Defense Analyses
Type: IDA Paper
Report Number: No. 1275

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Reference Type: Journal Article
Author: Ortiz, G.
Year: 1994
Title: Effectiveness of PC-based flight simulation
Journal: International Journal of Aviation Psychology
Volume: 4
Issue: 3
Pages: 285-291
Author's Affiliation and Title: Andrews University
Number of Pages: 7
Abstract: PC-based flight-simulation effectiveness was analyzed through a transfer-of-learning study. Sixty college students with no previous flight experience performed a designated-aircraft maneuver. Thirty of the subjects were trained in a computer-based training device (CBTD) before flying; the remaining 30 were taken directly to the aircraft. Chi-square and t-test analyses on the data revealed a statistical advantage at the .01 level of confidence for the CBTD-trained experimental group, which performed significantly better than the control group. The CBTD chosen for this study was AzureSoft's Electronic Instrument Flight Rules Environment (ELITE), run on a Zenith personal computer. Cessna 150 and 152 aircraft in flight training is recommended because they have the potential for reducing the amount of hours spent in the airplane.

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Reference Type: Report
Author: Osgood, R.K.
Year: 1988
Title: Pitch cueing in the dynamic seat: An exploratory study
Institution: Armstrong Aerospace Medical Research Laboratory Human Engineering Division (AAMRL/HE)
Date: February 29
Type: Technical Memorandum
Report Number: TM-87-RKO-001
Author's Affiliation and Title: Systems Research Laboratories, Inc., A Division of Arvin Calspan

Number of Pages: 10
Keywords: pitch cueing, dynamic seat, seat-pan, RMS error, ALCOGS, seat position, seat pitch angle
Abstract: Appendix includes a list of notes to trackers, a copy of the questionnaire for subjects in the pitch study, and a pitch study system block diagram.

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Reference Type: Conference Proceedings
Author: Padfield, G.D., Lee, D.N., Bradley, R.
Year of Conference: 2001
Title: How do helicopter pilots know when to stop, turn or pull up? Developing guidelines for vision aids
Conference Name: American Helicopter Society 57th Annual Forum
Conference Location: Washington, D.C.
Pages: 1476-1490
Date: May 9-11
Number of Pages: 15
Abstract: The title of this paper, posed as a question, reflects the current interest in gaining an improved understanding of visual perception in flight control to inform the development of design guidelines for future pilot vision aids. The paper develops the optical flow theory of visual perception into its most recent incarnation, tau-coupling, where tau is the time to closure to surfaces at current velocity. General tau-theory posits that the closure of any type of gap, using any form of sensory input, is guided by sensing and constantly adjusting the tau of the gap. According to the theory, and contrary to what might be expected, information about the distance to obstacles or the landing surface, for example, and about the speed and deceleration of approach, are not necessary for precise control of landing or stopping. Analysis is presented that supports the importance of tau-coupling in flight control. Results from simulation trials conducted at DERA and at The University of Liverpool demonstrate the considerable power of what we describe as tau-guides, that lead the pilot to adopt a prospective flight control strategy.

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Reference Type: Journal Article
Author: Parasuraman, R., Riley, V.
Year: 1997
Title: Humans and automation: Use, misuse, disuse and abuse
Journal: Human Factors
Volume: 39
Issue: 2
Pages: 230-252
Date: June
Author's Affiliation and Title: Parasuraman: Catholic University of America
Riley: Honeywell Technology Center
Number of Pages: 24
Abstract: This paper addresses theoretical, empirical, and analytical studies pertaining to human use, misuse, disuse, and abuse of automation technology. Use refers to the voluntary activation or disengagement of automation by human operators. Trust, mental workload, and risk can influence automation use, but interaction between factors and large individual differences make prediction of automation use difficult. Misuse refers to over reliance on automation, which can result in failures of monitoring workload, automation reliability and consistency, and the saliency of automation indicators. Disuse, or the neglect of underutilization of automation, is commonly caused by alarms that activate falsely. This often occurs because the base rate of the condition to be detected is not considered in settling the trade-off between false alarms and omissions. Automation abuse, or the automation of functions by designers and implementation by managers without due regard for the consequences for human performance, tends to define the operator's roles as by-products of the automation. Automation abuse can also promote misuse and disuse of automation by human operators. Understanding the factors associated with each of these aspects of human use of automation can lead to improved system design, effective training methods, and judicious policies and procedures involving automation use.

Reference Type: Report
Author: Parris, B.L., Cook, A.M.
Year: 1978
Title: Effects of visual and motion simulation cueing systems on pilot performance during takeoffs with engine failures
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: December
Type: NASA Technical Paper
Report Number: NASA Technical Paper 1365
Number of Pages: 79
Abstract: Data are presented that show the effects of visual and motion cueing on pilot performance during takeoffs with engine failures. Four groups of USAF pilots flew a simulated KC-135 using four different cueing systems. The most basic of these systems was of the instrument-only type. Visual scene simulation and/or motion simulation was added to produce the other systems. Learning curves, mean performance, and subjective data are examined. These data show that the addition of visual cueing results in significant improvement in pilot performance, but the combined use of visual and motion cueing results in far better performance.

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Reference Type: Newspaper Article
Reporter: Pearl, D.
Year: 1994
Title: Flight test: One air crash suggests pilot's mental state may pose safety risk
Newspaper: The Wall Street Journal
City: Chicopee, MA
Pages: 1, A10
Issue Date: May 25
Number of Pages: 2

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Reference Type: Book Section
Author: Perrott, D.R.
Year: 1982
Title: Studies in the perception of auditory motion
Editor: Gatehouse, R.W.
Book Title: Localization of Sound: Theory and Applications
City: Groton, CT
Publisher: Amphora Press
Pages: 169-193
Author's Affiliation and Title: Psychoacoustics Laboratory, California State University, Los Angeles, Los Angeles, CA 90032
Number of Pages: 25

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Reference Type: Report
Author: Peters, R.A.
Year: 1969
Title: Dynamics of the vestibular system

Institution: NASA
Report Number: NASA CR-1309

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Reference Type: Report
Author: Pfeiffer, M.G., Horey, J.D.
Year: 1987
Title: Training effectiveness of aviation motion simulation: A review and analysis of the literature
City: Orlando, FL
Institution: Naval Training Systems Center
Date: December
Type: Special Report
Report Number: 87-007

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Reference Type: Magazine Article
Author: Phillips, E.H.
Year: 1996
Title: Costs key factor in Part 121 upgrade
Magazine: Aviation Week and Space Technology
Pages: 59-61
Date: May 20
Number of Pages: 3

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Reference Type: Magazine Article
Author: Phillips, E.H.
Year: 1996
Title: CRM focus of FAA's commuter rule
Magazine: Aviation Week and Space Technology
Pages: 61-64
Date: May 20
Number of Pages: 4
Abstract: About 28 commuter airlines are currently upgrading their pilot training and to get ready for the increased use of flight simulators to meet the FAA's Commuter Rule to come into effect March 27. The more stringent training requirements include:
· Adoption of Line Oriented Flight Training (Loft) that will include more frequent use of simulators to practice Crew Resource Management in normal, abnormal and emergency situations. Simulators have not been widely used because of cost and scheduling difficulties. Flight Safety International, Simuflite and other training providers are currently building advanced simulators of turboprop aircraft.
· CRM training mandatory for pilots, cabin attendants and dispatchers
· Inclusion of Initial Operating Experience of the second in command pilot. SIC must have the same IOE as the PIC.
Aircraft most affected by the new training requirements are Jetstream 31/41, Beechcraft Model 1900 C and D, Bombardier/de Havilland Dash 8 series, Dornier 228, Embraer EMB-120 Brasilia, Fairchild Metro series and the Shorts 330/360 series.

Beechcraft Model 99 and Embraer EMB-110 would also be affected, but are likely to be phased out due to noncompliance with performance requirements. This is true also for the Shorts 330/360 series.

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Reference Type: Magazine Article
Author: Phillips, E.H.
Year: 1999
Title: NASA targets transport research
Magazine: Aviation Week and Space Technology
Pages: 41
Date: January 4
Number of Pages: 1
Keywords: NASA, Transport Research Facilities
Abstract: Engineers at the NASA/Langley Research Center are modifying a Boeing 757 into a flying laboratory as part of the agency's Transport Research Facilities project designed to support testing of advanced technology concepts.
In November, the aircraft was designated the Airborne Research Integrated Experiments Systems (Aries) and made its first flight on Dec.10 at Langley facilities in Hampton, Va.
Richard Couch, project manager, said the purpose of the Transport Research Facilities (TRF) program is to provide an efficient means to develop and test new technologies formulated by NASA, government and the civil aviation industry. According to Couch, a key objective of TRF is to support a simulation-to-flight process through use of same or similar hardware and software in both ground-based simulation facilities and the airplane.

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Reference Type: Magazine Article
Author: Phillips, E.H.
Year: 1999
Title: United 747 incident spotlights pilot training, safety issues
Magazine: Aviation Week & Space Technology
Pages: 39-40
Date: March 29
Number of Pages: 2
Abstract: United Airlines' Boeing 747-400 first officer's initial response to an engine failure is fueling concerns about pilot proficiency, current requirements and the airline industry's reliance on simulators to train pilots.

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Reference Type: Conference Proceedings
Author: Pinet, J.
Year of Conference: 1970
Title: Cockpit environment
Conference Name: Simulation
Conference Location: Ames Research Center, Moffett Field, CA
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 5-1 - 5-12
Date: March

Author's Affiliation and Title: S.N.I.A.S., Test Pilot assigned to Concorde, Usines de Toulouse, B.P, 1503, 31, Toulouse, France
Number of Pages: 12
Keywords: cockpit, visual, aural, visual display
Notes: Lead discussion by D. K. Mendela and Dr. Dora Dougherty Strother. Also includes an open discussion.

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Reference Type: Report
Author: Planning Systems International (PSI)
Year: 1984
Title: Airplane simulator use in airman certification: Special project team, facilities and services
City: Falls Church, VA
Institution: Planning Systems International
Pages: 1-24
Date: January 9
Type: Technical and Management Proposal
Report Number: DOT/FHA Regulatory Resume No. VS-83-105-R

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Reference Type: Newspaper Article
Reporter: Pope, S.
Year: 1997
Title: Flight simulators: New corporate and regional sims deliver virtual realism to today's business pilots
Newspaper: Aviation International News
City: Midland, NJ
Pages: 22-28
Issue Date: February 1

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Reference Type: Conference Proceedings
Author: Pouliot, N.A., Nahon, M.A., Gosselin, C.A.
Year of Conference: 1996
Title: Analysis and comparison of the motion simulation capabilities of third-degree-of-freedom flight simulators
Conference Name: Flight Simulation Technologies Conference
Conference Location: San Diego, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 37-47
Date: July 29-31
Author's Affiliation and Title: Nicolas A. Pouliot and Clement M. Gosselin: Departement de Genie Mécanique, University of Laval, Quebec, Qc, Canada
Meyer A. Nahon: Department of Mechanical Engineering, University of Victoria, Victoria, B.C., Canada
Number of Pages: 11
Abstract: We present results of a preliminary study aimed at determining the simulation realism which could be achieved using reduced degree of freedom (DOF) flight simulator motion bases. The quality of motion produced by two different 3-DOF platforms was compared to that produced

by a standard 6-DOF Stewart platform. The 3-DOF motion bases investigated include a spherical mechanism which allows only rotational motions, as well as a motion base capable of heave, pitch and roll motions. To compare the different motion bases, four characteristic maneuvers were simulated using a nonlinear model of a Boeing 747. The aircraft motions were then simulated on nine different combinations of virtual motion platforms and motion base drive algorithms. The motion cues (specific forces and angular velocities) produced in this manner were then graphically compared. The analysis revealed that, in most cases, a 3-DOF simulator is capable of producing motion simulation quality comparable to that produced by a 6-DOF Stewart platform. (Author)

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Reference Type: Journal Article
Author: Previc, F.H., Kenyon, R.V., Boer, E.R., Johnson, B.H.
Year: 1993
Title: The effects of background visual roll stimulation on postural and manual control and self-motion perception
Journal: Perception and Psychophysics
Volume: 54
Issue: 1
Pages: 93-107
Author's Affiliation and Title: Previc: Armstrong Laboratory, Brooks Air Force, TX
Kenyon, Boer: University of Illinois, Chicago, IL
Johnson: KRUG International, San Antonio, TX
Number of Pages: 15
Abstract: The effects of background visual roll stimulation on postural control, manual control, and self-motion perception were investigated in this study. In the main experiment, 8 subjects were exposed to wide field-of-view background scenes that were tilted and static, continuously rotating, or sinusoidally rotating at frequencies between 0.03 and 0.50 Hz, as well as a baseline condition. The subjects performed either a postural control task (maintain an upright stance) or a manual control task (keep an unstable central display horizontally level). Root-mean square (RMS) error in both the postural and manual control tasks was low in the static tilt condition and extremely high in response to continuous rotation. Although the phases of the postural and manual responses were highly similar, the power and RMS error generated by the sinusoidal visual background stimulation peaked at a lower frequency in the postural task. Vection ratings recorded at the end of the postural and manual trials somewhat paralleled the frequency tuning differences between tasks, which a subsequent experiment showed to be the result of the differential motion of the central display rather than the differential positioning of the subject. In general, these results show that the dynamic characteristics of visual orientation systems vary according to the specific motor and/or perceptual system investigated.

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Reference Type: Report
Author: Prince, C.
Year: 1998
Title: Guidelines for situation awareness training
Institution: NAWCTSD/UCF/FAA, Partnership for Aviation Team Training
Type: Training Guide
Author's Affiliation and Title: Ph.D., NAWCTSD/FAA/UCF Partnership for Aviation Team Training
Number of Pages: 75

Reference Type: Report
Author: Prophet, W.W., Boyd, H.A.
Year: 1970
Title: Device-task fidelity and transfer of training: Aircraft cockpit procedures training
City: Fort Rucker, Alabama
Institution: Human Resources Research Organization
Date: July
Type: Technical Report
Report Number: 70-10
Number of Pages: 45

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Reference Type: Report
Author: Prophet, W.W., Caro, P.W., Hall, E.R.
Year: 1972
Title: Some current issues in the design of flight training devices
Institution: Human Resources Research Organization (HumRRO)
Pages: 133-140
Date: March
Type: Professional Paper
Report Number: HumRRO-PP-5-72
Author's Affiliation and Title: Human Resources Research Organization (HumRRO)
Number of Pages: 8
Abstract: The value of the system engineering approach to training program development has become fairly well recognized. Not so well recognized, however, are the implications of the approach for training equipment design. Systems engineering of training focuses on the student and emphasizes the job for which training is to be given. All decisions concerning training should be made in favor of the student. The essential question is always, "How can he best be trained to perform the job he will be required to do?"
In selecting or designing training equipment, of whatever order of complexity, careful attention should be given to what the student needs to know and be able to do to perform successfully on the operational job. Care should be taken to ensure that equipment provides the necessary information context and/or allows for the creation of appropriate job-relevant conditions for performance practice. Too often, though, emphasis is placed solely on duplication of the operational system. The result may be an excellent simulation, but a less-than-optimal trainer. Attention should also be given to the inclusion within design of features whose sole function is to facilitate the student's acquisition of knowledge and skill, features based on the laws and principles which govern human learning and retention. These features may represent deliberate departures from the real-world or operational system model underlying the usual high-fidelity simulation. The learning and performance characteristics of the device user, the student, must be paramount if simulators or trainers are to be maximally effective learning systems.
This paper develops the rationale described and examines several considerations relevant to training equipment design from the systems engineering standpoint. Suggested design features based on particular student learning needs and on student learning characteristics are presented. Training equipment design features for particular categories of training objectives and for levels of training (e.g., initial training of aviators vs. transition training) are considered. Also discussed is the criticality of the synthetic training program with respect to the total training engineering process.

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Reference Type: Journal Article

Author: Prothero, J., Draper, M.H., Furness, T.A., Parker, D.E., Wells, M.J.
Year: 1997
Title: Do visual background manipulations reduce simulator sickness?
Author's Affiliation and Title: Human Interface Technology Laboratory, University of Washington, Seattle, WA USA 98105
Number of Pages: 3

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Reference Type: Report
Author: Puig, J.A., Harris, W.T., Ricard, G.L.
Year: 1978
Title: Motion in flight simulation: An annotated bibliography
City: Orlando, FL
Institution: Naval Training Equipment Center
Date: July
Type: Technical Report
Report Number: NAVTRAEQUIPCEN IH-298
Author's Affiliation and Title: Puig, Ricard: Human Factors Laboratory
Harris: Advanced Simulation Concepts Laboratory
Number of Pages: 159
Keywords: motion simulation, simulator sickness, effects of motion, flight training, motion drive algorithms, motion simulation requirements, motion simulators, cost-effectiveness
Abstract: In support of Project 7744 - *Motion Drive Signals for Flight Simulators*, a review of the literature concerning motion simulation was conducted. Abstracts were included for 682 references. A primary objective of this review was to compare data from the various studies to identify general trends on the effects of motion on performance and training. The publications were listed alphabetically by author, chronologically, and also grouped into eight major categories as follows: reviews and bibliographies; equipment descriptions; (Cont'd)

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Reference Type: Magazine Article
Author: Quantum3D
Year: 2003
Title: Scalable, COTS IG solutions
Magazine: Training & Simulation Journal
Date: May 22
Number of Pages: 1

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Reference Type: Magazine Article
Author: Ramsey, J.W.
Year: 1997
Title: GPS spells efficiency for regional carriers
Magazine: Avionics Magazine
Pages: 24-30
Date: September
Number of Pages: 7
Keywords: ACA
Abstract: United Express carrier Atlantic Coast Airlines is among regional airlines benefiting from GPS-based flight management systems

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Reference Type: Journal Article
Author: Randle, R.J., Sinacori, J.
Year: 1980
Title: Visual space perception
Pages: 257-258
Number of Pages: 2
Keywords: visual space perception, simulation fidelity, perceptual fidelity, functional fidelity

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Reference Type: Conference Proceedings
Author: Ray, P.A.
Year of Conference: 1996
Title: Quality flight simulation cueing - Why?
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: San Diego, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: July 29-31
Author's Affiliation and Title: Manager, Federal Aviation Administration, National Simulator Program
Number of Pages: 11
Abstract: The issue of flight simulation cueing is the subject of many proposals from highly motivated individuals and organizations. Such proposals take on many forms. Some would advocate the removal of motion from all simulation requirements. Others would propose that "PC" based representations of systems are sufficient to qualify as a Flight Training Device for a specific airplane.
This paper addresses the causes for the need for accurate cueing in simulation and the potential impact of less than faithful replication of those cues. Specific areas addressed include motion, visual and tactile feel cueing requirements. Examples of the results of less than accurate cueing are provided. Experiences of simulation within the medical community are reviewed and addressed regarding the impact of less than realistic simulation cueing.

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Reference Type: Conference Proceedings
Author: Ray, P.A.
Year of Conference: 1999
Title: Flight simulator qualification

Conference Name: The Fifteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Pages: 1-21
Date: January 11-15
Author's Affiliation and Title: Manager, Federal Aviation Administration, National Simulator Program
Number of Pages: 21

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Reference Type: Journal Article
Author: Reason, J.T.
Year: 1970
Title: Motion sickness: A special case of sensory rearrangement
Journal: Advancement of Science
Volume: 26
Issue: 130
Pages: 386-393
Author's Affiliation and Title: BSC/Ph.D., University of Manchester, Department of Psychology
Number of Pages: 8

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Reference Type: Journal Article
Author: Reason, J.T.
Year: 1978
Title: Motion sickness adaptation: A neural mismatch model
Journal: Journal of the Royal Society of Medicine
Volume: 71
Issue: November
Pages: 819-829
Author's Affiliation and Title: BSC/Ph.D., University of Manchester, Department of Psychology
Number of Pages: 10

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Reference Type: Journal Article
Author: Regan, W.C., Price, K.R.
Year: 1994
Title: The frequency of occurrence and severity of side-effects of immersion virtual reality
Journal: Aviation, Space, and Environmental Medicine
Volume: 1994
Issue: 65
Pages: 527-530
Author's Affiliation and Title: Regan: B.Sc.
Price: B.A.
Number of Pages: 4

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Reference Type: Electronic Source
Author: Regional Airlines Association (RAA)
Year: 1995
Title: Background on the single safety standard
Producer: Regional Airlines Association (RAA)
Number of Pages: 3
Keywords: safety, "commuter rule," Regional Airlines Association (RAA), regional airlines, Part 121, Part 135
Abstract: Next month, the FAA is expected to announce new regulations that will establish a single safety standard for regional and major airlines. Under the regulatory requirements that exist today, there are a set of rules which apply to aircraft with more than 30 passenger seats and a second set of rules which apply to aircraft with up to 30 passenger seats.
The different set of rules exist because scheduled airline service provided by aircraft with 30 seats or less was very limited when the safety rules were first developed. With the rapid growth of the industry and the advent of increasingly sophisticated new aircraft, the Federal Aviation Administration and the airlines recognized the need for a single rule which would apply to all scheduled airline service operating aircraft with ten passenger seats or more.
The Regional Airline Association and its member companies are strong supporters of the single safety standard. The FAA rulemaking will further enhance safety, increase public appreciation for regional airline services, and help dispel the myth that two sets of regulations means two levels of safety. Under the new rules, all aircraft with ten seats and more will operate under the same regulatory requirements. These standards cover pilot training, pilot rest requirements, safety equipment, dispatching procedures, and every other area of airline and aircraft operations.
Notes: On October 17, 2001 the web page was no longer accessible.
URL: http://www.raa.org/therule.htm

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Reference Type: Report
Author: Reid, L.D., Nahon, M.A.
Year: 1986
Title: Flight simulation motion-base drive algorithms: Part 3. Pilot evaluations
City: Toronto, Canada
Institution: Institute For Aerospace Studies, University of Toronto
Date: December
Report Number: UTIAS Report No. 319
CN ISSN 0082-5255
Author's Affiliation and Title: Reid: Ph.D., P. Eng. Professor, Institute for Aerospace Studies, 4925 Dufferin St., North York, Ontario, Canada M3H5T6, Phone: (416) 667-7705, Fax: (416) 667-7799
Abstract: This report covers the third and final phase of a project aimed at developing and testing flight simulator motion-vase drive algorithms suited to commercial jet transports. Full six degrees-of-freedom motion of a synergistic motion-base was studied. Three forms for these algorithms were considered:
(1) classical linear washout,
(2) optimal control,
(3) coordinated adaptive washout
It was felt that the latter two techniques might provide some advantages over the classical, which is currently employed in most commercial flight simulators. The aims of this project were to:
(1) develop the necessary equations,
(2) implement the necessary real-time software,
(3) evaluate the performance of the software with the help of airline pilots in a complete flight simulation

The present report describes the simulated aircraft and the flight scenarios employed during the evaluation process. The experimental plan and data gathering process are outlined fully. Both subjective pilot ratings and objective performance measures were obtained from seven pilots who evaluated tem different motion-base drive algorithm cases. In addition to using a direct pilot rating technique, about half of the experimental trials were used to obtain paired comparison results for four of the ten algorithm cases.
The pilot ratings, pilot comments and objective measures were analyzed and conclusions are presented based on this. The results highlight both pilot preferences in motion-based drive algorithms and the nature of pilot variability in assessing simulator motion quality.

