NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar: Visualizing Risk for Resilience

August 5, 2024

12:00 – 1:30 PM

PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.

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Purpose Statement

This webinar will address how to approach communicating risk. Presenters will discuss risk analysis and visually communicating that risk to support resilience strategies.

Learning Objectives

At the end of this webinar, you will be able to:

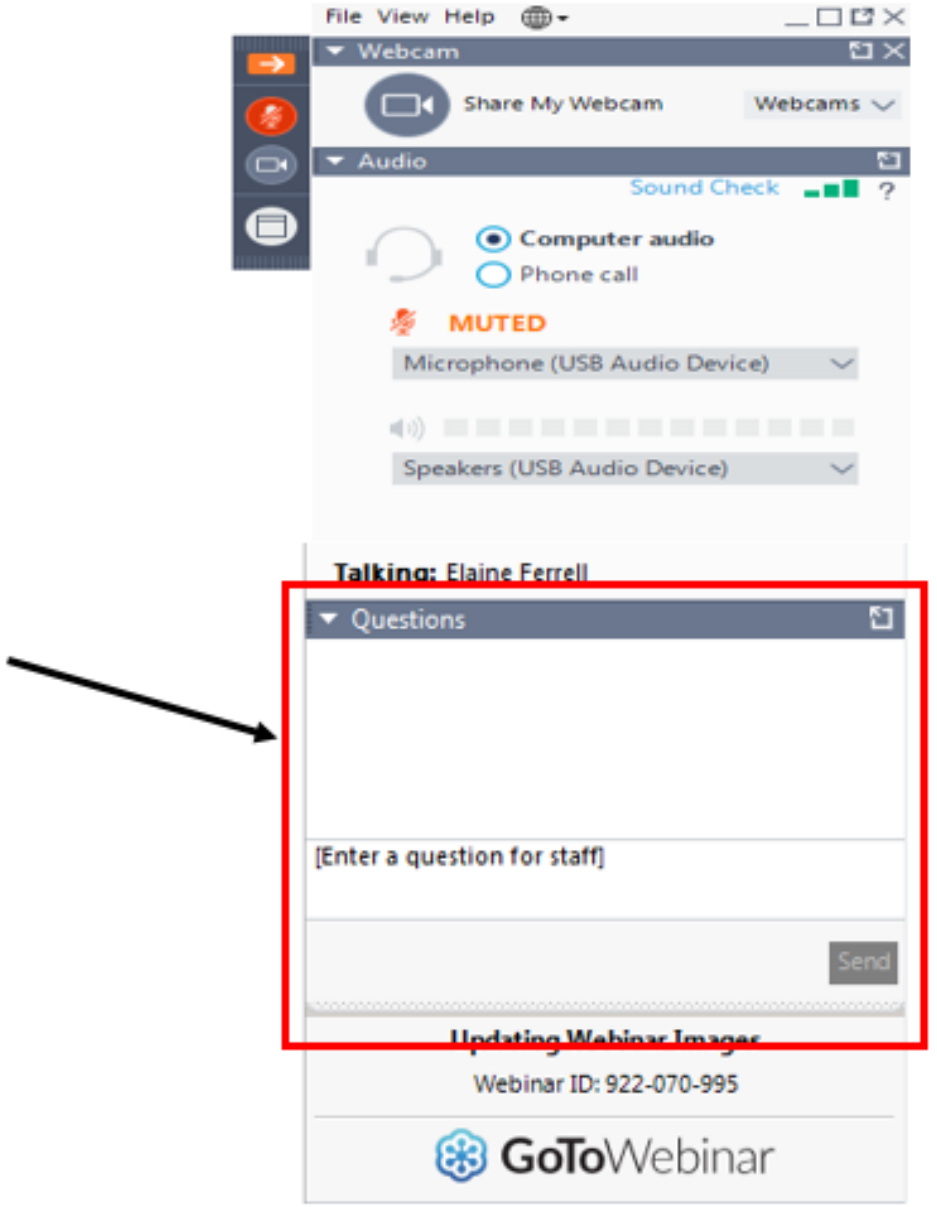
(1) Identify appropriate risks for a region

