



FINAL PROGRAM



First International Conference on Surface Transportation System Resilience to Climate Change and Extreme Weather Events

September 16–18, 2015

National Academy of Sciences Building

**2101 Constitution Avenue, NW
Washington, D.C.**

Sponsored by

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Federal Transit Administration

American Association of State Highway and Transportation Officials

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Conference Planning Committee

Mark Abkowitz, Vanderbilt University
Kathy Ahlenius, Wyoming Department of Transportation
Jeff Arnold, U.S. Army Corps of Engineers
Vicki Arroyo, Georgetown Climate Center
Annie Bennett, Georgetown Climate Center
Brian Beucler, Federal Highway Administration
Shannon Eggleston, American Association of State Highway and Transportation Officials
Elizabeth Habic, Maryland State Highway Administration
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Bob Noland, Rutgers University
Max Perchanok, Ontario Ministry of Transportation
Jeff Perlman, North Jersey Transportation Planning Authority
Paul Pisano, Federal Highway Administration
Laurel Radow, Federal Highway Administration
Carol Lee Roalkvam, Washington State Department of Transportation
Mike Savonis, ICF International
Adam Schildge, Federal Transit Administration
Adam Stephenson, Federal Transit Administration
Kees Van Muiswinkel, Rijkswaterstaat
Allison Yeh, Hillsborough County Metropolitan Planning Organization
Susan Yoon, Metropolitan Transportation Authority

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WELCOME

Welcome to the First International Conference on Surface Transportation System Resilience to Climate Change and Extreme Weather Events. This inaugural conference convenes experts from across the world to explore state-of-the-art research results as well as emerging best practices and policies on adapting surface transportation networks to the potential impacts of climate change and extreme weather events. Through a mix of plenary and breakout sessions, we will examine efforts to bring the consideration of climate change and extreme weather resilience into the mainstream of all aspects of transportation decision making: planning and programming, project design and capital improvements, and operations and maintenance—with a special focus on the development and application of climate information and innovative tools.

We hope that everyone—whether you are participating in person or virtually through the webcast—will ask questions, share ideas, and help further the ongoing dialogue on how we can create a more resilient transportation system.

—Heather Holsinger
Planning Committee Chair



Photo: Matt Buck

2011's Hurricane Katia caused stormy seas in Clevedon, United Kingdom.

TRB Staff

Monica Starnes, Senior Program Officer
Brittney Gick, Senior Program Associate
Ted Jamele, Meetings Assistant

September 16–18, 2015



SCHEDULE OF EVENTS

		Tuesday, September 15		Wednesday, September 16				
8:00 a.m.	Registration 8:00 a.m.–10:00 a.m. NAS 125			Networking Coffee and Pastries <i>Great Hall</i> 8:00 a.m.–9:00 a.m.				
8:30 a.m.				Conference Introduction and Keynote Speaker <i>Auditorium</i> 9:00 a.m.–10:30 a.m.				
9:00 a.m.								
9:30 a.m.				Break (10:30 a.m.–10:45 a.m.) <i>Great Hall</i>				
10:00 a.m.		ABR10 Committee Meeting NAS 125 9:00 a.m.–Noon	ABR20 Committee Meeting <i>Board Room</i> 9:00 a.m.–Noon			Climate Data: You Can't Always Get What You Want—But How Do I Get What I Need? <i>Auditorium</i> 10:45 a.m.–12:15 p.m.		
10:30 a.m.								
11:00 a.m.				Lunch <i>Great Hall</i> 12:15 p.m.–1:30 p.m.				
11:30 a.m.								
Noon	Registration Noon–2:00 p.m. NAS 120	Lunch <i>NAS Dining Hall</i> Noon–1:00 p.m.		Breakout 1 Decision Support for Planning <i>Auditorium</i> 1:30 p.m.–3:00 p.m.				
12:30 p.m.						Breakout 2 Designing Back to the Future: Looking at the Past and Turning Toward the Future NAS 125 1:30 p.m.–3:00 p.m.	Breakout 3 Floods Stop Traffic, DOTs Implement Management Strategies NAS 120 1:30 p.m.–3:00 p.m.	Breakout 4 Building Climate Resilience in Developing Countries <i>Lecture Room</i> 1:30 p.m.–3:00 p.m.
1:00 p.m.						Break <i>Great Hall</i> 3:00 p.m.–3:30 p.m.		
1:30 p.m.								
2:00 p.m.			Breakout 5 Resilient Freight Systems and Ports <i>Auditorium</i> 3:30 p.m.–5:00 p.m.	Breakout 6 Decisions, Decisions, Decisions NAS 125 3:30 p.m.–5:00 p.m.	Breakout 7 Weather and Climate: Different Sides of the Same Coin NAS 120 3:30 p.m.–5:00 p.m.	Breakout 8 Building Climate Resilience in Europe and North America <i>Lecture Room</i> 3:30 p.m.–5:00 p.m.		
2:30 p.m.			ABR00 Section Meeting NAS 120 1:00 p.m.–5:00 p.m.		Poster Session and Reception <i>Great Hall and West Court</i> 5:00 p.m.–7:00 p.m.			
3:00 p.m.								
3:30 p.m.								
4:00 p.m.								
4:30 p.m.								
5:00 p.m.								
5:30 p.m.								
6:00 p.m.								
6:30 p.m.								