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Reference Type: Report
Author: Reid, L.D., Nahon, M.A.
Year: 1987
Title: Response of airline pilots to flight simulator motion
City: Toronto, Canada
Institution: The University of Toronto Institute for Aerospace Studies
Report Number: AIAA 87-2436
Author's Affiliation and Title: The University of Toronto Institute for Aerospace Studies, Toronto, Ontario, Canada
Keywords: airline pilots, flight simulator motion, six degrees-of freedom, UTIAS flight research simulator, washout
Abstract: The use of physical motion in flight simulation is still a much debated topic. This paper investigates the more narrow issue of its application in commercial jet transport simulators. We have attempted to quantify the perceptions of airline pilots about the quality of motion possible when a number of different motion-drive algorithms are tested on a simulator employing a state-of-the-art six-degrees-of-freedom motion-base. Four broad categories of algorithms are tested: classical washout, optimal control, coordinated adaptive, and no-motion. It was found that although there was little impact of the algorithm type on performance and control activity, there was a definite effect on how the pilots perceived the simulation environment. Based on these findings, it appears that the coordinated adaptive algorithm is generally preferred by the pilots over the algorithms tested. There was almost unanimous dislike of the no-motion case.

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Reference Type: Journal Article
Author: Reid, L.D., Nahon, M.A.
Year: 1988
Title: Response of airline pilots to variations in flight simulator motion algorithms
Journal: Journal of Aircraft
Volume: 25
Issue: 7
Pages: 639-646
Date: July
Author's Affiliation and Title: Reid: Professor and Associate Director, Associate Fellow AIAA, University of Toronto Institute for Aerospace Studies, Toronto, Ontario, Canada
Nahon: Project Engineer, University of Toronto Institute for Aerospace Studies, Toronto, Ontario, Canada
Number of Pages: 8
Keywords: flight simulator motion algorithms, airline pilots, UTIAS, six-degrees-of-freedom, classical washout, visual displays, motion and visual cue timing, optimal controller

Abstract: The use of physical motion in flight simulation is still a much debated topic. This paper investigates the more narrow issue of its application in commercial jet transport simulators. We have attempted to quantify the perceptions of airline pilots about the quality of motion possible when a number of different motion-drive algorithms are tested on a simulator employing a state-of-the-art six-degrees-of-freedom motion-base. Four broad categories of algorithms were tested: classical washout, optimal control, coordinated adaptive, and no-motion. It was found that although there was little impact of algorithms type on performance and control activity, there was a definite effect on how the pilots perceived the simulation environment. Based on these findings, it appears that the coordinated adaptive algorithm is generally preferred by the pilots over the algorithms tested. There was almost unanimous dislike of the no-motion case.

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Reference Type: Report
Author: Reinach, S.
Year: 2001
Title: An examination of Amtrak's Acela High Speed Rail simulator for FRA research purposes
City: Waltham, MA
Institution: Foster-Miller Inc.
Date: April
Type: Technical Memorandum
Number of Pages: 80

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Reference Type: Journal Article
Author: Ricard, G.L., Parrish, R.V.
Year: 1984
Title: Pilot differences and motion cueing effects on simulated helicopter hover
Journal: Journal of Human Factors
Volume: 26
Issue: 3
Pages: 249-256
Author's Affiliation and Title: Ricard : Naval Training Equipment Center
Parrish : NASA Langley Research Center
Number of Pages: 7
Abstract: The effects that cues of aircraft motion, delays in visual scene, and movement of a ship model have on pilots' ability to hover a simulated helicopter near a destroyer-class ship were examined. Twelve pilots were tested in a within-subject factorial combination of fixed-base, moving-base, and G-seat conditions in which delays of 66 or 128 ms existed in the simulator's visual display and the pilots had to hover near a moving or stationary ship. Best control performance was seen under the moving-base conditions, whereas poorest control was associated with the fixed-base simulation. An intermediate level of performance was produced by the G-seat. In addition, visual delay affected control of the roll axis of the simulation, and interactions between pilots and motion cueing and visual delay were seen. Movement of the ship had little effect.

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Reference Type: Book Section
Author: Riccio, G.E.
Year: 1995

Title: Coordination of postural control and vehicular control: Implications for multimodal perception and simulation of self motion
Editor: Flach, J., Hancock, P., Caird, J., Vicente, K.
Book Title: The Ecology of Human-Machine Systems
City: Hillsdale, NJ
Publisher: Lawrence Erlbaum
Pages: 1-50 + Figures 51-13
Number of Pages: 63
Keywords: self motion, virtual environment, ecological psychology, control theory

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Reference Type: Report
Author: Riccio, G.E., McDonald, P.V.
Year: 1998
Title: Multimodal perception and multicriterion control of nested systems: I. Coordination of postural control and vehicular control
City: Houston, TX
Institution: National Aeronautics and Space Administration (NASA)
Date: January
Type: NASA Technical Paper
Report Number: Performing organization: S-835
Sponsoring organization: TP 3703
Author's Affiliation and Title: Riccio: Nascent Technologies, Ltd.
McDonald: KRUG Life Sciences, Inc.
Number of Pages: 66
Keywords: postural control, vehicular control, whole-body motion, locomotion, ecological psychology, control-systems engineering, motion, motion perception, perception, control, adaptive control
Abstract: The purpose of this report is to identify the essential characteristics of goal-directed whole-body motion. The report is organized into three major sections (Sections 2, 3, and 4). Section 2 reviews general themes from ecological psychology and control-systems engineering that are relevant to the perception and control of whole-body motion. These themes provide an organizational framework for analyzing the complex and interrelated phenomena that are the defining characteristics of whole-body motion. Section 3 of this report applies the organization framework from the first section to the problem of perception and control of aircraft motion. This is a familiar problem in control-systems engineering and ecological psychology. Section 4 examines an essential but generally neglected aspect of vehicular control: coordination of postural control and vehicular control. To facilitate presentation of this new idea, postural control and its coordination with vehicular control are analyzed in terms of conceptual categories that are familiar in the analysis of vehicular control.
Notes: Performing organization: Lyndon B. Johnson Space Center
Sponsoring organization: NASA

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Reference Type: Conference Proceedings
Author: Rich, H.H.
Year of Conference: 1989
Title: Tradeoffs in creating a low-cost visual simulator
Conference Name: Interservice/Industry Training, Simulation & Education Conference
Conference Location: Raleigh, N.C.
Pages: 214-223

Author's Affiliation and Title: Consultant, Star Technologies, Inc., Raleigh, NC
Number of Pages: 10
Abstract: Creating a low-cost visual system for training starts with deciding what features it will provide. Real-time training needs high scene content, photo-derived texture for realism, antialiasing, and careful attention to level of detail to avoid distracting the trainee; map-based CCCI needs fast access to large map databases; software and database development need integration into a workstation with full support for networking and windowing, including the ability to display training scenes under control of the windowing system. A visual system has three main components: a front end to manage the database, a geometric processor to compute the views of each element of the scene, and a shading processor to display the views. The design of each of these components provides a challenge to the system architect, with many old and new algorithms to be evaluated in the light of current technology. The most difficult problems are in shading, where the computational requirements of texturing call for parallel processing: we opted for processing full polygons in parallel, using MIP maps for texturing and a hybrid approach to hidden-surface removal. The front-end and geometry subsystems use easily-programmable processors to take advantage of coherency in the models and to provide flexibility for special effects.

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Reference Type: Conference Proceedings
Author: Ringland, R.F., Stapleford, R.L.
Year of Conference: 1971
Title: Motion cue effects on pilot tracking
Conference Name: Annual Conference on Manual Control
Conference Location: Los Angeles
Volume: 7
Pages: 327-338
Series Title: NASA SP
Author's Affiliation and Title: Systems Technology, Inc.
Number of Pages: 12
Abstract: The results of two successive experimental investigations of the effects of motion cues on manual control tracking tasks are reported. The first of these was an IFR single-axis VTOL roll attitude control task. Describing function data show the dominant motion feedback quantity to be angular velocity. The second experimental task was multiaxis, that of precision hovering of a VTOL using separated instrument displays with reduced motion amplitude scaling. Performance data and pilot opinion show angular position (i.e., g-vector tilt) to be the dominant cue when simulator linear motion is absent.

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Reference Type: Conference Proceedings
Author: Roberts, M.E.C., Murray, P.M.
Year of Conference: 1986
Title: Optical flow - The key to integration of visual and vestibular motion cueing
Conference Name: RAeS Advances in Flight Simulation - Visual and Motion Systems
Publisher: Royal Aeronautical Society (RAeS)
Pages: 191-203
Author's Affiliation and Title: Rediffusion Simulation, U.K.
Number of Pages: 13
Abstract: 1. Visual and Motion
The limitations of motion simulators and visual simulation and their non-linear interaction with the human senses tend to make difficult the prediction of the integrated performance of the two

systems. This paper is an Engineer's attempt to examine major factors involved in the integration so that separate measures of performance of these two systems can lead to a better prediction of integrated performance.

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Reference Type: Magazine Article
Author: Robinson, C.A., Jr.
Year: 1996
Title: Synthetic training duplicates emergency cockpit conditions
Magazine: SIGNAL Magazine
Pages: 1-4
Date: July
Number of Pages: 4
Keywords: reflectone, virtual reality

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Reference Type: Conference Proceedings
Author: Rodchenko, V.V., Boris, S.Y., White, A.D.
Year of Conference: 2000
Title: In-flight estimation of pilots' acceleration sensitivity to thresholds
Conference Name: AIAA Modelling and Simulation Technologies Conference and Exhibit
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics & Astronautics (AIAA)
Pages: 1-8
Date: August 14-17

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Reference Type: Electronic Source
Author: Rolfe, J.
Year: 1999
Title: Twenty-five years of flight simulation - or - It's a long time since I lost a buddy in a training accident
Producer: Royal Aeronautical Society (RAeS), AirSpace Flight Simulation Group
Access Year: 2006
Access Date: Sept. 6
Last Update Date: October 12, 1999
Abstract: (first two paragraphs) Twenty five years in no way encompasses the history of flight simulation, so why chose this time to look back? Two events prompted this article. The first was that in 1970 the Royal Aeronautical Society held its first conference devoted to flight simulation. The success of the conference generated interest and support for the formation of the Society's Flight Simulation Group. Since then the Group has maintained a highly successful international conference programme. Moreover, the Group has taken a number of productive initiatives to enhance understanding and encourage progress in the design and use of flight simulation. This article draws on the activities of the Group to consider the changes that have taken place and the progress that has been achieved.
The second reason for the title was that in 1971 Flight International published an article from me entitled 'The Future of Simulation'. In it I concluded that simulation, at a range of levels, had the potential to play a much greater role in aircrew training. To achieve this objective would require addressing the issue of motivating both users and legislators to accept simulation as a means

acquiring and maintaining competency. Twenty-five years later I will attempt to assess how accurate I was.
Notes: This may have been originally released in 1996. The current version includes a copyright from the Royal Aeronautical Society 1999.
URL: http://www.raes.org.uk/fl-sim/FSG%2025%20Years.htm

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Reference Type: Journal Article
Author: Rolfe, J.M., Hammerton-Fraser, A.M., Poulter, R.F., Smith, E.M.B.
Year: 1970
Title: Pilot response in flight and simulated flight
Journal: Ergonomics
Volume: 13
Issue: 6
Pages: 761-768
Author's Affiliation and Title: All: Royal Air Force Institute of Aviation Medicine
Number of Pages: 8
Abstract: This paper describes an experiment in which an attempt was made to assess the value of two types of response, control activity and physiological activity, as indications of the effect on simulator fidelity of adding pitch motion cues. The investigation used a general-purpose research simulator and a two-seater Hunter T7 aircraft. The responses of nine experienced pilots were compared when, flying on instruments, they undertook the same flight plan under three different conditions namely:
flight in the Hunter T7 aircraft:
simulated flight in the simulator with pitch motion present;
simulated flight in the same simulator without motion.

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Reference Type: Edited Book
Editor: Rolfe, J.M., Staples, K.J.
Year: 1986
Title: Flight simulation
Series Title: Cambridge aerospace series
City: Cambridge, United Kingdom
Publisher: Cambridge University Press
Edition: Paperback
ISBN: ISBN 0-521-35751-9
Author's Affiliation and Title: Rolfe: Senior Principal Psychologist, Ministry of Defence
Staples: Royal Aircraft Establishment, Bedford

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Reference Type: Journal Article
Author: Rolnick, A., Lubow, R.E.
Year: 1991
Title: Why is the driver rarely motion sick? The role of controllability in motion sickness
Journal: Ergonomics
Volume: 34
Issue: 7
Pages: 867-879

Author's Affiliation and Title: Rolnick: Israeli Naval Hyperbaric Institute, Motion sickness and Human Performance Laboratory, Haifa, Israel
Lubow: Tel-Aviv University, Department of Psychology, Tel-Aviv, Israel
Number of Pages: 13
Keywords: motion sickness, controllability, stress (psychological)
Abstract: The central hypothesis of the work is that the dimension of control-no control plays an important role in motion sickness. Although it is generally agreed that having control over a moving vehicle greatly reduces the likelihood of motion sickness, few studies have addressed this issue directly, and the theoretical explanation for this phenomenon is not completely clear. In the study, we equated groups differing in controllability for head movement, vision, activity, and predictability, which have often been suggested in the literature as explanations for the driver's immunity to motion sickness. Twenty-two pairs of yoked subjects were exposed to nauseogenic rotation. One subject of each pair had control over the rotation and head movements, while the other was exposed passively to the same motion stimulus. Subjects who had control reported significantly fewer motion sickness symptoms and less of a decrement in their well-being, as compared to the yoked subject without control. The results are discussed in relation to Reason's sensory rearrangement theory and the concept of feed-forward mechanisms in motion perception.

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Reference Type: Conference Proceedings
Author: Romano, R.
Year of Conference: 2001
Title: Round Table Discussion: Motion Cueing Issues
Conference Name: 1st Human Centered Transportation Simulation Conference
Conference Location: Iowa City, Iowa
Date: November 4-7

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Reference Type: Journal Article
Author: Roscoe, S.N.
Year: 1991
Title: Simulator qualification: Just as phony as it can be
Journal: International Journal of Aviation Psychology
Volume: 1
Issue: 4
Pages: 335-339
Author's Affiliation and Title: ILLIANA Aviation Sciences Limited, Arcata, CA and Las Cruces, NM
Number of Pages: 5
Abstract: The qualification of airplane simulators for pilot training is based on the assumption that transfer of such training is directly related to the similarity of the device to an actual airplane. The consequence of this widely held position has been the specification of training device requirements solely on the basis of engineering criteria. However, the proper criterion is the flight hours saved in airborne training for each incremental investment in ground training. Furthermore, research has shown that innovation in training strategies, in some cases involving intentional departures from reality, can have stronger effects than high simulator fidelity on the resulting quality of pilot performance. Ideally, each aspect of the training curriculum could be taught to some criterion performance level on the ground. Competence in each block of training would be demonstrated after a brief transition in the airplane. Certification for each license and rating would

be based on demonstrated competence, thereby making possible large reduction in the minimum required flying hours. Credit for ground-based training would no longer be a formal issue.

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Reference Type: Generic
Author: Roscoe, S.N.
Year: 2002
Title: The transfer of training effectiveness of personal Computer Aviation Training Devices (PCATDs)
Type of Work: Research paper

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Reference Type: Book
Author: Rosenthal, R., Rosnow, R.L.
Year: 1991
Title: Essentials of behavioral research methods and data collection
Publisher: McGraw-Hill
Number of Pages: 692
Edition: 2nd
Author's Affiliation and Title: Robert Rosenthal: Harvard University
Ralph L. Rosnow: Temple University

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Reference Type: Journal Article
Author: Rouse, W.B., Gopher, D.
Year: 1977
Title: Estimation and control theory: Application to modeling human behavior
Journal: Human Factors
Volume: 19
Issue: 4
Pages: 315-329
Date: August
Author's Affiliation and Title: Rouse: University of Illinois at Urbana-Champaign
Gopher: The Technion, Haifa, Israel
Number of Pages: 15
Abstract: The methodology of estimation and control theory is considered in terms of response, stability, estimation, and control of linear dynamic systems. Within the context of discrete-time systems, multi-input, multi-output, n^{th}-order linear systems are discussed, and general results for optimal estimation, optimal control, and other topics are presented. The application of these results to modeling human behavior is considered with special emphasis on man-machine system models.

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Reference Type: Generic
Author: Royal Aeronautical Society (RAeS)
Year: 1981, 1982, 1986, 1987, 1989

Title: Flight simulation papers
Notes: Table of contents only

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Reference Type: Conference Proceedings
Author: Royal Aeronautical Society (RAeS)
Year of Conference: 1986
Title: Some fundamentals of simulator cockpit motion generation
Conference Name: Advances in Flight Simulation: Visual and Motion Systems: International Conference Proceedings
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Pages: 81-100
Date: April 20-May 1
Number of Pages: 20
Keywords: problem areas of aircraft simulator motion generation, motion simulation, false motion cues, disturbance cues, confidence cues, onset, transient and sustained cues, simulation time-delays
Abstract: After showing a few examples of motion hardware quality assessment, the present paper highlights some problem areas of aircraft simulator motion generation. Since motion simulation is, by nature, an engineering compromise, motion simulation errors (false motion cues) have to be accepted.
A qualitative framework, featuring disturbance cues, confidence cues and false cues on the one side and onset, transient and sustained cues on the other, is proposed and some examples of false transient cues due to motion filtering will be considered in the light of recent man machine research at Delft University of Technology. Special attention is given to proper phasing of motion cues and the role of simulation time-delays in connection with measured human operator time-delays.

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Reference Type: Conference Proceedings
Author: Royal Aeronautical Society (RAeS)
Year of Conference: 1992
Title: Matching technology to training requirements
Conference Name: European Forum on Matching Technology to Training Requirements
Publisher: Royal Aeronautical Society (RAeS)
Date: May 19-20
Notes: Paper titles:
1) Area of Interest Parameters for Effective Pilot Training (By Hodgson, Murray, and Plummer)
2) Simulator Computer Systems - Technology for the 1990s (By Burgin)
3) Improved Reliability (By Irving)
4) An Instructor Station for the Instructor (By Goode and Evans)
5) The Civilian Simulator - A User's View (By Hall)
6) Quick-Response Training System Modification and its Impact on Army Aviation Sustainment Training (By Matusof, Polkowski, and Fullmer)
7) Issues in Training Device Design (By Wilson
8) Full Mission Simulation - An Operator's View (By Williams)
9) The Advanced Qualification Program: Matching Technology to Training Requirements (By Longridge)
10) Beyond AQP - Broad Spectrum Product Family Integration for Aircrew Training (By Francis and Heybroek)

11) The Cost Effective Flight Training Device (By Prime)
12) Flight Training Devices - Meeting the Low-End Requirements (By Upton)
13) The Simulation of Taxiing Aircraft (By Hogg, Self, Pearce, and Kapadoukas)
14) A Case for Simulator Motion Standards (By Boothe)
15) Some Considerations for the Definition of Motion Cue Validation Tests (By Luijt and van de Moesdijk)
16) Analysis and Development of Advanced Techniques for Cueing the Force and Motion Environment in the Simulator of the Future (By Cardullo and McMillan)
17) Designing a Truly Portable Simulation Application - It Can Be Done (By Nutt)

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Reference Type: Report
Author: Royal Aeronautical Society (RAeS)
Year: 1995
Title: Use of engineering simulator data as a supplement to flight test data to support flight simulator qualification for modified or derivative aeroplanes
Institution: Royal Aeronautical Society (RAeS)
Date: December 14
Type: Draft
Number of Pages: 11
Keywords: aeromodel, flight test data

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Reference Type: Conference Proceedings
Author: Royal Aeronautical Society (RAeS)
Year of Conference: 1996
Title: Proposal for use of engineering simulator data as a supplement to flight test data to support flight simulator qualification for modified or derivative aeroplanes
Conference Name: Flight Simulation Data Conference
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Edition: Draft
Date: May 17
Number of Pages: 15

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Reference Type: Conference Proceedings
Author: Royal Aeronautical Society (RAeS)
Year of Conference: 1996
Title: Training: Lowering the cost, maintaining the fidelity
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Date: May 15-16
Number of Pages: 2

