SAVE-IT

SAfety VEhicles using adaptive Interface Technology (Task 6)

Task Time and Glance Measures of the Use of Telematics: A Tabular Summary of the Literature

Prepared by

Paul Green
University of Michigan, UMTRI
Phone: (734)-763 3795
Email: PAGreen@umich.edu

Reshma Shah
University of Michigan, UMTRI
Phone: (734)-763 6081
Email: Reshmaps@umich.edu

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7.0 PROGRAM OVERVIEW

Driver distraction is a major contributing factor to automobile crashes. National Highway Traffic Safety Administration (NHTSA) has estimated that approximately 25% of crashes are attributed to driver distraction and inattention (Wang, Knipling, & Goodman, 1996). The issue of driver distraction may become worse in the next few years because more electronic devices (e.g., cell phones, navigation systems, wireless Internet and email devices) are brought into vehicles that can potentially create more distraction. In response to this situation, the John A. Volpe National Transportation Systems Center (VNTSC), in support of NHTSA's Office of Vehicle Safety Research, awarded a contract to Delphi Electronics & Safety to develop, demonstrate, and evaluate the potential safety benefits of adaptive interface technologies that manage the information from various in-vehicle systems based on real-time monitoring of the roadway conditions and the driver's capabilities. The contract, known as SAfety VEhicle(s) using adaptive Interface Technology (SAVE-IT), is designed to mitigate distraction with effective countermeasures and enhance the effectiveness of safety warning systems.

The SAVE-IT program serves several important objectives. Perhaps the most important objective is demonstrating a viable proof of concept that is capable of reducing distraction-related crashes and enhancing the effectiveness of safety warning systems. Program success is dependent on integrated closed-loop principles that, not only include sophisticated telematics, mobile office, entertainment and safety warning systems, but also incorporate the state of the driver. This revolutionary closed-loop vehicle environment will be achieved by measuring the driver’s state, assessing the situational threat, prioritizing information presentation, providing adaptive countermeasures to minimize distraction, and optimizing advanced collision warning.

To achieve the objective, Delphi Electronics & Safety has assembled a comprehensive team including researchers and engineers from the University of Iowa, University of Michigan Transportation Research Institute (UMTRI), General Motors, Ford Motor Company, and Seeing Machines, Inc. The SAVE-IT program is divided into two phases shown in Figure i. Phase I spans one year (March 2003--March 2004) and consists of nine human factors tasks (Tasks 1-9) and one technology development task (Task 10) for determination of diagnostic measures of driver distraction and workload, architecture concept development, technology development, and Phase II planning. Each of the Phase I tasks is further divided into two sub-tasks. In the first sub-tasks (Tasks 1, 2A-10A), the literature is reviewed, major findings are summarized, and research needs are identified. In the second sub-tasks (Tasks 1, 2B-10B), experiments will be performed and data will be analyzed to identify diagnostic measures of distraction and workload and determine effective and driver-friendly countermeasures. Phase II will span approximately two years (October 2004--October 2006) and consist of a continuation of seven Phase I tasks (Tasks 2C--8C) and five additional tasks (Tasks 11-15) for algorithm and guideline development, data fusion, integrated countermeasure development, vehicle demonstration, and evaluation of benefits.

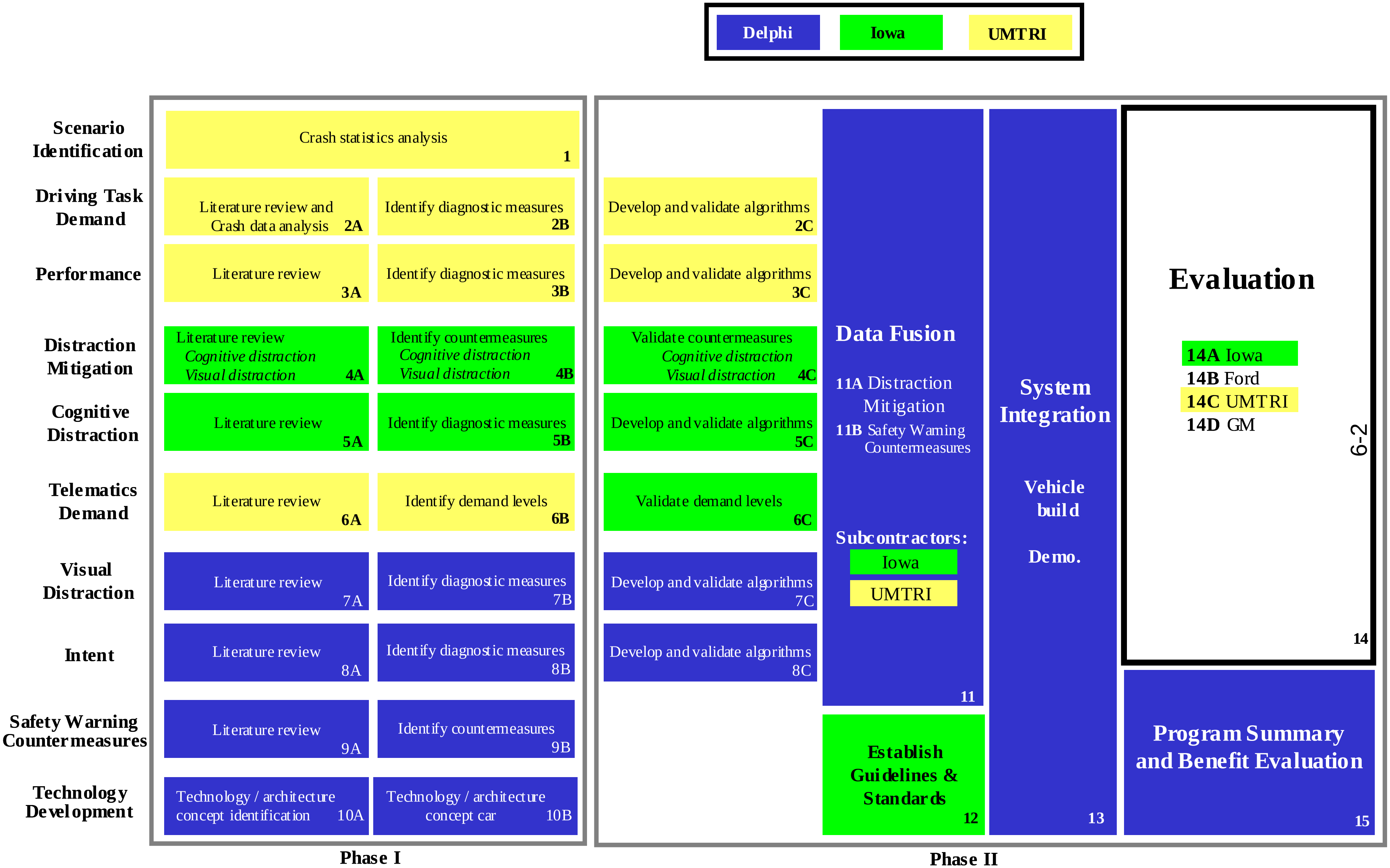


Figure i: SAVE-IT tasks

It is worthwhile to note the SAVE-IT tasks in Figure i are inter-related. They have been chosen to provide necessary human factors data for a two-pronged approach to address the driver distraction and adaptive safety warning countermeasure problems. The first prong (Safety Warning Countermeasures sub-system) uses driver distraction, intent, and driving task demand information to adaptively adjust safety warning systems such as forward collision warning (FCW) systems in order to enhance system effectiveness and user acceptance. Task 1 is designed to determine which safety warning system(s) should be deployed in the SAVE-IT system. Safety warning systems will require the use of warnings about immediate traffic threats without an annoying rate of false alarms and nuisance alerts. Both false alarms and nuisance alerts will be reduced by system intelligence that integrates driver state, intent, and driving task demand information that is obtained from Tasks 2 (Driving Task Demand), 3 (Performance), 5 (Cognitive Distraction), 7 (Visual Distraction), and 8 (Intent).

The safety warning system will adapt to the needs of the driver. When a driver is cognitively and visually attending to the lead vehicle, for example, the warning thresholds can be altered to delay the onset of the FCW alarm or reduce the intrusiveness of the alerting stimuli. When a driver intends to pass a slow-moving lead vehicle and the passing lane is open, the auditory stimulus might be suppressed in order to reduce the alert annoyance of a FCW system. Decreasing the number of false positives may reduce the tendency for drivers to disregard safety system warnings. Task 9 (Safety Warning Countermeasures) will investigate how driver state and intent information can be used to adapt safety warning systems to enhance their effectiveness and user acceptance. Tasks 10 (Technology Development), 11 (Data Fusion), 12 (Establish Guidelines and Standards), 13 (System Integration), 14 (Evaluation), and 15 (Program Summary and Benefit Evaluation) will incorporate the research results gleaned from the other tasks to demonstrate the concept of adaptive safety warning systems and evaluate and document the effectiveness, user acceptance, driver understandability, and benefits and weaknesses of the adaptive systems. It should be pointed out that the SAVE-IT system is a relatively early step in bringing the driver into the loop and therefore, system weaknesses will be evaluated, in addition to the observed benefits.

The second prong of the SAVE-IT program (Distraction Mitigation sub-system) will develop adaptive interface technologies to minimize driver distraction to mitigate against a global increase in risk due to inadequate attention allocation to the driving task. Two examples of the distraction mitigation system include the delivery of a gentle warning and the lockout of certain telematics functions when the driver is more distracted than what the current driving environment allows. A major focus of the SAVE-IT program is the comparison of various mitigation methods in terms of their effectiveness, driver understandability, and user acceptance. It is important that the mitigation system does not introduce additional distraction or driver frustration. Because the lockout method has been shown to be problematic in the aviation domain and will likely cause similar problems for drivers, it should be carefully studied before implementation. If this method is not shown to be beneficial, it will not be implemented.

The distraction mitigation system will process the environmental demand (Task 2: Driving Task Demand), the level of driver distraction [Tasks 3 (Performance), 5 (Cognitive Distraction), 7 (Visual Distraction)], the intent of the driver (Task 8: Intent), and the telematics distraction potential (Task 6: Telematics Demand) to determine which functions should be advised against under a particular circumstance. Non-driving task information and functions will be prioritized based on how crucial the information is at a specific time relative to the level of driving task demand. Task 4 will investigate distraction mitigation strategies and methods that are very well accepted by the users (i.e., with a high level of user acceptance) and understandable to the drivers. Tasks 10 (Technology Development), 11 (Data Fusion), 12 (Establish Guidelines and Standards), 13 (System Integration), 14 (Evaluation), and 15 (Program Summary and Benefit Evaluation) will incorporate the research results gleaned from the other tasks to demonstrate the concept of using adaptive interface technologies in distraction mitigation and evaluate and document the effectiveness, driver understandability, user acceptance, and benefits and potential weaknesses of these technologies.

In particular, driving task demand and driver state (including driver distraction and impairment) form the major dimensions of a driver safety system. It has been argued that crashes are frequently caused by drivers paying insufficient attention when an unexpected event occurs, requiring a novel (non-automatic) response. As displayed in Figure ii, attention to the driving task may be depleted by driver impairment (due to drowsiness, substance use, or a low level of arousal) leading to diminished attentional resources, or allocation to non-driving tasks[1]. Because NHTSA is currently sponsoring other impairment-related studies, the assessment of driver impairment is not included in the SAVE-IT program at the present time. One assumption is that safe driving requires that attention be commensurate with the driving demand or unpredictability of the environment. Low demand situations (e.g., straight country road with no traffic at daytime) may require less attention because the driver can usually predict what will happen in the next few seconds while the driver is attending elsewhere. Conversely, high demand (e.g., multi-lane winding road with erratic traffic) situations may require more attention because during any time attention is diverted away, there is a high probability that a novel response may be required. It is likely that most intuitively drivers take the driving-task demand into account when deciding whether or not to engage in a non-driving task. Although this assumption is likely to be valid in a general sense, a counter argument is that problems may also arise when the situation appears to be relatively benign and drivers overestimate the predictability of the environment. Driving

[1] The distinction between driving and non-driving tasks may become blurred sometimes. For example, reading street signs and numbers is necessary for determining the correct course of driving, but may momentarily divert visual attention away from the forward road and degrade a driver's responses to unpredictable danger evolving in the driving path. In the SAVE-IT program, any off-road glances, including those for reading street signs, will be assessed in terms of visual distraction and the information about distraction will be fed into adaptive safety warning countermeasures and distraction mitigation sub-systems.

environments that appear to be predictable may therefore leave drivers less prepared to respond when an unexpected threat does arise.

A safety system that mitigates the use of in-vehicle information and entertainment system (telematics) must balance both attention allocated to the driving task that will be assessed in Tasks 3 (Performance), 5 (Cognitive Distraction), and 7 (Visual Distraction) and attention demanded by the environment that will be assessed in Task 2 (Driving Task Demand). The goal of the distraction mitigation system should be to keep the level of attention allocated to the driving task above the attentional requirements demanded by the current driving environment. For example, as shown in Figure ii, "routine" driving may suffice during low or moderate driving task demand, slightly distracted driving may be adequate during low driving task demand, but high driving task demand requires attentive driving.