September 16–18, 2015



SCHEDULE OF EVENTS

	Thursday, September 17				Friday, September 18											
8:00 a.m.	Networking Coffee and Pastries <i>Great Hall</i> 8:00 a.m.–9:00 a.m.				Networking Coffee and Pastries <i>Great Hall</i> 8:00 a.m.–9:00 a.m.											
8:30 a.m.																
9:00 a.m.	Panel Discussion Transportation Resilience Policy <i>Auditorium</i> 9:00 a.m.–10:30 a.m.				Breakout 21 Asset Management <i>Auditorium</i> 9:00 a.m.–10:15 a.m.	Breakout 22 Two Case Studies: Big and Bigger <i>NAS 125</i> 9:00 a.m.–10:15 a.m.	Breakout 23 Benefit–Cost Analysis Tools and Methods <i>Board Room</i> 9:00 a.m.–10:15 a.m.	Breakout 24 Integrating Transportation System Resilience <i>NAS 120</i> 9:00 a.m.–10:15 a.m.								
9:30 a.m.																
10:00 a.m.	Break (10:30 a.m.–10:45 a.m.) <i>Great Hall</i>				Break (10:15 a.m.–10:30 a.m.) <i>Great Hall</i>											
10:30 a.m.																
11:00 a.m.	Breakout 9 Highway Systems Planning <i>Auditorium</i> 10:45 a.m.–12:15 p.m.	Breakout 10 Adapting to Uncertainty <i>NAS 125</i> 10:45 a.m.–12:15 p.m.	Breakout 11 Developing Climate Information <i>NAS 120</i> 10:45 a.m.–12:15 p.m.	Breakout 12 Approaches and Tools for State and Regional Analyses <i>Board Room</i> 10:45 a.m.–12:15 p.m.	Breakout 25 Crisis Management Planning <i>Auditorium</i> 10:30 a.m.–11:45 a.m.	Breakout 26 International and Regional Frameworks for Adaptation and Resilience <i>NAS 125</i> 10:30 a.m.–11:45 a.m.	Breakout 27 Integrating Resilience into Existing Management Tools <i>NAS 120</i> 10:30 a.m.–11:45 a.m.									
11:30 a.m.	Lunch <i>Great Hall</i> 12:15 p.m.–1:30 p.m.				Lunch <i>Great Hall</i> 11:45 a.m.–12:30 p.m.											
Noon																
12:30 p.m.	ABR30 Committee Meeting <i>Members' Room</i> 12:15 p.m.–1:30 p.m.				Closing Plenary Session and Closing Townhall Bringing It All Together <i>Auditorium</i> 12:30 p.m.–2:30 p.m.											
1:00 p.m.																
1:30 p.m.	Breakout 13 Mainstreaming Climate Resilience <i>Auditorium</i> 1:30 p.m.–3:00 p.m.	Breakout 14 Green and Gray Infrastructure and Climate Resilience <i>NAS 125</i> 1:30 p.m.–3:00 p.m.	Breakout 15 Development and Application of Derived and Extreme Climate Variables <i>NAS 120</i> 1:30 p.m.–3:00 p.m.	Breakout 16 Vulnerability Assessment and Adaptation: Tools and Guides <i>Board Room</i> 1:30 p.m.–3:00 p.m.	Registration (8:00 a.m.–11:00 a.m.) <i>Great Hall</i>											
2:00 p.m.	Break <i>Great Hall</i> 3:00 p.m.–3:30 p.m.															
2:30 p.m.	Breakout 17 Asset Management: Strengthening Operations and Maintenance <i>Auditorium</i> 3:30 p.m.–5:00 p.m.				Breakout 18 Cooperation and Peer Learning—Cities, Regions, and Countries <i>NAS 125</i> 3:30 p.m.–5:00 p.m.				Breakout 19 Developing and Applying Future Precipitation and Flows <i>NAS 120</i> 3:30 p.m.–5:00 p.m.				Breakout 20 Sea-Level Rise, Storm Surge, and Flooding Tools <i>Board Room</i> 3:30 p.m.–5:00 p.m.			
3:00 p.m.																
3:30 p.m.	Roundtable Discussion Lessons Learned from Recent Climate Change Adaptation Pilot Projects and Initiatives <i>Auditorium</i> 5:00 p.m.–6:00 p.m.															
4:00 p.m.																
4:30 p.m.																
5:00 p.m.																
5:30 p.m.																

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COMMITTEE MEETINGS

Tuesday, September 15

8:00 a.m.–10:00 a.m., *Outside NAS 125*

Registration

9:00 a.m.–Noon, *NAS 125*

Standing Committee on Critical Transportation Infrastructure Protection (ABR10)

9:00 a.m.–Noon, *Board Room*

Standing Committee on the Logistics of Disaster Response and Business Continuity (ABR20)

Noon–2:00 p.m., *Outside NAS 120*

Registration

1:00 p.m.–5:00 p.m., *NAS 120*

Transportation Systems Resilience Section (ABR00)

Thursday, September 17

12:15 p.m.–1:30 p.m., *Members' Room*

Standing Committee on Emergency Evacuations (ABR30)

Lunch will be provided in room.

CONFERENCE SESSIONS

Tuesday, September 15

3:30 p.m.–5:00 p.m.

Walking Tour of the National Mall

Meet at the National Academies of Sciences Building, Board Room.

The National Mall stretches from the foot of the U.S. Capitol to the Potomac River and is the premiere civic and symbolic space in the United States. This walking tour of the National Mall will highlight the anticipated impacts associated with climate change and extreme weather events on the National Mall and the surrounding infrastructure and how planners are beginning to address these risks.

Wednesday, September 16

8:00 a.m.–4:00 p.m., *Great Hall*

Registration

8:00 a.m.–9:00 a.m., *Great Hall*

Networking Coffee and Pastries

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9:00 a.m.–10:30 a.m., *Auditorium*

Conference Introduction

Heather Holsinger, Federal Highway Administration (FHWA)
Monica Starnes, Transportation Research Board

Welcome Addresses

Neil Pedersen, Transportation Research Board
Gloria Shepherd, Federal Highway Administration

Keynote Address

Setting the Stage on the Science: Why Is Climate Change Relevant to the Transportation Community?

Katharine Hayhoe, Texas Tech University

10:30 a.m.–10:45 a.m., *Great Hall*

Break

10:45 a.m.–12:15 p.m., *Auditorium*

Plenary Session

Climate Data: You Can't Always Get What You Want—But How Do I Get What I Need?

Jeff Arnold, U.S. Army Corps of Engineers, *presiding*

This plenary session will focus on the climate data needs of transportation practitioners and the degree to which climate data producers can fulfill those needs. The panel will include experts in climate science, hydrology, transportation planning, project implementation, and operations and maintenance.

Keith Dixon, National Oceanic and Atmospheric Administration (NOAA)

Andy Wood, National Center for Atmospheric Research

Karuna Pujara, Maryland State Highway Administration

Herby Lissade, California Department of Transportation (Caltrans)

Jeff Perlman, North Jersey Transportation Planning Authority (NJTPA)

Gordana Petkovic, Norwegian Public Roads Administration

12:15 p.m.–1:30 p.m., *Great Hall*

Lunch

1:30 p.m.–3:00 p.m.

