Beyond Bouncing Back

A Roundtable on

Critical Transportation Infrastructure Resilience

April 30, 2013

U.S. Department of Transportation
Research and Innovative Technology Administration
Volpe, The National Transportation Systems Center

Volpe

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Overview

Global transportation infrastructure today is confronted with significant vulnerabilities – an aging infrastructure; a growing concentration of populations at high-density coastal urban areas; increasing interdependencies among the nation's physical and cyber infrastructures; co-location of many transportation systems with large-scale and potentially hazardous production facilities; and the escalating threats of climate change. Together, they have coalesced to create significant challenges for the nation's critical infrastructure systems.

A framework for enhancing critical transportation infrastructure resiliency could potentially serve as a roadmap for addressing some of these pressing global challenges. Recently, the concept of resiliency, however, has become a buzzword used to characterize a system that recovers rapidly from a disruption in order to resume normal functions. But resilience is not just bouncing back.

Defining resilience

Resiliency is an overarching concept characterizing a complex transportation system that is able to better withstand disruptions. The transportation system includes physical, technical, social and institutional elements that are all critical to resilience. A resiliency framework should not be viewed as a mechanism for preserving the status-quo and returning the system to pre-disaster condition. What is envisioned is a framework that enables us to strategically harness capabilities and know-how to build or rebuild a transportation system that is much less vulnerable to disruption and better than the current transportation system. A resilient transportation system has design-level robustness so that it can withstand severe blows; it is adaptable so that it can respond appropriately to threats and it can mitigate the consequences of threats through response and recovery operations. These three attributes – ***robustness***, ***adaptiveness***, **and** ***consequence mitigation*** – form the foundations of a resilient transportation system.

Robustness – Adaptiveness – Consequence Mitigation

- **Robustness:** A resilient infrastructure is *robust* because it is designed and built to be fault-tolerant, capable of resisting disruptions and absorbing unexpected shocks. It has long-term plans to prepare for disruptions and protect its critical assets. This robustness is not solely due to the addition of layers of barriers. The system incorporates design-level safeguards to enable the system to withstand future disruptions.

- **Adaptiveness:** A resilient infrastructure is *adaptable*. It anticipates future disruptions – man-made and natural – and provides redundant layers of safeguards. Its adaptability enables it to maintain critical functions in a crisis situation. An adaptable infrastructure deploys monitoring technologies for real-time situational awareness that can potentially lead to heightened preparedness. A resilient adaptive transportation system is agile enough to change course and transfer to other resources when normal operations are disrupted.

- **Consequence Mitigation:** A resilient infrastructure has *mitigation* capabilities in place to help the system resume normal operations rapidly and with minimum disruption. Critical to resiliency of the transportation system is its capability for rapid recovery as well as long-term planning resulting in a better system capable of withstanding future disruptions.

About the Colloquia Series

Volpe, The National Transportation Systems Center, is pleased to present a Colloquia Series on Transportation Challenges and Opportunities. The series, which brings together industry experts from government, academia, and the private sectors, continues Volpe's long tradition of facilitating knowledge exchange across the transportation community and takes a fresh approach in addressing today's transportation challenges and issues. The series is available via webinar and members of the transportation community are encouraged to participate in question and answer periods.

This roundtable on **Beyond Bouncing Back: Critical Transportation Infrastructure Resilience** provides a forum for national experts to articulate their vision of a robust, adaptive transportation system that is capable of consequence mitigation. The expert panel will help to inform decision makers throughout the transportation community and beyond. An agenda follows. For further information, please contact Ellen Bell, Director of Strategic Initiatives for Research and Innovation at Volpe, ellen.bell@dot.gov; 617.494.2491.

Agenda

Beyond Bouncing Back:
A Roundtable on Critical Transportation Infrastructure Resilience

Tuesday, April 30, 2013
9:00 AM – 12:30 PM

The Program		Participants
9:00 AM	**Welcome and introductions**	**Robert C. Johns**, Associate Administrator and Director, Volpe Center
9:10 AM	**Opening Remarks**	**Gregory D. Winfree**, Deputy Administrator, Research and Innovative Technology Administration, U.S. Department of Transportation
9:30 AM	**Our Fracture-Critical Transportation System**	**Thomas Fisher**, Ph.D., Dean of the University of Minnesota College of Design
10:00 AM	**Resilience in Organizations, Systems and Communities**	**Christine Pommerening**, Ph.D. Assistant Research Professor George Mason University
10:30 AM	**Break**	
10:45 AM	**A State and Local Transportation Perspective**	**Randell H. Iwasaki,** Executive Director Contra Costa Transportation Authority, California; Former Transportation Director – State of California
11:15 AM	**Preparing for the Rising Tide**	**Vivien Li,** President, The Boston Harbor Association
11:45 AM	**Moderated Discussion and Question and Answer Period**	**Michael Dinning,** Director, Center of Transportation Logistics and Security, Volpe, the National Transportation Systems Center
12:15 PM	**Closing Remarks**	**Robert C. Johns**, Associate Administrator and Director, Volpe Center
12:30 PM	**Adjourn**	

Speaker Biographies — Beyond Bouncing Back: A Roundtable on Critical Transportation Infrastructure Resilience

U.S. Department of Transportation Officials

Gregory D. Winfree, Deputy Administrator
Research and Innovative Technology Administration

On June 2, 2011, Secretary Ray LaHood appointed Greg Winfree Deputy Administrator of RITA and he was sworn in on July 15, 2011. Greg originally came to RITA on March 15, 2010 as Chief Counsel. He has served as the agency's Acting Administrator, and as chairman of the Department of Transportation's Innovation Council.

Prior to his RITA appointment, Greg served as Chief Litigation Counsel for Freeport-McMoRan Corporation, one of the world's leading producers of copper, gold, molybdenum and other industrial and precious metals. He also served as Wyeth Pharmaceuticals' Director of Litigation and Union Carbide Corporation's Senior Litigation Counsel. Before embarking on an in-house career pathway, Greg served as a Trial Attorney in the Housing and Civil Enforcement Section of the United States Department of Justice Civil Rights Division which he joined after a stint at a prominent Washington, D.C., law firm.

Throughout his corporate career Greg has been affiliated with organizations with a strong focus in the STEM disciplines. Moreover, Greg is a holder of design and utility patents for innovations he developed. He earned a B.S. degree in Communications/Public Relations from St. John's University and a J.D. from Georgetown University where he served as a Lead Articles Editor for *The Tax Lawyer*, the A.B.A. journal of taxation.

Robert C. Johns, Director
Volpe National Transportation Systems Center
Research and Innovative Technology Administration

Robert C. Johns was named Director of the U.S. DOT's John A. Volpe National Transportation Systems Center in September 2009. The Volpe Center is a unique, fee-for-service, federal resource for developing and facilitating innovations in the nation's transportation system, with multidisciplinary expertise in all modes of transportation. The Center has about 570 federal employees, 420 on-site contractor employees, and 450 on-going projects, and annually obligates about $250 million.

Johns previously was Director of the Center for Transportation Studies at the University of Minnesota from 2001 to 2009, after serving as deputy director and associate director. Before joining the University in 1988, he held research and management positions with the Santa Fe Railway, the Minnesota Department of Transportation, and the Metropolitan Council of the Twin Cities. He is active in the Transportation Research Board (TRB) of the National Academies and from 2008 to 2011 served as chair of the Technical Activities Council, which oversees TRB's 200 technical committees. He earned a B.S. degree in Engineering Operations from Iowa State University and M.B.A. and M.A. degrees from the University of Iowa.

Michael G. Dinning, Director
Center for Transportation Logistics and Security
Volpe National Transportation Systems Center
Research and Innovative Technology Administration

Michael Dinning is Director of Transportation Logistics and Security at the U.S. Department of Transportation's Volpe National Transportation Systems Center. Mr. Dinning directs a wide variety of programs to improve transportation security and resilience, deploy innovative technologies and security systems, coordinate transportation emergency management and integrate global maritime and logistics information. His organization has led efforts to promote cyber security in all modes of transportation.

Mr. Dinning is a frequent speaker to industry, academia, and government agencies on cyber security, transportation emergency management and innovative technologies in transportation. He is coauthor of the book, *Smart Cards: Seizing Strategic Business Opportunities*. Mr. Dinning has been recognized by the Department of Transportation for his work in deploying advanced technology for public transit systems, and developing information technology for logistics management systems.

Mr. Dinning teaches a graduate level course in Transportation Security Management for the Massachusetts Maritime Academy.

Mr. Dinning received his bachelors and masters degrees from Northwestern University

The Expert Panel

Thomas Fisher, Professor in the School of Architecture and
Dean of the College of Design at the University of Minnesota

Thomas Fisher is a professor and dean of the College of Design at the University of Minnesota. Educated at Cornell University in architecture and Case Western Reserve University in intellectual history, he previously served as the regional preservation officer at the Western Reserve Historical Society in Cleveland, the historical architect of the Connecticut State Historical Commission in Hartford, and the editorial director of Progressive Architecture magazine in Stamford, CT.

He has lectured or juried at over 40 different schools of architecture and 60 professional societies, and has published 35 book chapters and over 250 articles in various magazines and journals. He has published five books over the last eight years: two with the University of Minnesota Press entitled, *In the Scheme of Things, Alternative Thinking on the Practice of Architecture* and *Salmela Architect*, one by Rockport Press *Lake/Flato Buildings and Landscapes,* and one by the Architectural Press *Architectural Design and Ethics*, *Tools for Survival.* He also co-edited a book with Wolfgang Preiser and Jack Nasar on the design of architecture school buildings, published by Fairchild Books, entitled *Designing for Designers*, and has recently completed a manuscript of case studies, *Ethics for Architects,* to be published by the Princeton Architectural Press in 2010.

Christine Pommerening, Research Assistant Professor at George Mason University's School of Public Policy

Christine Pommerening is an Assistant Research Professor at the George Mason University School of Public Policy with over 15 years experience in academic research and project management on the governance of large technical systems, especially in the information, communications, and transportation sectors, as well as infrastructure security and risk management.

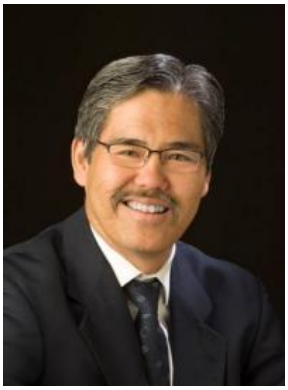
She is currently directing the development and implementation of an executive education program on principles of enterprise-wide risk management under a cooperative agreement with the Federal Emergency Management Agency. Before that, she was the program manager for a study on historical, legal, economic, and societal aspects of universal postal service, conducted on behalf of the Postal Regulatory Commission that was submitted to Congress in December 2008.

From 2004 until 2008, she was a Senior Research Associate at the Center for Infrastructure Protection and Homeland Security at the George Mason University School of Law, focusing on public and private sector approaches to infrastructure security, and institutional responses to low-probability/high-consequence events such as natural disasters and terrorist attacks.

As an instructor, she teaches graduate and executive courses in public policy and public administration.

Christine Pommerening holds a Ph.D. in Public Policy from George Mason University, and an M.A. in Sociology from Ruhr-Universität Bochum in Germany.

Randell H. Iwasaki
Executive Director, Contra Costa Transportation Authority



Randell "Randy" Iwasaki is the Executive Director of the Contra Costa Transportation Authority (CCTA). He was appointed by the CCTA Board on April 16, 2010. CCTA administers a one-half percent sales tax program. The 1988 "Measure C" program consists of $1.1 billion in projects and programs; the 2004 "Measure J" program totals $2 billion and will run from 2009 through 2034. The Authority is also the Congestion Management Agency, making recommendations on how state and federal transportation funds will be used in Contra Costa; and serves as manager for the Transportation Funds for Clean Air Program.

Prior to his appointment as Executive Director, Iwasaki was appointed by Governor Schwarzenegger in August 2009 as Director of the California Department of Transportation. He was in charge of the operation of the California state transportation system, including more than 50,000 lane miles of state highway, intercity passenger rail, state support for local mass transportation systems, 12,400 bridges and more than 250 general aviation airports. He oversaw an annual budget of almost $14 billion and a staff of more than 22,000 maintenance, planning, right of way, environmental, administrative, and engineering personnel. A licensed civil engineer, Iwasaki had been with Caltrans for more than 26 years serving in a number of high profile engineering and management positions. From November 2004 to August 2009, Iwasaki was appointed as the Department's Chief Deputy Director.

Iwasaki also serves on a number of national transportation panels. The panels include chairing the Technology Coordinating Committee Chair for the renewal portion of the Strategic Highway Research

Program and AASHTO's Special Committee on Transportation Security and Emergency Management. He is the past Chairman of ITS America.

In 2009, he was named to Government Technology's list of 25 "Doers, Dreamers and Drivers," and in 2008 was the recipient of the Thomas H. McDonald Memorial Award, which is considered the highest award presented by the American Association of State Highway and Transportation Officials for "rendering continuous outstanding service over an extended period of time or have made some exceptional contribution to the art and science of highway engineering." Iwasaki earned his bachelor's degree in Engineering from California Polytechnic State University, San Luis Obispo, and a Master's in Engineering from California State University, Fresno.