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Reference Type: Conference Proceedings
Author: Royal Aeronautical Society (RAeS)
Year of Conference: 2000
Title: Proceedings
Conference Name: Flight Simulation--The Next Decade
Conference Location: London, UK
Publisher: RAeS
Date: May 10-12
Notes: Contents:
Keeping Simulators in Pace with a Fourth Generation Fighter Aircraft (by S. Sandberg, Saab Aerospace, Sweden)
Interactive Hybrid Environment Training (by Sqn. Ldr. J. Sullivan, Ministry of Defence, UK)
Applications and Future Trends in Synthetic Environments for Military Training Systems (by Dr. P. Howells and D. Siksik, CAE Electronics, Canada)
Ab-Initio Simulation in the 21st Century (by Capt. S. Green, BAE SYSTEMS Flight Training (Europe), Spain)
Flight Crew Training Needs for the Future (by Capt. J. Pugh and Capt. S. Wood, Virgin Atlantic Airways, UK)
The Instructor/Operator Station - Where Do We Go From Here? (by V. Faconti, The Boeing Company, USA)
MSHATF - Delivering Military Helicopter Training in the New Millenium (by B. Symes, CAE Aircrew Training Services, UK)
Aviation Instruction through Flight Simulation: Enhancing Pilot Decision-Making Skills (by Dr. M. Green, Embry-Riddle Aeronautical University, USA)
The Future and Technology of Remote Training: "Bringing Training to the Pilot" (by Dr. D. White, Thomson Training & Simulation, UK)
The Role of the Regulator (by D. Otto, Joint Aviation Authorities, The Netherlands and D. Irving, Civil Aviation Authority, UK)
Is Today's Flight Simulator Prepared for Tomorrow's Requirements? (by P. Ray, Federal Aviation Administration, USA)
The Importance of Matching Technology Advancement With Training Needs (by Capt. K. Caudrey, Flight Safety Boeing Trading International, Canada)
Developments in Data Communications and their Effect on Simulation (by P. Brash, Thomson Training and Simulation, UK)
Improving the Value of Commercial Training Simulators: Key Concerns and the Search for Resolution (by R. Curnutt and K. Neville, Boeing Commercial Airplane Group, USA)
Predictive Models for Aerial Refueling Simulations (by C. Svoboda and G. Ryan III, Kohlman Systems Research, USA)
PC Simulators: Don't Call Them Games Anymore (by G. Pisanich, Jane's Combat Simulations/Electronic Arts, USA)
Simulator Fidelity - The Effect of Platform Motion (by Dr. J. Bürki-Cohen, US Department of Transportation, E. Boothe and Dr. N. Soja, Consultants, Dr. R. Disario, Bryant College, Dr. T. Go, Massachusetts Institute of Technology, and Dr. T. Longridge, Federal Aviation Administration, USA)
Integrated Motion Cueing Algorithm and Motion-Based Design for Flight Simulators (by Dr. S. Advani, Aircraft Development and Systems Engineering, and Dr. R. Hosman, Aerospace Man-Machine Systems Consulting, The Netherlands)
The "All Digital Display" (by P. Berwick, SEOS Displays Ltd., UK)
Future Visual Systems Technology (by A. Fernie, CAE Electronics, Canada)
Systems and Research in Networked Tactical Training (by Dr. R. Kruk, CAE Electronics, Canada, Dr. D. Wightman and Dr. W. Howse, US Army Research Institute, USA)
Distributed Simulation Using COTS Software and Commodity Hardware (by A. Jenkins and F. Lambert, Boeing Commercial Airplane Group, USA)
Network Enabled Image Generators in DIS and HLA Environment (by L. Call, Air Force Research Laboratory, USA)

Collective Training - Virtually a Reality or Still Over the Horizon (by A. Aylward, Thomson Training and Simulation, UK)

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Reference Type: Electronic Source
Author: Royal Aeronautical Society (RAeS)
Year: 2002
Title: Flight Simulation Group position paper: Flight simulation
Access Year: 2006
Access Date: Sept. 6
Last Update Date: March 5, 2002
Abstract: This paper is intended as a briefing document summarizing the advantages and uses of flight simulation, describing some of the current technology available, indicating how and why it works, and summarizing the current national and international regulatory framework.
URL: http://www.raes.org.uk/fl-sim/FSG%20Position%20Paper.htm

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Reference Type: Report
Author: Ryan, L.E., Scott, P.G., Browning, R.F.
Year: 1978
Title: The effects of simulator landing practice and the contribution of motion simulation to P-3 pilot training
City: Orlando, FL
Institution: Navy Training Analysis and Evaluation Group
Date: September
Report Number: TAEG Report No. 63
Number of Pages: 39

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Reference Type: Conference Proceedings
Author: Sabourin, M.-O., Sondermeyer, V.
Year of Conference: 2000
Title: G-cueing for fighter simulation training
Conference Name: Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-9
Date: August 14-17
Author's Affiliation and Title: CAE, Montreal, Canada
Number of Pages: 9
Abstract: An operator can be regarded as a set of sensors with a feedback algorithm (reflexes and skills), rules, and a knowledge base that are used in stabilizing and controlling an aircraft in a given flight path. Motion cueing devices play a role in the training tool by enabling the trainee to develop proper control strategy (tuning the gains of the feedback algorithm), and to acquire parts of the required set of rules and knowledge base (by simulating representative workload, for example). The motion system and the g-seat both have relative advantages and disadvantages and the choice of one, the other, or both must be made on the basis of an optimal alignment between the training objectives and the capabilities of the training device. This paper will describe an optimized g-cueing seat design and compare its training potential with a standard Stewart motion platform by evaluating their respective effects on the pilot control loop, on the required workload and on their effectiveness in facilitating the training of rule-based and knowledge-based behaviors.

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Reference Type: Edited Book
Editor: Salas, E., Bowers, C.A., Prince, C.
Year: 1998
Title: Simulation and training in aviation
Series Title: International Journal of Aviation Psychology
City: Mahwah, NJ
Publisher: Lawrence Erlbaum Associates
Volume: 8
Number of Pages: 317

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Reference Type: Edited Book
Editor: Salas, E., Bowers, C.A., Prince, C., (Guest Eds.)
Year: 1998
Title: International journal of aviation psychology - Special issue: Simulation and training in aviation
Series Editor: Jensen, R.S.
Series Title: International Journal of Aviation Psychology
Publisher: Lawrence Erlbaum Associates
Volume: 8 (3)
Notes: Contents:
Preface:
Special issue on Simulation and Training in Aviation (by E. Salas, C.A. Bowers, and C. Prince)
Formal Papers:
It Is Not How Much You Have but How You Use It: Toward a Rational Use of Simulation to Support Aviation Training (by E. Salas, C.A. Bowers, and L. Rhodenizer)

Event-Based Approach to Training (EBAT) (by J. Fowlkes, D.J. Dwyer, R.L. Oser, and E. Salas)
Evaluating the Effectiveness of Flight Simulators for Training Combat Skills: A Review (by H.H. Bell and W.L. Waag)
Evidence for the Validity of PC-Based Simulations in Studying Aircrew Coordination (by F. Jentsch and C.A. Bowers)
Computer-Based Simulations as an Adjunct to Ab Initio Flight Training (by K.A. Davis and D. Harris)
Personal Computer-Based Flight Training Devices (by J.M. Koonce and W.J. Bramble, Jr.)
Simulator Platform Motion - The Need Revisited (by J. Bürki-Cohen, N. Soja, and T. Longridge)

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Reference Type: Journal Article
Author: Salas, E., Bowers, C.A., Rhodenizer, L.
Year: 1998
Title: It is not how much you have but how you use it: Toward a rational use of simulation to support aviation training
Journal: The International Journal of Aviation Psychology
Volume: 8
Issue: 3
Pages: 197-208
Author's Affiliation and Title: Salas: Naval Air Warfare Center Training Systems Division, Orlando, FL
Bowers, Rhodenizer: Department of Psychology, University of Central Florida, Orlando, FL
Number of Pages: 12
Keywords: simulation use, aviation training, overreliance on high-fidelity simulation, misuse of simulation
Abstract: One of the most remarkable changes in aviation training over the past few decades is the use of simulation. The capabilities now offered by simulation have created unlimited opportunities for aviation training. In fact, aviation training is now more realistic, safe, cost-effective, and flexible than ever before. However, we believe that a number of misconceptions--or invalid assumptions--exist in the simulation community that prevent us from fully exploiting and utilizing recent scientific advances in a number of related fields in order to further enhance aviation training. These assumptions relate to the overreliance on high-fidelity simulation and to the misuse of simulation to enhance learning of complex skills. The purpose of this article is to discuss these assumptions in the hope of initiating a dialogue between behavioral scientists and engineers.

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Reference Type: Report
Author: Sallee, G.P., Gibbons, D.M.
Year: 1998
Title: AIA/AECMA project report on Propulsion System Malfunction plus Inappropriate Crew Response (PSM + ICR)
Date: November 1
Type: 2 Volumes of Project Report
Author's Affiliation and Title: Salle: AIA Co-Chair
Gibbons: AECMA Co-Chair
Number of Pages: Volume 1: 82
Volume 2: 179

Reference Type: Journal Article
Author: Sattler, D.E., Sinclair, M., Kereliuk, S.
Year: 1980
Title: An investigation of the recovery from an engine failure in a twin engine augmentor wing aircraft using the NAE Airborne Simulator
Journal: Canadian Aeronautics and Space Journal
Pages: 26-40
Author's Affiliation and Title: National Aeronautical Establishment
Number of Pages: 15
Abstract: A brief piloted simulation program was conducted using the NAE Airborne Simulator to investigate the airworthiness aspects of a twin engine augmentor wing aircraft experiencing an engine failure during final approach. Three evaluation pilots flew a series of STOL approaches (-7.5 degree glideslope to a 4000 ft runway) consisting of normal two engine approaches and approaches on which an engine was failed at a height ranging from 17 to 92 ft above the runway elevation. Quantitative and qualitative flight evaluation data were collected illustrating that acceptable touchdown sink rates could be achieved following an engine failure at any point on the approach, provided that adequate pilot warning systems and automatic thrust compensation systems were available, and that correct pilot recovery technique was employed.

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Reference Type: Report
Author: Scanlon, C.H.
Year: 1987
Title: Effect of motion cues during complex curved approach and landing tasks
Pages: 1-24
Date: December
Type: NASA Technical Paper
Report Number: NASA TP-2773
Author's Affiliation and Title: Arkansas State University, AR
Number of Pages: 27
Keywords: simulator motion, workload, complex approach paths
Abstract: A piloted simulation study was conducted to examine the effect of motion cues using a high-fidelity simulation of a commercial airplane during the performance of complex curved approach and landing tasks in the signal environment of the microwave landing system (MLS). The data from these tests indicate that in a high-complexity MLS approach task with moderate turbulence and wind, the pilot uses motion cues to improve path tracking performance. No significant differences in tracking accuracy were noted for the low- and medium-complexity tasks, regardless of the presence of motion cues. Higher control-input rates were measured for all the tasks when motion was used. Pilot eye scan, as measured by instrument dwell time, was faster when motion cues were used regardless of the complexity of the approach tasks. A pilot subjective rating, based on time, mental effort, and psychological stress loads, yielded larger work load ratings with motion than with no motion. Pilot comments indicated a preference for motion. With motion cues, pilots appeared to work harder in all levels of task complexity and to improve tracking performance in the most complex approach task.

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Reference Type: Journal Article
Author: Scerbo, M.W.
Year: 2005
Title: Medical virtual reality simulators: Have we missed an opportunity?
Journal: Human Factors and Ergonomics Society (HFES) Bulletin

Volume: 48
Issue: 5
Pages: 1-3
Date: May
Number of Pages: 4
Abstract: (taken from introduction) Interest in simulators for training has a long history within the human factors profession. In fact, articles addressing driving simulation and simulated displays for vigilance monitoring began appearing in the pages of Human Factors in the early 1960s. Since then, more than 400 articles on simulation topics such as flight, air traffic control, command and control, driving, power plant operation, and simulator networking have appeared in Human Factors, Ergonomics in Design, and the annual meeting proceedings (see also Swezey & Andrews, 2001). In the early 1970s, interest in medical issues also began to be reflected in the pages of Human Factors. A formal technical group called Medical Systems and Rehabilitation was formed in 1992 (now called the Health Care Technical Group). Today, more than 100 articles can be found in our literature addressing diagnoses,
medical devices, errors, procedures, and patient safety.
URL: http://www.hfes.org/web/BulletinPdf/bulletin0505.pdf

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Reference Type: Journal Article
Author: Schmerler, J.
Year: 1976
Title: The visual perception of accelerated motion
Journal: Perception
Volume: 5
Issue: 2
Pages: 167-185
Author's Affiliation and Title: Department of Social Science, Fordham University, Lincoln center Campus, New York 10023
Number of Pages: 19
Abstract: The present research is an investigation of how changes in the rate of motion are perceived. Five separate experiments were performed with the use of filmed stimulus material and a variety of response measures, including both categorical judgments and reproduction techniques. It was found that (a) the smaller the ratio of terminal to initial velocity, the less frequent the judgments of acceleration or deceleration, (b) deceleration was significantly easier to perceive than acceleration, (c) the perception of acceleration was facilitated when the velocity of a lead-in segment was the same as the velocity at onset of motion, (d) a short tunnel centered in the motion path facilitated the perception of acceleration and deceleration, and (e) instantaneous changes in velocity were much more easily perceived than gradual changes. A one-event model for the perception of motion change in which there is a continuous interplay between earlier, later, and interpolated motion segments is favored over a two-event model in which earlier and later segments of velocity are compared.

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Reference Type: Report
Author: Schmidt, S.F., Conrad, B.
Year: 1970
Title: Motion drive signals for piloted flight simulators
City: Palo Alto, CA
Institution: National Aeronautics and Space Administration (NASA)
Report Number: NASA CR-1601

Author's Affiliation and Title: NASA Ames Research Center
Number of Pages: 75
Abstract: An important aspect of many piloted flight simulators in their ability to provide realistic motion cues. Since such simulators are constrained to move within the confines of their mechanical drive systems, they cannot duplicate all motions (and hence all the motion cues) associated with a real aircraft. In order to use the limited motion capabilities of a simulator effectively it is thus necessary to a) determine which motion cues are important to a pilot; b) ascertain which cues are attainable within the drive system capabilities of a simulator; c) synthesize logic for commanding motion achievable by the drive system and realistic to a pilot. This report summarizes a mathematical approach to this problem and presents logic synthesized for the Ames All-Axis Motion Generator. Both the theory developed and the logic presented should be applicable to a wide variety of motion simulation problems.

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Reference Type: Report
Author: Schroeder, J., Chung, W., Tran, D., Laforce, S.
Year: 1998
Title: Pilot-induced oscillation prediction with three levels of simulation motion displacement
Institution: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-11
Report Number: 98-4333
Author's Affiliation and Title: Schroeder, Chung, Tran: NASA Ames Research Center, Moffett Field, CA
Laforce: SYRE Logicon, Moffett Field, CA
Number of Pages: 11
Abstract: Simulator motion platform characteristics were examined to determine if the amount of motion affects pilot-induced oscillation (PIO) prediction. Five test pilots evaluated how susceptible 18 different sets of pitch dynamics were to PIOs with three different levels of simulation motion platform displacement: large, small, and none. The pitch dynamics were those of a previous in-flight experiment, some of which elicited PIOs. These in-flight results served as truth data for the simulation. As such, the in-flight experiment was replicated as much as possible. Objective and subjective data were collected and analyzed. With large motion, PIO and handling qualities ratings matched the flight data more closely than did small motion or no motion. Also, regardless of the aircraft dynamics, large motion increased pilot confidence in assigning handling qualities ratings, reduced safety pilot trips, and lowered touchdown velocities. While both large and small motion provided a pitch rate cue of high fidelity, only large motion presented the pilot with a high fidelity vertical acceleration cue.

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Reference Type: Conference Proceedings
Author: Schroeder, J., Chung, W.W.Y., Hess, R.A.
Year of Conference: 1999
Title: Spatial frequency and platform motion effects on helicopter altitude control
Conference Name: Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 171-181
Date: August 9-11
Author's Affiliation and Title: Schroeder: NASA Ames Research Center, Moffett Field, CA
Chung: Logicon Information Systems & Services, Moffett Field, CA
Hess: University of California, Davis, CA

Number of Pages: 11
Abstract: An experiment examined how visual scene and platform motion variations affected a pilot's ability to perform altitude changes. Pilots controlled a helicopter model in the vertical axis and moved between two points 32-ft apart in a specified time. Four factors were varied: visual scene spatial frequency, visual scene background, motion filter gain, and motion filter natural frequency. Drawing alternating black and white stripes of varying widths between the two extreme altitude points varied visual scene spatial frequency. Visual scene background varied by either drawing the stripes to fill the entire field-of-view or by placing the stripes on a narrow pole with a natural sky and ground plane behind the pole. Both the motion filter gain and natural frequency were varied in the motion platform command software. Five pilots evaluated all combinations of the visual and motion variations. The results showed that only the motion filter natural frequency and visual scene background affected pilot performance and their subjective ratings. No significant effects of spatial frequency or motion system gain found for the values examined in this tracking task. A previous motion fidelity criterion was found to still be a reasonable predictor of motion fidelity.

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Reference Type: Journal Article
Author: Schroeder, J.A.
Year: 1996
Title: Evaluation of simulation motion fidelity criteria in the vertical and directional axes
Journal: Journal of the American Helicopter Society
Pages: 44-57
Date: February
Author's Affiliation and Title: Aerospace Engineer, NASA Ames Research Center, Moffett Field, CA
Number of Pages: 14
Abstract: An evaluation of existing motion fidelity criteria was conducted on the NASA Ames Vertical Motion Simulator. Experienced test pilots performed single-axis repositioning tasks in both the vertical and the directional axes using transfer-function approximations of a hovering helicopter. Gain and natural frequency variations were made only in the software filters that attenuate the commands to the simulator motion system. The variations spanned motion response characteristics from nearly full math-model motion to fixed-base. Between configurations, pilots recalibrated their motion response perception by flying the task with full motion. Pilots subjectively rated the motion fidelity of subsequent configurations relative to this full motion base, which was considered the standard for comparison. The results suggested that the existing vertical-axis criterion was accurate for combination of gain and natural frequency changes. However, if only the gain or the natural frequency was changed, the rated motion fidelity was better than the criterion predicted. In the vertical axis, the objective and subjective results indicated that a larger gain reduction was tolerated than the existing criterion allowed. Significant degradations in performance were noted between the full-vertical motion and no-vertical motion configurations. The limited data collected in the yaw axis revealed that pilots had difficulty in distinguishing among the variations in the pure yaw motion cues, thus indicating that pure yaw motion may be of little importance in hovering flight simulation.

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Reference Type: Report
Author: Schroeder, J.A.
Year: 1999
Title: Helicopter flight simulation motion platform requirements
Date: July

Report Number: Organization report number: A-9900432
Sponsor's report number: NASA/TP-1999-208766
Author's Affiliation and Title: Schroeder: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 84
Keywords: flight simulation, helicopters, motion platforms
Abstract: To determine motion fidelity requirements, a series of piloted simulations was performed. Several key results were found. First, lateral and vertical translational platform cues had significant effects on fidelity. Their presence improved performance and reduced pilot workload. Second, yaw and roll rotational platform cues were not as important as the translational platform cues. In particular, the yaw rotational motion platform cue did not appear at all useful in improving performance or reducing workload. Third, when the lateral translational platform cue was combined with visual yaw rotational cues, pilots believed the platform was rotating when it was not. Thus, simulator systems can be made more efficient by proper combination of platform and visual cues. Fourth, motion fidelity specifications were revised that now provide simulator users with a better prediction of motion fidelity based upon the frequency responses of their motion control laws. Fifth, vertical platform motion affected pilot estimates of steady-sate altitude during altitude repositionings. Finally, the combined results led to a general method for configuring helicopter motion systems and for developing simulator tasks that more likely represent actual flight. The overall results can serve as a guide to future simulator designers and to today's operators.

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Reference Type: Conference Proceedings
Author: Schroeder, J.A., Chung, W.W., Laforce, S.
Year of Conference: 1997
Title: Effects of roll and lateral flight simulation motion gains on a sidestep task
Conference Name: American Helicopter Society 53rd Annual Forum
Conference Location: Virginia Beach, VA
Date: April 29-May 1
Abstract: To represent coordinated maneuvers accurately in a ground-based flight simulator, the motion platform must translate laterally when it rolls. Typical platform lateral displacement limits often prevent an accurate representation of such maneuvers. The result is that the pilot receives an uncoordinated lateral specific force (ball not centered) when the model is not calculating one. This study examined the effects of these false uncoordinated roll-lateral motion cues when using a coordinated math model. The vehicle model represented a typical helicopter with satisfactory handling qualities in the roll-lateral axes. The task was a two-degree-of-freedom sidestep, in which the pilot controlled lateral position through roll attitude. Two gains varied in the motion platform control. One gain controlled the ratio between platform roll angle and math model (and thus visual) roll angle. The other gain controlled the amount of lateral platform movement, relative to the amount needed, to keep the apparent gravity vector aligned vertically about the pilot. Both gains varied from zero to one. With both gains equal to one, pilots evaluated the true 1:1 motion case, in which the motion cues matched the visual cues. As the motion cues degraded, both objective and subjective evaluations worsened. Pilot opinions of motion fidelity reasonably matched a combination of criteria developed previously.

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Reference Type: Conference Proceedings
Author: Schroeder, J.A., Johnson, W.W.
Year of Conference: 1995
Title: Yaw motion cues in helicopter simulation

Conference Name: AGARD FVP Symposium on "Flight Simulation -- Where are the Challenges?"
Conference Location: Braunschweig, Germany
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 5-1 - 5-15
Date: May 22-25
Author's Affiliation and Title: NASA Ames Research Center, Mail Stop 262-3, Moffett Field, CA
Abstract: 1. SUMMARY
A piloted simulation that looked at the effects of yaw motion cues on pilot-vehicle performance, pilot workload, and pilot motion perception was conducted on the NASA Ames Vertical Motion Simulator. The vehicle model that was used represented an AH-64 helicopter. Three tasks were performed in which only combinations of vehicle yaw and vertical displacement were allowed. The commands issued to the motion platform were modified to present the following four motion configurations for a pilot located forward of the center of rotation: 1) only the linear translations, 2) only the angular rotation, 3) both the linear translations and the angular rotations, and 4) no motion. The objective data indicated that pilot-vehicle performance was reduced and the necessary control activity increased when linear motion was removed; however, the lack of angular motion did not result in a measured degradation for almost all cases. Also, pilots provided subjective assessments of their compensation required, the motion fidelity, and their judgment of whether or not linear or rotational cockpit motion was present. Ratings of compensation and fidelity were affected by linear acceleration, and the rotational motion had no significant impact. Also, when only linear motion was present, pilots typically reported the presence of rotation. Thus, linear acceleration cues, not yaw rotational cues, appear necessary to simulate hovering flight.

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Reference Type: Conference Proceedings
Author: Schweikhard, W.G., Platz, S.J., Halverstadt, D.E., Landis, D., Bounajem, E.
Year of Conference: 1990
Title: Flight test data processing, plotting and analysis at your finger tips--A flexible, automated, integrated approach
Conference Name: AIAA/SFTE/DGLR/SETP Fifth Biannual Flight Test Conference
Conference Location: Ontario, Canada
Pages: 1-13
Date: May 22-24
Author's Affiliation and Title: Kohlman Systems Research (KSR), Lawrence, KS
Abstract: Modern flight test data acquisition systems do not put the data where it is needed, namely in the hands of the analysis engineer who is charged with producing the final report. Those that do, do not provide the analysis engineers the flexible versatile software that allows them to operate on it in the way they want. The Flight Test Applications Software Package (FTASP) is an example of the sort of software that is needed for accessing today's huge data bases, breaking them down to a size that is usable by the analysis engineer and providing all of the tools needed to operate on the data and prepare the final report. FTASP specifically addresses the analysis of aircraft performance, stability and control, but this is only a sample. The concept can be easily appended to accommodate the flight test disciplines of propulsion, loads, structural dynamics and systems test. Employing FTASP concepts and approaches could greatly enhance our ability to produce final results early and diminish our reliance on preliminary and partially complete real time quick look results as the basis for major decisions in the development of airplanes and systems.