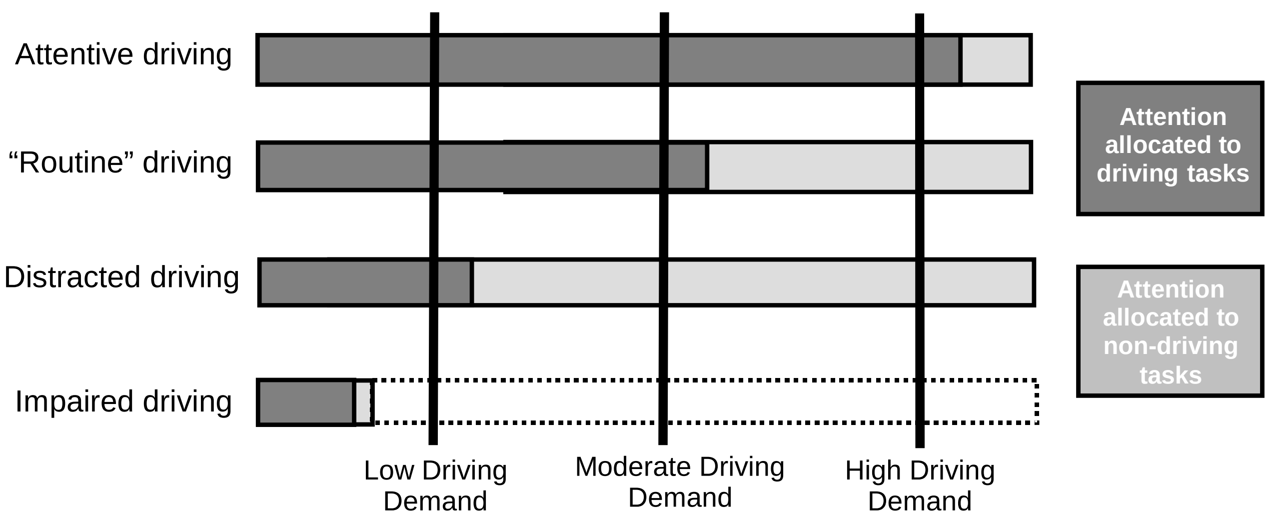


Figure ii. Attention allocation to driving and non-driving tasks

It is important to note that the SAVE-IT system addresses both high-demand and low-demand situations. With respect to the first prong (Safety Warning Countermeasures sub-system), the safety warning systems (e.g., the FCW system) will always be active, regardless of the demand. Sensors will always be assessing the driving environment and driver state. If traffic threats are detected, warnings will be issued that are commensurate with the real time attentiveness of the driver, even under low-demand situations. With respect to the second prong (Distraction Mitigation sub-system), driver state including driver distraction and intent will be continuously assessed under all circumstances. Warnings may be issued and telematics functions may be screened out under both high-demand and low-demand situations, although the threshold for distraction mitigation may be different for these situations.

It should be pointed out that drivers tend to adapt their driving, including distraction behavior and maintenance of speed and headway, based on driving (e.g., traffic and weather) and non-driving conditions (e.g., availability of telematics services), either consciously or unconsciously. For example, drivers may shed non-driving tasks (e.g., ending a cell phone conversation) when driving under unfavorable traffic and weather conditions. It is critical to understand this "driver adaptation" phenomenon. In principle, the "system adaptation" in the SAVE-IT program (i.e., adaptive safety warning countermeasures and adaptive distraction mitigation sub-systems) should be carefully implemented to ensure a fit between the two types of adaptation: "system adaptation" and "driver adaptation". One potential problem in a system that is inappropriately implemented is that the system and the driver may be reacting to each other in an unstable manner. If the system adaptation is on a shorter time scale than the driver adaptation, the driver may become confused and frustrated. Therefore, it is important to take the time scale into account. System adaptation should fit the driver's mental model in order to ensure driver understandability and user acceptance. Because of individual difference, it may also be important to tailor the system to individual drivers in order to maximize driver understandability and user acceptance. Due to resource constraints, however, a nominal driver model will be adopted in the initial SAVE-IT system. Driver profiling, machine learning of driver behavior, individual difference-based system tailoring may be investigated in future research programs.

Communication and Commonalities Among Tasks and Sites

In the SAVE-IT program, a "divide-and-conquer" approach has been taken. The program is first divided into different tasks so that a particular research question can be studied in a particular task. The research findings from the various tasks are then brought together to enable us to develop and evaluate integrated systems. Therefore, a sensible balance of commonality and diversity is crucial to the program success. Diversity is reflected by the fact that every task is designed to address a unique question to achieve a particular objective. As a matter of fact, no tasks are redundant or unnecessary. Diversity is clearly demonstrated in the respective task reports. Also documented in the task reports is the creativity of different task owners in attacking different research problems.

Task commonality is very important to the integration of the research results from the various tasks into a coherent system and is reflected in terms of the common methods across the various tasks. Because of the large number of tasks (a total of 15 tasks depicted in Figure i) and the participation of multiple sites (Delphi Electronics & Safety, University of Iowa, UMTRI, Ford Motor Company, and General Motors), close coordination and commonality among the tasks and sites are key to program success. Coordination mechanisms, task and site commonalities have been built into the program and are reinforced with the bi-weekly teleconference meetings and regular email and telephone communications. It should be pointed out that little time was wasted in meetings. Indeed, some bi-weekly meetings were brief when decisions can be made quickly, or canceled when issues can be resolved before the meetings. The level of coordination and commonality among multiple sites and tasks is un-precedented and has greatly contributed to program success. A selection of commonalities is described below.

Commonalities Among Driving Simulators and Eye Tracking Systems In Phase I
Although the Phase I tasks are performed at three sites (Delphi Electronics & Safety, University of Iowa, and UMTRI), the same driving simulator software, Drive Safety^{TM} (formerly called GlobalSim^{TM}) from Drive Safety Inc., and the same eye tracking system, FaceLab^{TM} from Seeing Machines, Inc. are used in Phase I tasks at all sites. The performance variables (e.g., steering angle, lane position, headway) and eye gaze measures (e.g., gaze coordinate) are defined in the same manner across tasks.

Common Dependent Variables An important activity of the driving task is tactical maneuvering such as speed and lane choice, navigation, and hazard monitoring. A key component of tactical maneuvering is responding to unpredictable and probabilistic events (e.g., lead vehicle braking, vehicles cutting in front) in a timely fashion. Timely responses are critical for collision avoidance. If a driver is distracted, attention is diverted from tactical maneuvering and vehicle control, and consequently, reaction time (RT) to probabilistic events increases. Because of the tight coupling between reaction time and attention allocation, RT is a useful metric for operationally defining the concept of driver distraction. Furthermore, brake RT can be readily measured in a driving simulator and is widely used as input to algorithms, such as the forward collision warning algorithm (Task 9: Safety Warning Countermeasures). In other words, RT is directly related to driver safety. Because of these reasons, RT to probabilistic events is chosen as a primary, “ground-truth” dependent variable in Tasks 2 (Driving Task Demand), 5 (Cognitive Distraction), 6 (Telematics Demand), 7 (Visual Distraction), and 9 (Safety Warning Countermeasures).

Because RT may not account for all of the variance in driver behavior, other measures such as steering entropy (Boer, 2001), headway, lane position and variance (e.g., standard deviation of lane position or SDLP), lane departures, and eye glance behavior (e.g., glance duration and frequency) are also be considered. Together these measures will provide a comprehensive picture about driver distraction, demand, and workload.

Common Driving Scenarios For the tasks that measure the brake RT, the "lead vehicle following" scenario is used. Because human factors and psychological research has indicated that RT may be influenced by many factors (e.g., headway), care has been taken to ensure a certain level of uniformity across different tasks. For instance, a common lead vehicle (a white passenger car) was used. The lead vehicle may brake infrequently (no more than 1 braking per minute) and at an unpredictable moment. The vehicle braking was non-imminent in all experiments (e.g., a low value of deceleration), except in Task 9 (Safety Warning Countermeasures) that requires an imminent braking. In addition, the lead vehicle speed and the time headway between the lead vehicle and the host vehicle are commonized across tasks to a large extent.

Subject Demographics It has been shown in the past that driver ages influence driving performance, user acceptance, and driver understandability. Because the age effect is not the focus of the SAVE-IT program, it is not possible to include all driver ages in every task with the budgetary and resource constraints. Rather than using different subject ages in different tasks, however, driver ages are commonized across tasks. Three age groups are defined: younger group (18-25 years old), middle group (35-55 years old), and older group (65-75 years old). Because not all age groups can be used in all tasks, one age group (the middle group) is chosen as the common age group that is used in every task. One reason for this choice is that drivers of 35-55 years old are the likely initial buyers and users of vehicles with advanced technologies such as the SAVE-IT systems. Although the age effect is not the focus of the program, it is examined in some tasks. In those tasks, multiple age groups were used.

The number of subjects per condition per task is based on the particular experimental design and condition, the effect size shown in the literature, and resource constraints. In order to ensure a reasonable level of uniformity across tasks and confidence in the research results, a minimum of eight subjects is used for each and every condition. The typical number of subjects is considerably larger than the minimum, frequently between 10-20.

Other Commonalities In addition to the commonalities across all tasks and all sites, there are additional common features between two or three tasks. For example, the simulator roadway environment and scripting events (e.g., the TCL scripts used in the driving simulator for the headway control and braking event onset) may be shared between experiments, the same distraction (non-driving) tasks may be used in different experiments, and the same research methods and models (e.g., Hidden Markov Model) may be deployed in various tasks. These commonalities afford the consistency among the tasks that is needed to develop and demonstrate a coherent SAVE-IT system.

The Content and Structure of the Report

The report submitted herein is a literature review report that documents the research progress to date (March 1, 2003—January 31, 2004) in Phase I. During that period, the effort has been focused on the first Phase I sub-task: Literature Review. In this report, previous experiments are discussed, research findings are reported, and research needs are identified. This literature review report serves to establish the research strategies of each task.

6.1 INTRODUCTION

6.1.1 Background

Telematics, the application of computer and communication technologies to provide information to drivers, is an important aspect of contemporary motor vehicle design. Common telematics applications include cell phones, navigation systems, warning systems, and so forth. The fraction of motor vehicles, especially passenger cars, equipped with such systems continues to grow at a steady rate, and there are numerous positive visions of the future (e.g., Cole and Londal, 2000; Green et al., 2001).

There are major concerns that some tasks, when performed with some telematics systems while driving, will impose an unreasonable risk on the motoring public. The most commonly cited application is cell phones (e.g., Goodman et al., 1997), but navigation systems are also of concern (Green, 1999; Takubo, Kihira, Hoshi, Kojima, and Takehiko, 2002), and so are other systems as well. The tasks of greatest concern are dialing, answering, and conversing for cell phones, and destination entry for navigation systems. As a consequence, guidelines (Green, Levison, Paelke, and Serafin, 1995; Ross et al., 1996; Campbell, Carney, and Kantowitz, 1997; Japan Automobile Manufacturers Association, 2000; Alliance of Automobile Manufacturers, 2002) and recommended practices (Society of Automotive Engineers, 2003) have been developed to promote safety and usability.

Another way to assure telematics systems are safe and easy to use is to provide a workload manager (Green, 2000). A workload manager continually measures the demand of the driving situation, and knowing the demands of the task (and possibly driver capability), determines if the task can be executed. The goal of a workload manager is to avoid placing drivers in situations in which distraction or overload might occur. In a practical sense, this might take the form of automatically routing incoming cell phone calls to an answering machine when the driver is driving in a heavy downpour or restricting the access to certain navigation system functions in heavy traffic. There have been a number of European studies relating to workload managers (e.g., Michon, 1993; Hoedemaeker, de Ridder, and Janssen, 2002) and Motorola has been working on the problem in the U.S. (Remboski et al, 2000) as well as UMTRI. Those studies represent a solid beginning.

To continue that line of investigation, the U.S. Department of Transportation funded the SAVE-IT project (**Sa**fety **Ve**hicle(s) using adaptive **I**nterface **T**echnology), which funded the review described in this report. SAVE-IT is unique in that it using information from the workload manager to influence the operation of safety countermeasures and warnings. The overall purpose of this project is to conduct additional research on workload managers and use that information to develop a proof of concept interface that reduces the likelihood of distraction-related crashes and enhances the effectiveness of safety warning systems. Delphi is the prime contractor and the University of Michigan, the University of Iowa, Ford, GM, and Seeing Machines are subcontractors.

6.1.2 Research Issues

To be able to make decisions about when a workload manager should allow particular tasks to be performed, the manager needs information about the distraction potential/difficulty of various in-vehicle tasks. This report gathers that information from the literature, emphasizing telematics tasks and other functions in passenger cars. Other parallel research, to be reported separately, is collecting additional assessment data for baseline conditions (e.g., Cullinane and Green, 2003).

There is a large number of ways in which distraction can be measured (e.g., Green, 1995; Tijerina, Angell, Austria, Tan, and Kochhar, 2003). One can assess driving performance, task performance, spare capacity, ratings of difficulty, and so forth. Driving task performance (e.g., standard deviation of lane position, standard deviation of speed) is examined in a subsequent report still being written.

To keep the scope of this report within reason, this report focuses on 4 common measures of in-vehicle tasks—

(1) task time,
(2) dynamic task time,
(3) the number of glances, and
(4) mean glance duration.

These measures are defined in the next section. These measures were selected because they are (1) cited in the design guidelines and recommended practices listed earlier relating to safety and ease of use, (2) commonly measured (so task data is extensive), and (3) readily measured and/or correlated with real-world crash experience. There are many more measures to choose from, but they could not be examined within the project budget and schedule.

Furthermore, this report considers visual-manual tasks only (not speech interfaces) because visual-manual tasks are often more demanding and most likely to distract drivers in the near term.

Therefore, more specifically, this report addresses the following question:

> What are typical task times, number of glances required, and mean glance durations for visual-manual telematics tasks completed while driving a passenger car?