Vivien Li, President
The Boston Harbor Association

Vivien Li is President of The Boston Harbor Association (TBHA), a non-profit public interest organization founded in 1973 by the League of Women Voters and the Boston Shipping Association to promote a clean, alive, and accessible Boston Harbor. TBHA successfully advocated for the clean-up of Boston Harbor, which is now swimmable more than 90% of the time; actively works to ensure completion of the 47-mile HarborWalk public access network through the six waterfront neighborhoods of Boston; and promotes an environmentally sustainable Working Port.

In 2010, The Boston Harbor Association convened the first-ever “Boston Harbor Sea Level Rise Forum” attended by more than 450 participants. Released in February, 2013 at a press conference with Boston Mayor Thomas Menino, TBHA’s “Preparing for the Rising Tide” report is helping to support the City of Boston and neighboring communities’ efforts to prepare for rising sea levels and coastal flooding.

Vivien is a graduate of Barnard College and Princeton University. She chairs MassDevelopment’s Brownfields Advisory Group, co-chairs the Advisory Council to the Woodrow Wilson School of Public and International Affairs at Princeton University, is an overseer of Beth Israel Deaconess Medical Center, a trustee of Eastern Bank Corporation, and a member of the Boston Conservation Commission. She and her family live in Boston.

The White House
Office of the Press Secretary
For Immediate Release: February 12, 2013

Presidential Policy Directive/PPD-21:
Critical Infrastructure Security and Resilience

The Presidential Policy Directive (PPD) on Critical Infrastructure Security and Resilience advances a national unity of effort to strengthen and maintain secure, functioning, and resilient critical infrastructure.

Introduction

The Nation's critical infrastructure provides the essential services that underpin American society. Proactive and coordinated efforts are necessary to strengthen and maintain secure, functioning, and resilient critical infrastructure – including assets, networks, and systems – that are vital to public confidence and the Nation's safety, prosperity, and well-being.

The Nation's critical infrastructure is diverse and complex. It includes distributed networks, varied organizational structures and operating models (including multinational ownership), interdependent functions and systems in both the physical space and cyberspace, and governance constructs that involve multi-level authorities, responsibilities, and regulations. Critical infrastructure owners and operators are uniquely positioned to manage risks to their individual operations and assets, and to determine effective strategies to make them more secure and resilient.

Critical infrastructure must be secure and able to withstand and rapidly recover from all hazards. Achieving this will require integration with the national preparedness system across prevention, protection, mitigation, response, and recovery.

This directive establishes national policy on critical infrastructure security and resilience. This endeavor is a shared responsibility among the Federal, state, local, tribal, and territorial (SLTT) entities, and public and private owners and operators of critical infrastructure (herein referred to as "critical infrastructure owners and operators"). This directive also refines and clarifies the critical infrastructure-related functions, roles, and responsibilities across the Federal Government, as well as enhances overall coordination and collaboration. The Federal Government also has a responsibility to strengthen the security and resilience of its own critical infrastructure, for the continuity of

national essential functions, and to organize itself to partner effectively with and add value to the security and resilience efforts of critical infrastructure owners and operators.

Policy

It is the policy of the United States to strengthen the security and resilience of its critical infrastructure against both physical and cyber threats. The Federal Government shall work with critical infrastructure owners and operators and SLTT entities to take proactive steps to manage risk and strengthen the security and resilience of the Nation's critical infrastructure, considering all hazards that could have a debilitating impact on national security, economic stability, public health and safety, or any combination thereof. These efforts shall seek to reduce vulnerabilities, minimize consequences, identify and disrupt threats, and hasten response and recovery efforts related to critical infrastructure.

The Federal Government shall also engage with international partners to strengthen the security and resilience of domestic critical infrastructure and critical infrastructure located outside of the United States on which the Nation depends.

U.S. efforts shall address the security and resilience of critical infrastructure in an integrated, holistic manner to reflect this infrastructure's interconnectedness and interdependency. This directive also identifies energy and communications systems as uniquely critical due to the enabling functions they provide across all critical infrastructure sectors.

Three strategic imperatives shall drive the Federal approach to strengthen critical infrastructure security and resilience:

1) Refine and clarify functional relationships across the Federal Government to advance the national unity of effort to strengthen critical infrastructure security and resilience;

2) Enable effective information exchange by identifying baseline data and systems requirements for the Federal Government; and

3) Implement an integration and analysis function to inform planning and operations decisions regarding critical infrastructure.

All Federal department and agency heads are responsible for the identification, prioritization, assessment, remediation, and security of their respective internal critical infrastructure that supports primary mission essential functions. Such infrastructure shall be addressed in the plans and execution of the requirements in the National Continuity Policy.

Federal departments and agencies shall implement this directive in a manner consistent with applicable law, Presidential directives, and Federal regulations, including those protecting privacy, civil rights, and civil liberties. In addition, Federal departments and agencies shall protect all information associated with carrying out this directive consistent with applicable legal authorities and policies.

Roles and Responsibilities

Effective implementation of this directive requires a national unity of effort pursuant to strategic guidance from the Secretary of Homeland Security. That national effort must include expertise and day-to-day engagement from the Sector-Specific Agencies (SSAs) as well as the specialized or support capabilities from other Federal departments and agencies, and strong collaboration with critical infrastructure owners and operators and SLTT

entities. Although the roles and responsibilities identified in this directive are directed at Federal departments and agencies, effective partnerships with critical infrastructure owners and operators and SLTT entities are imperative to strengthen the security and resilience of the Nation's critical infrastructure.

Secretary of Homeland Security

The Secretary of Homeland Security shall provide strategic guidance, promote a national unity of effort, and coordinate the overall Federal effort to promote the security and resilience of the Nation's critical infrastructure. In carrying out the responsibilities assigned in the Homeland Security Act of 2002, as amended, the Secretary of Homeland Security evaluates national capabilities, opportunities, and challenges in protecting critical infrastructure; analyzes threats to, vulnerabilities of, and potential consequences from all hazards on critical infrastructure; identifies security and resilience functions that are necessary for effective public-private engagement with all critical infrastructure sectors; develops a national plan and metrics, in coordination with SSAs and other critical infrastructure partners; integrates and coordinates Federal cross-sector security and resilience activities; identifies and analyzes key interdependencies among critical infrastructure sectors; and reports on the effectiveness of national efforts to strengthen the Nation's security and resilience posture for critical infrastructure.

Additional roles and responsibilities for the Secretary of Homeland Security include:

1) Identify and prioritize critical infrastructure, considering physical and cyber threats, vulnerabilities, and consequences, in coordination with SSAs and other Federal departments and agencies;

2) Maintain national critical infrastructure centers that shall provide a situational awareness capability that includes integrated, actionable information about emerging trends, imminent threats, and the status of incidents that may impact critical infrastructure;

3) In coordination with SSAs and other Federal departments and agencies, provide analysis, expertise, and other technical assistance to critical infrastructure owners and operators and facilitate access to and exchange of information and intelligence necessary to strengthen the security and resilience of critical infrastructure;

4) Conduct comprehensive assessments of the vulnerabilities of the Nation's critical infrastructure in coordination with the SSAs and in collaboration with SLTT entities and critical infrastructure owners and operators;

5) Coordinate Federal Government responses to significant cyber or physical incidents affecting critical infrastructure consistent with statutory authorities;

6) Support the Attorney General and law enforcement agencies with their responsibilities to investigate and prosecute threats to and attacks against critical infrastructure;

7) Coordinate with and utilize the expertise of SSAs and other appropriate Federal departments and agencies to map geospatially, image, analyze, and sort critical infrastructure by employing commercial satellite and airborne systems, as well as existing capabilities within other departments and agencies; and

8) Report annually on the status of national critical infrastructure efforts as required by statute.

Sector-Specific Agencies

Each critical infrastructure sector has unique characteristics, operating models, and risk profiles that benefit from an identified Sector-Specific Agency that has institutional knowledge and specialized expertise about the sector. Recognizing existing statutory or regulatory authorities of specific Federal departments and agencies, and

leveraging existing sector familiarity and relationships, SSAs shall carry out the following roles and responsibilities for their respective sectors:

1) As part of the broader national effort to strengthen the security and resilience of critical infrastructure, coordinate with the Department of Homeland Security (DHS) and other relevant Federal departments and agencies and collaborate with critical infrastructure owners and operators, where appropriate with independent regulatory agencies, and with SLTT entities, as appropriate, to implement this directive;

2) Serve as a day-to-day Federal interface for the dynamic prioritization and coordination of sector-specific activities;

3) Carry out incident management responsibilities consistent with statutory authority and other appropriate policies, directives, or regulations;

4) Provide, support, or facilitate technical assistance and consultations for that sector to identify vulnerabilities and help mitigate incidents, as appropriate; and

5) Support the Secretary of Homeland Security's statutorily required reporting requirements by providing on an annual basis sector-specific critical infrastructure information.

Additional Federal Responsibilities

The following departments and agencies have specialized or support functions related to critical infrastructure security and resilience that shall be carried out by, or along with, other Federal departments and agencies and independent regulatory agencies, as appropriate.

1) The Department of State, in coordination with DHS, SSAs, and other Federal departments and agencies, shall engage foreign governments and international organizations to strengthen the security and resilience of critical infrastructure located outside the United States and to facilitate the overall exchange of best practices and lessons learned for promoting the security and resilience of critical infrastructure on which the Nation depends.

2) The Department of Justice (DOJ), including the Federal Bureau of Investigation (FBI), shall lead counterterrorism and counterintelligence investigations and related law enforcement activities across the critical infrastructure sectors. DOJ shall investigate, disrupt, prosecute, and otherwise reduce foreign intelligence, terrorist, and other threats to, and actual or attempted attacks on, or sabotage of, the Nation's critical infrastructure. The FBI also conducts domestic collection, analysis, and dissemination of cyber threat information, and shall be responsible for the operation of the National Cyber Investigative Joint Task Force (NCIJTF). The NCIJTF serves as a multi-agency national focal point for coordinating, integrating, and sharing pertinent information related to cyber threat investigations, with representation from DHS, the Intelligence Community (IC), the Department of Defense (DOD), and other agencies as appropriate. The Attorney General and the Secretary of Homeland Security shall collaborate to carry out their respective critical infrastructure missions.

3) The Department of the Interior, in collaboration with the SSA for the Government Facilities Sector, shall identify, prioritize, and coordinate the security and resilience efforts for national monuments and icons and incorporate measures to reduce risk to these critical assets, while also promoting their use and enjoyment.

4) The Department of Commerce (DOC), in collaboration with DHS and other relevant Federal departments and agencies, shall engage private sector, research, academic, and government organizations to improve security for technology and tools related to cyber-based systems, and promote the development of other efforts related to

critical infrastructure to enable the timely availability of industrial products, materials, and services to meet homeland security requirements.

5) The IC, led by the Director of National Intelligence (DNI), shall use applicable authorities and coordination mechanisms to provide, as appropriate, intelligence assessments regarding threats to critical infrastructure and coordinate on intelligence and other sensitive or proprietary information related to critical infrastructure. In addition, information security policies, directives, standards, and guidelines for safeguarding national security systems shall be overseen as directed by the President, applicable law, and in accordance with that direction, carried out under the authority of the heads of agencies that operate or exercise authority over such national security systems.

6) The General Services Administration, in consultation with DOD, DHS, and other departments and agencies as appropriate, shall provide or support government-wide contracts for critical infrastructure systems and ensure that such contracts include audit rights for the security and resilience of critical infrastructure.

7) The Nuclear Regulatory Commission (NRC) is to oversee its licensees' protection of commercial nuclear power reactors and non-power nuclear reactors used for research, testing, and training; nuclear materials in medical, industrial, and academic settings, and facilities that fabricate nuclear fuel; and the transportation, storage, and disposal of nuclear materials and waste. The NRC is to collaborate, to the extent possible, with DHS, DOJ, the Department of Energy, the Environmental Protection Agency, and other Federal departments and agencies, as appropriate, on strengthening critical infrastructure security and resilience.

8) The Federal Communications Commission, to the extent permitted by law, is to exercise its authority and expertise to partner with DHS and the Department of State, as well as other Federal departments and agencies and SSAs as appropriate, on: (1) identifying and prioritizing communications infrastructure; (2) identifying communications sector vulnerabilities and working with industry and other stakeholders to address those vulnerabilities; and (3) working with stakeholders, including industry, and engaging foreign governments and international organizations to increase the security and resilience of critical infrastructure within the communications sector and facilitating the development and implementation of best practices promoting the security and resilience of critical communications infrastructure on which the Nation depends.

9) Federal departments and agencies shall provide timely information to the Secretary of Homeland Security and the national critical infrastructure centers necessary to support cross-sector analysis and inform the situational awareness capability for critical infrastructure.

Three Strategic Imperatives

1) Refine and Clarify Functional Relationships across the Federal Government to Advance the National Unity of Effort to Strengthen Critical Infrastructure Security and Resilience

An effective national effort to strengthen critical infrastructure security and resilience must be guided by a national plan that identifies roles and responsibilities and is informed by the expertise, experience, capabilities, and responsibilities of the SSAs, other Federal departments and agencies with critical infrastructure roles, SLTT entities, and critical infrastructure owners and operators.