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Reference Type: Generic
Author: Science Applications International Corporation, S.C.T.G.
Year: 1995
Title: Electro-load technical manual
Place Published: California, MD
Publisher: Science Applications International Corporation, Systems Control Technology Group
Date: April
Type of Work: Technical Manual
Number of Pages: 50
Keywords: electro-load, technical manual, control algorithm, FAA requirements, time response

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Reference Type: Generic
Author: Science Applications International Corporation Systems Control Technology Group
Year: 1994
Title: Electro-load: Installation procedure and acceptance test guide
Place Published: California, MD
Publisher: Science Applications International Corporation, Systems Control Technology Group
Date: April
Type of Work: Installation and Test Guide
Number of Pages: 22
Keywords: electro-load, installation, test guide, physical installation, parameter calculation

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Reference Type: Magazine Article
Author: Scott, W.B.
Year: 2004
Title: Rethinking upset training
Magazine: Aviation Week & Space Technology
Pages: 39-40
Date: January
Number of Pages: 2
Abstract: Using simulators to develop upset-recovery procedures could lead to negative training.

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Reference Type: Conference Proceedings
Author: Seamster, T.L., Glass, R.H.
Year of Conference: 1990
Title: Human factors considerations in the design of displays and switches for a flight simulator's onboard Instructor/Operator Station (IOS)
Conference Name: Human Factors Society 34th Annual Meeting
Pages: 1400-1404
Keywords: human factors, display design, instructor/operator station
Abstract: The MV-22A training device suite Operational Flight Trainer (OFT) and Aircrew System Trainer (AST) specification requirements provide for an instructor work environment that focuses on integrating the instructor's position with the training environment. This paper will describe the process to refine a display/switch design dedicated to over-the-shoulder instruction at the IOS. The time frame encompasses the period from the mockup through the IOS-specific design reviews which addresses a mature IOS display/switch design. This new IOS display/switch

design mirrors the aircraft's Multi-Function Displays (MFDs) which provide the pilots rapid and efficient access to aircraft systems and environmental data, while allowing for primary focus on flying the aircraft. Correspondingly, the IOS display/switch design for control and monitor of the training scenario, allows the instructor to focus on trainee actions, the aircraft instrument panel, and the visual system's forward field of view. Since the mockup, there has been a refinement process leading to some significant design initiatives. An analysis of this refinement process points out some key issues in designing for this new type of IOS display.

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Reference Type: Book Section
Author: Sedgwick, H.A.
Year: 1986
Title: Section IV: Space and motion perception
Editor: Boff, K.R., Kaufman, L., Thomas, J.P.
Book Title: Handbook of perception and human performance: Sensory processes and perception
City: New York
Publisher: John Wiley and Sons
Volume: I
Number of Volumes: 2
Author's Affiliation and Title: State University of New York, College of Optometry, New York, NY

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Reference Type: Conference Proceedings
Author: Seidensticker, S., Hecker, M.-E.
Year of Conference: 1985
Title: Real-time simulators: Dealing with their growing complexity
Conference Name: Interservice/Industry Training, Simulation & Education Conference
Pages: 164-168
Author's Affiliation and Title: Logicon, Inc., Tactical and Training Systems Division, San Diego, CA
Number of Pages: 5
Abstract: A number of technical and philosophical issues are emerging in the development of large real-time simulators that are going to have profound effects on the way such devices are designed and built.
Simulators are becoming more complex, both in the number of functions that each must perform, and the number of disciplines involved. In the near future it will not be uncommon to use speech generation, speech understanding, artificial intelligence, image generation, complex optics, embedded processors, graphic displays, and sophisticated motion cue generators in a single simulator. Existing approaches to design, implementation, and testing cannot support the integration of these disciplines into a single harmonious system.
Fortunately, technical developments have kept pace with this problem. High speed local area networks (LAN); ever faster, smaller, and cheaper processors; cheap and plentiful memory; object oriented design techniques; and procedures oriented programming languages all have major potential application to the integration of components in large real-time systems.
This paper will explore and suggest the application of these developments to future simulators. Examples of a relatively simple operational flight trainer (OFT) and a multi-cockpit weapon system trainer (WST) designed around a set of well defined modules will be used to illustrate the concepts.

Reference Type: Conference Proceedings
Author: Sele, M., Baetge, M.
Year of Conference: 1983
Title: Innovative uses of aircraft for flight training
Editor: Lee, A.T.
Conference Name: Flight Training Technology for Regional/Commuter Airline Operation
Conference Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: September 28-30
Author's Affiliation and Title: Sele: Air Wisconsin
Baetge: NASA

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Reference Type: Conference Proceedings
Author: Sharkey, T.J., McCauley, M.E.
Year of Conference: 1992
Title: Does a motion base prevent simulator sickness?
Conference Name: AIAA/AHS Flight Simulation Technologies Conference
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 21-28
Author's Affiliation and Title: Monterey Technologies, Inc., Carmel, CA
Number of Pages: 8
Keywords: simulator sickness, high fidelity motion cues, motion base, vertical motion simulator, motion washout, visual system
Abstract: Simulator sickness is an unwanted side effect of many current flight simulators. Various strategies for minimizing the problem have been discussed by the NASA Steering Committee on Simulator Induced Sickness. One common proposal is to provide high fidelity motion cues to reduce the discrepancy or conflict between the visually-implied motion and the actual motion. The assumption is that the reduction of cue conflict will reduce the incidence and severity of simulator sickness. This hypothesis was tested using the NASA Vertical Motion Simulator (VMS) at Moffett Field. Ten pilots flew a UH-60 Blackhawk model with two low altitude flight maneuvers: S-turns and sawtooths. These flight tasks were selected because they had generated a very high incident of simulator sickness in a previous study using a fixed-base wide FOV-simulator. The pilots flew maneuvers up to 60 minutes on each of two separate days, once with the motion base turned on and once with the motion base turned off. Several types of data were collected including periodic self-report, pre-post symptom checklists, dark focus, and pre-post postural equilibrium tests. The results indicate that the motion base condition did not result in a lower incidence or severity of simulator induced sickness.

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Reference Type: Journal Article
Author: Sharpe, D.
Year: 2004
Title: Beyond significance testing: Reforming data analysis methods in behavioral research
Journal: Canadian Psychology
Volume: 45
Issue: 4
Pages: 317-319
Date: November
Author's Affiliation and Title: University of Regina, Regina, SK, Canada
Number of Pages: 3

Keywords: significance testing; effect size; confidence interval estimation; statistical decision making; null hypothesis; data analysis; behavioral research
Abstract: Reviews Kline's book which reviews the controversy regarding significance testing, offers methods for effect size and confidence interval estimation, and suggests some alternative methodologies.

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Reference Type: Book Section
Author: Sheridan, T., Ferrell, W.R.
Year: 1974
Title: Fundamental considerations in modeling the human operator in a control system
Book Title: Man-machine systems: Information, Control and Decision Models of Human Performance
City: Cambridge, MA
Publisher: The MIT Press
Pages: 177-246
Number of Pages: 70

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Reference Type: Report
Author: Sheridan, T.B.
Year: 2001
Title: Considerations in development and use of a locomotive cab simulator for human factors research
Institution: Volpe National Transportation Systems Center
Date: December
Type: Research Report
Number of Pages: 11
Abstract: Consideration is being given by the Federal Rail Administration (FRA) to use of the Amtrak Acela simulator and also to the development of a new simulator facility devoted primarily for human factors research. In April 2001, Foster-Miller (Reinach 2001) issued a report examining the applicability of the Acela high speed rail simulator for human-centered research purposes. The primary intended use of that simulator is to familiarize locomotive engineers with Acela train sets; human factors research was not a consideration in specifying its design. Section 7 of the Foster-Miller report makes recommendations for the design of a simulator facility devoted to human factors research.

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Reference Type: Magazine Article
Author: Shifrin, C.A.
Year: 1996
Title: Regional airlines special report: Changing rules challenge U.S. regionals
Magazine: Aviation Week and Space Technology
Pages: 54-55
Date: May 20
Number of Pages: 2
Keywords: RAA, Regional Airlines Association, Part 135, Part 121

Reference Type: Conference Proceedings
Author: Shinn-Cunningham, B.
Year of Conference: 1998
Title: Applications of virtual auditory displays
Conference Name: 20th International Conference of the IEEE Engineering in Biology and Medical Society
Volume: 20
Pages: 1105-1108
Author's Affiliation and Title: Hear. Res. Center, Depts. of Cognitive and Neural Systems and Biomedical Engineering, Boston University, 677 Beacon St., Boston, MA 02215
Number of Pages: 4
Keywords: virtual environments, spatial hearing
Abstract: Current technology makes it possible to simulate naturally-occurring spatial auditory cues quite accurately. However, the cost of such a system is not justifiable, or even desirable, for all applications. This paper surveys some of the applications currently using virtual auditory displays and some of the issues important in the design of virtual auditory displays.
URL: http://cns-web.bu.edu/~shinn/pages/pdf/IEEE_VAS_Appl.pdf

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Reference Type: Report
Author: Shirachi, D.K., Shirley, R.S.
Year: 1981
Title: Visual/motion cue mismatch in a coordinated roll maneuver
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA)
Date: May
Report Number: NASA-CR-166259
Number of Pages: 48
Abstract: An experiment was performed to investigate the effects of bandwidth differences between visual and motion cueing systems on pilot performance for a coordinated roll task. In addition, for visual and motion cue configurations which were judged to be acceptable, the effects of reduced motion cue scaling on pilot performance were studied to determine the scale reduction threshold for which pilot performance was significantly different from full scale pilot performance. The major conclusions were that (1) the presence or absence of high frequency (w > 3.5 rad/sec) error information in the visual and/ or motion display systems significantly affects pilot performance, and (2) the attenuation of motion scaling while maintaining other display dynamic characteristics constant affects pilot performance.

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Reference Type: Report
Author: Shirley, R.S.
Year: 1968
Title: Motion cues in man-vehicle control
City: Cambridge, MA
Institution: Massachusetts Institute of Technology (MIT)
Date: January
Type: Sc. D. Thesis
Report Number: MIT Report No. MVT-68-1
Abstract: An investigation is made to determine how the human operator makes use of roll motion cues in a man-vehicle control system. To this purpose the human operator's describing function is measured over a wide range of vehicle dynamics and under conditions of visual inputs

only, motion inputs only, and combined visual and motion inputs. Both the describing function (amplitude and phase of the human operator's output relative to his input) and the remnant (power spectral density of that part of the human operator's output which is uncorrelated with his input) are measured as a function of frequency. The relative integral squared error is also measured. Visual inputs are made by means of a dot moving laterally on an oscilloscope, and roll motion inputs are made by means of a motion simulator.
An analytical method of correcting the experimental measurements for errors introduced by the remnant is developed and applied to the data. The corrections are generally small.
Examination of the describing function data leads to some conclusions about he human operator's use of angular motion cues in a man-vehicle control system. When the roll motion cues are added to the visual cues, the human operator is able to increase his lead in the frequency range above three radians per second. This permits him to increase his gain and cross-over frequency without decreasing his phase margin. The net effect of these changes in the human operator's control behavior is to increase the open loop gain without a loss of stability, and thus to reduce the relative integral squared error for the closed loop system.
The percentage reduction of the relative integral squared error upon the addition of the motion cues to the visual cues varies as a function of the controlled vehicle dynamics. The human operator can make the most use of motion cues for vehicle dynamics which lead to significant roll motions above one radian per second. Such vehicle dynamics include low order dynamics (1/s as opposed to $1/s^2$) and dynamics with an associated high control stick gain.
It is possible, in some cases, to use the body of data obtained for this thesis to predict actual in-flight or moving-base measurements of the human operator's describing function from fixed-base measurements of the human operator's describing function.

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Reference Type: Magazine Article
Author: Shirts, R.G.
Year: 1992
Title: Ten secrets of successful simulations
Magazine: Training
Date: October
Abstract: This article by Garry Shirts originally appeared in the October 1992 issue of Training magazine. It presents 10 suggestions for developing effective simulations. It is based on Garry Shirts' experience in designing more than 40 simulations and experiential programs.
URL: http://www.stsintl.com/business/articles/tensecrets.pdf

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Reference Type: Report
Author: Showalter, T.W., Miller, R.J.
Year: 1978
Title: G-Seat system step input and sinusoidal response characteristics
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: June
Type: Technical Memorandum
Report Number: NASA TM - 78478
Recipient's Affiliation and Title: National Aeronautics and Space Administration, Washington, DC 20546
NASA Ames Research Center, Moffett Field, CA 94035
Keywords: G seat, step input response, frequency response

Abstract: The step input and sinusoidal response characteristics of a pneumatically driven computer controlled G seat were examined in this study. The response data show that this system can be modeled as a first order system with an 0.08 sec time lag and a 0.53 sec time constant.

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Reference Type: Report
Author: Showalter, T.W., Parris, B.L.
Year: 1980
Title: The effects of motion and g-seat cues on pilot simulator performance of three piloting tasks
Institution: National Aeronautics and Space Administration (NASA)
Date: January
Report Number: NASA TP 1601
Author's Affiliation and Title: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 38
Keywords: motion and g-seat cue evaluation, ground-based simulation, flight simulation, pilot performance in simulators
Abstract: Data are presented that show the effects of motion system cues, g-seat cues, and pilot experience on pilot performance during takeoffs with engine failures, during in-flight precision turns, and during landings with wind shear. Eight groups of USAF pilots flew a simulated KC-135 using four different cueing systems. The basic cueing system was a fixed-base type (no-motion cueing) with visual cueing. The other three systems were produced by the presence of either a motion system or a g-seat, or both. Extensive statistical analysis of the data was performed and representative performance means were examined. These data show that the addition of motion system cueing results in significant improvement in pilot performance for all three tasks: however, the use of g-seat cueing, either alone or in conjunction with the motion system, provided little if any performance improvement for these tasks and for this aircraft type.

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Reference Type: Conference Proceedings
Author: Sifford, J.C.
Year of Conference: 1983
Title: Management training for cockpit crews at Piedmont Flight
Editor: Lee, A.T.
Conference Name: Flight Training Technology for Regional/Commuter Airline Operation
Conference Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: September 28-30
Author's Affiliation and Title: Piedmont Airlines

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Reference Type: Electronic Source
Author: Silbergeld, D.
Year: 2000
Title: Want to polish your flight skills? Try FLY! 2K
Producer: National Defense Online Magazine
Access Year: 2006
Access Date: Sept. 6
Last Update Date: November 2000

Type of Medium: Online Article
Number of Pages: 2
URL: http://www.nationaldefensemagazine.org/issues/2000/Nov/Want_to.htm

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Reference Type: Report
Author: Sinacori, J.B.
Year: 1977
Title: The determination of some requirements for a helicopter flight research simulation facility
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: September
Type: Technical Report
Report Number: 1097-1
Author's Affiliation and Title: National Aeronautics and Space Administration, Ames Research Center

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Reference Type: Report
Author: Sinacori, J.B.
Year: 1986
Title: Modeling flight simulator visual/motion cue effects on pilot performance: A summary
Date: July
Type: Technical Report
Report Number: AFAMRL-TR-86-064
Number of Pages: 11
Keywords: modeling flight simulator, pilot, motion cue
Abstract: The advent of the modern computer during WWII and its proliferation following that conflict has greatly enhanced the human thinking process. The words "model" and "simulation" are commonplace today and are used to describe mathematical formalisms usually implemented on a computer that mimes some intuitive thought. These models may be thought as a preliminary theory of the process involved, because if developed properly, their results are subject to experimental verification.

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Reference Type: Conference Proceedings
Author: Sinclair, S.R.M., West, T.C.
Year of Conference: 1978
Title: Handling qualities of a simulated STOL aircraft in natural and computer-generated turbulence and shear
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 8-1 - 8-16
Date: April 24-27
Author's Affiliation and Title: Sinclair: Flight Research Laboratory, National Aeronautical Establishment, Ottawa, Canada K1A OR6

West: Systems Research and Development Service, U.S. Federal Aviation Administration, Washington, DC 20591
Number of Pages: 16
Keywords: STOL aircraft, turbulence, shear

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Reference Type: Journal Article
Author: Sivan, R., Ish-Shalom, J., Huang, J.-K.
Year: 1982
Title: An optimal control approach to the design of moving flight simulators
Journal: IEEE Transactions on Systems, Man, and Cybernetics
Volume: SMC-12
Issue: 6
Pages: 818-827
Number of Pages: 10
Keywords: optimal control approach, moving flight simulators, ground based motion simulators, washout filter, cross-product scheme, crossfeed scheme, parameter optimization, optimal model reference designs, vestibular system, washout matrix
Abstract: An abstract simulator design problem is formulated as follows: we are given a dynamic system S^a called the actual system and another dynamic system S^s called a simulator for S^a. Furthermore, we are given an input signal which drives the actual system S^a. The problem is to find an operator, properly constrained, which generates the input to the simulator S^s on the basis of the input to S^a so that the discrepancy between the output S^a and S^s is as small as possible. This abstract simulator design problem is brought in the form of an optimal control problem and then solved for the linear-quadratic Gaussian special case. Next the solution of the abstract simulator problem is applied to the design of the motion generators for motion simulators. A fairly elaborate mathematical model of the vestibular organs is used. The optimization criterion that is selected is the mean-square difference between the physiological outputs of vestibular organs for the pilot in the airplane and for the pilot in the simulator. The dynamical equations are linearized and the input signal is modeled as a random process with a rational power spectral density. Subject to the above assumptions, the optimal structure as the motion generator for the simulator, also called a washout filter is derived. This method stands in contrast to existing design schemes for motion generators which generally assume a certain fixed structure for the motion generator and concentrate on optimizing its parameters. This paper concludes with an example of a design for a two degree of freedom flight simulator including simulations for simple inputs.

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Reference Type: Report
Author: Smith, R.M., Chung, V.I., Martinez, D.
Year: 1994
Title: Transport delays associated with the NASA Langley flight simulation facility
Number of Pages: 12

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Reference Type: Journal Article
Author: Smode, A.F.
Year: 1974
Title: Recent developments in instructor station design and utilization for flight simulators
Journal: Human Factors

Volume: 16
Issue: 1
Pages: 1-18
Author's Affiliation and Title: Dunlap and Associates, Inc., Darien, CT
Number of Pages: 19
Abstract: The instructional capability of the training simulator has improved in tempo with simulation technology. The business of shaping student behaviors has achieved a leap forward in efficiency due to digital computation and the computer display terminal. This paper discusses the impact of computer assistance on the capability for structuring and controlling synthetic flight training, and examines the instructional potential of the "new breed" of flight simulators presently on-line or in the developmental stage. A number of recent innovations in instructor station design is described. These developing, student-centered instructional techniques for promoting training effectiveness place the simulator quite realistically in contention as a major flight training medium of the future.

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Reference Type: Conference Proceedings
Author: Snow, A.E., Moon, R.N.
Year of Conference: 1986
Title: Providing high performance visual simulation at low cost, revisited
Conference Name: Interservice/Industry Training, Simulation & Education Conference
Pages: 58-63
Author's Affiliation and Title: Evans & Sutherland Computer Corporation, Salt lake City, UT
Number of Pages: 6
Abstract: In the process of transitioning from the theoretical to the actual, things often change greatly. This is also the case in the move from system design, to system implementation and finally the actual performance characterization. In a follow-up to last year's paper "Providing High Performance Visual Simulation at Low Cost," which described the system design and architecture, this paper will discuss what has been learned in the actual implementation and use of this system.
An evaluation of the low cost approach is presented, delineating the system capabilities and limitations under various training requirements. One aspect that will be discussed at length is the channelized system architecture and how this architecture responds to different types of visual imaging simulation including sensor channels, narrow fields of view, and combinations of imaging channels, all used in the same system.

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Reference Type: Journal Article
Author: So, R.H.Y., Ho, A., Lo, W.T.
Year: 2001
Title: A metric to quantify virtual scene movement for the study of cybersickness: Definition, implementation, and verification
Journal: Presence
Volume: 10
Issue: 2
Pages: 193-215
Date: April
Author's Affiliation and Title: Human Performance and Virtual Reality Laboratory
Hong Kong University of Science and Technology
Number of Pages: 23

Abstract: This paper presents a metric to quantify visual scene movement perceived inside a virtual environment (VE) and illustrates how this method could be used in future studies to determine a cybersickness dose value to predict levels of cybersickness in VEs. Sensory conflict theories predict that cybersickness produced by a VE is a kind of visually induced motion sickness. A comprehensive review indicates that there is only one subjective measure to quantify visual stimuli presented inside a VE. A metric, referred to as *spatial velocity* (SV), is proposed. It combines objective measures of scene complexity and scene movement velocity. The theoretical basis for the proposed SV metric and the algorithms for its implementation are presented. Data from two previous experiments on cybersickness were reanalyzed using the metric. Results showed that increasing SV by either increasing the scene complexity or scene velocity significantly increased the rated level of cybersickness. A strong correlation between SV and the level of cybersickness was found. The use of the spatial velocity metric to predict levels of cybersickness is also discussed.

