Incorporating Climate Change Impact Risks Into Transportation Infrastructure Asset Management

Costa Samaras, Lauren Cook, and Thiago Rodrigues

Civil and Environmental Engineering
Carnegie Mellon University
csamaras@cmu.edu
@CostaSamaras

TRB's 1st International Conference on Surface Transportation System Resilience to Climate Change and Extreme Weather Events
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Civil Engineering Sectors Affected by Climate Change Impacts

• Grades

Source: ASCE, 2013

America’s Infrastructure GPA: D+

$3.6 Trillion in reinvestment needed by 2020

Image: AP Photo/Viapandolhill
Source: ASCE 2014
Which Infrastructure Systems Are Affected by Climate Change Impacts?

- Transportation (highways, culverts, bridges, rail, airports, ports, navigation, pipelines)
- Water Resources (dams, levees, irrigation, reservoir management, flood risk management, drought management)
- Urban Water Systems (storm water management, municipal water supply and wastewater)
- Coastal Management (erosion, seawalls, dredging)
- Buildings and other structures (buildings of all types and structural aspects of other infrastructure)
- Energy supply (power generation: hydropower, energy infrastructure design, wind engineering, thermal plant cooling, fuel supply)
- Cold Regions (freeze-thaw cycling, changes to the permafrost environment, snow accumulation and distribution)

Source: ASCE, 2015
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New Approaches in Asset Management Needed

- Best possible condition for users
- Minimize life cycle costs
- Maximize performance
Outline for Today’s Discussion

• Risks to infrastructure from changing temperature and precipitation extremes

• Incorporating climate risk into asset management

• Discussion about path forward
Infrastructure Has Capital and Maintenance Costs

- Life Cycle Cost Analysis is used to minimize the total costs and choose among options
Asset Management Cycle

Planning & Programming

Maintenance Investments

Capital Construction

Annual Asset Condition Data
Infrastructure Deterioration and Costs are Not Linear

- Asset management tools used to inform timing of major rehabilitations

Markov Chain Processes Used to Predict Infrastructure Conditions

- Historical data from inspections used to generate probabilities of deterioration
Pavement Condition Index Is One Measure Of Deterioration

- Data from inspections from same surface type and roadway functional class
Cracking from Low Temperatures, Excess Moisture, Traffic
Surface Defects from Low Temperatures, Hot Weather, Traffic

Image: http://www.pavementinteractive.org/article/general-guidancepavement-distress/
Deformation from Low Temperatures, Hot Weather, Traffic
Disintegration from Freeze-Thaw Cycles, Precipitation, Traffic
Projecting Change in Average Annual Temperature By the End of the Century

Source: National Climate Assessment, 2014
Observed Change in Heavy Precipitation Especially in Northeast and Midwest

Source: National Climate Assessment, 2014

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Observed Change in Average Annual Precipitation

Source: National Climate Assessment, 2014
Projected Change in Average Annual Precipitation by the End of the Century

Rapid Emissions Reductions (RCP 2.6)

Winter

Spring

Summer

Fall

Continued Emissions Increases (RCP 8.5)

Winter

Spring

Summer

Fall

Precipitation Change (%)

Source: National Climate Assessment, 2014

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Infrastructure Has Capital and Maintenance Costs

- Life Cycle Cost Analysis is used to minimize the total costs and choose among options.

[Diagram showing investment over time with construction and rehabilitation costs.]
Projecting Number of Days Above 90° F

Projection considering only historical data

Projection considering climate change under higher emissions scenarios
Incorporating Climate Risks into Asset Management Models

- Probabilities of condition transitions can be informed by historical and projected climate extremes
- Capital and maintenance decisions should be robust across a range of futures

\[ OPI = f(Age, AADT, ADT_{max}, T_{90^\circ F}, VT_{0-4^\circ C}, P_{rain}, P_{snow}) \]

- \( Age \): Years since the last repair
- \( AADT \): Annual Average Daily Traffic
- \( ADT_{max} \): Maximum Average Daily Traffic
- \( T_{90^\circ C} \): Number of days over 90\(^\circ\)C
- \( VT_{0-4^\circ C} \): Times that the temperature varied through water freeze point
- \( P_{rain} \): Precipitation (rain)
- \( P_{snow} \): Precipitation (snow)
Incorporating Climate Risks into Asset Management Models

• Change in initial service life estimates can inform the frequency of inspections
• Inspections and projections provide feedback to model
• Interpret climate projections and uncertainty, and examine deterioration models in places currently experiencing those conditions
• Suggests a larger data linking effort across agencies
Incorporating Climate Risks into Asset Management Models

- Can also re-inform capital planning and programming

- Tradeoffs in time, annual appropriations, and life cycle costs

- Incentives are not aligned across stakeholders
“Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.”
Questions?

Thank you!

csamaras@cmu.edu

@CostaSamaras