During the past decade, new programs and initiatives have been established to address specific infrastructure issues, and priorities have shifted and expanded. As a result, Federal functions related to critical infrastructure security and resilience shall be clarified and refined to establish baseline capabilities that will reflect this evolution of knowledge, to define relevant Federal program functions, and to facilitate collaboration and information

exchange between and among the Federal Government, critical infrastructure owners and operators, and SLTT entities.

As part of this refined structure, there shall be two national critical infrastructure centers operated by DHS – one for physical infrastructure and another for cyber infrastructure. They shall function in an integrated manner and serve as focal points for critical infrastructure partners to obtain situational awareness and integrated, actionable information to protect the physical and cyber aspects of critical infrastructure. Just as the physical and cyber elements of critical infrastructure are inextricably linked, so are the vulnerabilities. Accordingly, an integration and analysis function (further developed in Strategic Imperative 3) shall be implemented between these two national centers.

The success of these national centers, including the integration and analysis function, is dependent on the quality and timeliness of the information and intelligence they receive from the SSAs and other Federal departments and agencies, as well as from critical infrastructure owners and operators and SLTT entities.

These national centers shall not impede the ability of the heads of Federal departments and agencies to carry out or perform their responsibilities for national defense, criminal, counterintelligence, counterterrorism, or investigative activities.

2) Enable Efficient Information Exchange by Identifying Baseline Data and Systems Requirements for the Federal Government

A secure, functioning, and resilient critical infrastructure requires the efficient exchange of information, including intelligence, between all levels of governments and critical infrastructure owners and operators. This must facilitate the timely exchange of threat and vulnerability information as well as information that allows for the development of a situational awareness capability during incidents. The goal is to enable efficient information exchange through the identification of requirements for data and information formats and accessibility, system interoperability, and redundant systems and alternate capabilities should there be a disruption in the primary systems.

Greater information sharing within the government and with the private sector can and must be done while respecting privacy and civil liberties. Federal departments and agencies shall ensure that all existing privacy principles, policies, and procedures are implemented consistent with applicable law and policy and shall include senior agency officials for privacy in their efforts to govern and oversee information sharing properly.

3) Implement an Integration and Analysis Function to Inform Planning and Operational Decisions Regarding Critical Infrastructure

The third strategic imperative builds on the first two and calls for the implementation of an integration and analysis function for critical infrastructure that includes operational and strategic analysis on incidents, threats, and emerging risks. It shall reside at the intersection of the two national centers as identified in Strategic Imperative 1, and it shall include the capability to collate, assess, and integrate vulnerability and consequence information with threat streams and hazard information to:

a. Aid in prioritizing assets and managing risks to critical infrastructure;

b. Anticipate interdependencies and cascading impacts;

c. Recommend security and resilience measures for critical infrastructure prior to, during, and after an event or incident; and

d. Support incident management and restoration efforts related to critical infrastructure.

This function shall not replicate the analysis function of the IC or the National Counterterrorism Center, nor shall it involve intelligence collection activities. The IC, DOD, DOJ, DHS, and other Federal departments and agencies with relevant intelligence or information shall, however, inform this integration and analysis capability regarding the Nation's critical infrastructure by providing relevant, timely, and appropriate information to the national centers. This function shall also use information and intelligence provided by other critical infrastructure partners, including SLTT and nongovernmental analytic entities.

Finally, this integration and analysis function shall support DHS's ability to maintain and share, as a common Federal service, a near real-time situational awareness capability for critical infrastructure that includes actionable information about imminent threats, significant trends, and awareness of incidents that may affect critical infrastructure.

Innovation and Research and Development

The Secretary of Homeland Security, in coordination with the Office of Science and Technology Policy (OSTP), the SSAs, DOC, and other Federal departments and agencies, shall provide input to align those Federal and Federally-funded research and development (R&D) activities that seek to strengthen the security and resilience of the Nation's critical infrastructure, including:

1) Promoting R&D to enable the secure and resilient design and construction of critical infrastructure and more secure accompanying cyber technology;

2) Enhancing modeling capabilities to determine potential impacts on critical infrastructure of an incident or threat scenario, as well as cascading effects on other sectors;

3) Facilitating initiatives to incentivize cybersecurity investments and the adoption of critical infrastructure design features that strengthen all-hazards security and resilience; and

4) Prioritizing efforts to support the strategic guidance issued by the Secretary of Homeland Security.

Implementation of the Directive

The Secretary of Homeland Security shall take the following actions as part of the implementation of this directive.

1) Critical Infrastructure Security and Resilience Functional Relationships. Within 120 days of the date of this directive, the Secretary of Homeland Security shall develop a description of the functional relationships within DHS and across the Federal Government related to critical infrastructure security and resilience. It should include the roles and functions of the two national critical infrastructure centers and a discussion of the analysis and integration function. When complete, it should serve as a roadmap for critical infrastructure owners and operators and SLTT entities to navigate the Federal Government's functions and primary points of contact assigned to those functions for critical infrastructure security and resilience against both physical and cyber threats. The Secretary shall coordinate this effort with the SSAs and other relevant Federal departments and agencies. The Secretary shall provide the description to the President through the Assistant to the President for Homeland Security and Counterterrorism.

2) Evaluation of the Existing Public-Private Partnership Model. Within 150 days of the date of this directive, the Secretary of Homeland Security, in coordination with the SSAs, other relevant Federal departments and agencies, SLTT entities, and critical infrastructure owners and operators, shall conduct an analysis of the existing public-

private partnership model and recommend options for improving the effectiveness of the partnership in both the physical and cyber space. The evaluation shall consider options to streamline processes for collaboration and exchange of information and to minimize duplication of effort. Furthermore, the analysis shall consider how the model can be flexible and adaptable to meet the unique needs of individual sectors while providing a focused, disciplined, and effective approach for the Federal Government to coordinate with the critical infrastructure owners and operators and with SLTT governments. The evaluation shall result in recommendations to enhance partnerships to be approved for implementation through the processes established in the Organization of the National Security Council System directive.

3) Identification of Baseline Data and Systems Requirements for the Federal Government to Enable Efficient Information Exchange. Within 180 days of the date of this directive, the Secretary of Homeland Security, in coordination with the SSAs and other Federal departments and agencies, shall convene a team of experts to identify baseline data and systems requirements to enable the efficient exchange of information and intelligence relevant to strengthening the security and resilience of critical infrastructure. The experts should include representatives from those entities that routinely possess information important to critical infrastructure security and resilience; those that determine and manage information technology systems used to exchange information; and those responsible for the security of information being exchanged. Interoperability with critical infrastructure partners; identification of key data and the information requirements of key Federal, SLTT, and private sector entities; availability, accessibility, and formats of data; the ability to exchange various classifications of information; and the security of those systems to be used; and appropriate protections for individual privacy and civil liberties should be included in the analysis. The analysis should result in baseline requirements for sharing of data and interoperability of systems to enable the timely exchange of data and information to secure critical infrastructure and make it more resilient. The Secretary shall provide that analysis to the President through the Assistant to the President for Homeland Security and Counterterrorism.

4) Development of a Situational Awareness Capability for Critical Infrastructure. Within 240 days of the date of this directive, the Secretary of Homeland Security shall demonstrate a near real-time situational awareness capability for critical infrastructure that includes threat streams and all-hazards information as well as vulnerabilities; provides the status of critical infrastructure and potential cascading effects; supports decision making; and disseminates critical information that may be needed to save or sustain lives, mitigate damage, or reduce further degradation of a critical infrastructure capability throughout an incident. This capability should be available for and cover physical and cyber elements of critical infrastructure, and enable an integration of information as necessitated by the incident.

5) Update to National Infrastructure Protection Plan. Within 240 days of the date of this directive, the Secretary of Homeland Security shall provide to the President, through the Assistant to the President for Homeland Security and Counterterrorism, a successor to the National Infrastructure Protection Plan to address the implementation of this directive, the requirements of Title II of the Homeland Security Act of 2002 as amended, and alignment with the National Preparedness Goal and System required by PPD-8. The plan shall include the identification of a risk management framework to be used to strengthen the security and resilience of critical infrastructure; the methods to be used to prioritize critical infrastructure; the protocols to be used to synchronize communication and actions within the Federal Government; and a metrics and analysis process to be used to measure the Nation's ability to manage and reduce risks to critical infrastructure. The updated plan shall also reflect the identified functional relationships within DHS and across the Federal Government and the updates to the public-private partnership model. Finally, the plan should consider sector dependencies on energy and communications systems, and identify pre-event and mitigation measures or alternate capabilities during disruptions to those systems. The Secretary shall coordinate this effort with the SSAs, other relevant Federal departments and agencies, SLTT entities, and critical infrastructure owners and operators.

6) National Critical Infrastructure Security and Resilience R&D Plan. Within 2 years of the date of this directive, the Secretary of Homeland Security, in coordination with the OSTP, the SSAs, DOC, and other Federal departments and

agencies, shall provide to the President, through the Assistant to the President for Homeland Security and Counterterrorism, a National Critical Infrastructure Security and Resilience R&D Plan that takes into account the evolving threat landscape, annual metrics, and other relevant information to identify priorities and guide R&D requirements and investments. The plan should be issued every 4 years after its initial delivery, with interim updates as needed.

Policy coordination, dispute resolution, and periodic in-progress reviews for the implementation of this directive shall be carried out consistent with PPD-1, including the use of Interagency Policy Committees coordinated by the National Security Staff.

Nothing in this directive alters, supersedes, or impedes the authorities of Federal departments and agencies, including independent regulatory agencies, to carry out their functions and duties consistent with applicable legal authorities and other Presidential guidance and directives, including, but not limited to, the designation of critical infrastructure under such authorities.

This directive revokes Homeland Security Presidential Directive/HSPD-7, Critical Infrastructure Identification, Prioritization, and Protection, issued December 17, 2003. Plans developed pursuant to HSPD-7 shall remain in effect until specifically revoked or superseded.

Designated Critical Infrastructure Sectors and Sector-Specific Agencies

This directive identifies 16 critical infrastructure sectors and designates associated Federal SSAs. In some cases co-SSAs are designated where those departments share the roles and responsibilities of the SSA. The Secretary of Homeland Security shall periodically evaluate the need for and approve changes to critical infrastructure sectors and shall consult with the Assistant to the President for Homeland Security and Counterterrorism before changing a critical infrastructure sector or a designated SSA for that sector. The sectors and SSAs are as follows:

Chemical:
Sector-Specific Agency: Department of Homeland Security

Commercial Facilities:
Sector-Specific Agency: Department of Homeland Security

Communications:
Sector-Specific Agency: Department of Homeland Security

Critical Manufacturing:
Sector-Specific Agency: Department of Homeland Security

Dams:
Sector-Specific Agency: Department of Homeland Security

Defense Industrial Base:
Sector-Specific Agency: Department of Defense

Emergency Services:
Sector-Specific Agency: Department of Homeland Security

Energy:
Sector-Specific Agency: Department of Energy

Financial Services:
Sector-Specific Agency: Department of the Treasury

Food and Agriculture:
Co-Sector-Specific Agencies: U.S. Department of Agriculture and Department of Health and Human Services

Government Facilities:
Co-Sector-Specific Agencies: Department of Homeland Security and General Services Administration

Healthcare and Public Health:
Sector-Specific Agency: Department of Health and Human Services

Information Technology:
Sector-Specific Agency: Department of Homeland Security

Nuclear Reactors, Materials, and Waste:
Sector-Specific Agency: Department of Homeland Security

Transportation Systems:
Co-Sector-Specific Agencies: Department of Homeland Security and Department of Transportation

Water and Wastewater Systems:
Sector-Specific Agency: Environmental Protection Agency

Definitions

For purposes of this directive:

The term "all hazards" means a threat or an incident, natural or manmade, that warrants action to protect life, property, the environment, and public health or safety, and to minimize disruptions of government, social, or economic activities. It includes natural disasters, cyber incidents, industrial accidents, pandemics, acts of terrorism, sabotage, and destructive criminal activity targeting critical infrastructure.

The term "collaboration" means the process of working together to achieve shared goals.

The terms "coordinate" and "in coordination with" mean a consensus decision-making process in which the named coordinating department or agency is responsible for working with the affected departments and agencies to achieve consensus and a consistent course of action.

The term "critical infrastructure" has the meaning provided in section 1016(e) of the USA Patriot Act of 2001 (42 U.S.C. 5195c(e)), namely systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters.

The term "Federal departments and agencies" means any authority of the United States that is an "agency" under 44 U.S.C. 3502(1), other than those considered to be independent regulatory agencies, as defined in 44 U.S.C. 3502(5).

The term "national essential functions" means that subset of Government functions that are necessary to lead and sustain the Nation during a catastrophic emergency.

The term "primary mission essential functions" means those Government functions that must be performed in order to support or implement the performance of the national essential functions before, during, and in the aftermath of an emergency.

The term "national security systems" has the meaning given to it in the Federal Information Security Management Act of 2002 (44 U.S.C. 3542(b)).

The term "resilience" means the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents.

The term "Sector-Specific Agency" (SSA) means the Federal department or agency designated under this directive to be responsible for providing institutional knowledge and specialized expertise as well as leading, facilitating, or supporting the security and resilience programs and associated activities of its designated critical infrastructure sector in the all-hazards environment.