For comparison purposes, some data on non-telematics tasks are also provided. (See Kurokawa, 1990 for additional information.) Besides providing context for various experiments conducted as part of this project, the data in this report will serve as the basis for lookup tables for various tasks in the workload manager software. For example, the workload manager might continuously monitor the driving situation and the driver, and knowing the likely duration, number of glances required, and mean time per glance from the data provided here, decide when destination entry might be locked out. At the current stage of the project, it is premature to specify the mathematical combination of these and possibly other measures a workload manager will use for the lockout decisions, or what the lockout criterion will be. Certainly, the time limits specified in SAE Recommended Practice J2364 (“the 15-Second Rule”) should be considered when selecting a lockout criterion (Society of Automotive Engineers, 2003a). However, the measures reviewed here are the most likely candidates.

6.1.3 Definitions of the Measures Examined

Each of those 4 measures is defined below. It must be emphasized there are no definitions that are both “official” and widely adhered to for these measures, though there is some degree of consistency in how these terms are defined and used in the literature. Definitions are provided here for clarification.

To understand the definitions, one must understand the process by which timesharing occurs while driving and performing an in-vehicle task, and what constitutes a task. The definition of a task was the subject of considerable debate in the development of SAE Recommended Practice J2364 (Society of Automotive Engineers, 2003a). J2364 (Definition 3.17) describes a task as “A sequence of control operations (i.e., a specific method) leading to a goal at which the driver will normally persist until the goal is reached. Example: Obtaining guidance by entering a street address using the scrolling list method until route guidance is initiated.” This definition includes 2 key elements, (1) a goal and (2) a method, which are commonly mentioned in the literature.

The goal is what the driver intends to achieve. Further information on this topic appears in the rationale document for SAE J2364, SAE Information Report J2378 (Society of Automotive Engineers, 2003b). The human-computer interaction literature (e.g., Card, Moran, and Newell, 1983), the source of the ideas here, uses the same term - goal, for the intermediate goals (e.g., enter a letter that is part of an address) and the ultimate goal (e.g., getting guidance). In the SAE Recommended Practice, goal only refers to the ultimate goal. This notion of what constitutes a goal and hence a task is important when task limits are to be set. If any micro element can be defined as a task, and micro elements can always be subdivided (because there are always subgoals), then no task will ever take too long or require too many eye fixations because the task could be subdivided further.

The second key element of a task is the method, how a goal is accomplished. For example, entering an address using a point of interest method is a different task from entering an address using an intersection. Hence, changing the method results in a new task.

With this in mind, how are task time and glance behavior to be characterized? Figure 6. 1 shows a possible time sequence for an in-vehicle task, depicting both the actions of the hand and the eyes as a function of time. At some time between points a and b, the driver begins to plan the execution of an in-vehicle task, for example entering a destination. One could argue a task begins to be a distraction when planning starts as “mind off the road” begins then. However, this point is not readily observed.

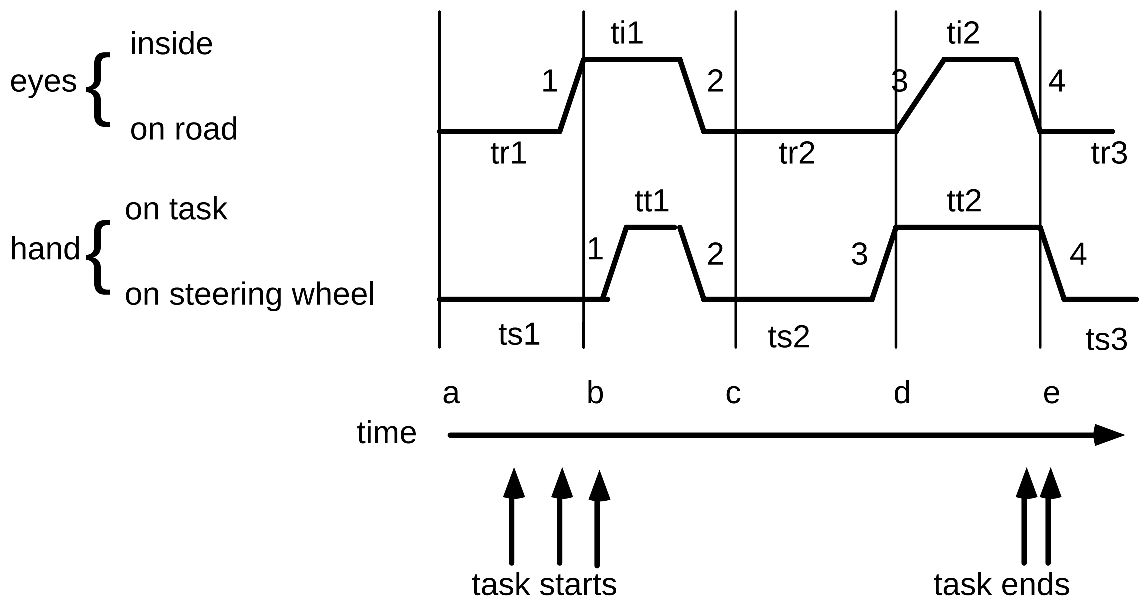


Figure 6.1. Possible Time Sequence for an In-vehicle Task

Note: ti = time inside, tr = time on road, tt = time on task, ts = time on steering wheel

The next action, usually, is that the driver moves their eyes from the road to the in-vehicle task. This transition takes time, though not very much. Some might suggest the task starts when the driver’s eyes leave the road, although others suggest a task starts when looking at the in-vehicle display. After drivers have seen where their hand needs to go, they begin to move there. Most commonly, for example in SAE Recommended Practice J2364 (SAE, 2003), the task is considered to begin when the hand is observed leaving the steering wheel, though one could suggest is should begin when the in-vehicle device is touched. Thus, there are a number of points that could be considered the start of a task though there is consensus as to a best choice. Many documents in the literature do not explicitly state when a task is considered to start (e.g., first thought about, eyes move, hands move), though hand movement is more commonly used because it is easiest to observe.

After the task begins, the driver then alternates between looking at the road and the task, and may move their hand back and forth between the task and steering wheel; though it is also quite possible that their hand may hover above the interface between switch operations. All of this usually occurs more than the 2 times shown in the figure.

Also, it is possible that in reaching for the in-vehicle display, the driver's hand begins to move before they look at the display.

When does the task end? SAE Recommended Practice 2364 says the task ends when the driver receives feedback that their entry sequence has been accepted. Does this occur when feedback begins or ends? The end point should be when drivers have received enough information so that they no longer attend to the in-vehicle task. One could also argue the task ends when the eyes have left the task and returned to the road, or when the hand has returned to the wheel.

Thus, although there is an accepted definition of when a task begins and ends, other interpretations are possible and, in fact, multiple definitions have been used in the literature. Since different authors have defined task times differently, comparisons across studies can be difficult to make.

The impact of this ambiguity will depend on the task duration and how the task duration data will be used. For example, the difference between the start of the first glance to the task and when the hand begins to move might be a half second or less. For a short task of 2 or 3 glances (say 4 to 6 seconds), this is about a 10% difference on average. For a longer task, say 15 seconds, the difference is 3%, or somewhat small. On the other hand, if the task starts when something is first thought of (an uncommon starting point), the difference might be 5 or 10 seconds.

In terms of when tasks end, the ending element might be a simple confirmation, such as a beep, or it could be more complicated, such as a message that might take several seconds to read. In most situations, the end point ambiguity will have a greater impact than the start time ambiguity.

The point of this discussion is that in aggregate, the uncertainty about the start and end time can be an issue, so task times from various studies need to be compared with caution. For most engineering decisions, the impact of comparing design alternatives is likely to be small. However, for compliance decisions (e.g., SAE J2364), the impact could be important if the measured duration is close to the limit.

In the literature, there are 2 variants of task time, dynamic and static, defined below in language largely drawn from SAE J2364. The language for glances is largely from SAE J2396 (Society of Automotive Engineers, 2001).

<u>Dynamic task time</u> – The time from the beginning until the end of the task (when the goal is reached) that occurs while a person is driving. If one uses the departure of the hand as the start point, then dynamic task time would be defined (using Figure 6.1) as hand transition 1 + tt1 + transition 3 + tt2. Transitions 2 and 4 were not included to be consistent with the definition of a glance in SAE J2396 (described later), where 1 of the transitions is bundled with the inside glances and 1 with the road glances. For glances, usually fixations are combined with their trailing transitions (e.g., ti1 with transition 2),

not the leading transition. Fortunately, transitions are short, so combining them only minimally affected the calculations.

Static task time – The time from when the subject starts a task until the task goal is achieved (the task ends). This time is determined in a parked vehicle, in a simulator with the vehicle stationary, or using a laboratory mockup. In contrast to dynamic time, there is no switching, so timing is simpler.

Mean glance time - Depending on the source, this could refer to the mean interior fixation time ((ti1 + ti2)/2), the mean glance time as defined by SAE J2396 (where glances are fixations plus the trailing fixation), or the time of the glances to the interior (ti1 + ti2) plus the leading (1, 3) and trailing (2, 4) glances. The SAE J2396 definition is preferred.

Mean number of glances – This is simply a count of how many times the driver looks inside a vehicle to complete a task. There is usually little dispute as to this value. Drivers invariably look back at the road when a task is complete, so there are no partial glances. Although the count for a particular event is an integer, the mean may not be because of averaging across trials (e.g., sometimes 3 glances are required and sometimes 2).

Thus, for many of the measures of interest, although there are more commonly accepted definitions for these 4 terms, the terms have been defined in multiple ways and the value reported will depend on the definition. Unfortunately, the definitions for these terms usually do not appear in the reports, proceedings papers, and journal articles using them, and as a consequence, it is uncertain if differences among studies are due to genuine underlying differences or simply inconsistent definitions. As noted above, the relative magnitude of these differences, relative to event durations, may be of practical significance for short tasks and is of less significance for long tasks.

6.2 METHOD

The goal of this report was to create a table of task times and glance data from the literature to support the design of a workload manager and the research related to it. Relevant studies were identified by searching the second author's personal collection, the UMTRI Library database (using terms such as "distraction" and "navigation"), and Google (using the same terms plus "driver"). Also, electronic journals and newspapers and networked electronic resources available through the University of Michigan Library (www.lib.umich.edu/eresources) were examined, in particular the ISI Web of Knowledge, LexisNexis Academic, MIRLYN (the on-line catalog for the University of Michigan Library), and ProQuest. In addition, the reference lists of the articles found in these initial steps were examined for additional leads as well electronic citation indexes.

Only articles that could be readily obtained, for which there was some confidence in their quality, and which were applicable were reviewed. The search is reasonably complete, but not exhaustive. More specifically, the criteria were as follows:

1. appropriate context – on the road, on a test track, or in a driving simulator of reasonable fidelity (not an abstract tracking task).
2. some confidence in quality – reported in a proceedings paper, journal article, or technical report of a known organization. (Student reports for courses were excluded, for example.)
3. published in English – the language of the authors. (For example, Asoh, Uno, Noguchi, and Kawaski, 2002 and Chalmé, Briffault, Denis, and Gaunet, 1999 were excluded.)
4. readily available – in the authors' personal collection, the UMTRI library, or available on request. There were a few exceptions of obtaining advance copies of papers on the ADAM (Advanced Driver Attention Metrics) project being conducted jointly by DiamlerChrysler and BMW, whose findings are particularly important and which should be published when this report is complete. In contrast, much of the research from the CAMP (Collision Avoidance Metrics Partnership) project (being conducted by GM, Ford, Toyota, and Nissan) is not yet publicly available, though it should be shortly. The authors were able to obtain 1 CAMP report when this manuscript was close to completion, too late to make much use of it.
5. examined real tasks – Of likely interest to readers is the research of Blanco (1999), which contains extensive task time and glance data for tables, paragraphs, and graphs of varying density for artificial (but realistic looking) interfaces. Unfortunately, it was unclear how those results could be linked to other studies in the literature. Nonetheless, readers are strongly encouraged to examine Blanco (1999) for relevant information.
6. passenger car focus. There was 1 case where tasks usually performed in passenger cars was examined in a heavy truck. That article was included because it was relevant.

One consequence of the availability criteria and the limited resources is that research from Europe and Japan is not covered as extensively as research done in the U.S. The authors apologize for this situation.

The analysis of the literature consisted of a 4-step process.

1. Review the articles. Each of the articles was read carefully, primarily by the second author, and a 1 to 2 page summary outline was written, providing information on the method, subjects, and findings. The purpose of those summaries was to assist in determining whether the results from various studies were similar and why.

2. Construct a master table. This table included performance data for the 4 measures of interest for telematics and other tasks along with information to identify key study aspects such as the data collection method, the subjects, and other important information. That table appears in Appendix A. Task times and glance measures were obtained from report text and tables, and by picking points off figures. Some times, such as the time/digit for dialing, were often computed by dividing the task time by the number of digits, the differences in digit string lengths may be a confounding factor.

3. Construct telematics tables. The data from the previous table were regrouped by function (instead of by study), with only telematics tasks being included. Those tables appear in the Results section. Data for the 3 most commonly reported tasks – dialing a phone, tuning a radio, and entering a street address – were provided, along with destination entry via other means as well as a few other telematics tasks.

4. Analyze the dialing, tuning, and street address data to find trends. Of particular interest were the range of values reported, differences due to context (on the road vs. simulator vs. test track), and differences due to driver age.

6.3 RESULTS

The master table containing the data for all tasks appears in Appendix A. The data are grouped by study and listed alphabetically by first author. Times have been reported to the nearest 0.01 second where that accuracy is available, though times estimated from figures are reported to the nearest 0.1 second.

The table has been provided to give a sense of the range of tasks explored, the frequency with which various tasks have been considered, and to provide the basis for a lookup table that might be used by a workload manager.