Breakout Sessions

Breakout 1

Decision Support for Planning, *Auditorium*

Michael Savonis, ICF International, *presiding*

How can we make better planning decisions about necessary adaptation measures? This session offers information on innovative approaches and applications—from dynamic learning to benefit–cost analysis—to include resilience in transport planning that leads to actionable results.

A Benefit–Cost Analysis Framework for Integrating Resilience into Transportation Planning and Operations

Samuel Merrill, GEI Consultants, Inc.; Jeffrey Western, Western Management and Consulting, LLC; Ron Frazier, Countermeasures Assessment and Security Experts, LLC

Presenters are shown in blue.

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Gaming Adaptation: Using Role-Play Simulation Exercises to Help Decision Makers and Other Stakeholders Enhance Their Resilience

Todd Schenk, Virginia Tech

IPSS: A Systems-Level Decision Support Tool for Actionable Climate Change Resilience Planning

Xavier Espinet and Amy Schweikert, Resilient Analytics; Paul Chinowsky, University of Colorado, Boulder

Dynamic Learning Process for Selecting Storm Protection Investments

Raymond Chan, Joseph L. Schofer, and Pablo L. Durango-Cohen, Northwestern University

Breakout 2

Designing Back to the Future: Looking at the Past and Turning Towards the Future, NAS 125

Brian Beucler, FHWA, *presiding*

This session focuses on the development of technical guidance and procedures for incorporating climate information into project designs. Engineers traditionally have looked at past recorded data to perform designs and are now being asked to incorporate climate information into future projections.

Incorporating Climate Change, Risk, and Resilience into Hydrologic Design Procedures for Transportation Infrastructure

Roger Kilgore, Kilgore Consulting and Management; George Herrmann and David Thompson, RO Anderson Engineering, Inc.; Wilbert Thomas, Michael Baker Jr., Inc.; Brian Beucler, Robert Kafalenos, Joe Krolak, and Cynthia Nurmi, FHWA

Assessing Vulnerability of Iowa's Highway Infrastructure to Climate Change and Stream Hydrology for Implementation of Resiliency and Hydraulic Design Practices

David Claman, Iowa Department of Transportation (DOT)

The Engineering Assessment Process Used in the Gulf Coast Study, Phase 2

Chris Dorney, Jake Keller, and Justin Lennon, WSP | Parsons Brinckerhoff; Anne Choate, Brenda Dix, and Beth Rodehorst, ICF International

Climate Resilience Guidelines for Transportation Infrastructure

Peter Adams and Susanne DesRoches, Port Authority of New York and New Jersey

Breakout 3

Floods Stop Traffic, DOTs Implement Management Strategies, NAS 120

Paul Pisano, FHWA, *presiding*

The impacts of flooding on infrastructure are well-studied and are a big part of climate resilience efforts. Less well-studied are the more frequent impacts of flooding on operations and maintenance, as well as the role that maintenance plays in reducing these impacts. This session examines these impacts and actions that can minimize them.

Robustness of Roads During a Flooding

Thomas Bles, Dirk Pereboom, Ruud Stoevelaar, and Wim Post, Deltares; Kees van Muiswinkel, Rijkswaterstaat

Assessment of Flood-Induced Damage in Hot-Mix Asphalt Pavements

Rajib Mallick, Worcester Polytechnic Institute; Leslie McCarthy, Villanova University; Jo Daniel and Jennifer Jacobs, University of New Hampshire

Presenters are shown in blue.



Resilience in Operations and Maintenance Activities: Lessons Learned from a Case Study of Pluvial Flooding in Norrala Railway Tunnel in Sweden, 2013

Monika Rydstedt Nyman and Magnus Johansson, Karlstad University; Eva Liljegren, Swedish National Transport Administration

Vulnerability Assessment of Critical Transportation Networks in Response to Extreme Precipitation Events: A Case Study of the 2013 Colorado Floods

Melissa Allen, Wei Lu, and Dale Kaiser, Oak Ridge National Laboratory

Breakout 4

Building Climate Resilience in Developing Countries, *Lecture Room*

Joshua DeFlorio, Cambridge Systematics, *presiding*

How can developing countries incorporate climate change considerations into the early stages of infrastructure development, despite the added challenges of limited financial resources and high levels of vulnerability to extreme weather events such as tropical storms? This session will highlight the strategies that several countries are exploring to build resilience to climate change.

The Costs and Benefits of Climate-Resilient Roads in the Philippines

Ben Campbell, Douglas Mason, and Yohannes Abebe, Millennium Challenge Corporation

Successful Strategies to Build Climate Resilience in Developing Cities

Joanne Potter, ICF International; John Furlow, Office of Global Change, U.S. Department of State

Adapting Road Infrastructure for Climate Change and Extreme Weather Events: Experience from Small Pacific Island States

Habiba Gitay, Asif Faiz, Sean Michaels, Christopher Bennett, Oliver Whalley, and Megan Schlotjes, World Bank

3:00 p.m.–3:30 p.m., *Great Hall*

Break

3:30 p.m.–5:00 p.m.

Breakout Sessions

Breakout 5

Resilient Freight Systems and Ports, *Auditorium*

Mark Abkowitz, Vanderbilt University, *presiding*

Presenters factor resilience into port and waterway investments and operations in response to climate change and extreme weather events.

Monitoring Airport Resilience to Climate Change and Extreme Weather Events: Developing a Prototype Resilience Index

Thomas Budd and Keith Mason, Cranfield University

Climate Risk and Adaptation Assessment of Port Investments

Amanda Rycerz and Richenda Connell, Acclimatise

Resilience Planning and Implementation at Massachusetts Port Authority

Robbin Peach, Massachusetts Port Authority

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Climate Change and Inland Waterways Operations: Experience of a U.S. Marine Carrier and Impacts on Other Modes

Craig Philip, Vanderbilt University

Breakout 6

Decisions, Decisions, Decisions: Vulnerability and Risk, NAS 125

Steve Miller, Massachusetts DOT, *presiding*

In this session, specific assets are analyzed for vulnerability and risk to inform decisions on resilient future solutions. Decisions are made throughout the project life cycle, from the planning and National Environmental Policy Act process to design and construction.