The terms "secure" and "security" refer to reducing the risk to critical infrastructure by physical means or defense cyber measures to intrusions, attacks, or the effects of natural or manmade disasters.

Summary:
National Climate Assessment Draft Report

Background: In January 2013, the National Climate Change Assessment and Development Advisory Committee (NCADAC) issued a draft copy of the 60-member committee report on Climate Change. The Committee was established under the auspices of the Department of Commerce in December 2010, with support from the National Oceanic and Atmospheric Administration (NOAA). Fifteen Federal agencies were represented on the committee. The U.S. Department of Transportation was represented by Arthur Rypinski, Office of the Secretary. *Link to draft report here*: http://ncadac.globalchange.gov/ This summary document has been prepared by Bahar Barami, Ph.D., Center of Transportation Logistics and Security, U.S. DOT, Volpe Center.

Key Findings and Recommendations

- **Global climate is changing.**

This is apparent across the U.S. in a wide range of observations. The climate change of the past 50 years is due primarily to human activities, predominantly the burning of fossil fuels. U.S. average temperature has increased by about 1.5°F since 1895, with more than 80% of this increase occurring since 1980.

Some extreme weather and climate events have increased in recent decades, and there is new and stronger evidence that many of these increases are related to human activities.

Human-induced climate change is projected to continue and accelerate significantly if emissions of heat-trapping gases continue to increase.

Impacts related to climate change are already evident in many sectors and are expected to become increasingly challenging across the nation throughout this century and beyond.

Climate change threatens human health and well-being in many ways, including impacts from increased extreme weather events, wildfire, decreased air quality, diseases transmitted by insects, food, and water, and threats to mental health.

- **Infrastructure across the U.S. is being adversely affected by phenomena associated with climate change, including sea level rise, storm surge, heavy downpours, and extreme heat.**

Reliability of water supplies is being reduced by climate change in a variety of ways that affect ecosystems and livelihoods in many regions, particularly the Southwest, the Great Plains, the Southeast, and the islands of the Caribbean and the Pacific, including the state of Hawaii.

Adverse impacts to crops and livestock over the next 100 years are expected. Over the next 25 years or so, the agriculture sector is projected to be relatively resilient, even though there will be increasing

disruptions from extreme heat, drought, and heavy downpours. U.S. food security and farm incomes will also depend on how agricultural systems adapt to climate changes in other regions of the world.

- **Natural ecosystems are being directly affected by climate change, including changes in biodiversity and location of species.**

The capacity of ecosystems to moderate the consequences of disturbances such as droughts, floods, and severe storms is being diminished. Life in the oceans is changing as ocean waters become warmer and more acidic.

- **Planning for adaptation -- to address and prepare for impacts -- and mitigation (to reduce emissions) is increasing, but progress with implementation is limited.**

In recent years, climate adaptation and mitigation activities have begun to emerge in many sectors and at all levels of government; however barriers to implementation of these activities are significant.

The level of current efforts is insufficient to avoid increasingly serious impacts of climate change that have large social, environmental, and economic consequences.

Well-planned and implemented actions to limit emissions and increase resilience to impacts that are unavoidable can improve public health, economic development opportunities, natural system protection, and overall quality of life.

Transportation Sector Findings

- **Greenhouse Gas (GHG) Emissions and Temperature Variations**

Transportation systems influence future climate characteristics and are also affected by changes in the climate. In 2010, the U.S. transportation sector accounted for 27% of U.S. greenhouse gas emissions (GHG) (EPA 2011). Petroleum accounts for 93% of the nation's transportation energy use (EIA 2011), while cars and trucks account for 65% of transportation emissions (EPA 2011).

Transportation systems are already experiencing costly climate change related impacts. Many inland states – for example, Vermont, Tennessee, Iowa, and Missouri – have experienced severe precipitation events and flooding during the past three years, damaging roads, bridges, and rail systems. Over the coming decades, all modes and regions will be affected by increasing temperatures, more extreme weather events, and changes in precipitation. Concentrated transportation impacts are likely in Alaska and along seacoasts.

- **Infrastructure Condition**

Transportation systems require expensive and long-lived (typically 50 to 100 years) infrastructure. The estimated value of U.S. transportation facilities in 2010 was $4.1 trillion (U.S. Bureau of Economic Analysis 2011). As climatic conditions shift, portions of this infrastructure will increasingly be subject to climatic stresses that will reduce the reliability and capacity of transportation systems (NRC 2008).

Transportation systems are also vulnerable to interruptions in fuel and electricity supply, as well as communications disruptions – which are also subject to climatic stresses (NRC 2008). Power outages resulting from Hurricane Katrina shut down three major petroleum pipelines for two days, and the systems operated at reduced capacities for two weeks (Wilbanks et al. 2012).

- **Direct and Indirect Transportation Impacts**

Climate change will affect transportation systems directly, through infrastructure damage, and indirectly, through changes in trade flows, agriculture, energy use, and settlement patterns. If, for instance, corn cultivation shifts northward in response to rising temperatures, U.S. agricultural products may flow to markets from different origins by different routes (Vedenov et al. 2011). If policy measures and technological changes reduce greenhouse gas emissions by affecting fuel types, there will likely be significant impacts on the transportation of energy supplies (pipelines, coal trains, and so on) and on the cost of transportation to freight and passenger users (CCSP 2008).

Disruptions to transportation system capacity and reliability can be partially offset by adaptations. Transportation systems *as networks* may use alternative routes around damaged elements or shift traffic to undamaged modes. Other adaptation actions include: new infrastructure designs for future climate conditions, asset management programs, at-risk asset protection, operational changes, and abandoning/relocating infrastructure assets that would be too expensive to protect.

- **Impacts on Transportation Reliability and Capacity at Risk**

The impacts from sea level rise and storm surge, extreme weather events, higher temperatures and heat waves, precipitation changes, Arctic warming, and other climatic conditions are reducing the reliability and capacity of the U.S. transportation system in many ways.

Global climate change has both gradual and extreme event implications. A gradually warmer climate and increased drought in the Southeast and the Southwest will affect slope stability and cause pavement buckling that will damage infrastructure like roads and rail lines. Streamflows based on increasingly more frequent and intense rainfall instead of slower snowmelt could increase the likelihood of bridge damage from faster-flowing streams. However, less snow in some areas will reduce snow removal costs and extend construction seasons. Shifts in agricultural production patterns will necessitate changes in transportation routes and modes.

- **Transportation Coastal Impacts and Storm Surge**

Sea level rise, coupled with storm surge, will continue to increase the risk of major coastal impacts, including both temporary and permanent flooding of airports, ports and harbors, roads, rail lines, tunnels, and bridges.

The transportation impacts of rising sea levels, which are expected to continue rising by an additional 1 to 4 feet in this century, and will vary widely by location and geography. When sea level rise is coupled with intense storms, the resulting storm surges will be greater, extend farther inland, and cause more

extensive damage. Ports and harbors will need to be reconfigured to accommodate higher seas. Many of the nation's largest ports are along the Gulf Coast, which is especially vulnerable due to a combination of sea level rise, storm surges, erosion, and land subsidence. In 2011, the U.S. had net imports of 45% of oil consumed and 56% of the imports passed through Gulf Coast ports (EIA 2012).

- **Weather Disruptions on Transportation**

Extreme weather events currently disrupt transportation networks in all areas of the country; projections indicate that such disruptions will increase. Changes in precipitation patterns, particularly more intense storms and drought, will affect transportation systems across the country. Severe storm delays disrupt almost all types of transportation. Storm drainage systems for highways, tunnels, airports, and city streets could prove inadequate, resulting in localized flooding. Bridge piers are subject to scour as runoff increases stream and river flows, potentially weakening bridge foundations. Severe storms will disrupt highway traffic leading to more accidents/delays. More airline traffic will be delayed or canceled.

Case Study - Hurricane Sandy

In October 2012, Hurricane Sandy dealt the transportation systems of New Jersey and New York and environs a massive blow, much in line with vulnerability assessments conducted over the past four years (Jacob et al. 2008; New York State 2011; New York State Sea Level Rise Task Force 2010; Zimmerman and Faris 2010). All tunnels and most bridges leading into New York City were closed during the storm.

A nearly 14- foot storm surge flooded the Queens Midtown, Holland, and Carey (Brooklyn Battery) tunnels, which remained closed for 1-2 weeks while floodwaters were being pumped out and power restored. The three major airports, Kennedy, Newark, and LaGuardia, flooded. LaGuardia absorbed the worst impact and closed for three days (The Port Authority of New York & New Jersey 2012a).

Almost 7.5 million passengers per day ride the NYC subways and buses (Metropolitan Transportation Authority 2012a). Much of the subway system below 34th Street was flooded, including all seven tunnels under the East River to Brooklyn and Queens. In addition to removing the floodwaters, all electrical signaling and power systems (the third rails) had to be cleaned, inspected, and repaired. Service on most Lower Manhattan subways was suspended for at least one week (Vantuono).

- **Transportation Costs and Adaptation Options**

Climate change impacts will increase costs to transportation systems and their users. These impacts can be reduced through rerouting, mode change, and a range of adaptive actions.

The economic cost of climate change to the transportation sector has been little studied. One recent report on climate change in New York, however, indicated that a storm surge severe enough to flood Manhattan tunnels might cost as much as $100 billion (Rosenzweig et al.2011b). A study of the risk to specific infrastructure elements in Alaska (Larsen 2007) estimated the net present value of the extra cost from climate change at $2-4 billion through 2030, and $4-8 billion through 2080.

The indirect evidence for significant costs from climate change impacts begin with the consequences of recent hurricanes, particularly on the Eastern Seaboard, where Hurricane Irene, a rather minor storm, produced unexpectedly heavy infrastructure damage from heavy rains. The economic cost of infrastructure damage is often greater than the cost of repairing or replacing infrastructure. For example, when the I-35W bridge collapsed in 2007, the State of Minnesota estimated the economic cost

of lost use at $0.4 million per day, while the replacement cost of the bridge was $234 million (Haugen 2008; Xie and Levinson 2011)

In addition, a recent study of on-road congestion estimates the annual cost of highway congestion at about $100 billion (Schrank et al. 2011) the Federal Highway Administration estimates that weather accounts for about 15 percent of total delay (Cambridge Systematics and Texas Transportation Institute 2005). Similarly, a recent study of aviation congestion indicates that the annual cost of airline delay is about $33 billion (Ball et al. 2010) and that weather accounts for more than a third of airline delays. There is a strong circumstantial case to be made that increased frequency of extreme events (as defined by climate scientists) will produce increase traffic and aviation delays. Given the scale of current costs, even small changes in delay can have substantial economic costs.

- **Adaptation Strategies for Transportation Systems**

There is little published material on transportation adaption costs and benefits in the literature, in part because "adaptation" is an abstraction. Climate change is statistical weather, and manifests itself as a change in the frequency of events that would still occur (but with lower frequency) in the absence of climate change. Transportation agencies decide to protect (or not) specific pieces of infrastructure based on a range of considerations, including age and condition, extent of current and future usage, and cost of protection, as well as changing weather patterns. The authors, however, are aware, that transportation systems have always been required to adapt to changing conditions, and that, in general, it is almost always far less expensive to protect useful infrastructure than to wait for it to collapse. This professional experience, based on examination of multitudes of individual engineering studies, is the basis for the conclusion in the report,

There are numerous examples of actions taken by state and local governments to enhance resilience and reduce climate impact costs on transportation including land- use planning to discourage development in vulnerable areas, establishment of design guidelines to reduce vulnerability to sea level rise, use of effective stormwater management techniques and coordinated emergency response systems.

Adaptation strategies can be employed to reduce the impact of climate change related events and the resulting consequences. Consideration of adaptation strategies in the transportation sector is especially important in the following five areas:

- ✓ **Transportation and land-use planning:** deciding what infrastructure to build and where to build it, also -planning for vulnerable areas of the community and impacts on specific populations.