The most important information from these tables are probably not trends or highlights, but the individual data themselves. However, there are a few key points worthy of note.

1. The table is sparse. For many of these studies, only a few of the measures have been collected, and even when all 4 categories of measures are provided, typically only the mean is available, not the standard deviations. As a consequence, a lookup table based on this data will be very incomplete, so it may be necessary to base decisions about overload on estimated times, number of glances, glance durations, and so forth, rather than on data from the literature.

2. In order for frequency of occurrence, total task time data is most common, followed by the number of glances and then glance durations.

3. Most of the data are derived from less than 10 primary studies.

4. The most commonly studied tasks are phone dialing, radio tuning, and destination entry.

5. As a rough approximation, the standard deviation of most performance measures (e.g., dynamic task time) was about one half of the mean of that measure.

Readers are encouraged to peruse Appendix A for additional insights.

6.3.1 Dialing a Phone

Data for telematics tasks drawn from Appendix A are shown in Tables 6.1, 6.2, 6.3, and 6.4. Table 6.1 shows the data for dialing a phone number from 10 experiments. Dynamic task times reported ranged from just over 5 to over 39 seconds depending on the driver age, the number of digits dialed (7, 10, or 11), the input device, and the driving context (on road, simulator, test track). Not reported here, but possibly an important factor, is how and whether the number to dial was presented (e.g., with or without area code, dialed from memory, etc.). Often the method of presentation is not reported in the literature.

Data on static task times is more limited, with values of 15 to 20 seconds being reported.

Data on glance behavior is also limited, with the number of glances varying from almost 4 to almost 13. Some of this may be accounted for by variations in the number of digits dialed (7 or 11), but that probably is only a partial explanation.

Table 6.1. Task Data for Dialing a Phone Number

Study and Context	Task & Device	Ages / Notes	Static Total Task Time (s)	Dynamic Total Task Time (s)	Mean Glance Duration (s)	Total # of Glances
			Mean±SD	Mean±SD	Mean±SD	Mean±SD
Bhise, Dowd, Smid, 2003 simulator	Find cell phone, dial home # backwards, experiment 1	12 Ss 16-48		12.5	1.98	6.3
Curry, Greenberg, & Blanco (2002) simulator	11-digit #	45-65		32.81	1.20	12.78
Farber et al. (2000) 2 static times are vehicle & (mockup)	11-digit home #	45-54	15.14 (14.11)	26.80±11.75		
		55-65	20.81 (15.88)	39.25±19.79		
Greenberg, et al. 2003 simulator	10-digit hand-held	Teen		24.88		
		25-34		26.48		
		35-44		30.50		
		45-54		31.77		
		55-65		42.02		
		Overall		30.74		
Hayes, Kurokawa, Wierwille, 1989 on road	Enter 4 digits on keypad (similar to dialing)	18-72		6.61±1.21	1.32±0.68	3.25±1.07
	Dial 7-digit # (plus phone & #)			9.02±3.96	1.41±0.62	4.27±1.76
	Dial 11-digit # (plus phone & #)			10.91±3.45	1.23±0.52	5.5±1.94

Study and Context	Task & Device	Ages / Notes	Static Total Task Time (s)	Dynamic Total Task Time (s)	Mean Glance Duration (s)	Total # of Glances
			Mean±SD	Mean±SD	Mean±SD	Mean±SD
Kames, 1978	Horizontal on dash, 7 digits?	18 drivers ages 19-65		11.3		
closed test course	Horizontal in visor			11.1		
	Vertical in dash			11.5		
	4x3 on dash (keypad)			11.3		
	Rotary			16.0		
	4x3 hand held			12.0		
	6x2 hand held			12.5		
Tijerina, Johnston, Parmer, Winter-bottom, 2000	10-digit Cell phone	35 or less		31		
See also Tijerina, Parmer, Goodman, 1998		>=55		21		
test track		All (16 Ss)		28	3.2	8
Serafin, Wen, Paelke, Green, 1993	HUD, IP display, 7 digit	12 drivers, 20-76 (20-35)		5.7		
primitive simulator	11 digit	20-35 mean=24)		9.3	0.83	5.5
	7 digit	>60		9.3		
	11 digit	>60 (mean =70		15.9	1.19	8.25
Wierwille, 1990	(# digits unknown)	Young		7		3.75
Wikman, Nieminen, Summala, 1998	8 digit # (home & random)				0.96	5.52

To get an overall impression of the phone dialing studies, the mean time per digit was computed. Where studies provided means for each age group, those data were used in analyses, not just the mean for the experiment. Hence, in several cases there were more data points than studies. Because of its primitive and nondemanding nature as a simulator, the Serafin et al. data was not included in the analysis. According to the remaining data, the mean time per digit was 1.23 seconds on the road, 1.86 seconds on the test track, and 2.93 seconds in the simulator. Thus, the lower the exposure to a driving risk, the longer drivers take to complete the task. Keep in mind these comparisons are based on very few studies, 4 in a simulator, 2 on a test track, and only 1 on the road, and there could be many undocumented reasons (e.g., interface design, differences in primary task difficulty) that provide an explanation. Because phone dialing is a task of particular concern, additional data on dialing is desired and it is quite likely that given additional resources, those data could be identified in the literature.

As shown in Figure 6.2, there were differences in the mean time per digit between contexts (1.23 seconds on the road, 1.86 seconds on the test track, and 2.93 seconds in the simulator). To determine if these differences were due to the ages of subjects, the mean age for each context was computed, using the mean of the range if the mean was not given. (For Tijerina et al., means of 28 and 60 were assumed for the younger and older samples.) Across studies, the mean ages were reasonably close: 44 in the simulator, 42 on the test track, and 45 on the road, so the differences among contexts were probably not due to subjects.

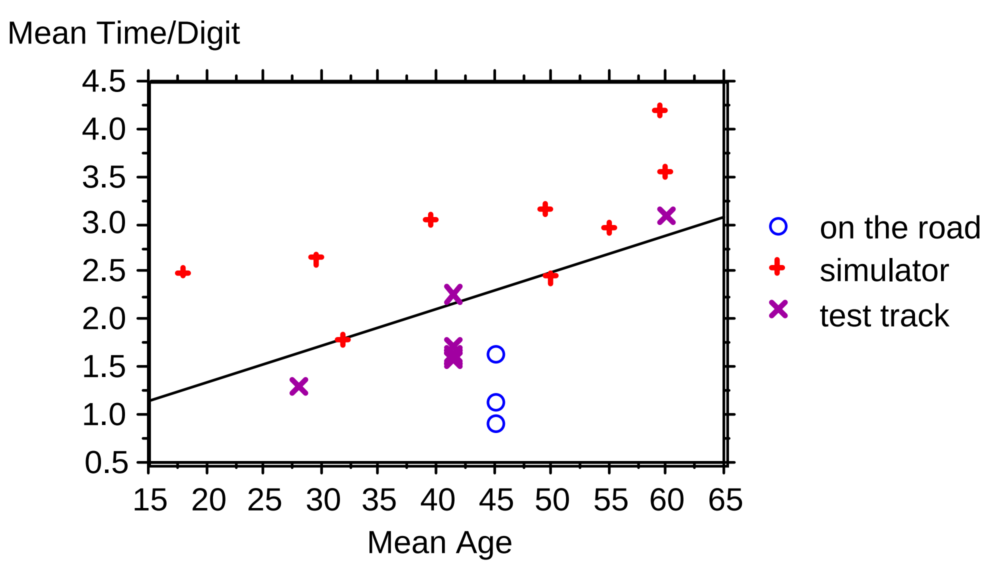


Figure 6.2. Mean Time per Digit for Dialing

Overall, time per digit did elevate with age (=0.55 + 0.039 (age)), $p<.05$. These values seem reasonable, with the time per digit estimated to be 1.49 seconds for a 24-year-old subject and 3.28 seconds for a 70-year-old subject. Typically the duration ratio of older to young subjects at these ages is about 1.5 to 2. Here it is 2.20, quite close.

6.3.2 Tuning a Radio

Table 6.2 shows the data for tuning a radio from 11 studies spanning 15 years. Times reported ranged from 8 to 30 seconds for dynamic conditions (Figure 6.3), with no static times reported. This is quite a large range. In part, the differences occurred because the number of digits was not the same in each experiment (4 to 11 digits), the devices differed, and so forth. As with dialing, times were less on the road (15.2 seconds) than in simulators (17.1 seconds) than on a test track (21.5 seconds). As a footnote, the test track results were drawn from a single experiment.

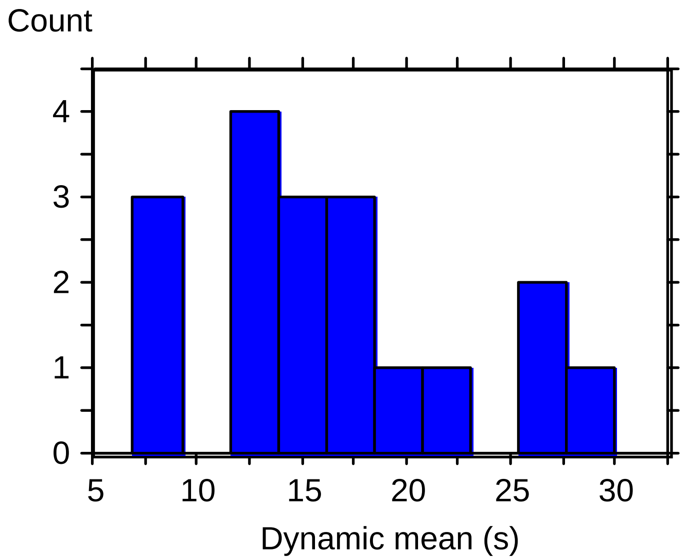


Figure 6.3. Mean Dynamic Time for Tuning a Radio

Table 6.2. Task Data for Tuning a Radio

Study and Context	Task & Device	Age / Notes	Static Total Task Time (s)	Dynamic Total Task Time (s)	Mean Glance Duration(s)	Total # of Glances
			Mean±SD	Mean±SD	Mean±SD	Mean±SD
Bhise, Dowd, & Smid, 2003;	Press FM, tune 95.5, 01 Taurus radio (button tune), in simulator + unknown radio	12 Ss 16-48			2.14	4.2
Experiment 1 simulator	FM, tune to 107.5				2.87	7.5
	FM, tune to 93.1				2.18	5.7
	FM, tune 105.7				2.07	5.7
Gellatly, Kleiss, 2000 road	Stop cassette, Tune radio to 94.9 using seek (multifunctional system)	6 drivers 21-27, 6 ages 65-78		27.5	1.0	15.0
	Stop cassette, Tune radio to 94.9 using seek (multifunctional system)			27.5	1.0	15.0
	Stop cassette, Tune radio to 94.9 using seek (conventional system)			19.5	1.05	12.0
Greenberg, et al., 2003	Tune radio	Teen		13.90		
		25-34		14.79		
		35-44		17.49		
		45-54		16.78		
		55-65		22.34		
simulator		Overall		16.91		

Study and Context	Task & Device	Age / Notes	Static Total Task Time (s)	Dynamic Total Task Time (s)	Mean Glance Duration(s)	Total # of Glances
			Mean±SD	Mean±SD	Mean±SD	Mean±SD
Hayes, Kurokawa, Wierwille, 1989 road	Manual tune (analog)	18-72	11.80±5.46	6.97±3.29	1.33±0.58	5.50±2.41
	Manual tune (digital)		19.32±8.78	11.76±5.97	1.28±0.46	9.17±3.81
Kiger, Rockwell, & Tijerina (1995)	Tune radio	32-60 (mean 47)			1.22±1.22	5.99±3.66
Lansdown, 2001 simulator	Select wavelength & manually tune to identified frequency	Novice (mean=24)			1.59	3.00
		Expert (mean=37)			0.96	2.96
	Turn radio on and search for 101.1 MHz	Novice (24)			0.77	4.00
		Expert (37)			0.67	2.36
		Other Studies			1.1	2-7
Monty, 1984	Radio (seek, balance, tune, preset)	1981 (knobs) 52Ss 18-30, 45-70		7.0		3.0
road		1984 (CRT)		18.0		6.6
Values from figure		1986 (CRT)		13.5		5.6

Study and Context	Task & Device	Age / Notes	Static Total Task Time (s)	Dynamic Total Task Time (s)	Mean Glance Duration(s)	Total # of Glances
			Mean±SD	Mean±SD	Mean±SD	Mean±SD
Rockwell, 1988	Radio A overall	does not identify radio tasks.			1.27±0.48	
(on road)	Radio B overall				1.28±0.50	
Evenly divided under 35 and over 45	Radio C overall				1.42±0.42	
	Select station				1.50	
	Tune station				1.50	
		Young men			1.43	
road		Young women			1.33	
		Total young			1.39	
		Mature men			1.56	
		Mature women			1.35	
		Total Mature			1.46	
		Total men			1.50	
		Total women			1.34	
		Overall			1.42	

Study and Context	Task & Device	Age / Notes	Static Total Task Time (s)	Dynamic Total Task Time (s)	Mean Glance Duration(s)	Total # of Glances
			Mean±SD	Mean±SD	Mean±SD	Mean±SD
Tijerina, Johnston, Parmer, Winterbottom, 2000	Clarion Eclipse	35 or less		13		
		>=55		30		
test track		All		21	2.8	6
Tijerina, Kantowitz, Kiger, Rockwell, 1994	Tune radio to 90.5 (on road)	Not given			1.77±1.33	7.81
Wierwille, 1990	Tune radio	18-25		8		4.75
	(same data below	26-48		12		4.75
road	across age)	49-72		15		6.25
Wierwille and Dingus, 1988 & Dingus, Antin, Hulse, and Wierwille, 1989 & Dingus, Antin, Hulse, and Wierwille, 1986 road	Tune radio	19-73		7.60±3.41	1.10±0.47	6.91±2.39

Figure 6.4 shows the effect of subject age on dynamic time to tune a radio (=3.67 + 0.3(age), p<.05) leading to estimates of 7.2 seconds for a 24-year-old driver and 21.0 seconds for a 70-year-old driver. The authors' impression is that these values seem low for younger drivers and high for older drivers. Keep in mind that these data represent a wide variety of radio interface designs, from simple knobs and analog scales to complex push-button tuning and numeric displays. In many cases the tuning task is incompletely described, and the starting frequency, the ending frequency, or both are not provided. For contemporary radios, magnitude of the change determines the minimum number of key presses required. Finally, the data for the simulator and test track each represent 1 experiment.

