Transportation Resilience: Adaptation to Climate Change and Extreme Weather Events

Summary of 4th EU-US Symposium on Transportation Research

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Chairman of the Symposium Planning Committee

TRB Executive Policy Committee meeting
January 2017
Adaptation of Transportation Systems to Climate Change

Already an Extensive Literature
Specialisms, Transport Modes and Countries Represented at the Symposium

**Subjects**
- Climate science
- Civil engineering
- Transport planning
- Risk analysis
- Economics
- Decision theory
- Logistics
- Insurance
- Hydrology
- Coastal adaptation
- Public policy
- Infrastructure design, construction, maintenance and management

**Transport modes**
- Highways
- Aviation
- Rail
- Ports
- Public transit
- Shipping
- Inland waterways

- United States
- 14 European countries
Symposium Program

Keynote addresses:
Jan Hendrik Dronkers, *Rijkwaterstaat*
Donald Wuebbles, *University of Illinois / White House*

White Paper: Gerry Schwartz and Lori Tavasszy

Chronology of weather-related transport disruptions: 3 case studies

**Preparatory phase**
- Gordana Petkovic
- Jeff Western / Sam Merrill
- Sea-Level Rise

**Disruption phase**
- Jennifer Jacobs
- Andre van Lammeren
- Flooding

**Recovery phase**
- Michael Meyer
- Alan O’Connor
- Extreme Heat

Plenaries
Break-out
Panel discussion

Rapporteur
Katie Turnbull

Potential portfolio of EU-US research
38 research topics
Strong Dutch presence at the Symposium: for good reason…

Snelwegen bij een evacuatie (highways for evacuation)

Dreiging zee (flood risk from sea)

Dreiging rivieren (flood risk from rivers)
Essence of Climate Change Adaptation in the Transportation Sector

Climate Changes
- Extreme precipitation
- Rising sea levels
- Temperature spikes

Impacts on Transportation
- Roadway flooding
- Damage to or destruction of bridges
- Pavement and rail buckling
- Subway flooding
- Seaport and airport flooding
- Slope failures
- Curtailment of barge operations

Consequences
- Freight traffic disrupted for days or weeks
- Power plants, water facilities, homes, businesses, hospitals cut off
- Passenger travel delays
- Higher transportation costs for government, businesses, and households
- Evacuation of urban areas

Adaptive Strategies to Reduce Impacts
- Retrofit facilities
- Relocate facilities
- Upgrade stormwater drainage facilities
- Build new facilities to climate-ready standards
- Protect existing infrastructure
- Incorporate climate change into maintenance cycles

Adaptive Strategies to Reduce Consequences
- Reroute freight and passenger flows
- Shift to alternative modes
- Land use regulations relating to development in vulnerable areas
- Evacuation and contingency strategies
- Building in network flexibility
- Traveler information systems
- Rapid rebuilding of damaged facilities
- Improved air traffic management

Where do you draw the boundary around the wider socio-economic consequences?

EU EWENT project estimated cost of extreme weather on the transport system of the EU 27 in 2010: €15.5-21.5 bn
Analysing and planning for extreme weather event is inherently difficult

- By definition, extreme events occur rarely; frequency based on historical records
- Rare occurrence makes datasets small and sparse
- Extremes are hard to measure - *instrumentation often performs poorly under extreme conditions*
- Processes that generate extremes are highly complex and difficult to model.

Jennifer Jacobs.

**5 dimensions of extreme weather**

- Frequency
- Intensity
- Duration
- Spatial extent
- Timing

Source: IPCC SREX (2011)
Translating Climate Science Data into Useful Information for Transport Planning

Geographical downscaling of climate data

Incorporating downscaled climate data into transport engineering models

Relaxing ‘stationarity’ assumptions

- Can no longer extrapolate from historic data
- Rate of climate change accelerating – need regular recalibration
- Trends may prove non-linear if ‘tipping points’ are crossed

Cornell University
EU Rain project

Intensity Duration Frequency Curves: 100-yr Return Period
RCF 8.5 Projection 2040-2069 vs. Observed (1970-1999)

Rates of climate change accelerating – need regular recalibration

Transport Planning process

Varying time-scales for transport decision-making
Risk Assessments, Stress Tests and Benefit-Cost Analyses (BCA)

Integrating climate risk assessment into the management of transportation assets

New BCA methodologies with risk-adjusted discounted rates and life-cycle costing of transport assets

Determining the ‘right’ level of transportation resilience

Measuring and benchmarking the relative cost-effectiveness of an extended range of adaptation options

Analysing the inter-relationship between mitigation and adaptation measures in the transportation sector:

*How can we minimise the carbon intensity of infrastructural ‘climate proofing’?*

*Are some mitigation and adaptation measures in conflict?*

Modal shift from road to rail and canal networks - with higher risk of weather-related disruption?

Powering transport with low carbon electricity - *increased dependence on electrical infrastructure?*
Developing Holistic Resilience Strategies

across critical infrastructures

infrastructural interconnections cause propagation of disruptive effects

across transport modes

modal substitution as a resilience option

across disciplines

- Climate science
- Civil engineering
- Transport planning
- Economics
- Logistics
- Behavioural sciences
- Insurance

across stakeholders

not simply an infrastructural responsibility

sharing of information, risks and costs with service providers and users

across jurisdictions

effects of extreme weather and response mechanisms cross political boundaries

Aiming for system-level resilience - but how do we define the system?

need new communication strategies and support tools to facilitate multi-agency and multi-level co-ordination

presents particular challenges in the EU, e.g. for the aviation sector
Impact of Technology

Technology in support of adaptation and resilience

- smart materials: e.g. self-healing concrete

- big data / IoT

- new sensors

- social media

Transport technologies creating new adaptation challenges
Some fertile areas for future research

Integration of climate data more effectively into transportation planning models.

Deployment of latest thinking on risk analysis, decision science and organizational learning.

Upgrading of ‘sense-and-response’ capabilities to manage the transportation system more effectively during extreme weather events and to accelerate recovery times.

Improving our understanding of the behavioral responses of transport users (both personal and corporate) during weather-related disruptions and how they can be modified.
Professor Alan McKinnon

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