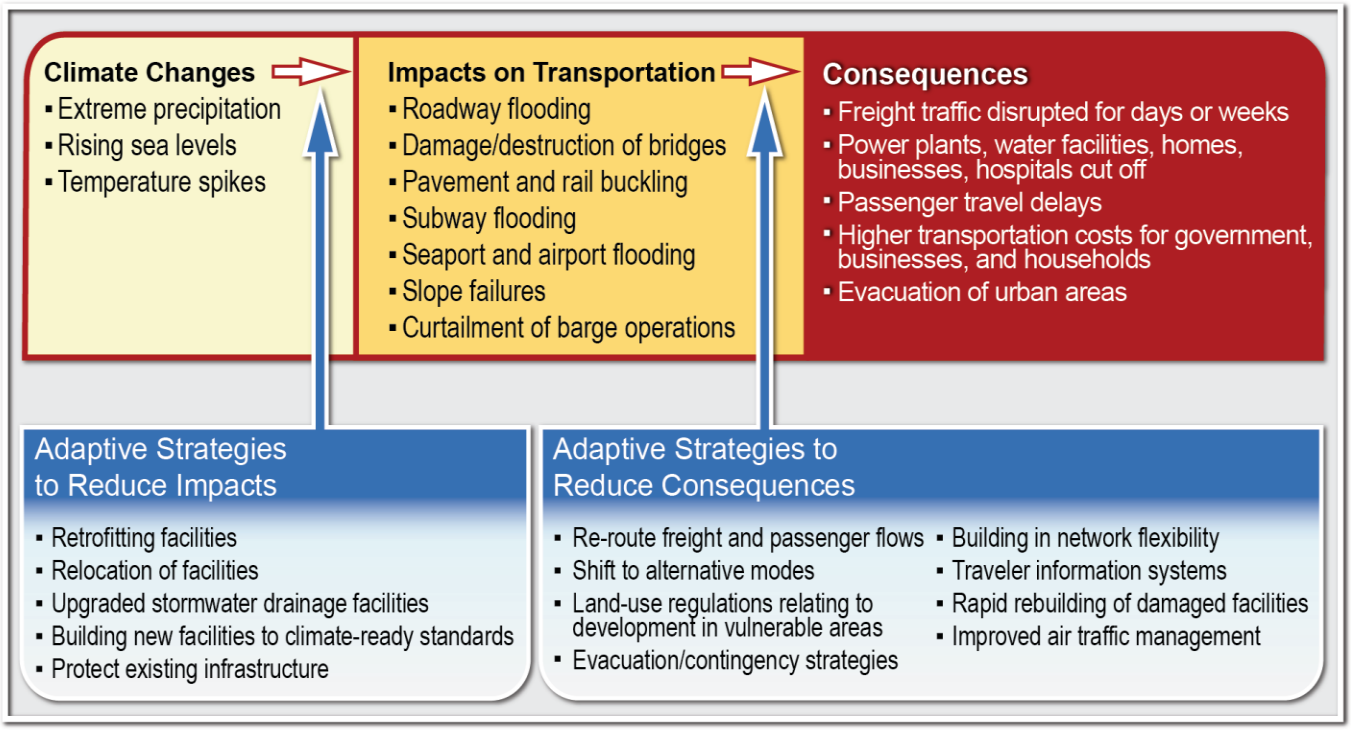
- ✓ **Vulnerability and risk assessment**: identifying existing vulnerable facilities and systems, together with the expected consequences.

- ✓ **New infrastructure design**: adapting new infrastructure designs that anticipate changing environmental and operational conditions.

- ✓ **Asset management**: adapting existing infrastructure and operations that respond to current and anticipated conditions, including changed maintenance practices and retrofits.

- ✓ **Emergency response:** anticipating expected disruptions from extreme weather events, and developing emergency response capability.

Role of Adaptive Strategies in Reducing Impacts and Consequences



Summary:
New York State (NYS) 2100 Commission Report

Background: On November 15, 2012, New York Governor Andrew Cuomo convened the New York State (NYS) 2100 Commission in response to the unprecedented weather events experienced by NYS and the surrounding region, including Superstorm Sandy, Hurricane Irene and Tropical Storm Lee. The Commission's role was to examine and evaluate key vulnerabilities in the State's critical infrastructure systems, and to recommend actions that should be taken to strengthen and improve the resilience of those systems. If done right, the State would have a tremendous opportunity not only to mitigate future damage and subsequent economic losses, but to invigorate New York's economy with a robust green technology sector and to enhance quality-of-life for its citizens.

The Commission prepared a report entitled *NYS 2100 Commission: Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure.* The Commission's chairs were Judith Rodin, President, The Rockefeller Foundation, and Felix G. Rohatyn, Special Advisor to the Chairman and CEO, Lazard Freres & Co. LLC. The Commission Advisory members included John Porcari, U.S. Transportation Deputy Secretary.

Link to the full text of the report is available here: http://www.governor.ny.gov/assets/documents/NYS2100.pdf

This summary document has been prepared by Bahar Barami, Ph.D., Senior Economist, Center for Transportation Logistics and Security, U.S. DOT, Volpe Center. Bahar.Barami@dot.gov

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Key Findings and Recommendations

What is Resilience? : A Resilient New York and Resilient New Yorkers

Resilience is the ability of a system to withstand shocks and stresses while still maintaining its essential functions. Systems that are more vulnerable – i.e., those that are brittle, at stretched capacity, or with very low diversity – are more at risk of catastrophic consequences when the next shock-event happens. Resilient systems are also better able to repair and recover afterwards.

Taken together, there are several features that are common to most resilient systems, including having spare or latent capacity (redundancy); ensuring flexibility and responsiveness; managing for safe failure (building resistance to domino effects); and having the capacity to recover quickly and evolve over time – to thrive, not just survive major disruptions. These characteristics form the basis for the Commission's ideas about which measures will help to make New York more resilient.

Resilience is not just a topic for times of crisis. We will never be able to perfectly predict or prevent all extreme events and eventualities. We must conserve the natural systems that protect us, and plan and develop systems that can quickly respond to, and rebound more effectively from, severe weather events and other emergencies. Building resilience will enable us to avoid unmanageable impacts, while managing the unavoidable risks that the future no doubt will present. Our capacity to deal with known

risks, while establishing countermeasures to contend with unknowns, will be critical in the coming century.

A resilience-planning framework provides a clear guide to the regular process of planning, assessment and re-evaluation. Through this framework, knowledge and feedback from past events can be applied to understand and prepare for future impacts. Flexible, long-term options must be favored over short-term fixes.

Building Blocks of Resilience: How Will These Recommendations Make New York More Resilient?

There are some **core characteristics** that all resilient systems share and demonstrate in good times and in times of stress. These include having spare capacity, staying flexible, managing failures, rebounding quickly, and improving continuously, not just when disaster strikes. These building blocks of resilience have been developed through research, practice, and hard experience with disasters around the world. Programs such as the Rockefeller Foundation's Asian Cities Climate Change Resilience Network have demonstrated that by reducing the vulnerabilities or weak links in one area resilience can be enhanced more broadly in a large urban area or across an entire region.

The **five characteristics** below highlight how projects or actions might enhance NYS' resilience.

- ✓ **Spare Capacity or Redundancy.** Spare capacity or redundancy provides a measure of security when a system is under stress by making sure that there are effective back-ups, alternatives, or reserves to respond to sudden or severe events. This spare or latent capacity in a system depends on up-front planning to ensure diversity and to build alternative strategies, pathways and options for maintaining core services and safety nets. Redundancy needs to be a part of NYS' planning and investment strategies across all of the State's critical infrastructure and services.

- ✓ **Flexibility or Responsiveness.** Flexibility in the face of disaster is the ability to change, evolve and adopt alternative near or long-term strategies in response to changing conditions. It implies recognizing when it is not possible to return to the previous way things worked, and evolving or finding new solutions.

- ✓ **Limited Failure.** Systems can be made more or less resilient depending on surrounding decisions, requirements, and actions. Decisions cannot be made in isolation. Resilient network infrastructures are designed to prevent cascading failures and allow for "safe failure" that is limited in scope. When one domino falls it should not take down a whole system. This is related to a system's ability to absorb shocks and manage the cumulative effects of slow-onset challenges in ways that avoid catastrophic failure. When part of a resilient system fails it does so progressively rather than suddenly, and limits ripples across other systems.

- ✓ **Rapid Rebound.** The capacity to rebound is part of a system's ability to re-establish function to contain losses and avoid further disruption. This ability requires feedback loops that facilitate effective reorganization to reestablish function quickly. Rapidity is a key part of responsiveness in

order to contain losses and prevent cascading failures or long-term disruption. A major part of rebounding quickly is making sure that rapid response measures do not limit pathways for learning, long-term response, and growth. The MTA shut down in advance of Superstorm Sandy was a good example of both limiting failure and rapid rebound. The MTA reduced the danger and damage by closing in an orderly way and getting all the trains and buses to higher ground before the floodwaters arrived. As the water receded the MTA was able to immediately restart service, slowly bringing the system back up to normal over hours, days, and weeks that followed.

- ✓ **Constant Learning.** Building resilience is a process not an outcome. As the future evolves and unfolds, how we plan for, approach, and face new challenges requires constant adaption and reinterpretation. Every critical experience – both failures and successes – must get folded into the calculus of how we safeguard the future. Each occurrence tests our resilience measures in unique ways. Each system reaction provides the opportunity fine-tune our approach to mobilizing our assets and human resources in flexible ways to find new solutions as conditions change.

General Recommendations

The next century will be defined by the extent to which our communities are resilient to the direct and indirect impacts of a rapidly changing climate and other long-term accelerators of change. We will never be able to predict or prevent all extreme events. But we must not waste the lessons learned and opportunities afforded by these recent storms to chart a course for NYS that prepares our communities for future eventualities. Planning for a more resilient tomorrow enables NYS to take cost-effective actions and to make investments that will benefit our communities today and far into the future.

The Commission reviewed the vulnerabilities faced by the State's infrastructure system in five main areas – *transportation, energy, land-use, insurance, and infrastructure finance* – and made recommendations aimed to:

- ✓ Identify immediate actions that should be taken to mitigate or strengthen existing systems;
- ✓ Identify future infrastructure projects that in the long-term would help to bring not only greater climate resilience but also other significant economic and quality of life benefits;
- ✓ Assess long-term options for the use of "hard" barriers and natural systems to protect coastal communities;
- ✓ Create opportunities to integrate resilience planning, protection and development approaches; and
- ✓ Shape the reform in the investment, insurance and risk management related to natural disasters and other emergencies.

Cross-Cutting Recommendations

All resilient systems share and demonstrate certain core characteristics in good times and in times of stress. Many of these recommendations are relevant to multiple sectors, create improvements

across systems, and enhance these essential resilience characteristics. The following are the nine major cross-cutting recommendations:

1. **Protect, upgrade, and strengthen existing systems.** State agencies and authorities can take specific short-term action to significantly improve the long-term resilience of NYS' critical infrastructure systems. These include returning aging and damaged transportation, energy, drinking water and wastewater systems to a state of good repair; replacing irreparably damaged infrastructure with more resilient alternatives; and providing services and protections through new measures, such as natural infrastructure projects and coastal ecosystem restoration, to create additional lines of storm defenses.

2. **Rebuild smarter: ensure replacement with better options and alternatives.** As the rapid recovery and response continue to move forward, it is essential to identify where one-to-one replacement is not the best option for long-term resilience-building. This recommendation focuses on transitioning from short-term solutions to long-term resilience measures. NYS should develop scenario-planning capability to explore policy options for guiding where to build, what to build, and how to strengthen communities in areas of greatest risk. Scenario planning exercises should be held with communities across the state to inform and guide decisions about long-term rebuilding efforts, future investment plans, and the level to which we rely upon "soft" solutions or harden and upgrade our infrastructure.

3. **Encourage the use of green and natural infrastructure.** NYS should adopt measures that promote the use of green and natural infrastructure through direct investment, new incentive programs, and education. A green infrastructure approach emphasizes the use of solutions that maintain and support services provided by natural systems, such as wetlands and dunes that can serve as natural buffers against storm surges and complement efforts to build new traditional infrastructure to protect communities. Broader adoption of green infrastructure could have minimized local problems with flooding, contamination or erosion.

4. **Create shared equipment and resource reserves.** Create statewide and regional pools or banks of critical infrastructure that allow for continuous improvement and modernization in the face of disruptions/failures. One of the major barriers to effective system upgrading and maintenance is weak links or limiting factors in critical supply chains. Creating regional pools of hard-to-procure equipment can facilitate rapid recovery from component failures and support more cost-effective regular system upgrades as newer parts are cycled through a system.

5. **Promote integrated planning and develop criteria for integrated decision-making for capital investments.** NYS has a variety of planning processes. Ensuring that resilience is effectively incorporated into the State's many complex systems and plans requires new approaches to both planning and implementation. Responsibility for the State's infrastructure is shared, with no single institution in charge. Transportation, energy, and utility infrastructure are networked systems. Delays or failures in one system can disrupt other systems.

6. **Enhance institutional coordination -** Several key actions should be taken to streamline NYS' approach to planning for and implementing resilient development strategies. Recommendations include the creation of a new Chief Risk Officer or unit to provide a platform for coordination between different State agencies and neighboring municipalities and create the basis for an "all hazards" approach to planning, investment, and decision-making. Improving coordination within and between levels of government also offers opportunities to minimize duplication and conflict among agencies.

7. **Improve data, mapping, visualization, communication systems.** Information systems include both the hard data that need to be found, processed, updated, secured and stored in ways that can be effectively used and also the wide range of institutions and individuals who make up the user community of these data. The hard data inform decision-making, interactions between systems, and coordinated management. They also serve as a tool to inform State decision-makers and others. For example, NYS' Critical Infrastructure Response Information System uses Geographic Information System (GIS) technology to support analysis, visualization, and decision-making. Improving the information systems can enhance the governance and management of the NYS' infrastructure during normal operations and create essential feedback loops to support real-time decision-making and response.

8. **Create new incentive programs to encourage resilient behaviors and reduce vulnerabilities.** In several areas, the Commission recommends the use of incentive programs to influence regional, municipal, and individual decisions and behaviors to encourage more resilient development. For example, various land use programs are identified to support longer-term smart growth patterns that avoid areas of high vulnerability. The Commission recommends programs designed to expand green storm-water infrastructure; promote energy efficiency and alternative fuels; and reinforce/mitigate vulnerable assets.