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Reference Type: Edited Book
Editor: Spanitz, J.
Year: 1995
Title: Federal Aviation Regulations Parts 25, 63, and 121
City: Renton
Publisher: Aviation Supplies and Academics, Inc. (ASA)
Edition: 1995

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Reference Type: Magazine Article
Author: Sparaco, P.
Year: 1994
Title: Human factors cited in French A320 crash
Magazine: Aviation Week and Space Technology
Pages: 30-31
Date: January 3
Number of Pages: 2

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Reference Type: Report
Author: Stapleford, R.L., Peters, R.A., Alex, F.R.
Year: 1969
Title: Experiments and a model for pilot dynamics with visual and motion inputs
Institution: NASA
Pages: 115
Date: May
Type: NASA Contractor Report
Report Number: CR 1325
Keywords: Pilot dynamics, pilot model, visual feedback, motion feedback
Abstract: This report describes the results of a simulator program to investigate the effects of motion cues on a manual-control tracking task. The experimental variables were controlled-element dynamics, linear motion characteristics, and angular motion characteristics. The data obtained include: pilot describing functions, both overall (combined visual and motion feedbacks)

and separate (independent visual and motion pathways); remnant characteristics; and tracking performance. These data are also compared with previous experimental results.
From the previous and present data, a multimodality pilot model for both visual and motion feedbacks is derived. The dynamics of the two (angular and linear) motion feedback paths and the integration of visual and motion feedbacks are discussed. The overall effects of motion on the crossover model are found to be the lower pilot effective time delays and higher crossover frequencies. The changes are roughly 0.15 sec and 1 rad/sec. These effects are primarily due to an angular rate feedback via the semicircular canals. The lead provided by this vestibular path allows the pilot to reduce his lead in the visual path and increase his low frequency gain. The relative magnitudes of the visual and vestibular feedbacks depend on the controlled element dynamics (whether or not pilot low frequency lead equalization is required).
The implications of the experimental data and the multimodality pilot model on the design requirements for moving-base simulators are also reviewed. While the effects of motion cues on manual tracking, failure detection, and realism must be considered, the only definitive requirements are those relating to tracking. Translational motion cues appear to be generally less important than rotational ones, although linear motions can be significant in special situations. A conservative estimate for the requirements on angular cues seems to be good fidelity over the frequency range of 0.5-10 rad/sec. A procedure for establishing tracking requirements for a specific problem is outlined.

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Reference Type: Conference Proceedings
Author: Staples, K.J.
Year of Conference: 1970
Title: Motion, visual, and aural cues in piloted flight simulation
Conference Name: Simulation
Conference Location: Ames Research Center, Moffett Field, CA
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 4-1 - 4-23
Date: March
Author's Affiliation and Title: Royal Aircraft Establishment, Bedford, England
Number of Pages: 23
Keywords: cues, motion, visual, aural, yaw motion, cue conflict
Abstract: An analysis is made of the part played by various cues in simulation. The aim is to highlight the problems rather than to summarize the state of the art. Each cue is considered in turn with particular emphasis on the interaction with human physiological sensors. The deficiencies in the cues compared with flying an actual aircraft are stated, and some assessment of their relative importance is attempted. The substitution of one cue by another is mentioned and the effect of the interaction between cues is discussed.
Notes: Lead discussion by R. Deque, O. H. Gerlach, and Richard S. Bray. Open discussion also included.

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Reference Type: Conference Proceedings
Author: Staples, K.J., Love, W., Parkinson, D.
Year of Conference: 1985
Title: Progress in the implementation of AGARD-AR-144 in motion system assessment and monitoring
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)

Pages: 8-1 - 8-11
Date: September 30 - October 3
Author's Affiliation and Title: Staples: Royal Aircraft Establishment, Bedford MK41 6AE
Love: Cranfield Institute of Technology, Cranfield, Bedford MK43 0AL
Parkinson: Singer Link Miles, Lancing, West Sussex BN15 8UE
Number of Pages: 11
Keywords: AGARD-AR-144, motion systems
Abstract: After a brief explanation of the techniques defined in AGARD-AR-144 a description is given of two systems which have been built and tested to satisfy the requirements in the AGARD Report. Each system is stand-alone and only requires the user to supply the sensors on the motion system itself. One system, from Singer Link Miles, is especially suited to six-degrees-of-freedom, synergistic motion systems, whereas the other, from the Cranfield Institute of Technology, is more appropriate to systems with independent axes. The systems have each been used on several different motion systems and some sampled measured results are given.
Notes: Published in September 1986.

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Reference Type: Audiovisual Material
Author: State University of New York at Binghamton
Year: 1999
Title: Flight and ground vehicle simulation update
Date: January 11-15
Type: CD of Powerpoint Presentations
Author's Affiliation and Title: Office of Continuing Education, Watson School of Engineering, State University of New York' Binghamton, New York
Abstract: Contents:
Fundamentals of Simulation
Professor Frank M. Cardullo
State University of New York at Binghamton

Simulators as Tools for Training and Design
Professor John M. Flach
Wright State University

Mathematical Modeling
R. Thomas Galloway
Naval Air Warfare Center, Training Systems Division
Simulator Validation and Verification
R. Thomas Galloway
Naval Air Warfare Center, Training Systems Division

Visual Simulation Overview
Walter S. Chambers
Future Technology, Inc.

Visual Display Systems
Dr. James L. Davis
GRADIENT Inc.
NON-CGI
VISUAL IMAGE GENERATION
Dr. James L. Davis
GRADIENT Inc.

Motion and Force Cuing I, Whole-body motion
Dr. Edward A. Martin
Wright-Patterson Air Force Base

Motion and Force Cuing II
Professor Frank M. Cardullo
State University of New York at Binghamton

Flight Control System Simulation
James R. Takats
OPINICUS Corporation

Distributed Simulation
Christina Bouwens
Science Application International Corporation

Flight Simulator Qualification
Paul A. Ray
FAA

Computer Image Generation
Michael Fortin
Raytheon, Corporation

PC Image Generators
Roy W. Latham
Computer Graphics Systems
Development Corporation (CGSD)
Real Time Computing
Roy W. Latham
Computer Graphics Systems
Development Corporation (CGSD)

Simulator Systems Integration
Professor Frank M. Cardullo
State University of New York at Binghamton

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Reference Type: Journal Article
Author: Stern, R.M., Hu, S., Anderson, R.B., Leibowitz, H.W., Kock, K.L.
Year: 1990
Title: The effects of fixation and restricted visual field on vection-induced motion sickness
Journal: Aviation, Space, and Experimental Medicine
Volume: 61
Pages: 712-715
Author's Affiliation and Title: Department of Psychology and Division of gastroenterology, Department of Medicine, Penn State University, University Park and Hershey, PA
Number of Pages: 4
Abstract: Approximately 60% of healthy human subjects experience motion sickness when exposed to a rotating optokinetic drum. The purpose of the present study was to determine the effects of certain visual factors on susceptibility to motion sickness. Vection data (illusory self-motion), horizontal eye movement recordings, subjective motion sickness report, and a measure of gastric myoelectric activity (electrogastrogram, EGG) were obtained from 45 subjects, who

were randomly divided into the following three groups: a control group that observed the entire visual field with no fixation, a group that fixated on a central target, and a third group that had a visual field restricted to 15 degrees. The experimental session was divided into the following three 12-min periods: baseline, drum rotation, and recovery. The results showed that fixation greatly reduced nystagmus and slightly reduced vection. The restricted visual field slightly reduced nystagmus and greatly reduced vection. Both of these manipulations significantly reduced symptoms of motion sickness and tachyarrhythmia, the abnormal gastric myoelectric activity that usually accompanies nausea.

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Reference Type: Book
Author: Stevens, B.L., Lewis, F.L.
Year: 1992
Title: Aircraft control and simulation
City: New York
Publisher: John Wiley & Sons
ISBN: ISBN 0-471-61397-5
Author's Affiliation and Title: Stevens: Georgia Tech Research Institute
Lewis: The University of Texas at Arlington

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Reference Type: Report
Author: Sticha, P.J., Singer, M.J., Blacksten, R.H., Morrison, J.E., Cross, K.D.
Year: 1990
Title: Research and methods for simulation design: State of the art
City: Alexandria, VA
Institution: United States Army Research Institute for the Behavioral and Social Sciences
Date: September
Type: Final Technical Report
Report Number: ARI Technical Report 914
Keywords: training system optimization, training system model, medium selection, fidelity, instructional features, training resource allocation
Abstract: This report reviews the empirical results and analytical methods available to the trading-device designer for tradeoff analyses necessary to predict cost-efficient training device designs. It addresses the problem of training system optimization in three ways. First, it describes existing methods that can aid training-device design functions. The function and operations of methods are compared to the model for the optimization of simulation-based training systems (OSBATS) developed for this project. Second, it reviews research on several issues related to training-device optimization. The issues covered in the review include training-device fidelity, instructional featured, skill acquisition, skill retention transfer of training, and cost estimation. Third, the review organizes the requirements for future research on the topics and sets priorities for research topics based on their cost and the benefit they could offer to the training-device designer. The review focused on quantitative models that can be used to estimate training cost and effectiveness and to determine optimal levels of training-device design variables. The research plan identifies the topics that reduce critical gaps in our knowledge at a reasonable cost. Research addressing (a) relative impact of fidelity features and instructional features on training effectiveness, (b) effects of student aptitudes on training-device design, and organization of nonmonetary reasons for simulation-based training can produce a moderate benefit at a relatively low cost. The most critical research issues involve the impacts of training-device fidelity and instructional features on training effectiveness.

This review provides information that may be used by researchers who wish to develop or improve methods to aid the training-device designers. Designers may use this review to identify methods to aid the training-device design process and individuals who manage research programs may use this information to set priorities for future research efforts.
Notes: This report was produced by Human Resources Research Organization, 1100 South Washington Street, Alexandria, VA 22314.

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Reference Type: Journal Article
Author: Stoffregen, T.A., Hettinger, L.
Year: 2000
Title: Postural instability and motion sickness in a fixed-base flight simulator
Journal: Human Factors
Volume: 42
Issue: 3
Pages: 458
Date: Fall
Author's Affiliation and Title: Stoffregen: University of Cincinnati
Hettinger: Logicon Technical Services Inc
Number of Pages: 12
Abstract: We evaluated the prediction that postural instability would precede the subjective symptoms of motion sickness in a fixed-base flight simulator. Participants sat in a cockpit in a video projection dome and were exposed to optical flow that oscillated in the roll axis with exposure durations typical of flight simulation. The frequencies of oscillation were those that characterize spontaneous postural sway during stance. Head motion was measured prior to and during exposure to imposed optical flow. Of 14 participants, 6 were classified as motion sick, either during or after exposure to the optical oscillation. Prior to the onset of subjective symptoms, head motion among participants who later became sick was significantly greater than among participants who did not become motion sick. We argue that the results support the postural instability theory of motion sickness. Actual or potential applications include the prevention of mitigation of motion sickness in virtual environments.

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Reference Type: Journal Article
Author: Strachan, I.
Year: 1998
Title: To move or not to move
Journal: Aerospace International
Volume: 25
Issue: 9
Pages: 48-52
Date: September
Number of Pages: 5
Abstract: The importance of producing cues of real motion in flight simulators, such as acceleration onset cues and motion cues from visual sources, is discussed. It is noted that, although in the military case many aspects of the training can be satisfied only be real aircraft flight, much cost-effective training can be undertaken in a simulator which accurately replicates the flight handling and other cues. The discussion covers relevant standards and regulations, motion platforms, simulator latency, simulator sickness, formation flying and air refueling, control law development, and training for high g. (AIAA)

Reference Type: Magazine Article
Author: Strachan, I.
Year: 2006
Title: Radical ideas at RAeS
Magazine: Civil Aviation Training (CAT) Magazine
Issue Number: 1
Pages: 26-27
Number of Pages: 2
Keywords: RAeS, Flight Simulation Group (FSG), International Working Group (IWG)
Abstract: The Flight Simulation Group (FSG) of the Royal Aeronautical Society (RAeS) in UK organises two two-day conferences each year in London, one in June and the other in November. The June meeting is normally on general matters; the November event on a more specialised subject. The specialist subject in November 2005 was, 'Regulation, is it time for an update?'
URL: http://cat.texterity.com/cat/2006-1/?pg=27

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Reference Type: Conference Proceedings
Author: Strachan, I.W.
Year of Conference: 1995
Title: Cueing for motion
Conference Name: RAeS Flight Simulation Group Symposium
Publisher: Royal Aeronautical Society (RAeS)
Pages: 1-13
Date: May 17
Abstract: Nine types of motion cues used by a pilot in flight are analyzed and evaluated for their characteristics, their strengths and limitations.
These flight cues are then compared with those which it is possible to generate in a simulated environment. Conclusions are drawn on the efficacy of various simulation systems. These include motion platforms of different sizes, degrees of freedom and other performance aspects such as latency, accelerations, bandwidth, buffet and vibration. Cueing for high Gz is discussed, considering G seats, anti-G suits, G-dimming, and the use of centrifuge-mounted cockpits. Motion cues from visual sources are also discussed. This includes head down and head-up instruments, sensor displays, and outside-world displays. Outside world scenes are considered from good visibility day conditions, through sensor displays, poor visibility and night, to pure instrument flight. Flight regimes discussed include taxiing, takeoff, enroute, approach and landing (including training for appropriate emergencies); and, for the military, low flying and ground attack, air combat, formation, and air-to-air refueling.
Conclusions are then drawn as to the best mix of simulator systems, the interfaces and phasing between systems, and the training tasks best carried out by different combinations of systems. The overall conclusion is that simulator systems are available to do most training tasks except realistic cueing for high Gz.
Civil training can therefore be particularly effectively accomplished and this is borne out by the success of Zero Flight Time simulator conversions. Most aspects of military training can also be effective using simulation systems; even in high-G situations there are many simulator systems that will produce a significant amount of cueing.
The civil side is working well under a sound system of standards and regulation, but the military side has some way to go both in a commitment to available technology and in creating a structure of standards and regulation as efficient as that developed over many years for civil aircraft.

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Reference Type: Journal Article

Author: Strasburger, H.
Year: 2001
Title: Converting between measures of slope of the psychometric function
Journal: Perception and Psychophysics
Author's Affiliation and Title: Generation Research Program
Institute for Psychology, Universität Leipzig
Number of Pages: 9
Abstract: The psychometric function's slope is a basic descriptor of human performance in a sensory task. It provides information about the reliability of psychophysical threshold estimates, and further allows to compare thresholds that were obtained at different performance criterion levels. Unfortunately, there is a bewildering variety of slope measures in use which hinders the communication between authors and the empirical validation of slope estimates by comparing slope results across studies. The present note provides conversion formulas for the most popular cases, including the logistic, Weibull, Quick, cumulative normal and hyperbolic tangent functions as analytic representations, in both linear and log coordinates and to different log bases, for the practical decilog unit, the empirically based interquartile-range (IQR) measure of slope, and slope in a d' representation of performance.

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Reference Type: Journal Article
Author: Streiner, D.L.
Year: 2003
Title: Unicorns do exist: A tutorial on "proving" the null hypothesis
Journal: Canadian Journal of Psychiatry
Volume: 48
Issue: 11
Pages: 756-761
Date: December
Keywords: significance testing, equivalence testing, null hypothesis equivalence testing
Abstract: There are times when it is necessary to try to prove the nonexistence of a difference between groups.

Reference Type: Conference Proceedings
Author: Sullivan, B.T., Soukup, P.A.
Year of Conference: 1996
Title: The NASA 747-400 flight simulator - A national resource for aviation safety research
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: San Diego, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 374-384
Date: July 29-31
Author's Affiliation and Title: Barry T. Sullivan: NASA, Ames Research Center, Moffett Field, CA
Paul A. Soukup: NSI Technology Services Corp., Sunnyvale, CA
Number of Pages: 11
Abstract: This paper describes the NASA Ames Research center's Current Technology Glass Cockpit Flight Training Simulator located at Moffett Field, CA. This unique simulator is used to conduct aviation human factors and airspace operations research. The simulator is an exact replica of a cockpit of one of the most sophisticated and advanced airplanes flying in the world today. Although the simulator replicates a typical flight training simulator, it has unique research capabilities above and beyond the normal training simulator that is used to train today's airline pilots. This paper will describe the NASA simulator and its advanced features, including its unique research capabilities. It will also describe some of the research that has been conducted in the

cab since its installation, and will also review some of the upgrades that are currently in progress, or will be conducted in the not too distant future.

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Reference Type: Audiovisual Material
Author: Summit Aviation
Year: 1999, 1998
Title: Break the paper barrier--Computerized aviation reference library
Type: CD-ROMs
Abstract: (There are too many topics to fit in one field, so A-L are in Abstract and M-Z are in Notes.)
A Hazard in Acrobatics: Effects of G-Forces on Pilots, AC 91-61.
A Model Zoning Ordinance to Limit Height of Objects Around Airports, AC 150/5190-4A.
Acceptable Methods, Techniques, and Practices - Aircraft Alterations, AC 43.13-2A.
Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair, AC 43.13-1A.
Accessibility to Excess Emergency Exits, AC 20-60.
Accident/Incident Investigation Procedures, 49 CFR Part 831 (NTSB 831).
The Accident Prevention Counselor Program, AC 60-13.
The Accident Prevention Program - Your Key To Safe Flight, FAA-P-8740-8.
Accident Prevention Program Publications, FAA.
Accidents Resulting from Wheelbarrowing in Tricycle Gear Equipped Aircraft, AC 90-34.
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Your Shoulder Harness, FAA-P-8740-45.

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Reference Type: Conference Proceedings
Author: Svensson, E., Angelborg-Thanderz, M.
Year of Conference: 2000
Title: Simulated landings in turbulence--Motion, predictive modelling, and psychometric aspects
Conference Name: Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-11
Date: August 14-17
Author's Affiliation and Title: National Defence Research Establishment (FOA), Linkoping, Sweden
Number of Pages: 11
Abstract: To maintain control in approach/landings under turbulence, the pilot requires prompt attention. The lead provided by non-visual cues is then important. One objective of two studies was to analyse whether a moving base dome simulator could produce more realistic cues than a fixed base simulator. In the first study half of 60 landings were performed with the motion system disengaged. The pilots rated risk, difficulty, workload, performance, handling qualities, and induced oscillations. Stick activity and difficulty were higher and performance lower under the motion condition. In a second study the importance of motion in turbulent landings was verified and analyses of the pilots' control responses showed that there were inter-individual differences. Model analyses showed that turbulence affects workload, and that workload, in its turn, influences performance. We found that handling qualities and induced oscillations could be predicted from the other variables. The variables turbulence and motion of the aircraft explains 65 percent of the variance in handling qualities ratings and 36 percent of the variance in ratings of pilot induced oscillations. Accordingly, handling qualities and pilot induced oscillations can be estimated and predicted in situations 'without man in the loop'. The analyses present psychological aspects related to and underlying aircraft handling qualities and pilot induced oscillations.

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Reference Type: Conference Proceedings
Author: Szczepanski, C., Leland, D.
Year of Conference: 2000
Title: Move or not to move? Continuous question
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Denver, CO

Publisher: American Institute of Aeronautics and Astronautics
Pages: 1-11
Date: August 14-17
Author's Affiliation and Title: Cezary Szczepanski: Ph.D., M.Sc.Eng, Warsaw University of Technology, ETC-PZL Aerospace Industries, Poland
Dick Leland: Environmental Techtonics Corporation, Southampton, PA
Number of Pages: 11
Abstract: The authors' many years experience in design and manufacture of flight simulators, aviation training devices, and ground vehicle simulators have provided extensive understanding regarding the importance of motion systems in simulators. This paper presents our conclusions on the necessity of motion systems in flight training simulators for fixed wing aircraft and helicopters used by the armed forces. Motion system options considered were no motion, less than 6 DoF, and 6 DoF. In preparing the paper, the following factors were considered:
- Type of simulated aircraft
- Range of simulator Usage
- User of the Simulator
- Technological Aspects
- Pilots' Psychological and Physiological needs
- Financial Aspects

Our conclusion is that motion systems are necessary for flight simulation, especially when training flight tasks where motion stimuli are important for the pilot to determine appropriate control inputs. When the simulation only stimulates the pilot visually, there is a great deal of missing information that is normally present in flight and learning transfer is often adversely affected. Pilots should be trained in an appropriate motion system equipped simulator in order not to sacrifice training effectiveness. This is especially essential when pilots are trained for high G tolerance and Spatial Disorientation avoidance.

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Reference Type: Conference Proceedings
Author: Talleur, D.A., Taylor, H.L., Bradshaw, G.L., Emanuel, T.W.J., Rantanen, E., Lendrum, L., Hulin, C.L.
Year of Conference: 2001
Title: Effectiveness of a personal computer aviation training device (PCATD) for maintaining instrument currency
Conference Name: The Eleventh International Symposium on Aviation Psychology
Conference Location: Columbus, OH: The Ohio State University
Number of Pages: 6
Abstract: This study investigates the potential of personal Computer Aviation Training Devices (PCATDs) to substitute for actual aircraft experience for maintaining instrument currency. A Jeppesen FS-2000 PCATD and a Frasca-141 flight training device (FTD) were tested. The experiment compared the flight performance of four groups after a six-month period between instrument proficiency check (IPC) flights. The control group received no training to maintain currency in this period. Three other groups training in either the PCATD, the Frasca, or the aircraft. Preliminary results for the 106 subjects are presented. The performance of the subjects on an initial evaluation flight test and a final proficiency flight test six months later were compared. All subjects were instrument current by FAA standards prior to the evaluation flight test. Forty-two percent of the 106 subjects passed the evaluation flight test while 52 percent passed the final test. Results also indicate that the additional training received during the six months had the effect of improving final flight performance as compared to the evaluation flight. In particular, both the PCATD and Frasca FTD subjects were more likely to pass the final proficiency test than the control or aircraft subjects. Poorer performance from the aircraft group was not expected. A detailed analysis of individual maneuvers was also performed in order to determine if a particular method of maintaining currency was better suited for certain maneuvers.

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Reference Type: Journal Article
Author: Taylor, H.L., Lintern, G.
Year: 1993
Title: Quasi-transfer as a predictor of transfer from simulator to airplane
Journal: The Journal of General Psychology
Volume: 120
Issue: 3
Pages: 257-276
Date: July
Author's Affiliation and Title: University of Illinois at Urbana-Champaign, Savoy, IL
Number of Pages: 20
Abstract: Simulators have emerged as important components of flight-training programs. Nevertheless, the development of design principles that can maximize training transfer and cost-benefit trade-offs are not well established. The most significant challenge to research that would bear on simulator design principles is the difficulty and expense of flight transfer experiments. This difficulty and expense can de reduced by the use of an in-simulator transfer design, designated here as a quasi-transfer study, in which transfer is to a high-fidelity configuration of a simulator. Of primary concern for such studies is whether the implied assumption of correspondence between quasi-transfer and transfer effects is well founded. In this article, we review evidence that bears on this issue. The evidence is not entirely supportive but does indicate some correspondence between quasi-transfer and transfer.