Analysis of Historical Streamflow Conditions Inducing Bridge Failures in the Continental United States for Validation of Climate Change Impact Assessments

Madeleine Flint, Stanford University and Virginia Tech; Sarah Billington, Noah Diffenbaugh, David Freyberg, and Oliver Fringer, Stanford University

Considering Hazard Risk and Uncertainty for Infrastructure Decisions at the Project Level

Sue McNeil, University of Delaware; Erik Archibald, Applied Research Associates

Case Study of Bridge Hurricane Vulnerability and Resilience Retrofit Planning Considering Varying Sea-Level Rise Predictions

Brian Joyner, Walter Kemmsies, and Eric Vugteveen, Moffatt & Nichol

Considering the Climate Impacts on and Environmental Impacts of Infrastructure Projects in Developing Countries

Dana Spindler, Michael Savonis, and Angela Wong, ICF International; Thuy Phung, USAID

Breakout 7

Weather and Climate: Different Sides of the Same Coin, NAS 120

Kathy Ahlenius, Wyoming DOT, *presiding*

Though day-to-day weather may not be an indicator of changes in the climate, the two are inextricably linked. Explored in this session are the tools and strategies used to manage these day-to-day impacts on the surface transportation system and that can address climate challenges.

Coordinated Transit Response Planning and Operations Support Tools for Mitigating Impacts of All-Hazard Emergency Events

Vadim Sokolov, Joshua Auld, and Hubert Ley, Argonne National Laboratory; Michael Bolton, Pace Suburban Bus

Climate Change and Sustainability: Operational Adaptation Guide

Laurel Radow and Paul Pisano, FHWA

Use of a Road Surface Model within the National Weather Service

Chris Gibson, Jonathan Rutz, and Chad Kahler, National Weather Service

Road Weather Information Systems and Connected Vehicle Data for the Mitigation of Extreme Weather Impacts

Ralph Patterson, Narwhal Group; Paul Pisano, FHWA

Presenters are shown in blue.



Breakout 8

Building Climate Resilience in Europe and North America, Lecture Room

Jeff Perlman, NJTPA, *presiding*

Europe and North America face similar problems when it comes to adapting to climate change. This session presents examples from both sides of the pond that are the results of recent initiatives and cooperative efforts to achieve a common goal: transportation system resilience.

Approaches and Case Studies in Transportation Resilience at a Local, State, National, and International Level

John Chow, Jake Keller, Hal Kassoff, and Michael Flood, WSP | Parsons Brinckerhoff

Adapting Roads to Climate Change: The ROADAPT Project

Thomas Bles and Arjan Venmans, Deltares; Janette Bessembinder, Royal Netherlands Meteorological Institute; Martial Chevreuil, Egis; Per Danielsson, Swedish Geotechnical Institute; Stefan Falemo, ÅF

Joint FHWA–Rijkswaterstaat Report on Resilient Infrastructure: Assessing Vulnerabilities and Risks and Incorporating the Results into Planning, Design, and Asset Management

Kees van Muiswinkel and Onno Tool, Rijkswaterstaat; Michael Culp, Tina Hodges, and Rob Kafalenos, FHWA

Norwegian Roads Adapting to Climate Change

Gordana Petkovic, Tore Humstad, and Bjørn Dolva, Norwegian Public Roads Administration

POSTERS

5:00 p.m.–7:00 p.m., *Great Hall* and West Court

Poster Session and Reception

Analysis of Decisions Related to Extreme Weather: A Decision Tool for the Specific Case of Transit Station Canopy Investment

Eric Welch, Arizona State University; P.S. Sriraj and Yun An Chou, University of Illinois, Chicago

Assessment of Flood Risk Under Climate Change Condition

Paul Chan and Peter Kokopeli, Climate Decision, LLC

Closing the Gap Between Climate Science and Project-Level Adaptation Needs

Beth Rodehorst, Rawlings Miller, Cassandra Bhat, and Anne Choate, ICF International; Robert Kafalenos, Brian Beucler, and Rob Hyman, FHWA

Decision-Making Tool for Assessment of Flooded Pavements

Ricardo Medina, Paul Kirshen, and Jo Daniel, University of New Hampshire

Development of Flood Mitigation Measures for Existing Transit Network: A Case Study of New York City Transit Projects

David Kinskey-Lebeda, Dennis Lowenwirth, and Timothy Savery, Arup

Flood Hazard Mapping Along Roads: Methods, Theory, and Practice

Zahra Kalantari and Steve Lyon, Stockholm University

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Linking System Resiliency to Transportation Planning and Decision Making: Lessons from Recent Studies

Michael Meyer, Michael Flood, and Christopher Dorney, WSP | Parsons Brinckerhoff

Michigan DOT Climate Vulnerability Assessment

Niles Annelin, Michigan DOT; Rachael Tupica, FHWA

Public Transit Reliability and Urban Accessibility to Cooling Centers During Extreme Heat Events

Andrew Fraser and Mikhail Chester, Arizona State University

Resilience in Rapid Airfield Pavement Repair Methods in Sustained Cold-Weather Environments

Lulu Edwards, Haley Bell, William Carruth, and Jeb Tingle, U.S. Army Engineer Research and Development Center

The Role of Transport Information in Extreme Weather Events

William Brazil, Brian Caulfield, and Alan O'Connor, Trinity College, Dublin

Scenario Planning for Sustainability and Resilience: Central New Mexico as a National Example

Benjamin Rasmussen, Volpe National Transportation Systems Center; Tina Hodges, FHWA; Aaron Sussman, Mid-Region Council of Governments

Selecting Physical Adaptation Strategies that Protect Critical Transportation Corridors While Integrating with the Natural Landscape and Providing Regional Co-Benefits

Stefanie Hom, Metropolitan Transportation Commission; Dick Fahey, Caltrans; Kris May, AECOM

Using Readily Available Climate Change Projection and Extreme Weather Data in Long-Range Transportation Planning

John Patrick O'Har and Michael Meyer, WSP | Parsons Brinckerhoff

Thursday, September 17

8:00 a.m.–4:00 p.m., *Great Hall*

Registration

8:00 a.m.–9:00 a.m., *Great Hall*

Networking Coffee and Pastries

9:00 a.m.–10:30 a.m., *Auditorium*

Plenary Session

Transportation Resilience Policy

Vicki Arroyo, Georgetown Climate Center, *presiding*

This panel discussion will include representatives and policy makers from the Council on Environmental Quality, FHWA, the Federal Transit Administration (FTA), and a state department of transportation.