9. **Expand education, job training and workforce development opportunities.** NYS should expand investment in education and workforce development programs to ensure the availability of skilled professionals in critical recovery and resilience building activities, including restoring ecosystems, creating/maintaining green infrastructure, repairing damaged equipment and upgrading services. Growing the pool of skilled workers is essential to handle the current and future needs of critical infrastructure systems such as electric power and environmental engineering. Creating a larger network of training programs will help form a foundation for the continued development of New York State's workforce for years to come.

Sector-Specific Recommendations for Transportation and Energy

The transportation-sector faces four key challenges:

- ✓ Subway tunnels and depots for both subway cars and buses in New York City lack sufficient protections against flooding and capacity to pump out water that not only stops mass transit service but also damages communications and other aging systems.

- ✓ Bridges, culverts, roads, and certain rail infrastructure are all susceptible to the threat of "scour," caused by flooding that erodes the foundations of structures and, if not addressed, undermines the structural integrity of critical transportation links.

- ✓ Flooding poses a major threat to airport runways, terminals, and other systems, especially at airports such as LaGuardia and JFK that are adjacent to water.

- ✓ Vulnerabilities to marine transportation (ports, rivers, canals) vary in nature, but include insufficient tidal gates, electrical power lines vulnerable to damage, and insufficient embankments to protect against flooding and severe winds.

The commission had four sector-specific recommendations for the transportation sector:

1. **Conduct a risk assessment of the NYS' transportation infrastructure.**
   Identify assets that are vulnerable to extreme weather events, storm surge, sea level rise and seismic events, and prioritize future investment by identifying critical facilities, corridors, systems, or routes that must remain functional during a crisis or be restored most rapidly.

2. **Strengthen existing transportation networks.**
   - ✓ Improve NYS' existing infrastructure with an emphasis on key bridges, roads, tunnels, transit, rail, airports, marine facilities, and transportation communication infrastructure;
   - ✓ Focus on improved repair, as well as protecting against multiple hazards including flooding, seismic impact and extreme weather;
   - ✓ Protect transit systems and tunnels against severe flooding;
   - ✓ Invest in upgrades to bridges, tunnels, roads, transit and railroads for all hazards;
   - ✓ Strengthen vulnerable highway and rail bridges;
   - ✓ Protect waterway movements;
   - ✓ Safeguard airport operations.

3. **Strategically expand transportation networks in order to create redundancies.**

   - ✓ Make the system more flexible and adaptive;
   - ✓ Encourage alternate modes of transportation
   - ✓ Modernize signal and communications systems;
   - ✓ Build a Bus Rapid Transit network;

- ✓ Expand rail access to/from Manhattan;
- ✓ Create new trans-Hudson tunnel connection;
- ✓ Expand capacity on the LIRR's Main Line

4. **Build for a resilient future with enhanced guidelines, standards, policies, and procedures.**

   - ✓ Change the way we plan, design, build, manage, maintain and pay for our transportation network in light of increased occurrences of severe events;
   - ✓ Review design guidelines;
   - ✓ Improve long-term planning and fund allocation;
   - ✓ Improve interagency and interstate planning; and
   - ✓ Seek expedited environmental review and permitting on major mitigation investments.

For the energy sector, two recommendations were relevant to transportation system resiliency:

1. **Design rate structures and create incentives to encourage distributed generation and smart grid investments.** Implement new technologies and system improvements to provide effective backup power, flexibility, distributed generation, and solutions for "islanding" vulnerable parts of the system. In addition to improving the resilience and stability of energy, electricity, and fuel supply systems, these solutions promote energy conservation, efficiency, and consumer demand response.

2. **Diversify fuel supply, reduce demand for energy, and create redundancies.** Lowering greenhouse gas (GHG) emissions in the power sector through the Regional Greenhouse Gas Initiative (RGGI) will contribute to reducing the impacts of climate change over the very long term. To build on the success of RGGI, NYS should encourage alternative fuel sources such as biogas, liquefied natural gas, and solar heating in transportation and other sectors. Plug-in electric vehicles, energy storage systems, and on-site fuel storage where feasible, should also be used to provide new energy storage mechanisms. Incentive programs to promote energy efficiency and renewable energy deployment should be strengthened to increase the level of private sector investment in this space, including steps that would facilitate greater investments in energy efficiency and renewable energy, diversify fuels in the transportation sector, support alternative fuels across all sectors, and lower the greenhouse gas emissions cap through RGGI.

Summary:
National Ocean Council's Policy Implementation Plan

Background: On July 19, 2010, President Obama issued Executive Order 13547 to establish the National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes. The policy highlights our responsibility to improve and maintain the health of the ocean, coasts, and Great Lakes. Through establishment of the National Ocean Council, the National Ocean Policy coordinates the ocean-related activities of Federal agencies. The policy does not create new regulations, supersede current regulations, or modify any agency's established mission. Rather, it helps coordinate the implementation of existing regulations and authorities by all Federal agencies.

In April 2013, the White House released the National Ocean Policy Implementation Plan (IP). The goal of the IP included improving forecasting and data-sharing, federal permitting, and habitat restoration. Link to the full text: http://www.whitehouse.gov/sites/default/files/national_ocean_policy_implementation_plan.pdf

The five actions outlined in the report – the Ocean Economy, Safety and Security, Coastal and Ocean Resilience, Local Choices, and Science and Information – are designed to support existing and new marine industries, maintain and enhance the vitality of coastal communities and regions, and preserve the marine ecosystems that support our quality of life.

This summary document has been prepared by Bahar Barami, Ph.D., Senior Economist, Center of Transportation Logistics and Security, U.S. DOT, Volpe Center. Bahar.Barami@dot.gov

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Key Findings and Recommendations

1 - The Ocean Economy

Greater access to high-quality data and information will enable maritime industries, resource managers, and decision makers at all levels of government to make responsible and effective decisions. Federal agencies will take the following actions:

- **Advance our mapping and charting capabilities and products to support a range of economic activities.** To sustain the flow of the trillions of dollars of goods that pass through our ports and the many businesses that rely on the ocean, our coasts, and Great Lakes, agencies will coordinate to produce better mapping and charting products, which serve to preserve, protect, and expand our Nation's maritime economic activities. Improved mapping, charting, and associated products will enhance the efficiency of maritime commerce through safer navigation and better accident-avoidance. Updated hydrographic charts and seafloor maps will support marine industries.

- **Provide greater accessibility to data and information to support commercial markets and industries, such as commercial fishing, maritime transportation, aquaculture, and offshore energy.** Agencies will take a series of actions to facilitate the availability of relevant ocean data to provide easier access to information for research, planning, and decision support. They will help identify and

communicate the economic value of ecosystem services, such as healthy and productive wetlands that support spawning, breeding, and feeding of important fish species.

- **Sustain and further develop observing systems for the economic benefit of maritime commerce and marine industry.** Federal agencies will support the development and maintenance of ocean observing systems. Real-time information on waterway conditions from ocean, coastal, and Great Lakes observing systems such as the NOAA Physical Oceanographic Real-Time System (PORTS) directly supports the daily operations and efficiency of maritime commerce nationwide.

2 – Safety and Security

The IP identified three broad safety and security actions:

2-1 Improving Maritime Domain Awareness

A solid understanding of the wide range of activities, infrastructure, and environmental conditions that occur in the ocean, coastal, and Great Lakes ecosystems enables informed decisions to events that occur in those waters. Maritime domain awareness is achieved by efficiently collecting/sharing information and by improving the Nation's infrastructure for ocean observing and remote sensing systems.

- **Enhance remote sensing systems for ocean observations to support maritime domain awareness.** Federal agencies will optimize use of enhanced remote sensing systems for ocean observations to improve awareness of real-time oceanographic, meteorological, and ecological conditions in the maritime domain. An integrated system of remote sensing assets designed for ocean observations will assist decision-makers by providing a more complete picture of the marine environment.

- **Engage internationally to exchange information, expertise, and knowledge about policy issues in the maritime domain.** The U.S. will collaborate with foreign governments and international bodies, such as the International Maritime Organization and Intergovernmental Oceanographic Commission in exchanging information, expertise, and knowledge to address high-priority ocean policy issues.

2-2 Providing Maritime Safety and Security in a Changing Arctic

The Arctic is rapidly changing. One of the most dramatic changes is the decrease in sea ice, which is likely to increase vessel traffic in the U.S. Arctic. Commercial vessels may capitalize on more expeditious routes, cruise ships and recreational vessels are expected to bring more tourists to the region, fishing grounds are shifting, and oil and gas companies are moving forward with exploration activities and obtaining leases to drill into the Arctic seabed.

- **Enhance communication systems in the Arctic to improve our capability to prevent and respond to maritime incidents and environmental impacts.** Federal agencies will improve Arctic communication systems by advancing both technical capabilities and partnerships.

- **Improve Arctic environmental incident prevention and response to ensure coordinated agency action, minimize the likelihood of disasters, and expedite response activities.** Increased Arctic vessel traffic brings increased risks of collisions, groundings, and other serious marine incidents that can lead to loss of life and property and damage the marine environment. A coordinated and prepared all-hazards response-management system will mitigate the impacts of marine-pollution events on fragile Arctic communities and ecosystems.

- **Improve Arctic sea ice forecasting to support safety at sea.** Sea ice forecasting is one of the most urgent and timely issues in the Arctic region. To ensure the best tactical and long-term ice forecasts are available for safe operations and planning, Federal agencies will work together to better quantify the rates of sea ice melt and regrowth, understand shifting patterns of distribution of ice, develop better maps of the ice edge, expand participation in the sea ice observation program, and coordinate with international partners to enable better model-based forecasting over larger areas.

- **Improve Arctic mapping and charting for safe navigation and more accurate positioning.** Advancements in hydrographic charting will enhance the safety of navigation in the Arctic region by reducing the risk of damaging maritime incidents. Federal agencies will update nautical charts and establish priorities, in concert with Native communities and stakeholders.

2-3 Enhancing the Safety and Security of Ports and Waterways

The safety and security of our people, property, and the marine environment and the viability of maritime commerce rely on safe, efficient, and secure navigation and waterways management systems. This includes effective planning for and response to emerging threats to our ports and harbors from illegal human activities, climate change, and extreme weather events or other natural disasters. Federal agencies will conduct several coordinated actions that leverage existing resources to ensure the safety and security of all those who rely on the health and vitality of our ports and waterways.

- **Conduct Waterway Analysis and Management System assessments and Port Access Route Studies to support decisions on waterways management and other navigational priorities.** The safe and secure navigation of commercial, recreational, and government vessels in and out of our Nation's ports depends on accurate and timely assessments of our waterways.

- **Assess the vulnerability of our ports and waterways to sea-level rise and extreme weather events or other natural disasters and enable actions that more effectively reduce risks and impacts.** The Nation's ports and waterways infrastructure support many economic, safety, and security activities. A better understanding of the potential impacts of climate change on our ports and waterways will prepare us to respond and adapt accordingly in order to preserve critical assets. Vulnerability assessments are critical to understanding how extreme weather, sea-level rise, and other manifestations of climate change may affect our coastlines.

- **Advance ocean observing systems to further enhance search and rescue operations and spill response in our ports and waterways.** Ocean observing systems provide real-time and near real-time oceanographic, meteorological, and ecological data, which feed into search and rescue and oil spill trajectory models. The reliability, quality, and resolution of ocean observing system data have a direct impact on the model output, which influences operational decisions for search and rescue and oil and hazardous substance spill response.

3 - Coastal and Ocean Resilience

The health and integrity of coastal habitats—e.g., coral reefs, wetlands, mangroves, salt marshes, and sea grass beds—are key to sustaining our Nation's valuable coastal/ocean ecosystems and the wealth of benefits they provide to us. Degradation of coastal habitats and ecosystems diminishes their ability to provide environmental, economic, and societal services to the Nation. The U.S. lost nearly 60,000 acres

of coastal wetlands each year between 1998-2004. Roughly half of the coral reefs under U.S. jurisdiction are in "poor" or "fair" condition because of ocean warming, disease, and human activities.

3-1. Reducing Adverse Conditions

Through National Ocean Policy actions, thousands of acres of wetlands and priority habitat will be protected, restored, or enhanced. Our Nation's coral reefs will be improved by better coordinating existing authorities and implementing projects to prevent or mitigate harmful impacts. Actions to support partnerships and efforts to locate, monitor, control, and eradicate invasive species will protect native aquatic populations and their habitats.

- **Reduce coastal wetland loss.** Federal agencies will work together and in cooperation with States and tribes to identify the underlying causes of wetland loss in coastal watersheds, and opportunities to more effectively protect and restore the important functions and values they provide. Agencies will conduct pilot studies to identify the most common underlying factors responsible for coastal wetland loss and the most successful tools for addressing it.

- **Protect, conserve and restore coastal and ocean habitats.** Agencies will coordinate to use and provide scientifically sound, ecosystem-based approaches to achieve healthy coastal/ocean habitats.

- **Locate, control, prevent, and eradicate invasive species populations.** Federal agencies will improve our ability to prevent and reduce impacts from invasive species, focusing on early detection and response, to protect important marine species and their habitats.

- **Improve and preserve our Nation's coastal and estuarine water quality to provide clean water for healthier waterways, communities, and ecosystems.** Through more effective use of voluntary programs, partnerships, and pilot projects, agencies will work to reduce excessive nutrients, sediments, and other pollutants.