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Reference Type: Report

Author: Taylor, H.L., Lintern, G., Hulin, C.L., Talleur, D., Emanuel, T., Phillips, S.
Year: 1997
Title: Transfer of training effectiveness of personal computer-based aviation training devices
Date: May
Type: Technical Report
Report Number: DOT/FAA/AM-97/11
Author's Affiliation and Title: University of Illinois at Urbana-Champaign, Institute of Aviation, Savoy, IL 61874
Number of Pages: 24
Keywords: personal computer-based aviation training devices, flight training, instrument flight, psychology, applied psychology
Abstract: The training effectiveness of Personal Computer-Based Aviation Training Devices (PCATDs) has received only limited testing. In the experiment reported here, a commercially available PCATD was evaluated in a transfer of training experiment for its effectiveness in supporting instrument flight training. The data show levels of savings in airplane flight time that varied from 15% to over 40% for certain training exercises. However, there were also cases in which savings were essentially zero or even showed decrements as high as 25%. In general, transfer savings were positive and substantial when new tasks were introduced. The data indicate that a PCATD can provide training benefit for certain tasks but, in addition, use of the PCATD in some areas is not expected to result in savings and will erode the overall potential to reduce costs.

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Reference Type: Journal Article
Author: Taylor, H.L., Lintern, G., Hulin, C.L., Talleur, D.A., Emanuel, J., Tom W., Phillips, S.I.
Year: 1999
Title: Transfer of training effectiveness of a personal computer aviation training device
Journal: The International Journal of Aviation Psychology
Volume: 9
Issue: 4
Pages: 319-335
Number of Pages: 17
Abstract: The training effectiveness of personal computer aviation training devices (PCATDs) has received only limited testing. In the experiment reported here, a commercially available PCATD was evaluated for its transfer effectiveness for teaching of instrument flight skills. Students from the beginning and advanced instrument courses at the University of Illinois were trained to criterion in the PCATD on a wide range of tasks and were then retained to criterion in the airplane on the same tasks. Other students were trained to criterion on the same tasks only in the airplane. Comparisons of trials to criterion in the airplane for the 2 groups, their times to complete each flight lesson in the airplane, and their course completion times were used to assess the training effectiveness of the PCATD. Transfer savings were generally positive and substantial when new tasks were introduced but low when tasks already learned in previous lessons were reviewed. A comparison of course completion times showed savings of 3.9hr in the airplane for the PCATD group compared to the airplane-control group.

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Reference Type: Report
Author: Taylor, H.L., Talleur, D.A., Phillips, S.I., Emanuel, T.W.J., Hulin, C.L.
Year: 1998
Title: Use of personal computers for instrument training
City: Savoy, IL

Institution: Institution of Aviation, University of Illinois
Type: Research Study
Number of Pages: 14
Abstract: The training effectiveness of Personal Computer Aviation Training Devices (PCATDs) has received only limited testing. This study evaluated a commercially available PCATD to determine its transfer effectiveness for the instruction of instrument skills. In order to evaluate transfer of training, the performance of a group of subjects trained in a PCATD, and later trained to criterion in an aircraft, was compared to the performance of a control group of subjects trained only in the airplane. For the PCATD group, all new maneuvers and procedures were introduced and trained to proficiency in a PCATD prior to training and skill validation in the aircraft. For the Airplane Control group, all new maneuvers were introduced and trained to proficiency in the airplane. Comparisons of trials to criterion in the airplane for the two groups, their times to complete each flight lesson in the airplane, and their course completion times were used to assess the training effectiveness of the PCATD. The data from this study indicates that the PCATD is an effective training device for teaching instrument tasks. Transfer savings were generally positive and substantial when new tasks were introduced but low when tasks already learned in previous lessons were reviewed. A comparison of course completion times showed savings of about four hours in the airplane for the PCATD group compared to the Airplane Control group. The cumulative transfer effectiveness ration was 0.15 or a saving of 1.5 flight hours for each ten hours of PCATD time.

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Reference Type: Electronic Source
Author: Technical Cooperation Program (TTCP)
Year: 2006
Title: Simulation evaluation
Access Year: 2006
Access Date: Sept. 6
Number of Pages: 5
Abstract: -What types of simulations are available?
-What is advanced/distributed distance learning (ADL)?
-How do you determine the effectiveness of representations?
-How do I measure simulator fidelity?
-What is the relationship between fidelity and training effectiveness?
URL: http://trainingsystems.org/TTCP/html/evaluation_simulation/simulation_eval.html

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Reference Type: Report
Author: Telban, R.J., Cardullo, F.M., Houck, J.A.
Year: 1999
Title: Developments in human centered cueing algorithms for control of flight simulator motion systems
Institution: American Institute of Aeronautics and Astronautics (AIAA)
Report Number: AIAA-99-4328
Number of Pages: 11
Abstract: The authors conducted further research with cueing algorithms for control of flight simulator motion systems. A variation of the so-called optimal algorithm was formulated using simulated aircraft angular velocity input as a basis. Models of the human vestibular sensation system, i.e. the semicircular canals and otoliths, are incorporated within the algorithm. Comparisons of angular velocity cueing responses showed a significant improvement over a formulation using angular acceleration input. Results also compared favorably with the

coordinated adaptive washout algorithm, yielding similar results for angular velocity cues while eliminating false cues and reducing the tilt rate for longitudinal cues. These results were confirmed in piloted tests on the current motion system at NASA-Langley, the Visual Motion Simulator (VMS). Proposed future developments by the authors in cueing algorithms are revealed. The new motion system, the Cockpit Motion Facility (CMF), where the final evaluation of the cueing algorithms will be conducted, is also described.

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Reference Type: Conference Proceedings
Author: Tomlinson, B.N.
Year of Conference: 1985
Title: Simulator motion characteristics and perceptual fidelity
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 6A-1 - 6A-12
Date: September 30 - October 3
Author's Affiliation and Title: FS(B)3 Division, Royal Aircraft Establishment, Bedford MK41 6AE, United Kingdom
Number of Pages: 12
Keywords: perceptual fidelity, motion characteristics, cue generation
Abstract: This paper is a progress report on a study, commission by the AGARD Flight Mechanics Panel, to review existing data and try to describe a relationship between certain motion systems parameters, identified in an earlier AGARD report (AR-144), and the fidelity of the pilot's perception of flight. Motion systems characteristics as a whole are discussed, this extending AR-144's treatment of motion mechanisms to include motion drive software and other features. Some of the key parameters of AR-144 are then examined in relation to total motion system fidelity. Finally, some proposals are made of a common format data structure with which to summarize research results on motion cues. The study is continuing.
Notes: Published in September 1986.

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Reference Type: Journal Article
Author: Treisman, M.
Year: 1977
Title: Motion sickness: An evolutionary hypothesis
Journal: Science
Volume: 197
Issue: July
Pages: 493-495
Author's Affiliation and Title: University of Oxford, Department of Experimental Psychology, South Parks Road, Oxford, England OX13UD
Number of Pages: 3
Abstract: Since the occurrence of vomiting as a response to motion is both wide-spread and apparently disadvantageous, it presents a problem for evolutionary theory. A hypothesis is proposed suggesting that motion sickness is triggered by difficulties which arise in the programming of movements in the eyes or head when the relations between the spatial frameworks defined by the visual, vestibular, or proprioceptive inputs are repeatedly and unpredictably perturbed. Such perturbations may be produced by certain types of motion, or by disturbances in sensory input or motor control produced by ingested toxins. The last would be the important cause in nature, the main function of the emesis being to rid the individual of

ingested neurotoxins. Its occurrence in response to motion would be an accidental by-product of this system.

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Reference Type: Conference Proceedings
Author: Tuxill, B.
Year of Conference: 2000
Title: United States perspective on long range training requirements
Conference Name: Royal Aeronautical Society (RAes) International Conference - Flight Simulation
Date: May 10-12
Notes: This is the text of a presentation given

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Reference Type: Report
Author: U.S. Department of Transportation
Year: 1989
Title: Cockpit human factors research requirements
City: Cambridge, MA 02142
Institution: Research and Special Programs Administration
Date: April
Number of Pages: 59

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Reference Type: Electronic Source
Author: U.S. Environmental Protection Agency
Year: 2002
Title: Comparison of multivariate methods
Access Year: 2002
Access Date: August 13
Type of Medium: website
Abstract: Most of the differences in multivariate methods can be understood in terms of the underlying model which can be defined by the number of independent and dependent variables on each side of the equation and the type of variables included in the model. The tables on this page compare the number and types of variables used in each method.
The tables below use a very simplified form for a multivariate statistical model:
Dependent variable(s) = f(independent variables).
Notes: As of Sept. 6, 2006, web page was no longer available.
URL: http://www.epa.gov/bioindicators/primer/tablemv.html

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Reference Type: Conference Proceedings
Author: Ungs, T.J.
Year of Conference: 1987
Title: Simulator induced syndrome: Evidence for long term simulator aftereffects
Conference Name: The Human Factors Society 31st Annual Meeting
Conference Location: Santa Monica, CA
Publisher: Human Factors and Ergonomics Society
Pages: 505-509
Author's Affiliation and Title: U.S. Coast Guard and Wright State University
Number of Pages: 5
Abstract: The purpose of this study was to determine the incidence, risk factors, and significance of adverse symptoms occurring in pilots more than 24 hours after completion of flight simulator training. This continued occurrence or recurrence of symptoms is termed by the author as "Long Term Simulator Aftereffects" (LTSA). Information was gathered by multi-part, anonymous, and voluntary questionnaire. Nine of 196 pilots studied reported LTSA. Several pilots reported symptoms up to one week and one three weeks post simulator training. Symptoms reported included: recurrent visual flashbacks, continued disturbance in balance, difficulties in concentrating and hand-eye coordination. Three pilots reported difficulties in flying aircraft. There was no statistically significant association between LTSA and: total flight time, total simulator time, length of simulator training, self-determined motion sickness susceptibility, and sex. Simulator training can result in the occurrence of long term (1 day) adverse symptoms which poses flight safety concerns.

Reference Type: Report
Author: University of Toronto
Year: 1991
Title: Annual progress report 1988-1989
City: Downsview, Ontario, Canada
Institution: University of Toronto, Institute for Aerospace Studies
Author's Affiliation and Title: University of Toronto, Institute for Aerospace Studies, 4925 Dufferin Street, Downsview, Ontario, Canada, M3H5T6
Number of Pages: 123
Notes: Presents summaries of work including references, participants, and equipment.

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Reference Type: Report
Author: USAF Scientific Advisory Board
Year: 1978
Title: Report of the ad hoc committee on simulation technology
Institution: Department of the Air Force
Date: April

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Reference Type: Journal Article
Author: Valverde, H.H.
Year: 1973
Title: A review of flight simulator transfer of training studies
Journal: Human Factors
Volume: 15
Issue: 6
Pages: 510-523
Date: December
Author's Affiliation and Title: Advanced Systems Division, Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, OH
Number of Pages: 14
Keywords: transfer, training, simulator, fidelity, motion
Abstract: Often operational equipment is considered to be the most effective and valid training equipment. However, this is not true in every instance. In fact, sometimes it may be undesirable to use real equipment for training if suitable simulators are available. For example, the use of operational equipment has several disadvantages which include (1) high costs, (2) limitation on practice of varied aspects of tasks, and (3) safety hazards. Practical decisions in the use of training devices depend upon compromises between economic and training objectives. A trainer need not duplicate operational equipment to have training value. Technical reports pertaining to flight simulator transfer of training studies available from the Defense Documentation Center are reviewed.

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Reference Type: Conference Proceedings
Author: van de Moesdijk, G.A.J.
Year of Conference: 1978
Title: Non-gaussian structure of the simulated turbulent environment in piloted flight simulation
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 7-1 - 7-27
Date: April 24-27
Author's Affiliation and Title: Delft University of Technology, Department of Aerospace Engineering, Delft, The Netherlands
Number of Pages: 27
Keywords: non-Gaussian, atmospheric turbulence, simulation, flight tasks, psychological effects
Abstract: After a description of the general non-gaussian characteristics of actual atmospheric turbulence as observed in the atmosphere, a non-gaussian turbulence simulation model has been described. The non-gaussian characteristics have been classified as patchiness and intermittency, both dependent on higher order statistics. These non-gaussian characteristics have been mathematically elaborated and described. The effects of patchiness on pilot's behaviour, using physiological parameters have been evaluated in a small simulator experiment.

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Reference Type: Journal Article
Author: van den Berg, A.V., Van de Grind, W.A.
Year: 1989
Title: Reaction times to motion onset and motion detection thresholds reflect the properties of bilocal motion detectors

Journal: Vision Research
Volume: 29
Issue: 9
Pages: 1261-1266
Number of Pages: 6
Keywords: vision, motion detection threshold, motion detection reaction time
Notes: Referenced in Ruud Hosman's book, Pilot's perception and control of aircraft motions (1996).

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Reference Type: Journal Article
Author: van der Steen, F.A.M.
Year: 1996
Title: Simulating self-motion
Journal: Brain Research Bulletin
Volume: 40
Pages: 473-475
Author's Affiliation and Title: Delft University of Technology, Faculty of Aerospace Engineering, Kluyverweg 1, 2629 HS Delft, The Netherlands, Email: Han.Steen@LR.TUDelft.NL
Number of Pages: 3
Keywords: virtual environments, vehicle simulation, self-motion perception, visual-vestibular, interaction, perception model
Abstract: In general, vehicle motions far exceed the mechanical constraints of an Earth-fixed simulator base. Inertial motions can therefore only be simulated in partial agreement with those of the actual vehicle. As a consequence, physical mismatches between inertial and environmental motion are inevitable. Here, the concept of a subjective reference frame is introduced, relative to which perceived self-motion is defined. This frame must be released from the Earth-fixed frame in order to evoke simulated self-motion. In addition, self-motion and environmental motion need to be perceived reciprocal, in order to evoke a stationary perceived environment. Due to the only limited accuracy of human self-motion perception, however, perceived self-motion and perceived environmental motion need not be *exactly* reciprocal. The extent to which self-motion and environmental motion may differ, can be expressed by a just noticeable difference. This just noticeable difference denotes the threshold at which the environment is perceived to move. In this paper, a self-motion perception model is outlined in which perceived environmental motion and perceived self-motion are separated. The perception model and the just noticeable differences can then be applied to determine the inertial stimulation that is needed to evoke perceived self-motion, in which the environment is perceived stationary throughout simulation.

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Reference Type: Report
Author: van der Steen, F.A.M.
Year: 1996
Title: A stationary perceived visual scene during roll and yaw motions in a flight simulator
Author's Affiliation and Title: Delft University of Technology, Faculty of Aerospace Engineering, Delft, The Netherlands
Number of Pages: 36
Keywords: self-motion, perception, visual-vestibular, simulator
Abstract: In two experiments, human observers in a moving base flight simulator were subjected to angular accelerations. The first experiment concerned accelerations about the longitudinal roll axis. The second experiment concerned accelerations about the vertical yaw axis. It was determined to which extent the amplitudes of inertial body motion (with respect to an earth-fixed

frame) and visual scene motion (with respect to the simulator cabin) may differ, while maintaining the perception of an earth-stationary visual scene. Both the body and visual motion consisted of a 0.75 *s* acceleration, followed by a 1.50 *s* deceleration, and a 0.75 *s* acceleration. The visual acceleration amplitude *W* was fixed at either 0, 2, 4, 8, or 12 deg/s^2 while the inertial acceleration amplitude *I* was varied by a staircase procedure, depending on whether the subject had perceived the scene to be stationary or not. Following the visual and inertial motion presentation, the subjects pushed a button when they perceived the scene to be not stationary. At each displayed visual motion amplitude, the “slow” and “fast” inertial threshold amplitudes were determined in between which the visual scene was perceived to be stationary. At the slow threshold, the inertial amplitude is too small while at the fast threshold, this amplitude is too large to evoke the perception or an earth-stationary visual scene. The slow thresholds were determined for $W = 0$ through W =12 deg/s^2 and satisfy the linear relation $I = 2.7 + 1.7\ W$ for roll and $I = 2.2 + 1.4\ W$ for yaw. When considering the slow and fast threshold amplitudes to have symmetry at the $W = 0$ condition, a strong non-linearity of the thresholds near $W = 0$ was found.

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Reference Type: Thesis
Author: van der Steen, H.
Year: 1998
Title: Self-motion perception
City: Delft, The Netherlands
University: Delft University of Technology
Thesis Type: Ph.D.
Keywords: perception of self-motion

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Reference Type: Conference Proceedings
Author: van der Steen, H.
Year of Conference: 2000
Title: Measuring the realism of motion in flight simulators
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 14-17
Author's Affiliation and Title: Siemens - Traffic, Transport and Special Projects division
Number of Pages: 6
Abstract: A prominent issue in flight simulation technology is the extent to which inertial (mechanical) motions are necessary. A condition that refers to the need for inertial motions is the perceptual condition that the simulator trainee may not perceive self-movements as unrealistic. This paper describes results of experiments in a flight simulator which determined inertial motion amplitudes which are needed to provide realistic motion. Two motion directions were tested: roll and yaw.
The experiments demonstrated that the perception of an earth-stationary visual scene corresponds to the perception of realistic self-motion. It is outlined that rather large ranges exist in which visual and inertial self-motion stimuli may physically mismatch, while the simulated self-motion is perceived as realistic.

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Reference Type: Conference Proceedings

Author: van der Steen, H.F.A.M., Hosman, R.J.A.W.
Year of Conference: 1995
Title: Perception of coherence of visual and vestibular velocity during rotational motion
Conference Name: IFAC Symposium on Analysis, Design and Evaluation of Man-Machine Systems
Conference Location: Massachusetts Institute of Technology, Cambridge, MA
Author's Affiliation and Title: Delft University of Technology, Faculty of Aerospace Engineering, P.O. Box 5058, 2600 GB, Delft, The Netherlands
Number of Pages: 6
Keywords: human perception, visual motion, thresholds, many-degrees-of-freedom systems, simulators
Abstract: Psychophysical experiments are described that concern the ability of subjects to indicate the velocity coherence of vestibular and visual stimuli during rotations. The coherence zone is determined by the thresholds at which the suggested outside visual world is no longer perceived as stationary. The results show high gains for roll and swing (1 to 6) and gains about one (0.5 to 2) for yaw motions. The use of perceived coherence zones in moving-base vehicle simulation is discussed.

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Reference Type: Report
Author: van der Vaart, J.C., Hosman, R.J.A.W.
Year: 1987
Title: Compensatory tracking in disturbance tasks and target following tasks. The influence of cockpit motion on performance and control behaviour
City: Delft, The Netherlands
Institution: Delft University of Technology
Date: December
Report Number: Report LR-51 l
Number of Pages: 53

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Reference Type: Conference Proceedings
Author: van Gool, M.F.C.
Year of Conference: 1978
Title: Influence of motion washout filters on pilot tracking performance
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 19-11 - 19-15
Date: April 24-27
Author's Affiliation and Title: National Aerospace Laboratory NLR, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands
Number of Pages: 5
Keywords: motion washout filters, human motion perception, tracking
Abstract: An investigation has been carried out on the NLR moving base flight simulator to establish the influence of the simulator motion wash-out filters in the pitch and roll axis in the performance of four pilots when stabilizing an aircraft disturbed by turbulence in one of these axes. For this compensatory tracking task, pilot describing functions, remnant spectra and other performance measures have been determined.

The results lead to the conclusion that, for the task under consideration, no significant differences can be observed when the break frequency of the (linear second-order) wash-out filter is varied from 0.1 rad/sec to 0.5 rad/sec. However performance in either condition is considerably better when compared to fixed-rate results. This is also reflected in the pilot comments and effort ratings, stating that the task is easier with motion.

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Reference Type: Journal Article
Author: Veltman, J.A.
Year: 2002
Title: A comparative study of psychophysiological reactions during simulator and real flight
Journal: The International Journal of Aviation Psychology
Volume: 12
Issue: 1
Pages: 33-48
Author's Affiliation and Title: Veltman: TNO Human Factors, Soesterberg, The Netherlands
Number of Pages: 16
Abstract: During selection tests in a flight simulator and a real aircraft, physiological workload measures were evaluated. The selection context guaranteed high motivation in the participant to exert additional effort during difficult flight tasks. The aim of the study was to obtain information about the sensitivity to mental effort of several physiological measures and to explore the applicability of these measures in real flight. The following measures were used: heart rate, heart rate variability, respiration (frequency and amplitude), blood pressure, eye blinks (frequency, duration and amplitude), and saliva cortisol. Blood pressure was the only measure that was difficult to obtain during real flights.
All physiological measures showed large differences between baseline and flight tasks. Heart rate, heart rate variability, and respiratory frequency showed similar results in the simulator and real flight. Blink frequency showed an expected decrease during simulator flight, whereas a large increase was found during real flight. This can be partly explained by eye movements, which were made more frequently during real flight. Blink duration was shorter and amplitude was larger during both flights. This indicates that a combination of blink parameters provides better information about workload than blink frequency alone. Cortisol was not affected by the simulator flight, whereas greatly increased levels were found after the real flight. This indicates that cortisol is not affected by mental effort. G-forces during the real flight most likely caused the increased cortisol levels.

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Reference Type: Journal Article
Author: Vinje, E.W., Pitkin, E.T.
Year: 1972
Title: Human operator dynamics for aural compensatory tracking
Journal: IEEE Transaction on Systems, Man, and Cybernetics
Volume: SMC-2
Issue: No. 4
Pages: 504-512
Keywords: human operator dynamics, compensatory tracking, aural display
Abstract: The effects of aural and combined aural and visual displays of tracking error on human operator dynamics were investigated using a compensatory tracking task. The aural displays indicated error magnitude with tone pitch and error polarity by either modulating the tone or by switching it between the ears. Describing functions, remnants, and rms tracking performance were measured with test conditions which were similar to those for previous studies of visual

tracking performance. Human operator control characteristics measured for aural displays agree closely with those which result for visual displays. Also, operators could control equally well with either one- or two-ear displays. However, the reduction in operator time delays, expected because of the generally faster human response to aural stimuli, was not clearly evident in the results. Results also indicate that the combined aural and visual presentation of tracking error improved operator performance slightly.

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Reference Type: Conference Proceedings
Author: Vogl, E.
Year of Conference: 1978
Title: Differences between simulation and real world at the IABG Air to Air Combat Simulator with a wide angle visual system
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 24-21 - 24-11
Date: April 24-27
Author's Affiliation and Title: Industrieanlagen-Betriebsgesellschaft, 8012 Ottobrunn, FRG
Number of Pages: 11
Keywords: wide angle visual system, air to air combat
Abstract: This paper presents the experiences of IABG with its Dual Flight Simulator (DFS) for air-to-air combat. First of all IABG has discovered that air-to-air combat simulation without a motion system is no problem to its pilots. During the verification phase it was found that the results of simulators at DFS were very good.
On the other hand IABG has researched all simulator effects in respect to human factors. All of the following effects are existent, but have an unimportant influence on the results of air-to-air combat simulations.