Jainey Bavishi, White House Council on Environmental Quality

Michael Lewis, Colorado DOT

Ellen Partridge, FTA

Michael Culp, FHWA

10:30 a.m.–10:45 a.m., *Great Hall*

Break

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10:45 a.m.–12:15 p.m.

Breakout Sessions

Breakout 9

Highway Systems Planning, Auditorium

Ben Rasmussen, Volpe National Transportation Systems Center, *presiding*

Changing climate and extreme weather have very different impacts on infrastructure, whether flooding is from sea-level rise, from surface runoff, or from changing air temperature and rainfall. Presented are tools and procedures for infrastructure planning for climate impacts in different parts of the world.

Working Toward Climate Resilient Highway Infrastructure in the Netherlands

Kees van Muiswinkel and Paul Fortuin, Rijkswaterstaat

Risk Mapping Major Danish Roads with Blue Spot Identifications: Implementing Results Organizationwide with an Interdisciplinary Approach

Marianne Grauert and Christian Axelsen, Danish Road Directorate

Risk Analysis for the Adaptation of the German Road Network to Climate Change

Beata Krieger and Jürgen Krieger, Federal Highway Research Institute of Germany; Susanne Mayer, Alfen Consult GmbH

Resiliency Planning at Caltrans

Julia Biggar and Garth Hopkins, Caltrans

Breakout 10

Adapting to Uncertainty, NAS 125

Jake Keller, WSP | Parsons Brinckerhoff, *presiding*

These presentations describe ways to make decisions that account for the uncertainty of the future and how to plan, prioritize, and adapt transportation assets to the effects of climate change.

Increasing Resilience in Transportation Projects Through Robust and No-Regret Decision Making

Xavier Espinet and Amy Schweikert, Resilient Analytics; Paul Chinowsky, University of Colorado, Boulder

A Case Study Approach for Engineering and Economic Analysis for Climate Change Adaptation: Alaska's Dalton Highway

Amit Armstrong, FHWA; Michael Flood, Elias Schecker Da Silva, Isabella Bejarano, and Michael Meyer, WSP | Parsons Brinckerhoff

NJ TRANSITGRID: Microgrid Technology as the Cornerstone of a Transportation Resilience Strategy

Eric Daleo and Steven Santoro, New Jersey Transit; Rima Oueid, U.S. Department of Energy

Arizona DOT: Mainstreaming Climate Change and Extreme Weather Resilience

Steven Olmsted, Arizona DOT

Breakout 11

Developing Climate Information for Use by Engineers and Planners, NAS 120

Robert Kafalenos, FHWA, *presiding*

This session focuses on examples of climate projections, information, and tools developed for use by planners and engineers.

Presenters are shown in blue.

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Climate Products for Engineers

Ellen Mecray, NOAA; Cameron Wake, Paul Kirshen, Jo Daniel, Jennifer Jacobs, University of New Hampshire; Katharine Hayhoe and Anne Stoner, Texas Tech University; Bruce Anderson, Boston University; Ellen Douglas, University of Massachusetts, Boston

Future Projections of Infrastructure-Relevant Climate Indices for Washington, D.C.

Anne Stoner and Katharine Hayhoe, Texas Tech University

European Guidelines for the Use of Climate Data for Road Infrastructure: ROADAPT and CliPDaR

Thomas Bles, Deltares; Janette Bessembinder, KNMI; Joachim Namyslo, DWD; Christoph Matulla, ZAMG

Breakout 12

Approaches and Tools for State and Regional Analyses, Board Room (overflow room, NAS 118)

Bob Noland, Rutgers University, *presiding*

This session will highlight innovative tools and approaches for considering the potential impacts of climate change and extreme weather events at the state and regional level.

Vulnerability Assessment of the Maryland State Highway Network

Elizabeth Habic and Michael Sheffer, Maryland State Highway Administration

Evaluating the Vulnerability of Transportation Infrastructure to Extreme Weather Events: A Regional Approach

Leah Dundon and Mark Abkowitz, Vanderbilt University; Alan Jones, Tennessee DOT

In the Wake of Hurricane Sandy: Creating a More Resilient Regional Transportation System in New York, New Jersey, and Connecticut

Jeff Perlman, NJTPA; Joshua DeFlorio, Cambridge Systematics

A Robust and Open-Source Climate Change Analysis Tool for Scenario-Based Planning

Alexander Epstein, Benjamin Rasmussen, and Christopher Cutler, Volpe, U.S. DOT

12:15 p.m.–1:30 p.m., *Great Hall*

Lunch

1:30 p.m.–3:00 p.m.

Breakout Sessions

Breakout 13

Mainstreaming Climate Resilience in Transportation Infrastructure Around the World, Auditorium

Allison Yeh, Hillsborough County Metropolitan Planning Organization (MPO), *presiding*

Examples from cities in Mozambique, Peru, the Dominican Republic, Sweden, and the United States illustrate adaptation techniques used to evaluate and integrate climate vulnerability considerations into the planning and prioritization processes of transportation agencies and municipalities.

Flexible Approaches to Climate Vulnerability Assessment for Urban Public Infrastructure

Joanne Potter, Christopher Evans, Judsen Bruzgul, Molly Hellmuth, Charlotte Mack, Michael Savonis, John Snyder, and Angela Wong, ICF International

Presenters are shown in blue.