3-2 Preparing for Change

Agencies will take a number of coordinated actions to improve the resilience of coastal communities. Actions will guide relevant Federal Emergency Management Agency efforts such as national preparedness, disaster response and recovery, and flood hazard map development.

- **Strengthen and integrate observations into a coordinated network of sentinel sites to enhance the Nation's ability to provide early warnings, risk assessments, and forecasts for impacts.** Federal agencies will strengthen and integrate observations from the Nation's protected areas, research sites, and observing systems into a coordinated network of climate sentinel sites.

- **Determine the impacts of interacting stressors on ecological systems, economies, and communities.** Will develop an integrated research agenda to help address gaps in our current understanding. Will provide information for better forecasts of changes in ecological, economic, and social systems due to climate change and ocean acidification, and improved effectiveness of adaptation actions, with the goal of reducing risks and negative impacts on communities.

- **Assess the vulnerability of coastal communities and ocean environments to climate change and ocean acidification and, in partnership with tribes, coastal communities and States, design and implement adaptation strategies to reduce vulnerabilities.** Will develop methods and guidance for assessing the vulnerability and resiliency of resources to a changing climate, building off existing

efforts such as the National Climate Assessment. These tools will enable local decision makers to avoid actions that increase vulnerability of human communities or degrade natural resources, and take actions that increase resilience of both natural systems and communities.

3-3 Recovering and Sustaining Ocean Health

Agencies will act to significantly improve our Nation's capacity to address the long-term challenges and impacts of natural and human-caused environmental changes. These actions will provide a lasting foundation for enhancing many vital benefits our Nation derives from healthy ocean, coastal, and Great Lakes ecosystems.

- **Establish a framework for collaboration and a shared set of goals to promote ecosystem-based management.** Agencies will increase their collaboration with all stakeholders to enhance the efficiency, consistency, and transparency of their development and implementation of ecosystem approaches to management based on existing statutes and regulations.
- **Improve coastal and estuarine restoration efforts through better monitoring, coordination, and planning.** Monitoring restoration efforts provides important data and information to improve the science of restoration and track the societal benefits of restoration activities, such as increased fish populations and enhanced protection of coastlines from storms.

- **Improve the Nation's preparedness for, and response to, environmental hazards through better forecasts, increased and more integrated monitoring, and strengthened preparedness.** Agencies will establish a Health Early Warning System that alerts public health officials and managers to marine-related threats to human and ecosystem health from diseases, toxins, and pathogens.

- **Protect significant natural and cultural marine and Great Lakes areas and sufficient habitat to ensure maintenance of ecosystem processes.** Identifying ecologically significant areas for focused protection or management supports the long-term sustainability of ocean resources.

4 – Local Choices

4-1 Providing Tools for Regional Action

- **Identify and implement pilot projects that use an ecosystem-based approach to partnering in the stewardship of ocean and coastal resources.**

- **Assess the vulnerability of our ports and waterways to sea-level rise and extreme weather events or other natural disasters and enable actions that more effectively reduce risks and impacts.** A better understanding of the potential impacts of climate change on our ports and waterways will prepare us to respond and adapt accordingly in order to preserve critical assets. Vulnerability assessments are critical to understanding how extreme weather, sea-level rise, and other manifestations of climate change may affect our coastlines.

- **Expand and improve discovery of and access to non-classified Federal data and decision-support tools, including ocean/coastal mapping products, to support decision-making**.

5 – Science and Information

The actions in this section address existing priorities and apply new knowledge to improve how we pursue new opportunities.

5-1. Enhancing Our Understanding of Ocean and Coastal Systems
For the U.S. to continue to be a global leader, we need to continue expanding our knowledge of the ocean and our coasts. Towards this goal, the following actions will be pursued:

- Advance fundamental scientific knowledge through exploration and research.
- Advance technologies to explore and better understand the complexities of land, ocean, atmosphere, ice, biological, and social interactions on a global scale.
- Increase ocean and coastal literacy.

5-2. Strengthening Our Ability to Acquire Marine Data and Provide Information
Vital to ocean and coastal research is the availability of modern ships, undersea vehicles, moorings, satellites, laboratories, instruments, and observing systems.

- **Increase efficiencies in decision-making by improving permitting processes and coordinating agency participation in planning and approval processes.** Improve efficiency across Federal agencies, including permitting, planning, and approval processes to save time and money for ocean-based industries and decision makers at all levels of government while protecting health, safety, and the environment.

- **Waterway Analysis and Management System assessments and Port Access Route Studies to support decisions on waterways management and other navigational priorities.** The safe and secure navigation of commercial, recreational, and government vessels in and out of our Nation's ports depends on accurate and timely assessments of our waterways.

- **Advance ocean observing systems to further enhance search and rescue operations and spill response in our ports and waterways.** Ocean observing systems provide real-time and near real-time oceanographic, meteorological, and ecological data, which feed into search and rescue and oil spill trajectory models.

Summary:
Disaster Resilience: A National Imperative

Background: Disaster Resilience: A National Imperative, The National Academies, 2012, was prepared by the Committee on Increasing National Resilience to Hazards and Disasters, and Committee on Science, Engineering, and Public Policy. Link to the full text of the report: http://www.nap.edu/catalog.php?record_id=13457

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Key Findings and Recommendations

Disaster resilience is everyone's business and is a shared responsibility among citizens, the private sector, and government. Increasing resilience to disasters requires bold decisions and actions that may pit short-term interests against the longer term goals. As a nation we have two choices. We can maintain the status quo and move along as we have for decades. Or, we can embark on a new path – one that also recognizes and rewards the values of resilience to the individual, household, community and nation. Such a path requires a commitment to a new vision that includes shared responsibility for resilience and one that puts resilience in the forefront of many of our public policies that have both direct and indirect effects on enhanced resilience.

The nation needs to build the capacity to become resilient, and we need to do this now. Such capacity building starts with individuals taking responsibility for their actions. Enhancing national resilience is a lofty goal, but like all lofty goals the devil is in the details.

Increasing disaster resilience is an imperative that requires the collective will of the nation and its communities. Although disasters will continue to occur, actions that move the nation from reactive approaches to disasters to a proactive stance where communities actively engage in enhancing resilience will reduce many of the broad societal and economic burdens that disasters can cause.

The report made six key recommendations.

Recommendation 1 – Vision of a Resilience Nation

Federal government agencies should incorporate national resilience as an organizing principle to inform and guide the mission and actions of the federal government and the programs it supports at all levels. This recommendation embodies an approach that includes the development of a national vision and a national strategy towards a more resilient nation, and a set of short-and long-term implementation steps to achieve this goal, including:

- ✓ Development of the resilience vision;
- ✓ Development of communication strategies for promoting resilience among federal, state, and local governments, communities, and the private sector;
- ✓ Analysis of appropriate investment strategies for increasing resilience;
- ✓ Establishment of processes for interagency coordination for data and resilience metrics;
- ✓ Establishment of incentives for increasing resilience; and
- ✓ Conducting periodic reviews of federal agency progress toward increasing resilience.

The vision drafted by the committee members was termed *"Resilient Nation in 2030."*

Characteristics of a Resilient Nation in 2030

The nation, from individuals to the highest levels of government, has embraced a "culture of resilience." Information on risks and vulnerability to individuals and communities is transparent and easily accessible to all. Proactive investments and policy decisions including those for preparedness, mitigation, response, and recovery have reduced the loss of lives, costs, and socioeconomic impacts of disasters. Community coalitions are widely organized, recognized, and supported to provide essential before and after disasters occur. Recovery after disasters is rapid and includes funding from private capital. The per capita federal cost of responding to disasters has been declining for a decade.

Key Characteristics

- ✓ Realization by individuals/communities that they provide their own first line of defense against disasters.
- ✓ National leadership in resilience implemented by policy decisions, funding, and actions throughout all federal agencies and Congress.
- ✓ Pervasive federal, state, and regional investment in/support for community-led resilience efforts.
- ✓ Site-specific information on risk that is readily available, transparent, and effectively communicated.
- ✓ Based on risk information, zoning ordinances are enacted and enforced that protect critical functions and help communities reap the benefit of natural defenses to natural hazards (e.g., flood plains, coastal wetlands, sand dunes).
- ✓ Building codes and retrofit standards have been widely adopted and are strictly enforced.
- ✓ A significant proportion of disaster recovery is funded through private capital and insurance payouts.
- ✓ Insurance premiums are risk-based, and private insurers provide substantial premium reductions for buildings meeting current codes or retrofit standards.
- ✓ To speed recovery, community coalitions have developed contingency plans for governance and business continuity as well as for providing services, particularly for the most vulnerable populations.
- ✓ Post-disaster recovery is greatly accelerated by sufficient redundancy in infrastructure upgraded and hardened to take into account regional interdependencies.

Recommendation 2 – A Risk Management Strategy

The public and private sectors in a community should work cooperatively to encourage commitment to and investment in a risk management strategy that includes complementary structural and nonstructural risk-reduction and risk-spreading measures or tools. Such tools might include an essential framework (codes, standards, and guidelines) that drives the critical structural functions of resilience and investment in risk-based pricing of insurance.

Finding: Varieties of complementary structural and non-structural measures exist to manage disaster risk. Risk management is at its foundation a community decision and will only be as effective if community members commit to using the risk management tools and measures available. Examples from actual disasters and their aftermaths, such as the June 2008 flood in Cedar Rapids, show that implementation of risk management strategies involves a combination of actors in local, state, and federal government, NGOs, researchers, the private sector, and individuals in the neighborhood community. Each will have different roles and responsibilities in developing the risk management strategy and in characterizing and implementing measures or tools, whether structural or nonstructural, to be added to the community's risk management portfolio.

The portfolio of the tools should seek equitable balance among the need of all parties involved. Implementation steps include development of an essential framework (codes, standards, and guidelines) that drives the critical structural functions of resilience. Focus should be on risk reduction measures such as building codes and standards, and insurance premium incentives.

Recommendation 3 – A Disaster Database

A national resource of disaster-related data should be established that documents injuries, loss-of-life, property losses, and impacts on economic activity. Such a database will support efforts to develop more quantitative risk models and better understand structural and social vulnerability to disasters.

Finding: The ability to measure and evaluate the assets of communities and to understand the economic and human value of resilience is critical to improving disaster resilience. Because the assets of a community involve more than the high-value essential assets such as hospitals and utilities, but also include other resources with high social, cultural, and environmental value, decision-making models developed by communities have to involve both quantitative and qualitative "valuation" of assets in order to prioritize resilience investments. In developing the case for enhancing resilience now and providing motivation for community decision makers to understand their inventory of assets, the Disaster Database should help the community with reliable data for decision making and preventive as well as response and recovery options.

Implementation steps include efforts by the National Science and Technology Council (NSTC), in collaboration with federal agencies such as NOAA, USDA, and USACE.

Recommendation 4 – A National Resilience Scoreboard

The U.S. Department of Homeland Security in conjunction with other federal agencies, state and local partners, and professional groups should develop a National Resilience Scorecard.

Finding: Without some numerical basis for assessing resilience, it would be difficult to monitor changes or show that community resilience has improved. No consistent basis for such measurement exists.

Steps for implementation include development of a scoreboard that is readily adaptable to the needs of the stakeholders. The scoreboard should not attempt at unreasonable precision. Rather, qualitative and quantitative measures should be mingled and reduced to ordinal (ranking) scales.

Recommendation 5 – Resilience Coalitions

Federal, state and local governments should support the creation and maintenance of broad-based community resilience coalitions at local and regional levels.

Building local capacity and accelerating progress through promoting resilience from the bottom up is the key to getting the entire community engaged in problem solving.

Finding: Resilience requires reinforcement of our physical environment – the buildings and critical infrastructures that constitute the communities in which people live. The focus of the coalition should be on establishing problem-solving ties. A truly robust coalition has at its core a strong leadership and governance structure.

The first step for implementation involves getting all relevant federal agencies – including the DHS and HHS – as well as state, local and private stakeholders involved.

Lifeline Infrastructures: Linking Private and Public Infrastructure Interests

Lifelines are essential utility and transportation systems —are both publicly and privately owned and share the attributes of being distributed systems, rather than isolated facilities. They provide products and services that are transferred through networks that often cross legal and jurisdictional boundaries (Source: American Lifeline Alliance, or ALA, 2005). It is essential to conduct assessments of the quality and condition of these, and to make needed improvements in order to enhance resilience.

Genuine resilience of community lifelines cannot be achieved in piecemeal fashion by private and public entities acting on their own. Resilience requires local infrastructure leaders to come together to assess the status, vulnerability, and interdependencies of their holdings; set performance metrics for individual components and entire systems; and develop plans for enhancing the infrastructure's ability to withstand failure and for speeding the resumption of operations during disaster response and recovery. As a locally-based method of risk management, private-public infrastructure coalitions can also run joint community exercises using stress scenarios to test their systems for weak spots, initiate operational improvements to keep their enterprises functioning, and establish multiyear regional capital investment priorities.

The second step for enhancing resilience at the local level is to link private and public infrastructure performance and interests. Accountability for critical infrastructure systems is dispersed across the public and private sectors.