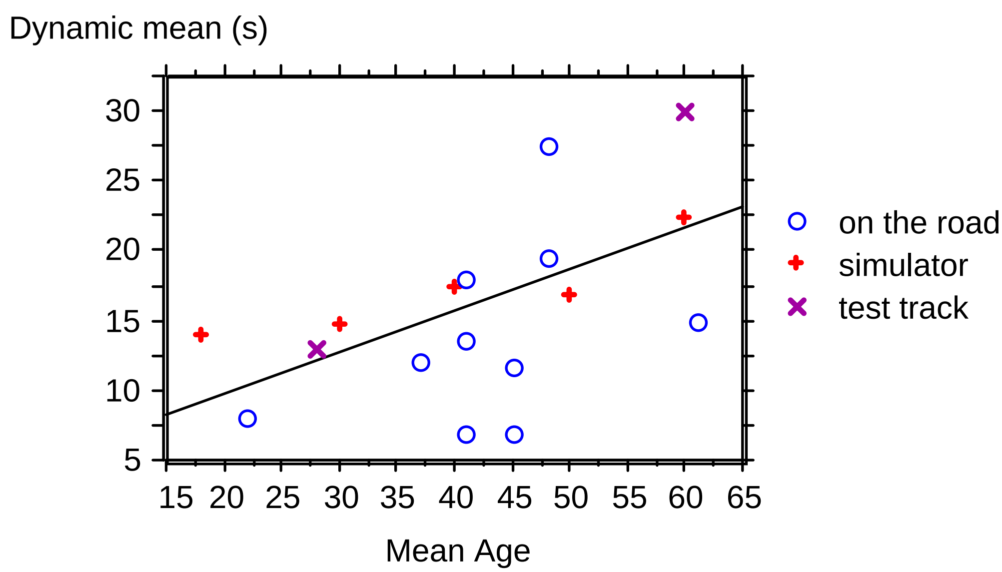


Figure 6.4. Mean Dynamic Time (s) to Tune the Radio versus Age

Figure 6.5 shows the number of glances required to tune the radio, data reported 11 studies. Again the range of the data is quite large, a factor of roughly 6.

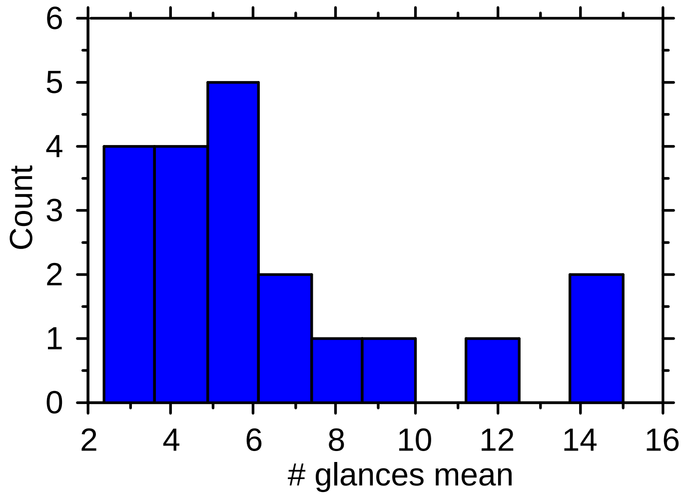


Figure 6.5. Mean Number of Glances to Tune the Radio

Figure 6.6 shows the relationship between the number of glances to tune the radio and driver age (=-1.05 + 0.19(age), p<.05). Notice that the number of glances increases with age, but this is partially confounded with the experimental context (simulator vs. on the road), with subjects making far fewer glances in the simulator than on the road (4.4 vs. 7.8).

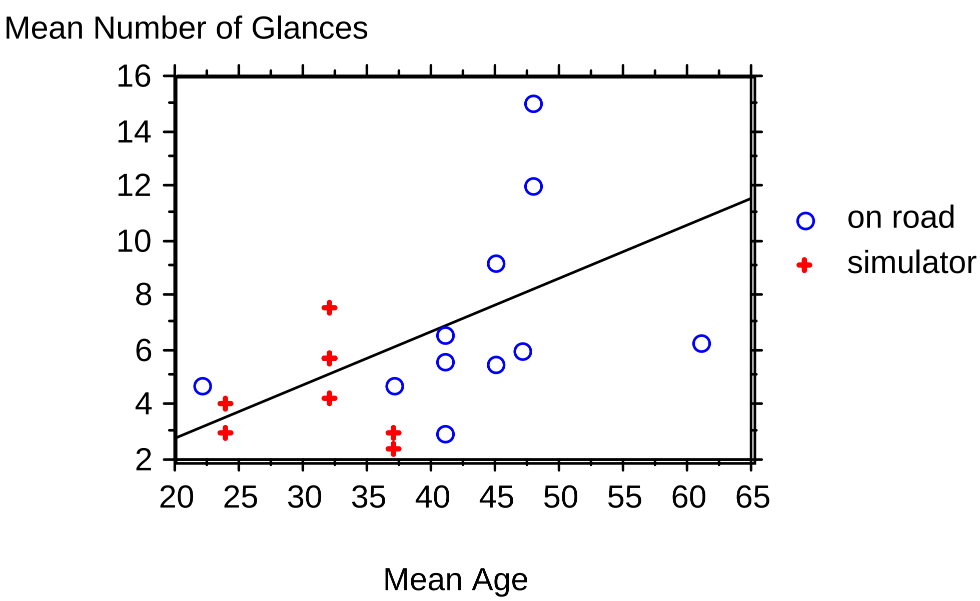


Figure 6.6. Age vs. Mean Number of Glances for Tuning the Radio

As shown in Figure 6.7, the number of glances for radio tuning ranged from 3 to 15, and the number of glances was highly correlated with the dynamic mean time (=2.61 + 1.575(# glances), r=0.91, p<.0001). Given the reasonably fixed pattern of making an adjustment, checking it by looking at the radio, glancing to the road, and then repeating the process, this correlation makes sense. According to these data, each glance pair (to the road, to the radio, and the transitions between them), takes about 1.6 seconds.

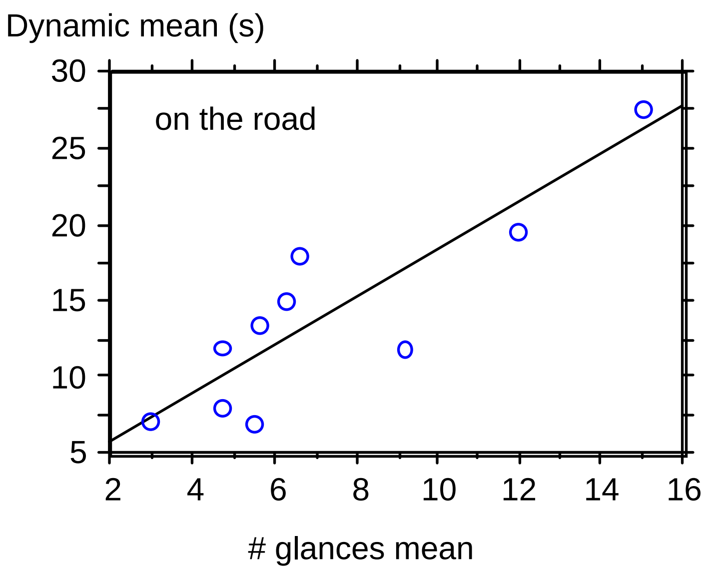


Figure 6.7. Mean Number of Glances vs. Dynamic Mean Time

Figure 6.8 shows the distribution of mean glance durations from studies in the literature. Notice that several of the means are in excess of 2.0 seconds, a time that many believe is the upper limit. Keep in mind that these data are not distributions from studies, but means.

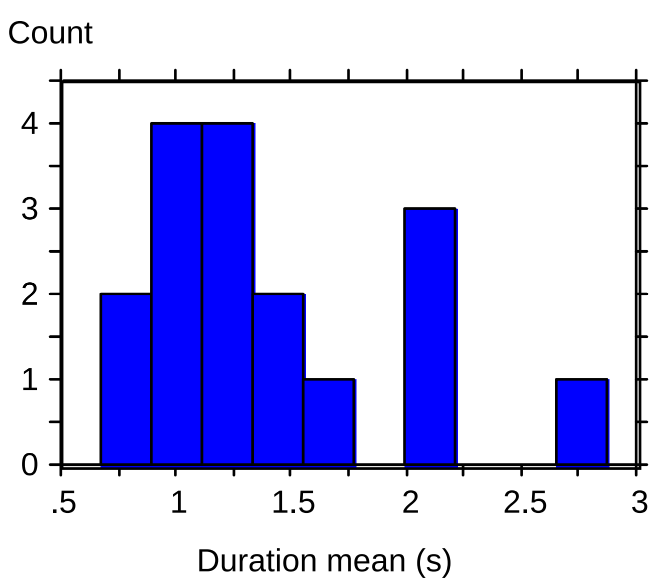


Figure 6.8. Mean Glance Durations for Radio Tuning

Figure 6.9 shows the relationship between mean glance duration and age, with this data indicating a nonstatistically ($p>0.1$) significant decline with age (=2.52 – 0.29(age)). In contrast to the data for the number of glances for tuning the radio (Figure 6.6, where the number of glances increased with subject age), here the mean glance duration for subjects in simulator studies was slightly greater than for on the road.

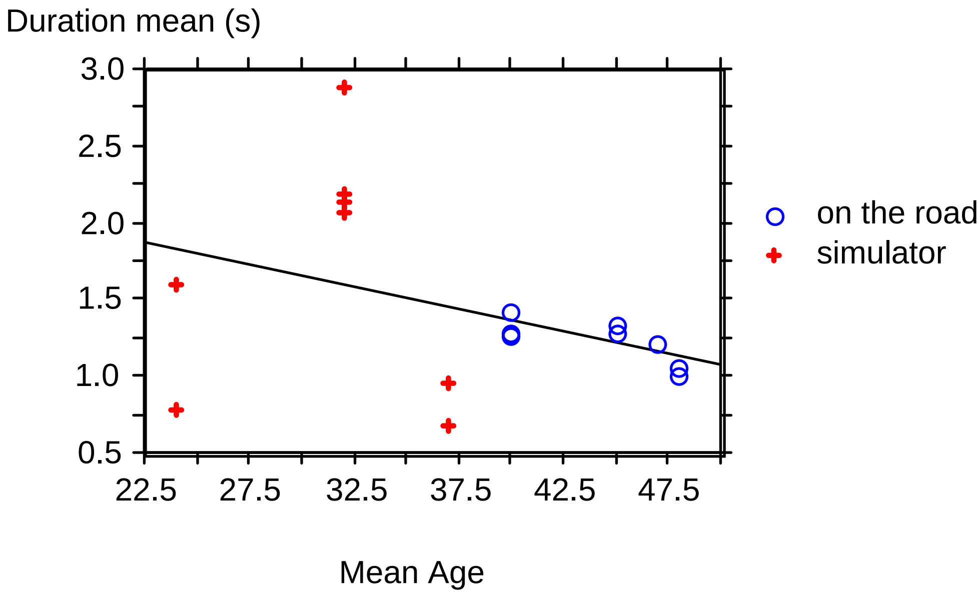


Figure 6.9. Mean Glance Duration vs. Subject Age

Figure 6.10 more directly represents the nonstatistically significant ($p>0.1$) relationship between mean glance duration and the number of glances (=1.59 + -0.21(# glances)). If anything, these data suggest that mean glance durations for tuning the radio increase with the number of glances in the simulator and decrease on the road. It is uncertain if this is due to differences in the 2 contexts or confounded differences such as age, driver interface, or task specifics.