Transit System Resilience Building Through Prioritization, Institutionalization, and Implementation of Identified Climate Adaptation Options

Andrea Martin and Nora Ferm, Cascadia Consulting Group

From Frameworks to Action: How Three Transportation Agencies Are Integrating Climate Resilience into their Operations

Claire Bonham-Carter, AECOM; Cris Liban, LA Metro; Tian Feng and Norman Wong, San Francisco Bay Area Rapid Transit District

Combining Risk Identification Methods to Prevent Roads and Railways in Sweden from Suffering from Increased Risk Due to Climate Change

Eva Liljegren, Swedish Transport Administration; Monika Nyman Rydstedt, Karlstad University

Breakout 14

Green and Gray Infrastructure and Climate Resilience, NAS 125

Michael Meyer, WSP | Parsons Brinckerhoff, *presiding*

These presentations will demonstrate the effectiveness of “green” infrastructure as one tool for adapting to the impacts of climate change and will provide suggestions of ways that transportation departments can develop a standardized approach to assessing culvert vulnerability—the “gray.”

Green Infrastructure and Transportation System Resilience

Sara Hoverter and Matthew Goetz, Georgetown Climate Center

Culvert Vulnerability and Prioritization: Reconciling Currently Available Approaches and Data

Thomas Wall, Argonne National Laboratory; Adjo Amekudzi-Kennedy, Georgia Institute of Technology

Prevention Is Better than Cure: Bioengineering Applications for Climate Resilient Slope Stabilization of Transport Infrastructure Assets

Asif Faiz, World Bank; Aysha Faiz, Faiz and Associates, LLC; Bashir Hussain Shah, National Highway Authority, Pakistan

Steady Habits (Culverts): Anticipating Increased Precipitation in the Litchfield Hills of Connecticut

Stephanie Molden, Connecticut DOT

Breakout 15

Development and Application of Derived and Extreme Climate Variables at the Regional Level, NAS 120

Jeff Arnold, U.S. Army Corps of Engineers, *presiding*

This session explores the techniques and challenges associated with applying global climate model information to various localities faced with specific climate stressors.

Extreme Weather Exposure Identification for the Primary Road Network in the Alpine Region

Matthias Schlögl, Christian Stefan, and Michael Aleksa, Austrian Institute of Technology; Gregor Laaha, University of Natural Resources and Life Sciences, Vienna

Developing Transportation-Relevant Historical Trends and Future Climate Projections for Decision Support in the South Central United States

Esther Mullens, Renee McPherson, and Derek Rosendahl, South Central Climate Science Center; Carlos Gaitan, Geophysical Fluid Dynamics Lab and South Central Climate Science Center

Presenters are shown in blue.

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A Process for Efficient, Scientifically Informed Climate Data Downscaling for Large-Scale Resilience Assessments: The Arizona DOT Approach

Steven Olmsted, Arizona DOT, and Timothy Grose and Joshua DeFlorio, Cambridge Systematics

Exploration of Climate Change Impacts: Modeling Projections of Extreme Events

Lorenzo Cornejo, Rafael Aldrete, and Edwin Varela, Texas A&M Transportation Institute

Breakout 16

Vulnerability Assessment and Adaptation: Tools and Guides, Board Room (overflow room, NAS 118)

Robert Hyman, FHWA, *presiding*

This session explores tools and guides for climate risk assessment developed for use in multiple countries and contexts.

Climate and Disaster Risk Screening Tool for Roads

Kanta Rigaud and Ana Bucher, World Bank; Angela Wong, Michael Savonis, and Peter Schultz, ICF International

FHWA Vulnerability Assessment Tools

Cassandra Bhat, Beth Rodehorst, and Anne Choate, ICF International; Robert Hyman, Robert Kafalenos, and Brian Beucler, FHWA

A Quicksan for Risks to Roads in a Changing Climate

Thomas Bles and Mike Woning, Deltares

Toward Sustainable and Resilient Pavement Systems

Thomas Van Dam, NCE

3:00 p.m.–3:30 p.m., *Great Hall*

Break

3:30 p.m.–5:00 p.m.

Breakout Sessions

Breakout 17

Asset Management: Strengthening the Operations and Maintenance Connection, Auditorium

Laurel Radow, FHWA, *presiding*

While traditional transportation asset management programs tend to focus on optimizing infrastructure assets, efforts to broaden the scope to operations and maintenance are under way. This session examines the intersection of these two areas within the context of climate resilience.

Incorporating Climate Change Impact Risks into Transportation Infrastructure Asset Management

Constantine Samaras, Lauren Cook, and Thiago A. Rodrigues, Carnegie Mellon University

Using Asset Management Systems as a Platform for Continual Adaptation Planning

Michael Meyer and Michael Flood, WSP | Parsons Brinckerhoff

Projected Impact of Climate Change on Frost–Thaw Profiles Beneath Roadways in Northern Maine

Heather Miller, Ashley Thomas, and Benjamin Mitsmenn, University of Massachusetts, Dartmouth; Anne Stoner, Texas Tech University; Jennifer Jacobs, Jo Daniel, Lee Friess, Cameron Wake, and Jillian Crowley, University of New Hampshire

Presenters are shown in blue.



Emergency Management and Resilience in Transportation

Herby Lissade, Caltrans

Breakout 18

Cooperation and Peer Learning Across Cities, Regions, and Countries, NAS 125

Kees Van Muiswinkel, Rijkswaterstaat, *presiding*

The challenges of extreme weather and changing climate do not follow jurisdictional boundaries. This session explores efficient ways to meet the challenge: the sharing of knowledge and the integration of activities across political boundaries at all levels.

The Infrastructure and Climate Network: Lessons from a Regional Collaborative

Jennifer Jacobs, Jo Daniel, Paul Kirshen, and Lee Friess, University of New Hampshire; Gina Campoli, Vermont Agency of Transportation; Rajib Mallick, Worcester Polytechnic Institute; Ellen Mecray, NOAA; Katharine Hayhoe, Texas Tech University; Linda Silka, University of Maine; Heather Miller, University of Massachusetts, Dartmouth

Peer Learning Across Developing Cities

Wendy Jaglom and Joanne Potter, ICF International

The Engineering for Climate Extremes Partnership

Mari Tye and Greg Holland, National Center for Atmospheric Research

Cross-Border Cooperation on Adaptation Strategies for Roads in Europe

Marianne Grauert, Danish Road Directorate

Breakout 19

Developing and Applying Future Precipitation and Flows: Dealing with Uncertainty, NAS 120

Brian Beucler, FHWA, *presiding*

This session looks at the challenges and limitations of working with downscaled precipitation data, the conversion of precipitation to flow, and the well-informed decisions that consider a range of future hydrologic scenarios.