(2) Approach the analysis of some risks

(3) Visualize and communicate risk

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's presenters

Matt Haubrich
matthew.haubrich@hdrinc.com

Frank Broen
Metro Analytics

frank@metroanalytics.com

Dr. Silvana Croope
Systems & Technology Resilience Solutions LLC

Sil.Croope-STRS@protonmail.com

Herby Lissade
Consultant
hlissade@interwestgrp.com

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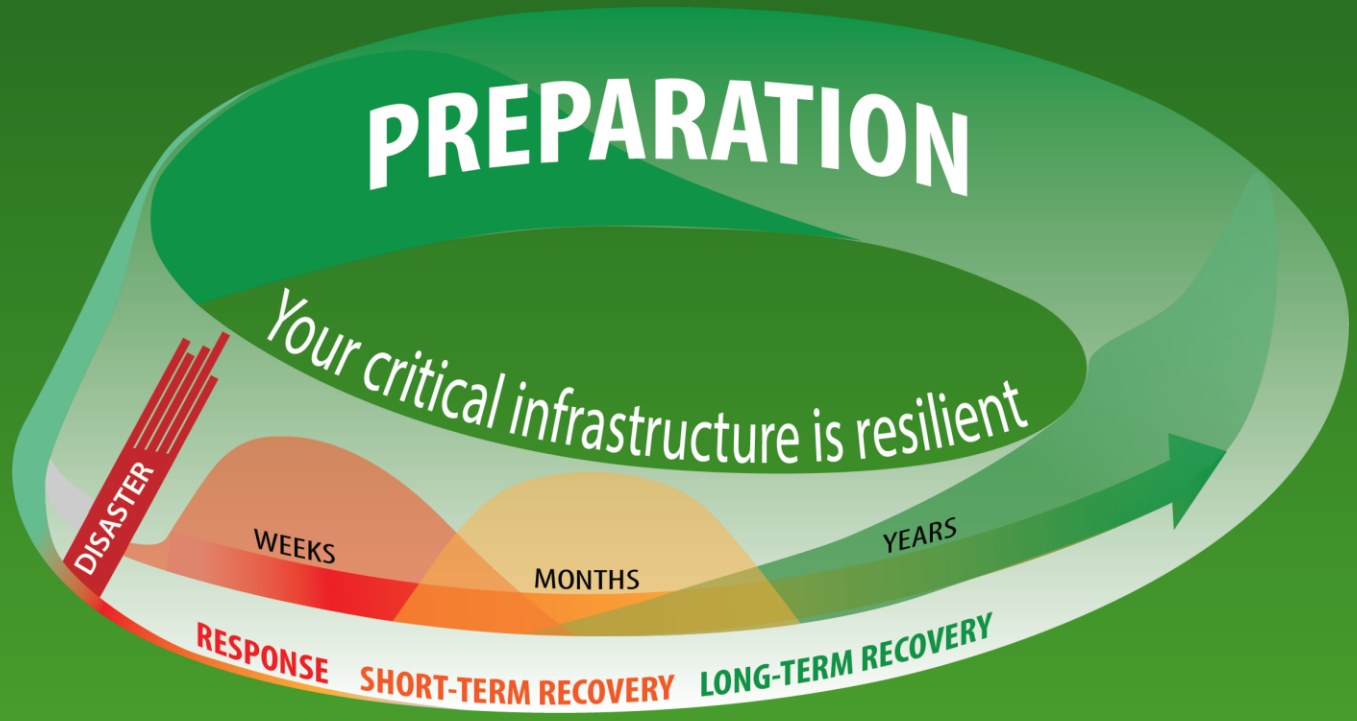
INTERWEST A SAFEbuilt COMPANY