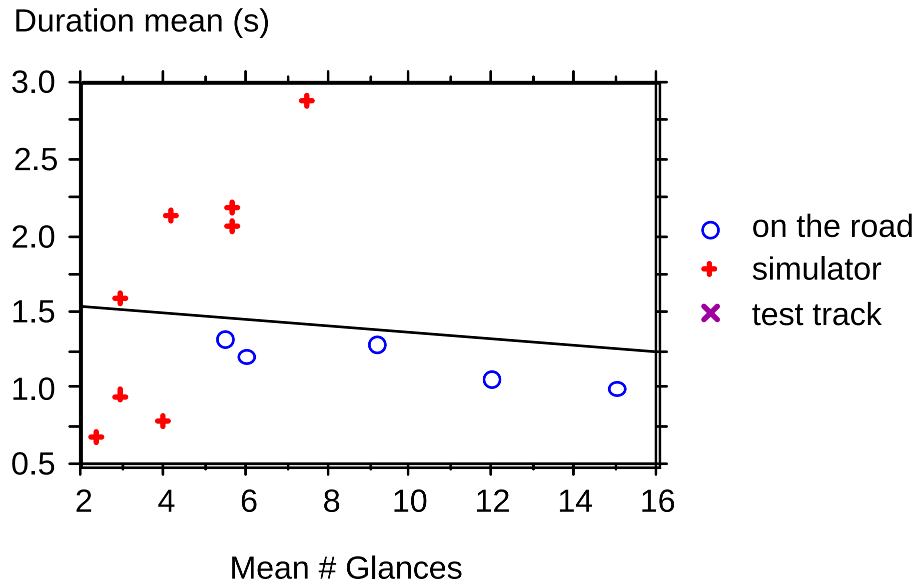


Figure 6.10. Mean Glance Duration vs. Mean Number of Glances for Radio Tuning

The radio tuning data suggest there might be differences due to context (simulator vs. test track vs. on the road). However, in several cases, the data for a particular context are based on a single study and comparisons are between, not within, study. Furthermore, the values reported are quite wide ranging. Although these differences may be explainable to some degree (context, age of the subjects sampled), in many cases the details necessary to ascertain the source of other differences (task, driver interface) are not available. Unfortunately, radio tuning may not be a suitable benchmark for an acceptable task, due to its sometimes unacceptable completion times (based on glance duration) and widely varying estimates for task times and eye glance behavior.

6.3.3 Entering a Street Address

Table 6.3 shows the data for entering a street address, a task of particular concern. Most of these studies were completed in the last 3 years. Mean static total task times are 39.4 to 145 seconds, depending on the experiment and age group. Mean dynamic times, reflecting more modern interfaces, range from 34.3 to 185.12 seconds. Only 2 studies reported glance data.

Table 6.3. Task Data for Entering a Street Address

Study and Context (comment)	Task & Device	Age / Notes	Static Total Task Time (s) Mean±SD	Dynamic Total Task Time (s) Mean±SD	Mean Glance Duration (s) Mean±SD	Total # of Glances Mean±SD
Chiang, Brooks, Weir, 2001 on road 2000 Acura RL, glance estimate from figure	Street address entry, Alpine navigation system, city streets	10 drivers, 26-44		34.3	1.0-1.5	19.4
	Urban freeway			34.1	1.0-1.5	19.0
Dingus, Hulse, Krage, Szczublewski, Berry, 1991 static	Touch screen in lab, TravTek Enter unfamiliar street address	72Ss, 18-55+	(130)			
	Enter & save street address		(50)			
Farber, Blanco, Foley, Curry, Greenberg, & Serafin, 2000 static times are vehicle & (mockup)	Enter street address via an alpha-numeric intelligent speller via 4 way cursor	45-55	40.09 (39.40)	71.38		
		55-65	51.07 (41.24)	91.94		
Curry, Greenberg, & Blanco (2002) simulator	Enter street address via an alpha-numeric intelligent speller, Lincoln Navigator nav system	45-55 & 55-65		81.30	1.39	30.09

Study and Context (comment)	Task & Device	Age / Notes	Static Total Task Time (s)	Dynamic Total Task Time (s)	Mean Glance Duration (s)	Total # of Glances
			Mean±SD	Mean±SD	Mean±SD	Mean±SD
Nowakowski, Utsui, Green, 2000 dynamic times are estimates	Address entry keyboard	20-30	70.8±18.2	89.92		
		55-65	145.8±31.3	185.12		
Steinfeld, Manes, Green, Hunter, 1996	Enter destination with Ali Scout (bad interface)	12 Ss 18-30	37.75			
		12 Ss 40-55	52.31			
		12 Ss >65	75.52			
Tsimhoni, Smith, Green, 2001	Enter a street address via a touch-screen keyboard	20-30	23.0±5	41.4±15.6	1.4±0.3	20.6±10.7
		65-72	42.1±15	91.8±40.8	1.1±0.3	34.5±11.9

Figure 6.11 shows the relationship between the static and dynamic mean times (dynamic time = 33.12 + 1.03*static time, r=0.96, p<.01) with much of the relationship due to a single point from the Nowakowski et al. study. Given the nature of the task, a multiplier for the static term much greater than 1 was expected.

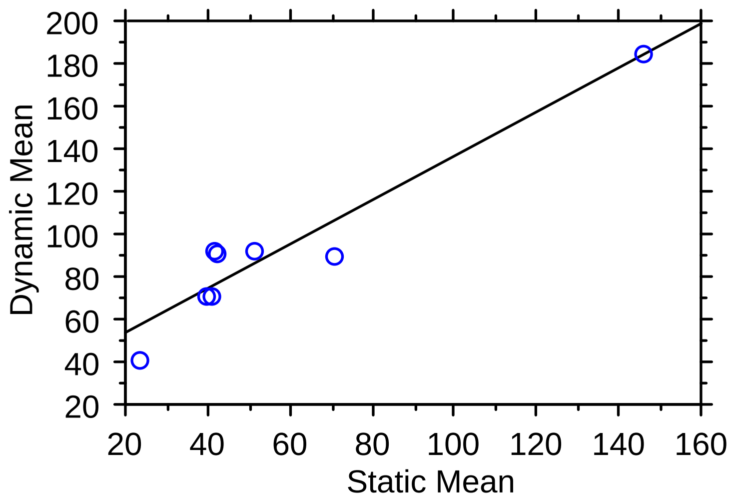
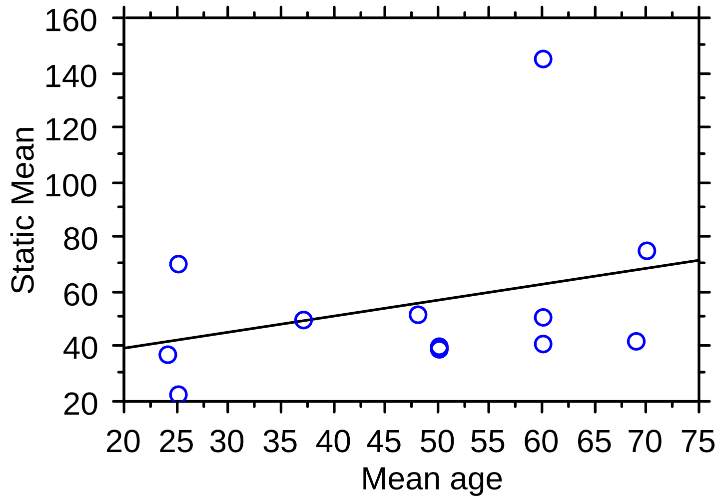


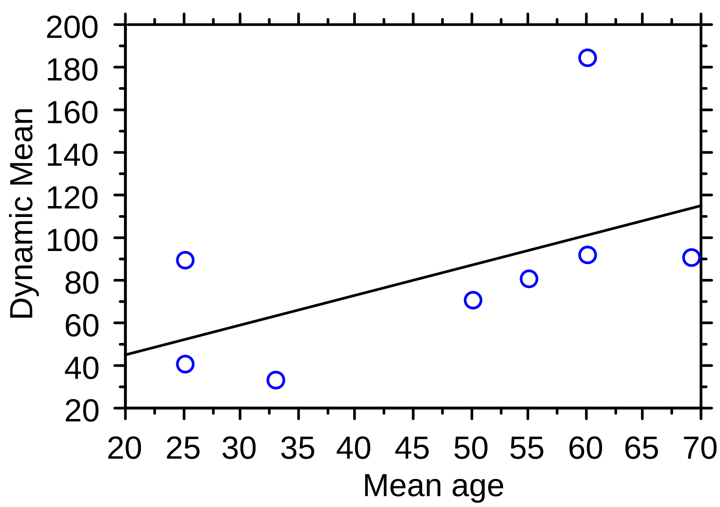
Figure 6.11. Dynamic Mean vs. Static Mean Time for Destination Entry

As with the other tasks, the effects of age were examined and, as shown in Figures 6.12 and 6.13, both the static and dynamic times for destination entry increased with age, though the effects were more pronounced for dynamic times. Neither relationship was statistically significant (p>0.1). Using the regression values provided, the estimated static task time for address entry is 41.56 seconds for a young driver (age 24) and 68.67 seconds for an older (age 70) driver. The authors' impression is that the time for the younger driver is reasonable, as is the ratio of older to younger driver performance (1.65:1). For dynamic times, the estimates are 50.59 and 114.76 seconds respectively, and the ratio is 2.27, all of which seem reasonable. Obviously, these and all other estimates will depend on the quality of the interface implemented, the interface location, the driving workload, the age and experience of the driver, and many other factors.



Static Mean = 27.44 + .59 * Mean age; R^2 = .098

Figure 6.11. Static Mean Time vs. Age for Destination Entry



Dynamic Mean = 17.11 + 1.40 * Mean age; R^2 = .29

Figure 6.12. Dynamic Mean Time vs. Age for Destination Entry

6.3.4 Other Destination Entry Tasks

Finally, Table 6.4 shows data for entering destinations other than the street address. Task times ranged from 7 to 240 seconds (4 minutes). The number of other telematics tasks reported is limited. Most of the data were associated with addresses selected from lists, for example a Point of Interest (POI) such as an airport. There are too few data points for much in the way of comparisons across studies.

Table 6.4. Task Data for Entering a Destination by Other Than a Street Address and Other Telematics Tasks

Study and Context	Task & Device	Age / Notes	Static Total Task Time (s)	Dynamic Total Task Time (s)	Mean Glance Duration (s)	Total # of Glances
			Mean±SD	Mean±SD	Mean±SD	Mean±SD
Curry, Greenberg, Blanco, 2002	destination entry-street address via scrolling lists			80.17	1.28	30.29
Dingus, Hulse, Krage, Szczublewski, Berry, 1991	Touch screen in lab, TravTek; retrieve stored address	72 ages, 18-55+	50			
	Check congestion on map		240			
	Yellow pages-select business (similar to POI)		90			
	Set speech output level		40			
	Request tow		40			
Farber, Blanco, Foley, Curry, Greenberg, Serafin, 2000 Static times are vehicle & (mockup)	destination entry-street address via scrolling lists	15 ages 45-55	35.04 (34.01)	71.06		
		14 ages 55-65	49.56 (36.26)	89.92		
	finding and selecting an entry on a short nav menu	45-55	7.66 (6.83)	13.38		
		55-65	9.00 (7.55)	17.49		
Nowakowski, Utsui, Green, 2000	list select keyboard	20-30	17.5±6.2	20.6±4.7		
		55-65	36.4±12.4	46.8±13.1		
	list select using hand-held remote	20-30	21.7±8.4	23.0±4.8		
		55-65	32.5±13.6	37.6±8.5		

Study and Context	Task & Device	Age / Notes	Static Total Task Time (s)	Dynamic Total Task Time (s)	Mean Glance Duration (s)	Total # of Glances
			Mean±SD	Mean±SD	Mean±SD	Mean±SD
Steinfeld, Manes, Green, Hunter, 1996	Retrieve destination with Ali Scout (bad interface)	12 Ss 18-30	5.71			
		12 Ss 40-55	9.58			
		12 Ss >65	16.15			
Tijerina, Johnston, Parmer, & Winterbottom, 2000	Destination Entry- POI, Alpine	Young		79		
		Old		159		
		All		119	2.6	33
	Destination Entry- POI, Delco Telepath	Young		57		
		Old		98		
		All		77	2.7	22
	Destination Entry- POI, VAAN	Young		75		
		Old		76		
		All		75	1.05	4
	Destination Entry- POI, Zexel	Young		70		
		Old		140		
		All		102	2.75	27

6.4 CONCLUSIONS AND COMMENTS

6.4.1 What are typical task time and glance characteristics for visual-manual telematics tasks completed while driving?

The times reported to dial a phone while driving ranged from about 5 to 39 seconds depending on the driver age, the number of digits dialed (7, 10, or 11), the input device, and the driving context (simulator, on road). Data on static task times were limited, with values of 15 to 20 seconds reported. Dialing was associated with almost 4 to almost 13 glances, depending on the number of digits dialed (7 or 11) and other factors. As a rough estimate, dialing takes about 2 seconds per digit, though the on-the road times were somewhat lower than times reported for simulator studies, which in turn were lower than those reported for test tracks.

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The time to tune a radio when driving ranged from 8 to 22 seconds. No static times were reported. The number of glances varied by a factor of 6 across studies, with simulator studies reporting fewer glances. Glance durations ranged from 0.77 to almost 3 seconds, with most values being in the 1.5 to 2.0 second range. Several studies reported value in excess of 2.0 seconds, which many consider to be at or above an upper bound for glance duration.

The Alliance of Automobile Manufacturers has proposed using radio tuning as a benchmark for a maximally acceptable task. However, given the wide range of values reported and the uncertainties about why differences have occurred among studies, the radio tuning task appears to be a poorly defined reference point. Furthermore, from personal experience, most radio tuning occurs using presets, either a single key press to get another station (usually of 6 available choices) in the active band, and a second or third key press to access other bands. Radio tuning, on the 2 knob-5 button interface previously involved turning a knob and watching a pointer on a visual display while listening for appropriate auditory feedback. The task now involves multiple key presses and watching a digital display for an exact value, which is a more time consuming task. Increasingly, tuning a radio will first require going through a menu system to get to the radio so the existing steps for tuning are completed.

Mean static total task times to enter a destination ranged from 50 to 140 seconds depending on the experiment and age group. Mean dynamic times, reflecting more modern interfaces, range from 34 to 185 seconds. Only 2 studies reported glance data. As elsewhere, static and dynamic times were correlated.

Most of the other tasks reported, primarily selecting a point of interest using a navigation system, range from 7 to 240 seconds.