Recommendation 6 – Promoting National Resilience in Programs

All federal agencies should ensure they are promoting and coordinating national resilience in their programs and policies. A resilience policy review and self-assessment within agencies and strong communication among agencies are keys to achieving this kind of coordination.

Finding: the development of appropriate policies, creation of optimal governance structure, and informal and coordinated management at all levels of government are crucial to this.

Implementation steps should include a resilience self-assessment conducted by each federal agency.

Finding: Unintended consequences of government policies could be significant. Community resilience may also be affected by policies that are seemingly unrelated to resilience. Policies and practices promulgated to address a wide variety of other national problems may have the unintended consequence of reducing resilience. In some cases, failure to enact a policy that would increase resilience results in a deterioration of resilience. In other words, the absence of a specific beneficial policy is, in itself, a policy.

Agricultural policies provide one example of unintended consequences that reduce resilience. In this example, shifts in agriculture practice in the U.S. in response to farm policies designed to improve field drainage and productivity have unintentionally but significantly exacerbated flooding in the Midwest. Improvement in field drainage was accomplished by the installation of drain tiles or perforated pipes just under the surface of the field to remove excess water. The effect of this accelerated drainage during the spring months of each year was to move water quickly from the fields to the streams and rivers, which exacerbated –and still exacerbates – flooding along many stream and rivers in the Midwest.

The nature of resilience requires some flexibility and adaptability because the patterns of risk, development, and culture vary so widely among communities. Consideration of this need for flexibility is important for policy makers pursuing mechanisms to enhance the resilience of communities.

The fluid and progressive nature of seeking a resilient community does not lend itself to laws or policies mandating resilience as a perfect condition of a community.

Any federal, state, or local policies that attempts to mandate resilience would imply that resilience is a perfectly definable condition, which it is not.

Community resilience is highly desirable, but broadly complex, and would be extremely difficult to codify in a single comprehensive law.

Summary:
Adapting to the Impacts of Climate Change

Background: In In 2010, the National Research Council (NRC) released a report entitled *Adapting to the Impacts of Climate Change.* The report was prepared by the Board on Atmospheric Sciences and Climate. Link here for full text of the report:

http://www.climateneeds.umd.edu/reports/NRC-Adapting%20to%20the%20Impacts%20of%20Climate%20Change.pdf

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Key Findings and Recommendations

What is Adaptation?

Adapting to climate change is a relatively new topic for U.S. citizens, who have only recently become fully aware of the implications of changes in the Earth that will result from having more heat trapped in the oceans and the atmosphere. Recently, some states, cities, and sectors have begun to make plans to adapt to current and anticipated changes in the climate system.

Some "early adopters" have focused primarily on limiting greenhouse gases (GHGs), though others are also addressing ways to limit impacts of the anticipated changes. We are recognizing that regardless of efforts to limit emissions, adaptation is required now and will become even more important in the coming decades. Although planning for adaptation is still in its infancy, there is a groundswell of interest in moving forward quickly to avoid future impacts of climate change.

Adaptation to climate change requires attention now because impacts are already being felt and further impacts are unavoidable, regardless of how immediately and stringently GHG emissions are limited.

Adaptation to climate *variability* is nothing new to humanity, but it now seems very likely that climate conditions by the later part of the 21st century will move outside the range of past human experiences. Therefore, historical records and past experience are becoming incomplete guides for the future, and adaptation to climate change needs to become a high national priority.

Either we adapt by mobilizing to reduce sensitivities to climate change and to increase coping capacities now, or we will adapt by accepting and living with impacts that are likely in many cases to disrupt our lives. The questions are how, where, and when to adapt—and whether in some cases, if climate change is relatively severe, we may face limits on our ability to avoid painful impacts by adapting.

What are the Risks of Climate Change?

Across the vast area of the U.S. and islands located within U.S. territory, many regions, sectors, populations, or resources exhibit vulnerabilities to climate variations and change. A recent report of the U.S. Global Change Research Program (USGCRP) highlights the range of climate change impacts on the U.S. (2009). Areas of particular concern include low-lying coastlines, especially coastal areas of the Southeast that are susceptible to hurricanes, sea level rise, saltwater intrusion, and land subsidence; the West, where water supplies are largely dependent on snowpack, particularly those with little storage relative to annual flow; inner cities in the Midwest and Northeast, where many residents do not have access to air conditioning; natural ecosystems and native villages in northern Alaska that are subject to rapid changes in temperature, thawing of permafrost, and loss of sea ice; and Western forests that are susceptible to wildfire and bark beetle infestation. In the absence of adaptation, the risks of negative consequences that could accompany these types of impacts are heightened.

Adaptation is intended to reduce climate change vulnerabilities and impacts. That means any consideration of adaptation planning must begin with consideration of risks associated with climate change vulnerabilities and impacts, to the extent that these can be anticipated. More specifically, adaptation includes (1) the strategies, policies, and measures implemented to avoid, prepare for, and effectively respond to the adverse impacts of climate change on natural and human systems, and (2) the social, cultural, economic, geographic, ecological, and other factors that determine the vulnerability of places, systems, and populations. Climate-related changes can create new or interact with existing vulnerabilities to cause impacts, including changes in:

- ✓ Temperature, both averages and extremes;
- ✓ Precipitation, both averages and extremes;
- ✓ The intensity, frequency, duration, and/or location of extreme weather events;
- ✓ Sea level; and
- ✓ Atmospheric carbon dioxide (CO2) concentrations.

Vulnerability is often defined as the capacity to be harmed. It is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. Vulnerabilities can be reduced by limiting the magnitude of climate change through actions to limit GHG emissions (*ACC: Limiting the Magnitude of Future Climate Change*; NRC, 2010c), reducing sensitivity (the underlying social, cultural, economic, geographic, ecological, and other factors that interact with exposures to determine the magnitude and extent of impacts), or improving coping capacity (the ability to avoid, prepare for, and respond to an impact so that it is not seriously disruptive). Actions to reduce sensitivity and increase coping capacity are keys to effective adaptation to climate change.

A risk perspective considers the probability of an exposure and its consequences, including uncertainties in projecting the magnitude, rate, and extent of climate change. It also considers factors that shape sensitivities and coping capacities, which are as important as exposures in determining impacts.

Impacts of Climate Change on Energy and Transportation Sectors

Climate change impacts on the energy industry are likely to be most apparent at subnational scales, such as regional effects of extreme weather events, reduced water availability leading to constraints on energy production, and sea level rise affecting energy production and delivery systems. Warming will be accompanied by decreases in demand for heating energy and increases in demand for cooling energy. This is projected to drive up overall electricity use and create higher peak demands in most regions, but it also may reduce the use of heating oil and natural gas in winter.

Although the energy industry will be affected in multiple ways by changing weather patterns, it is generally considered to have the financial and the managerial resources to adapt. Sea level rise and storm surges will increase the risk of major coastal impacts on vulnerable energy and industrial infrastructure and transportation, including temporary or permanent flooding of airports, roads, rail lines, and tunnels.

More frequent extreme precipitation events would increase the risk of disruptions and delays in air, rail, and road transportation, as well as damage from mudslides in some areas. Increases in the intensity of strong hurricanes would lead to more evacuations, infrastructure damage and failure, and transportation interruptions (NRC, 2008c). Arctic warming will lengthen the marine transport season, while permafrost thaw on land will damage infrastructure and reduce the ice road season.

As experienced in Melbourne, Australia during a 2009 heat wave, an increase in extreme heat can limit some transportation operations (including airports) and cause pavement and track damage when heat compromises construction materials (NRC, 2008c). On the other hand, decreases in extreme cold can provide benefits such as reduced snow and ice removal costs and reduced snow-related road closures, as well as a potential decrease in snow- and ice-related traffic fatalities.

What are America's Options for Adaptation?

If the U.S. is to cope effectively with the impacts of climate change, it will need an array of adaptation options to choose from. Unfortunately, adaptation to climate change has been a low national priority, and very little research has been devoted to identifying and evaluating options for adaptation. In the short term, the nation can draw lessons from past experience with adaptations to climate *variability*, limited experience with climate change adaptation already undertaken in some regions of the world, a limited number of careful analyses of adaptation possibilities, and from an onrush of creative thinking in connection with emerging efforts to do adaptation planning. But, in many cases, the options that we can identify for *adaptation to impacts of climate change* lack solid information about benefits, costs, potentials, and limits for three reasons:

1. *Attribution*. Climate change is just now emerging as a cause of impacts; therefore, it is difficult at this stage to document effects of adaptation in reducing those impacts.

2. *Diversity*. Which adaptation actions make sense depends very heavily on context: the nature of the impact, the geographical scale and location, and the sector(s) affected. As a result, general conclusions about effects of particular options are often difficult to support.

3. *Knowledge base*. Very little research has been carried out on climate change adaptation actions to date (as distinguished from determinants of adaptation capacity.

Society's need to cope with changing climate and environmental conditions is not new; people have been adjusting to their environment since the dawn of civilization. Agriculture is one of the earliest examples: over the ages, farmers have repeatedly adjusted cultivation practices and bred new plant and animal varieties suited to varying climate conditions. In recent times, the development of floodplain regulations, insurance, wildlife reserves, drinking water reservoirs, and building codes all reflect efforts to stabilize and protect our homes, livelihoods, and food supplies in the face of a variable climate. However, for the past 10,000 years, climate has been relatively stable, and weather patterns have fluctuated within a rather predictable range. Our growing awareness that the Earth's climate is changing in that we are facing novel future climate conditions that will interact with and compound our current economic and environmental challenges. This has created a new context and a sense of urgency for climate adaptation planning.

Transportation Sector

Substantial engineering options are already available for strengthening and protecting transportation facilities such as bridges, ports, roads, and railroads from coastal storms and flooding to achieve short-term and long-term adaptation (NRC, 2008c). Infrastructure can be elevated, built stronger, protected by levees or dikes, and/or moved. For example, several of the major Gulf Coast highway bridges destroyed by storm surges during Hurricane Katrina have been redesigned and replaced by new bridges elevated well above anticipated future storm surges. Because most transport transportation systems are designed to last for decades, it is important for transportation planners to incorporate climate change in the planning and design cycle for such infrastructure (NRC, 2008c). The Federal Highway Administration already encourages and funds the inclusion of climate change in metropolitan planning activities.

Water-based transportation (e.g., Great Lakes Canal System and Mississippi, Ohio, Colombia, and Yukon rivers) may be constrained in some regions where runoff from the watershed declines and/or water demands for agriculture and cities increase. Adaptation may require redesign of ships and barges, a shortened shipping season, or a shift to alternate modes of transportation. Conversely, more extreme inland storms may well result in greater flood frequencies and levels. Revision of Federal Emergency Management Agency (FEMA) flood maps to reflect the probabilities of greater storm and flood events is critical to the construction of resilient structures along these inland waterways. Retreat of Arctic sea ice will likely open a new transportation corridor between the Atlantic and Pacific oceans. This may require new ship designs to deal with seasonal sea ice, development of new harbors, and development of new technology to handle fuel spills in water with sea ice.

Urgency of Climate Change Planning and Readiness for Implementation

Development of climate change adaptation plans has occurred most conspicuously in regions around the globe that currently experience severe climate change impacts (e.g., Alaska, Australia) or where leaders are concerned about vulnerability to impending impacts, particularly of sea level rise (e.g., Pacific Island States, Bangladesh, Maryland, Florida, California, and New York City). Alaska, for example, is warming at twice the global average rate, and several of the coastal communities eroding into the Bering Sea are already actively planning relocation to areas less threatened by coastal erosion. Similarly, Australia, which has experienced a decade-long a decade-long drought, has taken dramatic actions to

reduce water withdrawals and restructure water rights and has reorganized its agricultural enterprise to be better positioned to take advantage of climate opportunities and reduce climate risks. (Maryland, New York City, and Bangladesh are developing plans to accommodate sea level rise, and California and the entire lower Colorado River region (the states of Arizona and Nevada as well as Mexico) are planning adaptations to reduce the impacts of increasing water scarcity.

These climate change adaptation plans are consistent with both recent climate trends and future projections. The co-location of adaptation planning with areas of observed or perceived impending risk suggests that scientific studies that identify such vulnerability hot spots and outreach efforts to leaders and the public in these regions (e.g., RISA efforts in King County) could stimulate local - to-regional adaptation planning where it is most urgent. On the other hand, other vulnerable regions such as the U.S. Gulf Coast have been slow to develop comprehensive climate change adaptation plans, indicating that vulnerability, by itself, does not necessarily lead to comprehensive adaptation planning.

Developing an Adaptation plan

Like other planning processes, adaptation planning includes identifying potential problems, developing options to address them, ranking them according to criteria, and selecting the ones to be implemented. Climate change adaptation should, if possible, be incorporated into established planning activities, or "mainstreamed," as New York City has done, rather than requiring a separate approach. There may be common solutions to some problems, but no one approach will be appropriate for all applications.

The most important principles behind effective adaptation planning are flexibility and an adaptive approach designed to meet objectives and goals under a wide variety of future climate conditions:

1. Identify current and future climate changes relevant to the system;
2. Assess the vulnerabilities and risk to the system;
3. Develop an adaptation strategy using risk-based prioritization schemes;
4. Identify opportunities for co-benefits and synergies across sectors;
5. Implement adaptation options; and
6. Monitor and reevaluate implemented adaptation options.