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Reference Type: Report
Author: von der Heyde, M., Riecke, B.E.
Year: 2001
Title: How to cheat in motion simulation - Comparing the engineering and fun ride approach to motion cueing
Pages: 1-8
Date: December
Type: Technical Report
Report Number: TR No. 089
Number of Pages: 9
Abstract: The goal of this working paper is to discuss different motion cueing approaches. They stem either from the engineering field of building flight and driving simulators, or from the modern Virtual Reality fun rides presented in amusement parks all over the world. The principles of motion simulation are summarized together with the technical implementations of vestibular stimulation with limited degrees of freedom. A psychophysical experiment in Virtual Reality is proposed to compare different motion simulation approaches and quantify the results using high-level psychophysical methods as well as traditional evaluation methods.

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Reference Type: Magazine Article
Author: Voorhees, J.W., Waddington, M.J.
Year: 1994
Title: Fidelity in human-in-the-loop driving simulation
Magazine: Traffic Technology International
Issue Number: Winter
Pages: 76-77, 79-80
Author's Affiliation and Title: In-Mar-Tech, Australia
Number of Pages: 4
Keywords: physical fidelity, system fidelity, environmental fidelity, situational fidelity, Real Drive simulator
Abstract: This article examines the technologies for designing successful vehicle simulators, and describes the Real Drive simulator commissioned by the Victorian Transport Accident Commission (TAC) in Australia. 'Fidelity' is the degree of correspondence between a simulated system and the real world system that it represents. It has several forms (physical, system, environmental, and situational) and many different levels. It is important in simulation, because training, assessment and research all aim to improve performance in the real world. Cost and design flexibility are also important. The Victorian TAC and the Monash University Accident Research Centre (MUARC) decided to investigate the young driver problem by using driving simulators as a training device and research tool. After their worldwide survey found no suitable existing simulators, the Real Drive simulator project was launched. Situational and physical fidelity were found to be essentially important, and system and environmental fidelity to relate to research and training needs. The Real Drive simulator toured the USA during Summer 1994. Over 1000 people had an opportunity to drive it and record their opinions about its four types of fidelity. The article reports some of these comments.

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Reference Type: Report
Author: Waag, W.L.
Year: 1981
Title: Training effectiveness of visual and motion simulation
City: Williams Air Force Base, AZ
Institution: Air Force Human Resources Laboratory
Date: January
Type: Interim Report
Report Number: AFHRL-TR-79-72
Author's Affiliation and Title: Operations Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, AZ 85221
Number of Pages: 27
Keywords: visual simulation, motion simulation, flight simulation, transfer of training, flight training
Abstract: A review of the literature concerning the training effectiveness of visual and motion simulation is presented in this report. Although there exist much pilot opinion and in-simulator performance data, their extrapolation to training effectiveness information is questioned. The present review focuses on data obtained through the application of the transfer-of-training methodology. The results are discussed in terms of study design factors, and recommendations are made wherein additional research data are needed.

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Reference Type: Report
Author: Wade, M.G., Hammond, C.
Year: 1998
Title: Simulation validation: Evaluating driver performance in simulation and the real world
Date: July
Type: Technical Report
Report Number: MN/RC - 1998-28
Author's Affiliation and Title: University of Minnesota, Human Factors Research Laboratory, 1901 4th Street, S.E., Minneapolis, MN 55455
Number of Pages: 101
Keywords: simulation performance, collision avoidance, driver behavior
Abstract: Simulation offers a cost-effective way to conduct research on collision avoidance and accident prevention. To be effective, simulated performance must be a valid measure of real world performance. This project sought to validate real world driving performance based on the performance of individuals driving in simulation.
The study presents performance data on 14 male and 12 female volunteer subjects who drove a route adjacent to the University of Minnesota campus and then performed in a similar computer-generated driving route. Generally, subjects reported the simulated driving test comfortable and realistic; performance and characteristics of driving in the simulator closely paralleled the real world; the qualitative pattern of driving was similar; and errors and the control parameters of driving performance suggested acceptable reliability between both driving worlds. Researchers concluded that the simulator performed reliably and provided a valid set of performance data that could be used to better understand driving behavior, especially as it related to accident prevention and collision avoidance.

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Reference Type: Magazine Article
Author: Walker, K.
Year: 2005

Title: Plugging in
Magazine: Training & Aviation Journal
Pages: 40
Date: October
Number of Pages: 1
Abstract: latest full-flight simulators feature electric motion systems.

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Reference Type: Report
Author: Wargo, M.J., Kelley, C.R., Mitchell, M.B., Prosin, D.J.
Year: 1967
Title: Human operator response speed, frequency, and flexibility: A review, analysis and device demonstration
City: Santa Monica, CA
Institution: Dunlap and Associates, Inc.
Pages: 1-74
Date: November
Report Number: NASA CR-874
Author's Affiliation and Title: Dunlap and Associates, Inc., Santa Monica, CA
Recipient's Affiliation and Title: Electronics Research center, National Aeronautics and Space Administration (NASA)
Number of Pages: 75
Abstract: (taken from Summary) The human operator's manual control speed, frequency and flexibility is limited by his innate characteristics and by the state-of-the-art in manual control technology. The basis of these limitations was reviewed and analyzed and recommendations for overcoming or reducing these limitations were suggested. On the basis of these suggestions a muscle action potential control, simultaneous visual-auditory display device was developed to demonstrate the increase in operator response speed, frequency and flexibility that accrue from advanced manual control techniques.
In a discrete control situation muscle action potential control was found to increase response speed by approximately 100 ms and simultaneous visual-auditory display was found to reduce response time by an additional 40 ms. In a continuous control situation, muscle action potential control via the facial muscles increased operator response bandwidth across a range of forcing function amplitudes. These results demonstrate the increase in response speed, frequency and flexibility that accrues from use of muscle action potential control and suggests that further development of muscle action potential control devices is warranted.

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Reference Type: Magazine Article
Author: Warwick, G.
Year: 1996
Title: SIMONA seeks realism
Magazine: Flight International
Pages: 57
Date: April 17-23
Number of Pages: 1

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Reference Type: Conference Proceedings

Author: Weingarten, N.C.
Year of Conference: 2003
Title: History of in-flight simulation & flying qualities research at general dynamics
Conference Name: AIAA Atmospheric Flight Mechanics Conference
Conference Location: Austin, TX
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-15
Date: August
Author's Affiliation and Title: General Dynamics Advanced Information Systems, Flight and Aerospace Research, Buffalo, NY 14225
Number of Pages: 16
Abstract: General Dynamics–Advanced Information Systems (GDAIS) (formerly Veridian) has been the primary innovator, developer, and operator of in-flight simulators in the United States, as well as the rest of the world, since 1947. Though other agencies and countries have developed their own in-flight simulators, the focus is on GDAIS accomplishments in this field. In-flight simulation puts the pilot in the real flight environment and has been used in the development of new aircraft, research of flying qualities and flight-control systems, and training of pilots and engineers in these areas. More recent uses have been in the field of display systems and as avionics test beds. Early technologies that led to the development of variable stability aircraft and their earlier applications, are described first, followed by GDAIS's history in the development and utilization of in-flight simulation, starting in 1949 with the first flight of the F4U-5 and its auxiliary rudder surface, up to the present with the five-degree-of-freedom F-16 Variable Stability In-Flight Simulator and Test Aircraft. Specific case studies are presented that describe the development and distinctive features of each of the GDAIS in-flight simulators and some of the more significant applications of these unique tools are highlighted.

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Reference Type: Conference Proceedings
Author: Welch, B.L.
Year of Conference: 1978
Title: Recent advances in television visual systems
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 13-11 - 13-12
Date: April 24-27
Author's Affiliation and Title: CAE Electronics Ltd., P.O. Box 1800, St. Laurent, Montreal, Quebec H4L 4X4 Canada
Number of Pages: 12
Keywords: television visual systems, display system
Abstract: A closed circuit television (CCTV) model board visual system, which was designed for a CH-47 helicopter, is described herein. The attributes and deficiencies of the system are discussed in an attempt to show how a model board based visual system suitable for full mission simulation in Nap of the Earth (NOE) environments could be designed. A new computer generated image (CGI) visual system which makes extensive use of texture is presented as an alternative to the model board approach. The importance of realism in full mission simulators as distinct from flight and weapons trainers is also discussed.

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Reference Type: Journal Article

Author: Wertheim, A.H.
Year: 1994
Title: Motion perception during self-motion: The direct versus inferential controversy revisited
Journal: Behavioral and Brain Sciences
Volume: 17
Issue: 2
Pages: 293-355
Author's Affiliation and Title: TNO Institute for Perception, P.O. Box 23, 3769 ZG, Soesterberg, The Netherlands
Keywords: motion perception, velocity perception, self-motion, extraretinal signal, efference copy, direct perception, visual-vestibular interactions
Abstract: According to the traditional inferential theory of perception, percepts of object motion or stationarity stem from an evaluation of afferent retinal signals (which encode image motion) with the help of extraretinal signals (which encode eye movements). Direct perception theory, on the other hand, assumes that the percepts derive from retinally conveyed information only. Neither view is compatible with a special perceptual phenomenon which occurs during visually induced sensations of ego-motion (vection). A modified version of inferential theory yields a model in which the concept of an extraretinal signal is replaced by that of a reference signal. Reference signals do not encode how the eyes move in their orbits, but how they move in space. Hence reference signals are produced not only during eye movements but also during ego-motion, (i.e., in response to vestibular stimulation and to retinal image flow, which may induce vection). The present theory describes how self-motion and object motion percepts interface. Empirical tests (using an experimental paradigm that allows quantitative measurement of the magnitude and gain of reference signals and the size of the Just Noticeable Difference (JND) between retinal and reference signals) reveal that the distinction between direct and inferential theories largely depends on: (1) a mistaken belief that perceptual veridicality is evidence that extraretinal information is not involved, and (2) a failure to distinguish between (the perception of) absolute object motion in space and relative motion of objects with respect to each other. The new model corrects these errors, thus providing a new, unified framework for interpreting many phenomena in the field of motion perception.
URL: http://www.bbsonline.org/Preprints/OldArchive/bbs.wertheim.html

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Reference Type: Journal Article
Author: Wertheim, A.H.
Year: 1998
Title: Working in a moving environment
Journal: Ergonomics
Volume: 41
Issue: 12
Pages: 1845
Date: December
Number of Pages: 14
Keywords: motion, simulators, work load, task performance, motion sickness
Abstract: The present paper provides a review of research and theories concerning the question of how and why working in a moving environment may affect performance. It is argued that performance decrements can be expected to occur as a result of general factors or as a result of specific impairments of particular human skills. General effects happen when environmental motion, simulated or real, reduces motivation (due to motion sickness), increases fatigue (due to increased energy requirements), or creates balance problems. Specific effects of moving environments on task performance may only be expected through biomechanical influences on particular skills such as perception (interference with oculomotor control) or motor skills (such as

manual tracking. There is no evidence for direct effects of motion on performance in purely cognitive tasks.

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Reference Type: Report
Author: Westra, D.P.
Year: 1982
Title: Simulator design features for carrier landing: II. In-simulator transfer of training
City: Orlando, FL
Institution: Naval Training Equipment Center
Date: December
Type: Technical Report
Report Number: NAVTRAEQUIPCEN 81-C-0105-1
Author's Affiliation and Title: Canyon Research Group, Inc., Westlake Village, CA 91361
Number of Pages: 79
Keywords: simulation, carrier landing, transfer of training, field of view, scene detail, motion simulation, holistic design, visual simulation, visual technology research simulator (VTRS)
Abstract: The Visual Technology Research Simulator (VTRS) at the Naval Training Equipment Center was used to study the effects of six factors on carrier-landing training. An in-simulator transfer paradigm was chosen in which students were trained under various conditions and then tested under a standard condition that represented maximum realism. The experimental design permitted a relatively large number of variables to be studied, using a relatively small number of student subjects. The subjects were pilots who had no prior carrier-landing experience: 16 recent graduates of Air Force T-38 training, and 16 highly experienced Navy P-3 pilots.
Display and simulator factors investigated were field of view (160 x 80 vs. 48 X 36 degrees), scene detail (day, solid-surface vs. night, point-light) and platform motion (six-degrees-of-freedom vs. no motion). Two training factors were included: descent-rate cuing (presence or absence of an extra element on the Fresnel lens display that provided information on glideslope descent-rate error), and approach type (training on straight-in approaches vs. circling approaches). Turbulence was included as a factor and pilot type (Navy P-3 vs. Air Force T-38) was also included as a factor to control this source of subject variability. After training under a certain factor-level combination, students were tested on the day, wide field of view, circling task with motion and without descent-rate cuing.
Results showed some temporary transfer advantages for the wide field of view and high scene detail conditions. Training on straight-in approaches resulted in transfer performance that was better than that produced by training on circling approaches. There was no motion or FLOLS rate cuing effects on the transfer task. Display and simulator transfer effects did not differ between the two pilot groups despite large differences in mean group performances.
As a result of these findings, it was suggested that a simulator-to-field transfer study be conducted with field of view, scene detail and approach type as factors. Such a study, using pilots from the target population of undergraduate Naval aviators, would provide the necessary information to make final simulator design decisions for the carrier-landing task.

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Reference Type: Report
Author: Westra, D.P., Simon, C.W., Collyer, S.C., Chambers, W.S.
Year: 1981
Title: Simulator design features for carrier landing: I. Performance experiments
City: Orlando, FL
Institution: Naval Training Equipment Center
Date: December

Type: Interim Report
Report Number: NAVTRAEQUIPCEN 78-C-0060-7
Author's Affiliation and Title: Naval Training Equipment Center
Number of Pages: 62
Keywords: Visual Technology Research Simulator (VTRS), multifactor experiments, holistic experimentation, flight simulation, carrier landing research, visual stimulation, motion simulation
Abstract: The effects of twelve factors on carrier landing performance in the Visual Technology Research Simulator (VTRS) at the Naval Training Equipment Center (NTEC), Orlando, Florida, were investigated in a series of three experiments. Subjects for the experiment were experienced naval aviators. The purpose was to determine and rank order the sizes of effects, identify factors having no effect, and to obtain information for making decisions about future transfer-of-training studies.
[some text was unreadable] experiment, the task was a straight-in approach and landing. Seven visual display factors (Fresnel Lens Optical Landing System type, ship detail, field of view, visual lags, seascape, brightness, TV line rate), two non-visual factors (motion and engine lags), one environmental factor (turbulence) and subjects as a factor were studied. In the second experiment, a circling approach to landing was employed as the task and included as factors ship detail, visual lags, seascape, brightness, motion, and turbulence. In the third experiment, a straight-in approach was employed. Two simulation factors, G-seat and ship type, were studied along with turbulence.
Results generally showed small to null effects for equipment factors although several had statistically reliable effects. As the display and simulator factors were manipulated over a wide range of interest representing expensive vs. inexpensive simulation options, the implication is that simulation for carrier landing skill maintenance and transition training for experienced pilots does not require the highest levels of fidelity for these features. Simulator requirements for training at the undergraduate level are currently being examined.
Notes: See also:
·Waag (1981). Training effectiveness of visual and motion simulation.
·Westra (1982). Simulator design features for carrier landing: II. In-simulator transfer of training.

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Reference Type: Report
Author: White, A.D.
Year: 1994
Title: The impact of cue fidelity on pilot behaviour and performance
City: Bedford, United Kingdom
Institution: FDS Department, Defence Research Agency
Author's Affiliation and Title: FDS Department, Defence Research Agency, Bedford, United Kingdom
Number of Pages: 12

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Reference Type: Conference Proceedings
Author: White, A.D., Hall, J.R., Tomlinson, B.N.
Year of Conference: 1991
Title: Initial validation of an R&D simulator with large amplitude motion
Conference Name: Flight Mechanics Panel Symposium on Piloted Simulation Effectiveness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 24-21 - 24-24
Date: October 14

Author's Affiliation and Title: Flight Systems Department, Defence Research Agency, Bedford MK41 6AE, United Kingdom
Number of Pages: 24
Keywords: AFS, large amplitude motion, validation
Abstract: The Advanced Flight Simulator (AFS) Complex at DRA Bedford has been enhanced by the addition of a large displacement motion platform and a three channel Computer Generated Image (CGI) outside world visual system. The trial described in this report was the first in a series of trials aimed at validating the AFS in its present configuration and in particular at demonstrating its ability to address a wide range of vehicle handing qualities with a high degree of fidelity and user confidence. It concluded a direct comparison between the ground based AFS and the Calspan Learjet in-flight simulator.
The comparison between the AFS and Learjet involved three pilots flying the same offset approach landing racks using the same aircraft model in both the AFS and in flight. The lateral handling qualities were varied by adjusting the time constant of a filter in the pilots roll control loop. Pilot comments, handling quality and PIO ratings indicate that the AFS reproduces the lateral handling qualities and roll PIO tendencies of the Learjet in-flight simulator with high fidelity. The degradation in handling qualities and increase in PIO tendencies with increasing filter time constant were clearly revealed in both the AFS and Learjet. The importance of good platform motion cueing and task design when evaluation handling qualities was also determined.
Notes: Published in February 1992.

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Reference Type: Conference Proceedings
Author: White, A.D., Rodchenko, V.V.
Year of Conference: 1999
Title: Motion fidelity criteria based on human perception and performance
Conference Name: Modeling and Simulation Technologies Conference and Exhibit
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 485-493
Date: August 9-11
Author's Affiliation and Title: White: Defence Evaluation and Research Agency (DERA), Bedford, United Kingdom
Rodchenko: Central Aerohydrodynamic Institute (TsAGI), Zhukovsky, Russia
Number of Pages: 9
Abstract: Based on experience accumulated by DERA and TsAGI in developing and using moving-base flight simulators and on the results of recent experiments the following aspects of motion cueing are considered: the role of accelerations in piloting, motion system drive law criteria and the requirements for motion system dynamic performance. The paper presents a theoretical approach to estimating the effect of accelerations, proposes criteria to evaluate motion fidelity for different driving laws and identifies the requirements for motion platform dynamics. Estimates according to the theoretical approach and criteria are compared with the experimental data.

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Reference Type: Journal Article
Author: Whiteside, T.C.D.
Year: 1983
Title: Simulators and realism
Journal: Quarterly Journal of Experimental Psychology
Volume: 35A
Pages: 3-15

Number of Pages: 13
Abstract: The objectives of simulation are discussed on the basis of training in procedures or neuromuscular skills, and in relation to the amount of realism required. Motion sickness arising from inadequate co-ordination of visual and motion cues, is considered in relation to fixed and moving base simulators. In the perception of distance and size, the role of ocular convergence is discussed and an experimental approach suggested. The mentally stressful effects of increased responsibility, as robots enable the operator to extend his output, are discussed in relation to its covert symptomatology and to advanced flight concepts.

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Reference Type: Book Section
Author: Wickens, C.D.
Year: 1986
Title: The effects of control dynamics on performance
Editor: Boff, K.R., Kaufman, L., Thomas, J.P.
Book Title: Handbook of perception and human performance
City: New York
Publisher: John Wiley and Sons
Volume: II
Pages: 39.31 - 39.60
Author's Affiliation and Title: Wickens: University of Illinois Institute of Aviation, Aviation Research Laboratory, Savoy, IL
Number of Pages: 60

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Reference Type: Journal Article
Author: Wickens, C.D., Gopher, D.
Year: 1977
Title: Control theory measures of tracking as indices of attention allocation strategies
Journal: Human Factors
Volume: 19
Issue: 4
Pages: 349-365
Date: August
Author's Affiliation and Title: Wickens: University of Illinois, Department of Psychology
Gopher: The Technion, Haifa, Israel
Number of Pages: 17
Abstract: In an intelligent man-machine control system, control theory measures describing the operator's tracking performance can provide useful information concerning an operator's attentional state. This information may be used to implement adaptive aiding procedures. Research is reviewed that relates attentional manipulations to variation in control theory parameters, and an experiment is then described in which 29 subjects performed a tracking task alone, and concurrently with a serial reaction-time task. Within the time-sharing condition, relative priorities between the two tasks were manipulated. The results are interpreted in terms of the separate effects of time-sharing and of priority manipulations upon measures of tracking gain, remnant, time-delay and response "holds," and the feasibility of on-line measurement of those variables.

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Reference Type: Journal Article
Author: Wightman, D.C., Lintern, G.
Year: 1985
Title: Part-task training for tracking and manual control
Journal: Human Factors
Volume: 27
Issue: 3
Pages: 267-283
Number of Pages: 17
Abstract: Part-task training was defined as practice on some set of components of the whole task as a prelude to performance of the whole task. Part-task procedures are intended to improve learning efficiency and to reduce costs. Our review focused on the instruction of tracking skills for manual control. Transfer of training was emphasized and crucial features of the methodology and of means of assessing transfer were discussed. The part-task procedures of segmentation, fractionation, and simplification were explained, and procedures for reintegrating parts into whole task were summarized.

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Reference Type: Conference Proceedings
Author: Williams, K.W.
Year of Conference: 1994
Title: Summary proceedings on the joint industry-FAA conference on the development and use of PC-based aviation training devices
Conference Name: Joint Industry-FAA Conference on the Development and Use of PC-Based Aviation Training Devices
Conference Location: Oklahoma City, OK
Publisher: Federal Aviation Administration (FAA), Civil Aeromedical Institute
Date: June 16-17
Number of Pages: 23
Keywords: personal computer-based aviation training devices, flight training, psychology, applied psychology, memory
Abstract: This report is a summation of the proceedings of a joint industry-FAA conference on the development and use of PC-Based aviation training devices (PCATDs) that was held June 16-17 1994 in Oklahoma City, Oklahoma. The primary purpose of the conference was to provide a forum of open dialog among interested PCATD parties, with the aim of finding common ground or areas of consensus, through which progress can be made in reducing or resolving any differences in viewpoint.
Notes: Published in November 1994.