In all of the cases explored in detail, there were pronounced differences due to age, with the differences between younger and older drivers sometimes being less than and sometimes being greater than the 1.5-2.0:1 commonly found. Given the size of the age differences reported, it is important for workload managers to consider the effect of driver age when estimating if overload is likely to occur.

Also of note were differences across contexts, with times on the road being shorter than those for simulators and even shorter than those on test tracks. It is uncertain why these differences occurred, and given there is interest in using simulators to predict exact levels of performance, not just rank order differences or identify statistically significant differences, this warrants further exploration. Finally, the limited data available suggested drivers made shorter, but more, eye glances on the road than in simulator studies.

For all measures, the standard deviation was reported far less often than the mean. Overall, the standard deviations were about one half of the mean.

6.4.2 Why are the data so variable?

1. The driving situation is incompletely specified.

In some papers there is reference to the driving situation. As an example, Parkes and Ward, and Vaughn, 2001, p. 21 state: “The motorway route was 40 km in length and took approximately 30 minutes to complete… After exiting the motorway, the subject returned to the Renault Research Center by a 3 km suburban route.” An enterprising researcher could find a map for Guyancourt, France where the Renault Technocentre is located, make some guess about the unnamed roads that might have been driven, and then contact the French national road authorities for data. It would have been ideal if the report had provided better information on traffic volume (or traffic class) at the time of day the study was conducted, the weather, speed limit, lane width, and other road geometric data, along with some measure of visual demand. The authors do not mean to single out Parkes and Ward as the situation in their paper is typical of what appears in the literature. In many simulator studies, no data are given about the roads driven.

2. The vehicle is unknown.

This is much less common, but some simulator studies fail to provide the package the cab represents. Most problems arise because the location of the device is incompletely specified. An interior picture would help immensely. Particularly problematic are vehicles where the telematics device is mounted low in the center console.

3. The driver interface/device is not completely specified.

Bhise, Smid, Davis, and Dowd (2003) describe research for a “production radio” and show the radio, but they do not name the manufacturer. This leads the astute researcher to go to a web site for radios and try to find a matching image. One needs both the radio manufacturer and model number for purpose of identification and a picture of the radio because tuning task times, for example, depend on whether a button or knob is used for that task.

4. The task is not completely specified.

As an example, this might include (1) a dialing task where the number of digits is unspecified, or (2) selection from an address book where the menu hierarchy and the number of the items in the address book are not given. In the case of radio tuning, the task time largely depends on the difference between the starting and ending frequencies, which determines the number of key presses required.

5. The measures collected are undefined.

As noted in the introduction, the measures of interest have been defined in various ways. For example, glance time to a display might include only the fixation duration to the display, or might include the trailing transition back to the road, or might include the transition from the road to the display, or both transitions. Task times can start and end at various times. Glance measures should be used as specified in SAE Recommended Practice J2396. An SAE Recommended Practice should be developed to define other measures. In such a document, there should be provisions for multiple definitions (static total task time-cases A & B) where necessary.

6.4.3 Are these data useful for workload manager design?

The authors would argue they are useful, but to a limited degree. They can be useful to provide a very rough estimate of the time required to complete a task, and for a very few tasks, glance data are available. However, it may not be necessary for a workload manager to have an accurate estimate of a task time or other measures of demand. For example, it might be that simply knowing that a task usually takes longer than 15 seconds (or in some cases, much longer) is sufficient to classify when a particular task should be permitted.

If a more precise estimate is needed, task time might be estimated using SAE Recommended Practice J2365 (Society of Automotive Engineers, 2002) or using the IVIS model (Hankey, Dingus, Hanowski, Wierwiile, and Andrews, 2000a,b). Some of those estimates should be validated using experimental data.

6.4.4 Are these data useful for research?

As others conduct further research on the telematics tasks, they will need to examine the prior research as a first step. Hopefully, the tables and Appendix A will save them time in retrieving the relevant research. Furthermore, the commentary earlier in this section should encourage others to report more details about test situations.

6.4.5 Are these data useful for standards development?

There has been a great deal of discussion in developing the AAM guidelines about using the radio tuning task as a benchmark for acceptable task performance. The data from this report suggest that using radio tuning as a benchmark will be a problem as there is a wide range of driver performance associated with the radio tuning task, and it is not clear that the full range of performance is acceptable.

As a whole, if anything, these data indicate that even though there have been a significant number of studies reporting data on static and dynamic task times, and the mean and standard deviation of the number and duration of glances for several telematics tasks, gaps in current data are quite large.

Those producing documentation of research are encouraged to report not only statistical differences, but also specific values (e.g., task times, number of glances) for various tasks and devices to assist in product engineering. Even burying those data in report appendices can be extremely helpful.

6.4.6 What are possible implications for SAVE-IT?

a. Collect additional task data.

> To some extent this will be done as part of the validation portion of the project.

b. Try to learn move about why differences occurred.

> The extent to which this can occur will depend upon the resources available for the validation experiment and is focus on basic versus applied research. The design of these studies is open.

c. Abandon the use of look-up tables and focus on only real-time measures.

> The authors expect that with collection of additional data, a better sense of typical values can be obtained, and accordingly, look-up tables should continue to serve a role. However, the extent to which the final implementation of the workload manager relies strictly on real time performance measures or predictive models has yet to be determined.

d. Develop standardized protocols for specifying what is to be collected.

> As was suggested earlier, the authors believe that specifications for data collection protocols may lead to more consistent data collection and reduce between study variability. One way for that to occur is to publish the results of this project in a public forum, such as the HFES Proceedings, and to do so at the earliest possible date (the 2005 Annual Meeting).

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APPENDIX A – TASK TIMES & GLANCE DATA SORTED BY STUDY

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Asoh, Kamiya, Ito, 1999	Short headway - 0 characters	# Ss unknown			00.8					
Experiment 1: (rural road)	10 chars				1.5					
Experiment 2: (test track)	20 chars				2.5					
	30 chars				3.5					
Total glance times	Long headway - 0 characters				0.8					
estimated	10 chars				1.3					
from	20 chars				2.3					
figure	30 chars				3.5					

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Bengler, Huesmann, Praxenthaler, to appear Simulator	Searching a city in a map book	20 Ss, 35-55			12.5	9				
	Searching a name in an address book									
	Tune Radio (CARIN system)				21	9				
	Unpacking Kleenex				2.5	2				
	Changing cassette (CARIN system)				8	5				
	Searching for sweets in a bag and unwrapping them									
	Destination Entry Map				29	15				
	Destination entry spelling				21	10				
	Searching for coins in a purse									
	Sound adjustment (CARIN system)				8	2				
	PIN-4 digit entry in a cell phone				7	6				

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Bhise, Dowd, Smid, 2003 01 Taurus radio, + unknown radio simulator Total glance time & # of glances estimated from figure Mean glance duration was computed	Press FM, select preset 6	12 Ss 16-48			3		1.50		2.0	
	Press CD, eject CD, insert CD				17		2.74		6.2	
	FM, listen to 3 presets, pick 1				8		2.00		4.0	
	Adjust bass & treble				8.5		2.07		4.1	
	(5+9 – 6) x 23=?				0		0.00		0	
	Press CD, seek track 4				4.0		1.60		2.5	
	Press FM, tune 95.5				9		2.14		4.2	
	Turn volume up				0.5		0.63		0.8	
	Find cell phone, dial home # backwards				12.5		1.98		6.3	
	FM, tune to 107.5				21.5		2.87		7.5	
	Turn volume down				0.3		0.60		0.5	
	FM, tune to 93.1				12.4		2.18		5.7	
	FM, tune 105.7				11.8		2.07		5.7	
	CD, seek track 2				2.8		1.08		2.6	

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Experiment 2 on road	Press CD, eject CD, insert CD				12		2.67		4.5	
	Answer phone				3.5		1.46		2.4	
	Press FM, select Preset 6	6 Ss, 25-48								
	Press CD, eject CD, insert CD									
Chiang, Brooks, Weir, 2001	Street address entry, Alpine nav	10 drivers, 26-44 city streets	34.3		19.4		1.0-1.5			
2000 Acura RL on road glance est. from figure		Urban free-way	34.1		19.0		1.0-1.5			
Curry, Greenberg, Blanco, 2002 simulator	CD	15 drivers 44-55, 14 ages 56-65	13.41		8.37		1.31		6.54	
	Spell		81.30		41.24		1.39		30.09	
	List		80.17		38.02		1.28		30.29	
	Phone		32.81		15.09		1.20		12.78	
	Menu		15.37		8.39		1.21		6.97	
	TMC		15.27		8.70		1.42		6.60	

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Dingus, Hulse, Krage, Szczublewski, Berry, 1991	Touch screen in lab, TravTek Enter unfamiliar street address Time includes route select, top level select	72Ss, 18-55+	(130)							
static	Retrieve stored address		(50)							
	Check congestion on map		(240)							
	Enter & save street address		(160)							
	Yellow pages-select business (similar to POI)		(90)							
	Set speech output level		(40)							
	Request tow		(40)							
Farber, Blanco, Foley, Curry, Greenberg, Serafin, 2000 simulator	CD	15 age 45-55	11.56 (8.67)	3.79 (2.33)					9.51	
		14 age 55-65	15.04 (11.50)	5.64 (2.94)					12.12	
	Spell	15 age 45-55	71.38 (40.09)	22.86 (.970)					50.29	
		14 age 55-65	91.94 (51.07)	42.67 (51.07)					61.42	

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Where 2 static values are shown they are vehicle & (mock-up)	List	15 age 45-55	71.06 (35.04)	34.90 (5.12)					46.70	
		14 age 55-65	89.92 (49.56)	49.57 (20.64)					58.58	
	Phone	15 age 45-55	26.80 (15.14)	11.75 (4.52)					18.68	
		14 age 55-65	39.25 (20.81)	19.79 (9.37)					25.31	
	Menu	15 age 45-55	13.38 (7.66)	7.16 (4.49)					9.29	
		14 age 55-65	17.49 (9.00)	13.79 (4.24)					11.35	
	TMC	15 age 45-55	14.04 (8.70)	4.50 (2.84)					10.38	
		14 age 55-65	16.58 (11.49)	6.75 (3.49)					12.60	
Gellatly, Kleiss, 2000 On road	Fan, Adjust to medium (multifunction system)	6 drivers 21-27, 6 ages 65-78	16.0				1.05		8.5	
	Play Cassette (multifunction system)		10.0				1.0		6.0	
	Access email and delete message (multifunction system)		21.0				1.0		10.5	
	Stop cassette, Tune radio to		27.5				1.0		15.0	

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
	94.9 using seek (multifunction system)									
	Play digital video disk (multifunction system)		22.5				1.0		12.5	
	Increase bass (multifunction system)		10.0				1.0		6.0	
	Activate phone and call preset number starting with ‘953 (multifunction system)		21.5				1.0		12.5	
	Activate A/C, decrease temp to 70º (multifunction task)		26.0				1.0		13.0	
	Find route information to gas station (multifunction system)		19.5				1.05		10.0	
	Fan, adjust to medium (conventional system)		5.0				1.15		3.0	

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
	Play cassette (conventional system)		7.5				0.8		2.5	
	Stop cassette, Tune radio to 94.9 using seek (conventional system)		19.5				1.05		12.0	
	Change balance to right speakers (conventional system)		7.5				1.0		2.5	
	Activate phone, call preset 1 (conventional system)		11.5				0.95		7.0	
	Activate A/C, temp 70º		10.0				1.0		6.0	

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Greenberg, Tijerina, Curry, Artz, Cathey, Grant, Kochhar, Kozak, Blommer, 2003 simulator	Dial hands-free	Teen	43.91							
		25-34	35.81							
		35-44	38.95							
		45-54	38.01							
		55-65	50.11							
		Overall	40.97							
	Dial hand-held	Teen	24.88							
		25-34	26.48							
		35-44	30.50							
		45-54	31.77							
		55-65	42.02							
		Overall	30.74							
	Incoming call-hands free	Teen	13.98							
		25-34	16.49							
		35-44	17.84							
		45-54	18.07							
		55-65	18.03							
		Overall	16.73							
	Incoming call hand-held	Teen	17.46							
		25-34	20.12							
		35-44	21.90							
		45-54	20.93							
		55-65	22.58							
		Overall	20.45							

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
	Voice mail hands-free	Teen	147.61							
		25-34	145.25							
		35-44	152.27							
		45-54	153.11							
		55-65	162.61							
		Overall	151.99							
	Voicemail hand-held	Teen	154.19							
		25-34	157.57							
		35-44	168.13							
		45-54	170.31							
		55-65	212.88							
		Overall	171.74							
	Tune Radio	Teen	13.90							
		25-34	14.79							
		35-44	17.49							
		45-54	16.78							
		55-65	22.34							
		Overall	16.91							
	Climate control	Teen	7.55							
		25-34	7.86							
		35-44	8.28							
		45-54	8.93							
		55-65	10.31							
		Overall	8.54							

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Hayes, Kurokawa, Wierwille,	Insert cassette, radio high on instrument panel	18-72			7.65	3.13	0.86	0.33	4.00	1.53
1989	Enter 4 digits on keypad				6.61	1.21	1.32	0.68	3.25	1.07
On road	Dial 7-digit # (plus phone & #)				9.02	3.96	1.41	0.62	4.27	1.76
	Dial 11-digit # (plus phone & #)				10.91	3.45	1.23	0.52	5.5	1.94
	Manual tune (analog)				11.80	5.46	1.33	0.58	5.50	2.41
	Manual tune (digital)				19.32	8.78	1.28	0.46	9.17	3.81
Ishida,	Insert cassette	50 mostly			1.05		1.20			
Matsuura, 2001	Answer phone-hand held	young drivers			1.90		2.04			
Follow on test course	Answer phone-hands free				1.66		2.02			
Kames, 1978	Horizontal on dash	18 drivers ages 19-65	11.3							
Drive closed	Horizontal in visor		11.1							
test course	Vertical in dash		11.5							
	4x3 on dash (keypad)		11.3							
	Rotary		16.0							
	4x3 hand held		12.0							
	6x2 hand held		12.5							