Incorporating Climate Data and Uncertainty into Stormwater Management Design Decisions for Transportation Infrastructure

Lauren Cook and Constantine Samaras, Carnegie Mellon University

Framework for Determining Suitable and Credible Climate Information for Hydraulic Adaptation Design

Christopher Anderson, Iowa State University; Ricardo Mantilla and Felipe Quintero, University of Iowa; David Claman, Iowa DOT

Incorporating Climate Projections into Design Metrics with Uncertainty Bounds

Ricardo Mantilla and Felipe Quintero, University of Iowa; Christopher Anderson, Iowa State University; David Claman, Iowa DOT

Breakout 20

Sea-Level Rise, Storm Surge, and Flooding Tools from Coast to Coast, Board Room (overflow room, NAS 118)

Adam Schildge, FTA, *presiding*

Presenters are shown in blue.

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This session will provide an overview of some of the innovative tools and technologies being used to model, map, and manage sea-level rise and storm surge risks across the United States.

Sea-Level Rise Inundation Mapping and Shoreline Vulnerability Analysis for California SR- 37

Justin Vandever and Kris May, AECOM; Fraser Shilling, University of California, Davis; Ina Gerhard, Caltrans

The Sea-Level Scenario Sketch Planning Tool: A Planning Tool for Assessing At-Risk Transportation Infrastructure

Crystal Goodison, Alexis Thomas, Russell Watkins, and Reginald Pierre-Jean, University of Florida GeoPlan Center; Maria Cahill, Florida DOT

Use of Innovative Technology to Identify Flood Vulnerabilities and Mobilize Response for New York City Transit

David Kinskey-Lebeda and Christopher Taylor, Arup

State-of-the-Art Flood Modeling: World Trade Center Water Intrusion Protection Plan

Mark Osler, Anna Lantin, Tom Ryan, and Mujahid Chandoo, Michael Baker International

5:00 p.m.–6:00 p.m., *NAS Auditorium*

Roundtable Discussion

Lessons Learned from Recent Climate Change Adaptation Pilot Projects and Initiatives

Rebecca Lupes, FHWA, *presiding*

Friday, September 18

8:00 a.m.–11:00 a.m., *Great Hall*

Registration

8:00 a.m.–9:00 a.m., *Great Hall*

Networking Coffee and Pastries

9:00 a.m.–10:15 a.m.

Breakout Sessions

Breakout 21

Asset Management, Auditorium

Michael Savonis, ICF International, *presiding*

Transportation practitioners are finding effective ways to include extreme weather risks into their asset management systems. This session provides examples from Canada to Florida on practical and successful ways to adapt asset management systems to address extreme weather risk.

Geotechnical Asset Management for Improved Highway Resilience in Alaska

Paul Thompson, Consultant; Mark Vessely, Shannon and Wilson, Inc.; Darren Beckstrand, Landslide Technology, Inc.; David Stanley, Stanley Consulting; Barry Benko, Alaska Department of Transportation and Public Facilities

The Resilience of Ontario Highway Drainage Infrastructure to Climate Change

Hani Farghaly and Carolina Cautillo, Ministry of Transportation Ontario; Reenste Filler and Dorothy Poon, University of Waterloo

Presenters are shown in blue.



Incorporating Climate Change Adaptation into Routine Bridge Preservation Decision Making at Florida DOT

Paul Thompson, Consultant; John Sobanjo, Florida State University; Richard Kerr, Florida DOT

Breakout 22

Two Case Studies: Big and Wicked Big, NAS 125

Ellen Mecray, NOAA, *presiding*

This session will provide an in-depth examination of two large climate vulnerability assessment projects on sea-level rise and storm surge effects on the Stamford Hurricane Barrier in Connecticut and the Central Artery Tunnel in Boston, Massachusetts. These projects push the state of practice in employing advanced coastal modeling and time-dependent scenario decision making.

Climate Vulnerability Assessment for a Water Resources Infrastructure Project

Patrick O'Brien, Kathleen White, and Hans Moritz, U.S. Army Corps of Engineers

Storm Surge Risk Modeling in a Changing Climate: Assessing Impacts to Key Transportation Assets of the Central Artery System in Boston, Massachusetts

Kirk Bosma, Woods Hole Group, Inc.; Ellen Douglas and Chris Watson, University of Massachusetts, Boston; Paul Kirshen, University of New Hampshire; Steven Miller, Massachusetts DOT

A Detailed Assessment of Climate Change Vulnerability and Adaptation Options for the Central Artery–Tunnel System in Boston, Massachusetts: The Good, the Bad, and the Wicked Difficult

Ellen Douglas and Chris Watson, University of Massachusetts, Boston; Steven Miller and Katherin McArthur, Massachusetts DOT; Kirk Bosma, Woods Hole Group, Inc.; Paul Kirshen, University of New Hampshire

Breakout 23

Benefit–Cost Analysis Tools and Methods for Adaptation Planning and Resilience, Board Room (overflow room, NAS 118)

Adam Stephenson, FTA, *presiding*

This session will explore benefit–cost analysis tools and approaches that transportation agencies are using to incorporate climate and extreme weather risks in their planning, design, and investment decisions.

Incorporating Benefit–Cost Analysis Approaches into Adaptation Planning: Approaches and Applications from Recent Studies

Michael Flood, Elias Scheker Da Silva, Chris Dorney, and Michael Meyer, WSP | Parsons Brinckerhoff

A Dynamic Restricted Equilibrium Model to Evaluate the Traffic Network Resilience Under Extreme Weather Events

Beatriz Martinez-Pastor, Maria Nogal, Alan O'Connor, and Brian Caulfield, Trinity College Dublin

Risk and Resilience Methodology to Analyze Design Alternatives to Reduce Risk and Improve Resilience

Aimee Flannery and Maria Pena, Applied Engineering Management Corporation

FTA Hazard Mitigation Cost Effectiveness Tool and Flood Recurrence Interval Calculator for Benefit–Cost Analysis of Transit Resilience

John Squerciati and Kaveh Zomorodi, Dewberry; Adam Schildge, FTA

Presenters are shown in blue.