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Reference Type: Report
Author: Williams, K.W.
Year: 2001
Title: Qualification guidelines for personal computer-based aviation training devices: Private pilot certificate
City: Oklahoma City, OK
Institution: Federal Aviation Administration (FAA), Civil Aerospace Medical Institute
Date: July
Type: Final Technical Report
Report Number: DOT/FAA/AM-01/13
Number of Pages: 63

Label: As part of the development of qualification guidelines for a personal computer-based aviation training device (PCATD), a task analysis of flight tasks for the private pilot certificate has been completed and is reported in this paper. The primary goal of the task analysis was to identify training device requirements for supporting specific private pilot maneuvers. Before PCATDs can be authorized for use as qualified and approved training devices within a private pilot flight training course, a set of qualification guidelines must be developed for use by the FAA in evaluation such potential training devices. This task analysis constitutes the first steps in the development of those qualification guidelines.
Keywords: PCATD, Transfer of Training, Private Pilot Training, Task Analysis

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Reference Type: Report
Author: Williams, K.W., Blanchard, R.E.
Year: 1995
Title: Development of qualification guidelines for personal computer-based aviation training devices
City: Oklahoma City, OK
Institution: Federal Aviation Administration (FAA), Civil Aeromedical Institute
Date: February
Report Number: DOT/FAA/AM-95/6
Number of Pages: 28
Keywords: personal computer-based aviation training devices, flight training, instrument flight, applied psychology
Abstract: Recent advances in the capabilities of personal computers have resulted in an increase in the number of flight simulation programs made available as Personal Computer-Based Aviation Training Devices (PCATDs). The potential benefits of PCATDs have been recognized by researchers and software/hardware developers alike. The purpose of this report is twofold: 1) present a conceptual approach based upon human learning and available flight training data for use in the development and evaluation of PCATDs; and 2) provide a detailed technical plan for an initial effort to develop and test guidelines for assessing the use of PCATDs in a training curriculum of a flight school conducted in accordance with the regulations stated in FAR Part 141.

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Reference Type: Electronic Source
Author: Willingham, S.
Year: 2000
Title: Navy seeks balance between simulator and flight training
Producer: National Defense Online Magazine
Access Year: 2006
Access Date: Sept. 6
Last Update Date: April, 2000
Type of Medium: Online Article
Number of Pages: 5
URL: http://www.nationaldefensemagazine.org/issues/2000/Apr/Navy_Seeks.htm

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Reference Type: Electronic Source
Author: Willingham, S.

Year: 2000
Title: U.S. Air Force to invest $500 million in simulators through 2006
Producer: National Defense Magazine
Access Year: 2006
Access Date: Sept. 6
Last Update Date: November 2000
Number of Pages: 2
URL: http://www.nationaldefensemagazine.org/issues/2000/Nov/US_Air.htm

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Reference Type: Report
Author: Wilson, D.
Year: 1965
Title: Visual simulation - Where we are - Where we are going
Institution: Society of Automotive Engineers (SAE)
Pages: 55-59
Date: February 1
Type: Technical Paper
Report Number: SAE TR 670303
Author's Affiliation and Title: General Precision Systems Ltd.
Number of Pages: 5
Abstract: Visual simulation has added a new dimension to flight training simulators. Monochrome TV projection preceded the early colour displays which are, in turn, superseded by high definition colour systems incorporating features such as full runway and approach lighting.
The paper outlines the progress in visual simulation and high definition colour systems which we have today. The requirements of all-weather operation are detailed. New developments are discussed which will further advance the art of visual simulation.

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Reference Type: Conference Proceedings
Author: Wolf, J., Gibb, G., Hampton, S., Wise, J.A.
Year of Conference: 1996
Title: An evaluation of full flight simulators and flight training devices in air carrier initial flight training programs
Conference Name: Fifteenth Biennial Applied Behavioral Sciences Symposium
Conference Location: Colorado Springs, CO
Pages: 346-352
Date: April
Author's Affiliation and Title: Embry-Riddle Aeronautical University, Center for Aviation/Aerospace Research, Daytona Beach, FL
Number of Pages: 6
Abstract: The effectiveness of motion in flight simulators used to train and certify pilots is examined. Two groups of pilots were put through two similar training programs: one was a traditional program in which a full flight simulator (FFS)--including motion--was used for all training and certification, and the other program in which a FFS was used only at the final stage to measure pilot skill. This second group (the experimental group) received training in a simulator featuring all of the FFS features (including visual simulation) except motion. Training effectiveness was measured by using the simulator computer to determine the error in pilot control for six maneuvers. A flight instructor rating sheet was also filled out by an independent observer pilot.

Results show no significant difference between the training measures for four of the six maneuvers. In one maneuver, the angle of bank portion of the steep turn maneuver, the control group did perform significantly better than the experimental group. In the visual approach maneuver, however, the experimental group performed better than the control group.
URL: http://home.earthlink.net/~johnwise/wise-delta-dod-paper

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Reference Type: Book
Author: Wood, S.J.
Year: 1995
Title: Airplane flight simulation evaluation handbook
Series Title: International standards for the qualifications of airplane simulators
City: London
Publisher: Royal Aeronautical Society (RAeS)
Volume: II
Edition: Draft
Keywords: simulator evaluation, subject evaluation
Abstract: Lists methods, evaluations, and discussions on the different training tasks

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Reference Type: Conference Proceedings
Author: Woomer, C.W., Williams, R.L.
Year of Conference: 1978
Title: Environmental requirements for simulated helicopter/VTOL operations from small ships and carriers
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 5-1 - 5-13
Date: April 24-27
Author's Affiliation and Title: Woomer: Engineering Test Pilot, US Navy, Rotary Wing Aircraft Test Directorate, Naval Air Test Center, Patuxent River, MD 20670
Williams: Branch Manager, Marketing, Simulation Systems, McDonnell Douglas Electronics Company, Box 426, St. Charles, MO 63301
Number of Pages: 13
Keywords: takeoff and landing tasks, environmental requirements
Abstract: Helicopter/VTOL operations from ships create demanding flying qualities and performance requirements. The environment in which takeoff and landing evolutions must occur has a significant influence on these tasks. Aircraft and simulator designers, each in their own way, must make appropriate provision for environmental factors, such as visual landing aids (VLA), ship motion, turbulence, relative wind, and ground effect.
The unique characteristics of a helicopter combined with the shipboard operations of a naval environment have been successfully simulated in Device 2F106, the SH-2F Weapons System Trainer (WST). It is equipped with a VITAL III computer-generated image (CGI) calligraphic visual system. The development and validation of this device have provided valuable experience on environmental requirements needed to perform takeoff and landing tasks from ships. Technical advances in the state-of-the-art of CGI visual systems now offer capabilities which overcome many previous limitations. This permits additional tasks to be successfully simulated, improving the safety and economics of training.

The paper discusses the specific requirements for the simulated environment to satisfactorily provide training for shipboard takeoff and landing. Test techniques to validate trainer fidelity in flying qualities, performance, and environmental simulation are discussed. The specific subject of calligraphic visual systems is extensively covered including a report on the current state-of-the-art as related to the at-sea environment. Finally, the utilization of a high-fidelity trainer is explored for research as well as for expanded fleet training.

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Reference Type: Electronic Source
Author: Wuensch, K.L.
Year: 2001
Title: Factorial MANOVA
Producer: Karl L. Wuensch
Abstract: A factorial MANOVA may be used to determine whether or not two or more categorical independent variables (and their interactions) significantly affect optimally weighted linear combinations of two or more normally distributed dependent variables.
URL:
http://72.14.203.104/search?q=cache:85a32V0dL0QJ:core.ecu.edu/psyc/wuenschk/MV/MANOVA/MANOVA2.doc+factorial+manova+2001&hl=en&gl=us&ct=clnk&cd=1

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Reference Type: Conference Proceedings
Author: Yanus, T.M., Maelstrom, F.V.
Year of Conference: 1994
Title: Is motion sickness hereditary?
Conference Name: Human Factors and Ergonomics Society, 38th Annual Meeting
Pages: 2-4
Author's Affiliation and Title: Embry-Riddle Aeronautical University
Number of Pages: 5
Keywords: motion sickness, fatigue, headache, nausea, genetics, hereditary
Abstract: Motion Sickness surveys were administered to 77 male graduate students and 95 male and female members of an Air Force Reserve medical unit. Results of Survey 1 indicated significant and sizeable correlations between sons and their natural fathers for severity of motion sickness symptoms of fatigue, headache, and nausea. Stepwise multiple regression indicated that the father's nausea accounted for 59.4% of the total variance of their son's nausea during travel. Results of Survey 2 indicated sizeable and significant correlations between respondents and both natural parents for percentage of reported symptoms of fatigue and headache. Stepwise multiple regression indicated that both parents reported percentage of fatigue (26.6%) and headache (33.6%) reliably predicted the respondents' percentage of fatigue and headache symptoms but not the nausea symptoms. In addition, there were no significant correlations between self-reported symptoms of fatigue, headache, and nausea. Findings suggest (1) hereditary factors may be a significant contributor to motion sickness, both in severity and frequency of symptoms, and (2) fatigue, headache, and nausea are largely independent of each other. Indications are that motion sickness be considered a syndrome rather than a unitary disorder.

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Reference Type: Journal Article
Author: Young, L.R.
Year: 1967
Title: Some effects of motion cues on manual tracking
Journal: Journal of Spacecraft and Rockets
Volume: 4
Issue: 10
Pages: 1300-1303
Date: October
Author's Affiliation and Title: Massachusetts Institute of Technology, Cambridge, MA
Number of Pages: 4
Abstract: Although sustained high acceleration or vibration can have a deleterious effect on a pilot's tracking ability, there are some situations in which motion cues, as felt in flight or moving-base simulation, yield a significant improvement in pilot performance. The first of these situations is in a control task requiring more lead compensation than is easily developed from visual displays. The vestibular and tactile sensations contribute velocity and acceleration information which is used in stabilization. Experiments on control of inverted pendulums and VTOLS with and without motion cues are discussed. Tests of labyrinthine defective patients on similar tasks demonstrated the critical importance of vestibular inputs. The second situation required rapid adaptation to controlled element failures in a simulated blind landing experiment. Other tests showed motion effects to be important in a class of flexible booster control problems. These results were combined with many comparisons of fixed-base-moving-base flight experiments in the literature to arrive at some general conclusions regarding the effects of motion cues on tracking.

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Reference Type: Conference Proceedings
Author: Young, L.R.
Year of Conference: 1978
Title: Visually induced motion in flight simulation
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 16-11 - 16-18
Date: April 24-27
Author's Affiliation and Title: Massachusetts Institute of Technology, Man Vehicle Laboratory, Department of Aeronautics and Astronautics, Cambridge, MA 02139
Number of Pages: 8
Keywords: visually induced motion, flight simulation, visual-vestibular interaction, visual cues, circularvection
Abstract: Much of the attention to visual displays for flight simulation in recent years has been devoted toward precision wide field presentations. The significant advances in multiscreen computer image generation and point light source displays have quite literally widened our horizons for presentation of "out-the-window" information. Most attention has been devoted to the precise static display considerations including perspective, grain and contrast. Relatively less attention has been devoted to the dynamic properties of the visual scene and in particular the role of moving wide field presentation in sustaining a pilots motion sense. This paper addresses the experimental data accumulation on the subject of visually induced motion for all linear and angular degrees of freedom. In particular, we discuss visually induced yaw (circularvection) resulting from a moving wide field presentation, and its interaction with vestibular cues and the low frequency use of visual cues to support sustained angular velocity. The implications for fixed and moving base flight simulate design are discussed. Similar considerations apply to visually induced linear velocity (linearvection) and interesting asymmetries in the fore-aft direction are noted. Finally, visually induced pitch and roll are discussed and modeled in terms of conflict between the visually induced motion and the information regarding attitude based upon graviceptor signals.

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Reference Type: Journal Article
Author: Young, L.R., Dichgans, J., Murphy, R., Brandt, T.
Year: 1973
Title: Interaction of optokinetic and vestibular stimuli in motion perception
Journal: Acta Otolaryng
Volume: 76
Pages: 24-31
Number of Pages: 8
Abstract: The sensation of self-rotation (circularvection) was produced by rotation of a stripe pattern to the left or to the right at constant angular velocity. During circular vection, subjects were randomly accelerated in constant acceleration steps. The major experimental findings are:
1) Thresholds for detection of angular acceleration are raised when this acceleration is opposite to the direction of circular vection. Times to detect these accelerations are similarly increased.
2) Magnitude estimates of angular velocity show the effect of a visually induced velocity offset which is increased slightly by vestibular responses in the same direction and decreased markedly when the vestibular responses are in the direction opposite to self-rotation.
3) Many of the effects of angular acceleration on perceived velocity are accurately predicted by the adaptation model of the vestibular system. However, an important nonlinear interaction exists whereby rapidly occurring conflicts between visual and vestibular sensation, especially those

involving direction disparities, result in precipitous decline in circular-vection and temporary domination by the vestibular response.

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Reference Type: Conference Proceedings
Author: Young, L.R., Oman, C.M., Curry, R.E., Dichgans, J.M.
Year of Conference: 1973
Title: A descriptive model of multi-sensor human spatial orientation with applications to visually induced sensations of motion
Conference Name: Visual and Motion Simulation Conference
Conference Location: Palo Alto, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-4
Date: September 10-12
Author's Affiliation and Title: Young, Oman, Curry: Massachusetts Institute of Technology, Cambridge, MA
Dichgans: Neurologische Universitatsklinik, Freiburg, West Germany
Number of Pages: 4
Keywords: multi-sensor human spatial orientation, visually induced sensations to motion, vestibular sensors, circularvection, exteroceptive tactile information
Abstract: The physiological systems underlying human sensation of spatial orientation and postural control are of particular interest from a control point of view and are reviewed in the first part of the paper. The second part of the paper summarizes recent experiments investigating visually induced motion sensations.

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Reference Type: Journal Article
Author: Zacharias, G.L., Young, L.R.
Year: 1981
Title: Influence of combined visual and vestibular cues on human perception and control of horizontal rotation
Journal: Experimental Brain Research
Volume: 41
Pages: 159-171
Author's Affiliation and Title: Man Vehicle Laboratory, Department of Aeronautics and Astronautics, Massachusetts Institute of technology, Cambridge, MA 02139
Number of Pages: 13
Keywords: vestibular, motion perception, visual-vestibular interaction, manual control
Abstract: Measurements are made of manual control performance in the closed-loop task of nulling perceived self-rotation velocity about an earth-vertical axis. Self-velocity estimation is modeled as a function of the simultaneous presentation of vestibular and peripheral visual field motion cues. Based on measured low-frequency operator behavior in three visual field environments, a parallel channel linear model is proposed which has separate visual and vestibular pathways summing in a complementary manner. A dual-input describing function analysis supports the complementary model; vestibular cues dominate sensation at higher frequencies. The describing function model is extended by the proposal of a non-linear cue conflict model, in which cue weighting depends on the level of agreement between visual and vestibular cues.

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Reference Type: Conference Proceedings
Author: Zahorik, P., Tam, C., Wang, K., Bangayan, P., Sundareswaran, V.
Year of Conference: 2001
Title: Localization Accuracy in 3-D Sound Displays: The Role of Visual-Feedback Training
Conference Name: Advanced Displays Consortium: ARL's 5th Federated Laboratory Annual Symposium
Author's Affiliation and Title: P. Zahorik: Department of Psychology, University of California - Santa Barbara, Santa Barbara, CA 93106-9660
C. Tam, K. Wang, P. Bangayan, & V. Sundareswaran: Rockwell Science Center, 1049 Camino Dos Rios, Thousand Oaks, CA 91360
Number of Pages: 6
Abstract: Using an inexpensive headphone-based 3-D sound display, sound localization accuracy was assessed for six listeners, before, during, and after a perceptual feedback training procedure which provided listeners with paired auditory/visual feedback as to the correct sound source position. We show that feedback training markedly improved localization accuracy, with the largest improvements resulting from listener's enhanced abilities to distinguish sources in front from sources behind. Further, these improvements were not transient short-term effects, but appear to last a number of days between training and testing sessions. These results suggest that simple and relatively short periods of perceptual training can effectively mitigate technical deficiencies in low-cost 3-D sound systems due to the use of non-individualized head-related transfer functions.
URL: http://www.recveb.ucsb.edu/pdfs/ZahorikEtAl01.pdf

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Reference Type: Conference Proceedings
Author: Zaichik, L.E., Rodchenko, V.V., Rufov, I.V., Yashin, Y.P., White, A.D.
Year of Conference: 1999

Title: Acceleration perception
Conference Name: Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 512-520
Date: August 9-11
Author's Affiliation and Title: Zaichik, Rodchenko, Rufov, Yashin: Central Aerohydrodynamic Institute (TsAGI), Handling Qualities and Flight Simulation Section, Zhukovsky, Russia
White: Defence Evaluation and Research Agency (DERA), Bedford, UK
Number of Pages: 19
Abstract: This results of simulator experiments on acceleration perception using a 6-dof motion platform are presented and compared with previously published data. The roles of different sensory systems (vestibular, kinesthetic, tactile) in perception of the accelerations are analyzed and acceleration perception math-models are discussed. Absolute and differential sensitivity thresholds are determined for sinusoidal accelerations of different frequencies and the influence of different factors on the threshold values is estimated. The laws governing the perception of acceleration over-threshold values are substantiated.

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Reference Type: Conference Proceedings
Author: Zaichik, L.E., Rodchenko, V.V., Yashin, Y.P., Rufov, I.V., White, A.D.
Year of Conference: 2000
Title: A theoretical approach to estimation of acceleration effects on piloting
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics & Astronautics (AIAA)
Pages: 1-8
Date: August 14-17

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Reference Type: Conference Proceedings
Author: Zeyada, Y., Hess, R.A.
Year of Conference: 1999
Title: A methodology for evaluating the fidelity of ground-based flight simulators
Conference Name: Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-17
Date: August 9-11
Author's Affiliation and Title: Department of Mechanical and Aeronautical Engineering, One Shields Avenue, University of California, Davis, CA 95616-5294
Number of Pages: 17
Abstract: An analytical and experimental investigation was undertaken to model the manner in which pilots perceive and utilize visual, proprioceptive, and vestibular cues in a ground-based flight simulator. The study was part of a larger research effort which has the creation of a methodology for determining flight simulator fidelity requirements as its ultimate goal. The study utilized a closed-loop feedback structure of the pilot/simulator system which included the pilot, the cockpit inceptor, the dynamics of the simulated vehicle and the motion system. With the exception of time delays which accrued in visual scene production in the simulator, visual scene effects were not included in this study. The NASA Ames Vertical Motion Simulator was used in a simple, single-degree of freedom rotorcraft bob-up/down maneuver. Pilot/vehicle analysis and

fuzzy-inference identification were employed to study the changes in fidelity which occurred as the characteristics of the motion system were varied over five configurations. The data from three of the five pilots that participated in the experimental study were analyzed in the fuzzy-inference identification. Results indicated that both the analytical pilot/vehicle analysis and the fuzzy-inference identification can be used to reflect changes in simulator fidelity for the task examined.

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Reference Type: Journal Article
Author: Zeyada, Y., Hess, R.A.
Year: 2000
Title: Modeling human pilot cue utilization with applications to simulator fidelity assessment
Journal: Journal of Aircraft
Volume: 37
Issue: 4
Pages: 588-597
Date: July-August
Author's Affiliation and Title: University of California, Davis California
Number of Pages: 10
Abstract: An analytical investigation to model the manner in which pilots perceive and utilize visual, proprioceptive, and vestibular cues in a ground-based flight simulator was undertake. Data from a NASA Ames Research Center vertical motion simulator study of a simple, single-degree-of-freedom rotorcraft bob-up/down maneuver were employed in the investigation. The study was part of a larger research effort that has the creation of a methodology for determining flight simulator fidelity requirements as its ultimate goal. The study utilized a closed-loop feedback structure of the pilot/simulator system that included the pilot, the cockpit inceptor, the dynamics of the simulated vehicle, and the motion system. With the exception of time delays that accrued in visual scene production in the simulator, visual scene effects were not included in this study. Pilot/vehicle analysis and fuzzy-inference identification were employed to study the changes in fidelity that occurred as the characteristics of the motion system were varied over five configurations. The data from three of the five pilots who participated in the experimental study were analyzed in the fuzzy-inference identification. Results indicate that both the analytical pilot/vehicle analysis and the fuzzy-inference identification can be used to identify changes in simulator fidelity for the task examined.

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Reference Type: Journal Article
Author: Zeyada, Y., Hess, R.A.
Year: 2003
Title: Computer-aided assessment of flight simulator fidelity
Journal: Journal of Aircraft
Volume: 40
Issue: 1
Pages: 179-180
Date: January-February
Author's Affiliation and Title: University of California, Davis, CA 95616-5294
Number of Pages: 8
Abstract: A technique for computer-aided assessment of flight simulator fidelity is presented. The assessment procedure utilizes a mathematical model of the human pilot that includes proprioceptive, visual, and vestibular cues. The quality of the latter two cues can be varied to capture the effects of flight simulator limitations associated with visual and motion cueing. A MATLAB-based tool that automates the selection of the majority of parameters in the pilot model

and the generation of a fidelity metric is described. In addition, a prediction of the task-dependent handling qualities of the nominal flight vehicle can be obtained. The assessment procedure is exercised in a hypothetical example involving the six-degree-of-freedom control of a rotocraft completing a vertical remask maneuver. It is demonstrated that by varying the quality of the visual and vestibular cues in the pilot/vehicle model the effects of simulator limitations upon fidelity can be systematically addressed.

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Reference Type: Conference Proceedings
Author: Zeyada, Y.H., R. A.
Year of Conference: 1999
Title: A methodology for evaluating the fidelity of ground-based flight simulators
Conference Name: AIAA Modeling and Simulation Conference and Exhibit
Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-17
Date: August 9-11
Author's Affiliation and Title: Department of Mechanical and Aeronautical Engineering, One Shields Ave., University of California, Davis, CA 95616-5294
Number of Pages: 18
Keywords: An analytical and experimental investigation was undertaken to model the manner in which pilots perceive and utilize visual, proprioceptive, and vestibular cues in a ground-based flight simulator. The study was part of a larger research effort which has the creation of a methodology for determining flight simulator fidelity requirements as its ultimate goal. The study utilized a closed-loop feedback structure of the pilot/simulator system which included the pilot, the cockpit inceptor, the dynamics of the simulated vehicle and the motion system. With the exception of time delays which accrued in visual scene production in the simulator, visual scene effects were not included in this study. The NASA Ames Vertical Motion Simulator was used in a simple, single-degree of freedom rotorcraft bob-up/down maneuver. Pilot/vehicle analysis and fuzzy-inference identification were employed to study the changes in fidelity which occurred as the characteristics of the motion system were varied over five configurations. The data from three of the five pilots that participated in the experimental study were analyzed in the fuzzy-inference identification. Results indicate that both the analytical pilot/vehicle analysis and the fuzzy-inference identification can be used to reflect changes in simulator fidelity for the task examined.

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