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Kamp, Marin-Lamellet, Forzy, Caseur, 2001	Select item from menu (of 5), cancel, select another item touchpad	27 drivers, 26-69	15							
Simulator	keyboard		15							
Times estimated from figure	Enter 6 letter name Touchpad		21							
	Keyboard		50							
	Find a particular cinema on Paris map Touchpad		10							
	keyboard		13							
Kiger, Rockwell, Tijerina, 1995	Instrument panel	30 Ss					0.88	0.36		
	Digital clock-requested						1.27	0.41	1.07	0.28
	Air pressure gauge-requested						1.53	0.61	1.17	0.50
On road, heavy truck	Adjust radio volume						0.93	0.93	1.19	0.62
	Tune radio						1.22	1.22	5.99	3.66

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Kimura, Yamauchi, Kanamori, 1999 Test track	Retrieving a list (4 characters)*1	Not given			6.6		1.1		6	
	Selecting a menu item (4 options)*2				6.0		1.5		4	
	Selecting menu item (6-8 options)*3				6.0		1.0		6	
	Ten-key input (1 numeral at a time)				6.0		1.0		6	
	Ten-key input (2 numerals at a time *4)				6.0		1.5/2		4	
Kishi, Sugiura, Kimura, 1992	Speedometer						0.80	0.20		
	Radio volume						0.70	0.20		
	Radio tuning						0.95	0.33		
	Fresh/recirc air mode						0.95	0.33		
	Heater mode						1.10	0.30		
	Clock						0.75	0.22		
	Speedo-meter						0.90	0.32		
	Radio volume						0.85	0.37		
	Radio tuning						1.10	0.43		
	Fresh/recirc air mode						1.20	0.50		
	Heater mode						1.40	0.30		
	clock						0.95	0.25		

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Lansdown (2001) simulator	Switch radio on/off	Novice					1.25		0.99	
		Expert					0.53		0.80	
	Insert cassette	Novice					0.50		1.38	
		Expert					0.53		1.25	
	Adjust volume	Novice					0.50		1.09	
		Expert					0.53		0.50	
	Select pre-set station	Novice					0.65		1.00	
		Expert					0.77		1.18	
	Turn cassette over	Novice					0.66		2.15	
		Expert					0.52		2.02	
	Fast forward cassette	Novice					0.50		1.50	
		Expert					0.50		1.56	
	Select wavelength and pre-set	Novice					1.24		2.58	
		Expert					0.98		2.32	
	Insert cassette & fast forward tape	Novice					0.58		1.56	
		Expert					0.53		1.80	
	Eject cassette and adjust	Novice					0.58		1.56	
		Expert					0.52		1.80	
	Eject cassette & manually search for identified frequency	Novice					1.26		3.00	
		Expert					0.75		2.64	
	Adjust the balance & fader volume	Novice					0.77		1.49	
		Expert					0.65		1.67	

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
	Select wavelength & manually tune to identified frequency	Novice					1.59		3.00	
		Expert					0.96		2.96	
	Turn radio on & search for 101.1 MHz	Novice					0.77		4.00	
		Expert					0.67		2.36	
Monty, 1984 On road Values from figure	Radio (seek, balance, tune, preset)	1981 (knobs)	7.0						3.0	
		1984 (CRT)	18.0						6.6	
		1986 (CRT)	13.5						5.6	
	Trip	1981 (knobs)	6.0						2.4	
		1984 (CRT)	11.0						4.3	
		1986 (CRT)	10.5						4.2	
	Climate Control (model, temp select)	1981 (knobs)	4.5						2.2	
		1984 (CRT)	10.5						4.0	
		1986 (CRT)	7.5						3.3	

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Nowakowski, Utsui, Green, 2000 simulator	Address entry keyboard	20-30	89.92 (70.8)	(18.2)						
		55-65	185.12 (145.8)	(31.3)						
	List select keyboard	20-30	20.6 (17.5)	4.7 (6.2)						
		55-65	46.8 (36.4)	13.1 (12.4)						
	List select remote	20-30	23.0 (21.7)	4.8 (8.4)						
		55-65	37.6 (32.5)	8.5 (13.6)						
	Cursor once keystroke (remote)	20-30	0.98							
		55-65	1.63							
	Cursor additional keystroke (remote)	20-30	0.43							
		55-65	0.53							
	Enter keystroke (remote)	20-30	0.99							
		55-65	1.53							
	Overall mean keystroke times (remote)	20-30	0.80							
		55-65	1.23							
	List selection total task time (remote)	20-30	21.70							
		55-65	32.50							

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
	List selection total task time (keyboard)	20-30	17.50							
		55-65	145.80							
	Address entry total task time (keyboard)	20-30	70.80							
		55-65	36.40							
Parkes, Ward, Vaughan, 2001 On road	Satellite System	15 Ss, 23-67	7.74		3.53		0.61		2.86	
	Traditional audio system		7.63		3.83		0.95		2.76	
Rockwell, 1988 On road	Radio experiment A						1.27	.48		
	Radio experiment B						1.28	.50		
	Radio experiment C						1.42	.42		
	Left mirror A						.40	.40		
	Left mirror B						.28	.28		
	Left mirror C						.33	.33		
	Select Station						1.50			
	Tune station						1.50			
	Volume						0.97			
	Sound quality						1.51			
	Basic cassette						1.59			
	Memory set						1.37			

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
	Radio	Young males					1.43			
		Young females					1.33			
		Total young					1.39			
		Mature Males					1.56			
		Mature Females					1.35			
		Total Mature					1.46			
		Total Males					1.50			
		Total Females					1.34			
		Overall					1.42			

<table>
<tr><th rowspan="2">Study

comment</th><th rowspan="2">Device & Task</th><th rowspan="2">Age or Group</th><th colspan="2">Total Task Time Dynamic (Static)</th><th colspan="2">Total Glance Time</th><th colspan="2">Mean Glance Duration(s)</th><th colspan="2">Total # of Glances</th></tr>
<tr><th>mean</th><th>sd</th><th>mean</th><th>sd</th><th>mean</th><th>sd</th><th>mean</th><th>sd</th></tr>
<tr><td rowspan="4">Serafin, Wen, Paelke, Green, 1993

Primitive simulator

Glance data from a subset of Ss</td><td rowspan="4">HUD, IP display</td><td>12 drivers, 20-76 young 7 digit</td><td>5.7</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Young 11 digit</td><td>9.3</td><td></td><td>4.57 (from 2 Ss)</td><td></td><td>0.83</td><td></td><td>5.5</td><td></td></tr>
<tr><td>Old 7 digit</td><td>9.3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Old 11 digit</td><td>15.9</td><td></td><td>9.81 (from 2 Ss)</td><td></td><td>1.19</td><td></td><td>8.25</td><td></td></tr>
<tr><td rowspan="2">Sodhi, Reimer, Llamazares, 2002
On road, Total glance time is computed</td><td>2-lane road turn on radio, change to 1610AM</td><td rowspan="2">28 drivers, >20 years old

(only 5 good)</td><td>21.15</td><td></td><td>12.56</td><td></td><td>0.76</td><td></td><td>11.8</td><td></td></tr>
<tr><td>Read odometer</td><td>9.23</td><td></td><td>3.86</td><td></td><td>0.69</td><td></td><td>5.6</td><td></td></tr>
<tr><td rowspan="6">Steinfeld, Manes, Green, Hunter, 1996</td><td rowspan="3">Enter destination with Ali Scout</td><td>12 Ss 18-30</td><td>(37.75)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>12 Ss 40-55</td><td>(52.31)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>12 Ss >65</td><td>(75.52)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Retrieve destination with Ali Scout</td><td>12 Ss 18-30</td><td>(5.71)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>12 Ss 40-55</td><td>(9.58)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>12 Ss >65</td><td>(16.15)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Tijerina, Johnston, Parmer, Winterbottom, 2000 values from figure See also Tijerina, Parmer, Goodman, 1998 Test track	Alpine-Destination Entry-POI	Young	79							
		Old	159							
		All	119				2.6		33	
	Delco	Young	57							
		Old	98							
		All	77				2.7		22	
	VAAN	Young	75							
		Old	76							
		All	75				1.05		4	
	Zexel	Young	70							
		Old	140							
		All	102				2.75		27	
	Dial 10-digit Cell phone	Young	31							
		Old	21							
		All	28				3.2		8	
	Tune Radio-Clarion Eclipse system	Young	30							
		Old	13							
		All	21				2.8		6	
	Overall	Young	68							
		Old	118							

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Tijerina, Kantowitz, Kiger, Rockwell, 1994 on road sd of glance duration computed as sqrt of variance	Read exact speed	7 Ss					1.60	1.26	1.29	
	Compare posted speed with speedo-meter						1.42	1.19	1.25	
	Read air pressure						2.11	1.45	2.00	
	Read engine RPM						1.66	1.29	1.61	
	Read fuel gauge						1.88	1.37	1.78	
	Read clock						1.20	1.10	1.88	
	Read elapsed time						1.65	1.28	2.67	
	Radio volume up/down						1.10	1.04	1.62	
	Select preset station						1.46	1.20	3.19	
	Tune radio to 90.5						1.77	1.33	7.81	
	Change CB frequency						1.34	1.16	3.76	
	Turn CB volume up/down						1.06	1.02	1.29	
	AC temp up/down						1.65	1.28	2.40	
	Fan speed higher/lower						1.35	1.16	12	

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Taoka, 1990 Road & sim, varies with study	Radio				1.44	.50				
	Speedo				0.62	.48				
	Temp. gauge				1.10	.52				
	Defroster				1.14	.61				
Tsimhoni, Smith, Green, 2001	Enter street address via touch-screen keyboard	20-30	41.4 (23.0)	15.6 (5.0)	28.8	3.2	1.4	0.3	20.6	10.7
		65-72	91.8 (42.1)	40.8 (15.0)	38.0	3.6	1.1	0.3	34.5	11.9
Wierwille, 1990 On road		25 and younger	4.32		2.63		1.00			
		26-34	4.81		2.86		0.98			
		35-49	4.86		2.80		0.99			
		50 and older	6.01		4.12		1.29			
Values from figure	Tune radio	Young	8						4.75	
		Middle	12						4.75	
		Older	15						6.25	
	Dial Number	Young	7						3.75	
		Middle	8						4.2	
		Older	10						4.5	
	Reading time	Young	4						2.5	
		Middle	6						3	
		Older	9.75						5	
	Volume	Young	3.2						1.5	
		Middle	4						1.75	
		Older	6.25						3.2	

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
Wierwille and Dingus, 1988 & Dingus, Antin, Hulse, and Wierwille, 1989 On road	Turn Signal	32 Ss, 18-73			0.30	.56	0.30	0.39	0.63	0.73
	Speed				0.78	0.65	0.62	0.48	1.26	0.40
	Following Traffic				0.98	0.60	0.75	0.36	1.31	0.57
	Time				1.04	0.56	0.83	0.38	1.26	0.46
	Vent				1.13	0.99	0.62	0.40	1.83	1.03
	Destination Direction				1.57	0.94	1.20	0.73	1.31	0.62
	Remaining Fuel				1.58	0.95	1.04	0.50	1.52	0.71
	Tone Controls				1.59	1.03	0.92	0.41	1.73	0.82
	Info. Lights				1.75	0.93	0.83	0.35	2.12	1.16
	Destination Distance				1.83	1.09	1.06	0.56	1.73	0.93
	Fan				1.95	1.29	1.10	0.48	1.78	1.00
	Balance Volume				2.23	1.50	0.86	0.35	2.59	1.18
	Sentinel				2.38	1.71	1.01	0.47	2.51	1.81
	Defrost				2.86	1.59	1.14	0.61	2.51	1.49
	Fuel Economy				2.87	1.09	1.14	0.58	2.48	0.94
	Correct Direction				2.96	1.86	1.45	0.67	2.04	1.25
	Fuel Range				3.00	1.43	1.19	1.02	2.54	0.60
	Temperature				3.50	1.73	1.10	0.52	3.18	1.66

Study comment	Device & Task	Age or Group	Total Task Time Dynamic (Static)		Total Glance Time		Mean Glance Duration(s)		Total # of Glances	
			mean	sd	mean	sd	mean	sd	mean	sd
	Play cassette tape				1.59 (1.64)	0.96 (0.59)	0.80	0.29	2.06	1.29
	Heading				3.58	2.23	1.30	0.56	2.76	1.81
	Zoom Level				4.00	2.17	1.04	0.65	2.91	1.65
	Cruise Control				4.82	3.80	0.82	0.36	5.88	2.81
	Power Mirror				5.71	2.78	0.86	0.34	6.64	2.56
	Tune Radio				7.60	3.41	1.10	0.47	6.91	2.39
	Cross Street				8.63	4.86	1.66	0.82	5.21	3.20
	Roadway Distance				8.84	5.20	1.53	0.65	5.78	2.85
	Roadway Name				10.63	5.80	1.63	0.80	6.52	3.15
Wikman, Nieminen, Summala, 1998 Road # glances estimated	Insert/ remove cassette	47 drivers, 29-44			6.3		0.91		6.92	
	Dial 8 digit # (home & random)				5.3		0.96		5.52	
	Tune to soft music						1.02			