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Breakout 24

Integrating Transportation System Resilience at the Local, State, and TRB Level, NAS 120

Heather Holsinger, FHWA, *presiding*

This session will explore how transportation system resilience to climate change and extreme weather events can align with climate adaptation efforts in other sectors—at both the local and state level—as well as broader resilience initiatives.

New Transportation Research Board Transportation System Resilience Section

Tom Wakeman, Stevens Institute of Technology; Brian Wolshon, Louisiana State University; John Contestabile, Johns Hopkins University; Anne Strauss-Wieder, NJTPA; Jeffrey Western, Jeffrey Western Consulting; Craig Philip, Vanderbilt University

Evaluating Urban Resilience to Climate Change Across Transportation and Seven Additional Sectors: Washington, D.C., Case Study

Julie Blue, Emily Seyller, and Nupur Hiremath, The Cadmus Group, Inc.; Susan Julius, U.S. Environmental Protection Agency

Successes in Transportation System Resilience Through Statewide Adaptation Planning

Vicki Arroyo, Annie Bennett, and Jessica Grannis, Georgetown Climate Center

10:15 a.m.–10:30 a.m., *Great Hall*

Break

10:30 a.m.–11:45 a.m.

Breakout Sessions

Breakout 25

Crisis Management Planning, Auditorium

Ben McFarlane, Hampton Roads Planning Commission, *presiding*

Effective crisis management can help transportation agencies prepare for extreme weather events and respond to them effectively as they occur. This session will provide examples of how transportation agencies can identify and assess vulnerabilities, develop policies to improve resilience, and implement practices to reduce the impacts of extreme weather events on surface transportation infrastructure.

Minnesota DOT Flash-Flood Vulnerability and Adaptation Assessment Pilot Project

Bryan Anderson and Philip Schaffner, Minnesota DOT

Crisis Management of Unusually Severe or Sustained Snow Events

Gabriel Guevara, FHWA; Stewart Leggett, Transport Scotland

NJ Transit Incorporates Resilience into Planning, Engineering, and Emergency Management Processes

Ayesha Dolasa, BEM Systems, and John Geitner, NJ Transit

Transportation System Disaster Response: Resilience Planning and Implementation

Vince Sobash, Pete Hankovszky, and Warren Meyers, David Evans and Associates, Inc.; John Susino, FTA; Mike Marino, Port Authority Trans-Hudson Corporation

Presenters are shown in blue.



Breakout 26

International and Regional Frameworks for Adaptation and Resilience, NAS 125

Annie Bennett, Georgetown Climate Center, *presiding*

Several methods and frameworks can assess vulnerability and can take adaptation measures all over the world. Three interesting examples of these are explored in this session, presenting perspectives from the international to the corridor level.

An International Climate Change Adaptation Framework for Road Infrastructure

April Marchese, FHWA; Caroline Toplis, AECOM; Robin Sebille, World Road Association; Helen Murphy, VicRoads; Stephen Thomas, Transport Scotland; Cristina Maruntu, National Professional Association of Roads and Bridges, Romania

North Atlantic Coast Comprehensive Study: Applicability to Regional Adaptation Planning

Amy Guise, Roselle Henn, Joseph Vietri, and Naomi Fraenkel, U.S. Army Corps of Engineers

The String of Pearls: Balancing Risk and Benefits of Considering Resiliency by Corridor or Asset

Judy Gates, Maine DOT, and Sam Merrill, GEI Consultants, Inc.

Breakout 27

Integrating Resilience into Existing Management Tools, NAS 120

Rebecca Lupes, FHWA, *presiding*

This session will highlight approaches to integrating climate change and extreme weather resilience into existing management tools, from planning to asset management and operations.

Applying the Sea-Level Scenario Sketch Planning Tool to Enhance the Resilience of Long-Range Transportation Plans: Lessons Learned from Two Florida MPOs

Joshua DeFlorio, Cambridge Systematics; James Cromar, Broward MPO; Crystal Goodison, University of Florida GeoPlan Center; and Allison Yeh, Hillsborough County MPO; and Maria Cahill, Florida DOT

The Long and Short of It: Climate Change for Asset Managers

Srirama Bhamidipati, Telli van der Lei, Paulien Herder, and Emile Chappin, Delft University of Technology, Netherlands; Kees van Muiswinkel, Rijkswaterstaat

Using Park and Refuge Asset Management Systems to Screen for Extreme Weather Vulnerability

Susan Asam and Cassandra Bhat, ICF International; Shawn Norton and Bryce Lloyd, National Park Service; Aung Gye and Lewis Grimm, FHWA; Steve Suder, U.S. Fish and Wildlife Service

Enhancing System Operations Through Improved Reliability & Resiliency of Traffic Signals in an Urban Environment

Soumya Dey, Harvey Alexander, Benito Perez, and Rahul Jain, District DOT; Michael Keatley, M.C. Dean, Inc.

11:45 a.m.–12:30 p.m., *Great Hall*

Lunch

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12:30 p.m.–2:30 p.m., *Auditorium*
Closing Plenary Session
Bringing It All Together
Michael Culp, FHWA, *presiding*

In this closing session, speakers from the Netherlands and Massachusetts DOT will draw linkages between the state-of-the-art research and practices presented during the conference and their implementation in their own agencies and communities.

Steve Miller, Massachusetts Department of Transportation
Kees van Muiswinkel, Rijkswaterstaat

What We Heard and Next Steps
Michael Culp, FHWA, *presiding*

Members of the Conference Planning Committee will present a summary of the key findings, initiatives, and ideas brought forward during the conference. Conference participants will be invited to join a facilitated discussion on potential next steps.

Elizabeth Habic, Maryland State Highway Administration
Kathy Ahlenius, Wyoming DOT
Ellen Mecray, NOAA
Robert Kafalenos, FHWA
Michael Savonis, ICF International
Adam Schildge, FTA



Transportation Research Board 95th Annual Meeting

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The program will cover *all* transportation modes, with 5,000 presentations in nearly 750 sessions and specialty workshops, addressing topics of interest to policy makers, administrators, practitioners, researchers, and representatives of government, industry, and academic institutions.

Also, many sessions and workshops will focus on the spotlight theme for the 2016 meeting, *“Research Convergence for a Multimodal Future.”* The full program will be available online in November 2015.

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