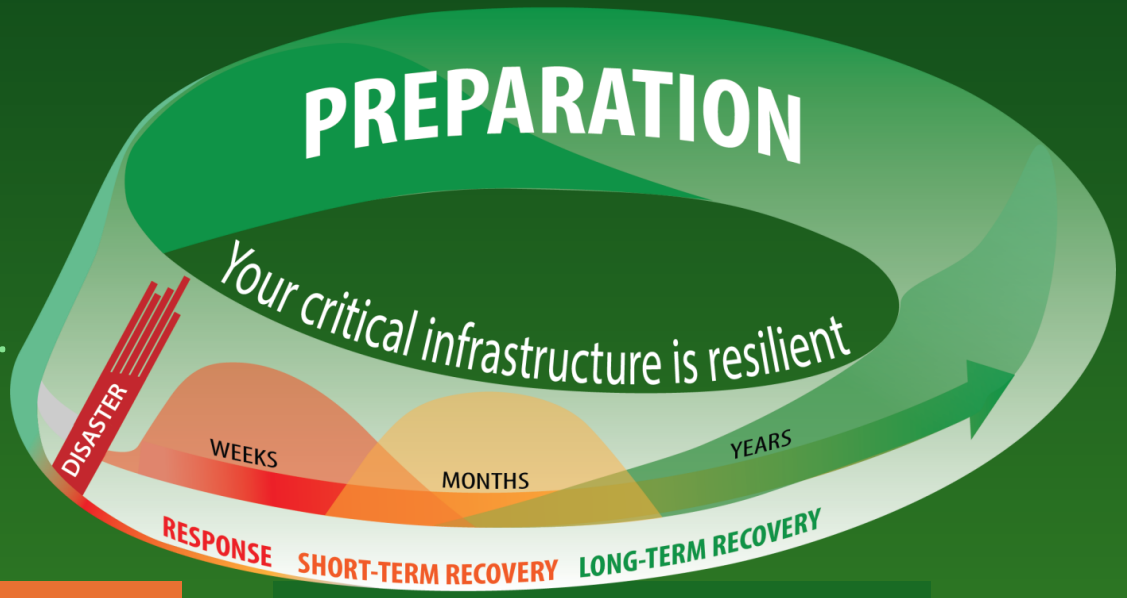
Visualizing Risk for Resilience

Frank Broen
Metro Analytics
frank@metroanalytics.com



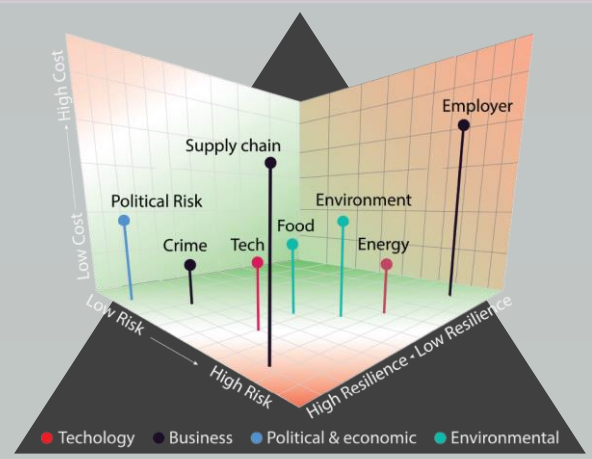
Visualizing Risk for Resilience

The ability to withstand or overcome changes or challenges.

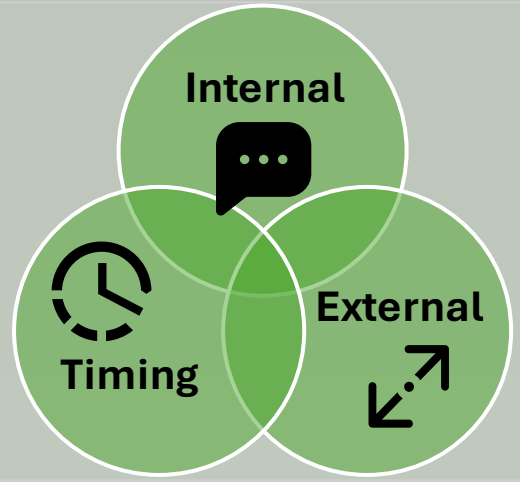


Definition STEP 1

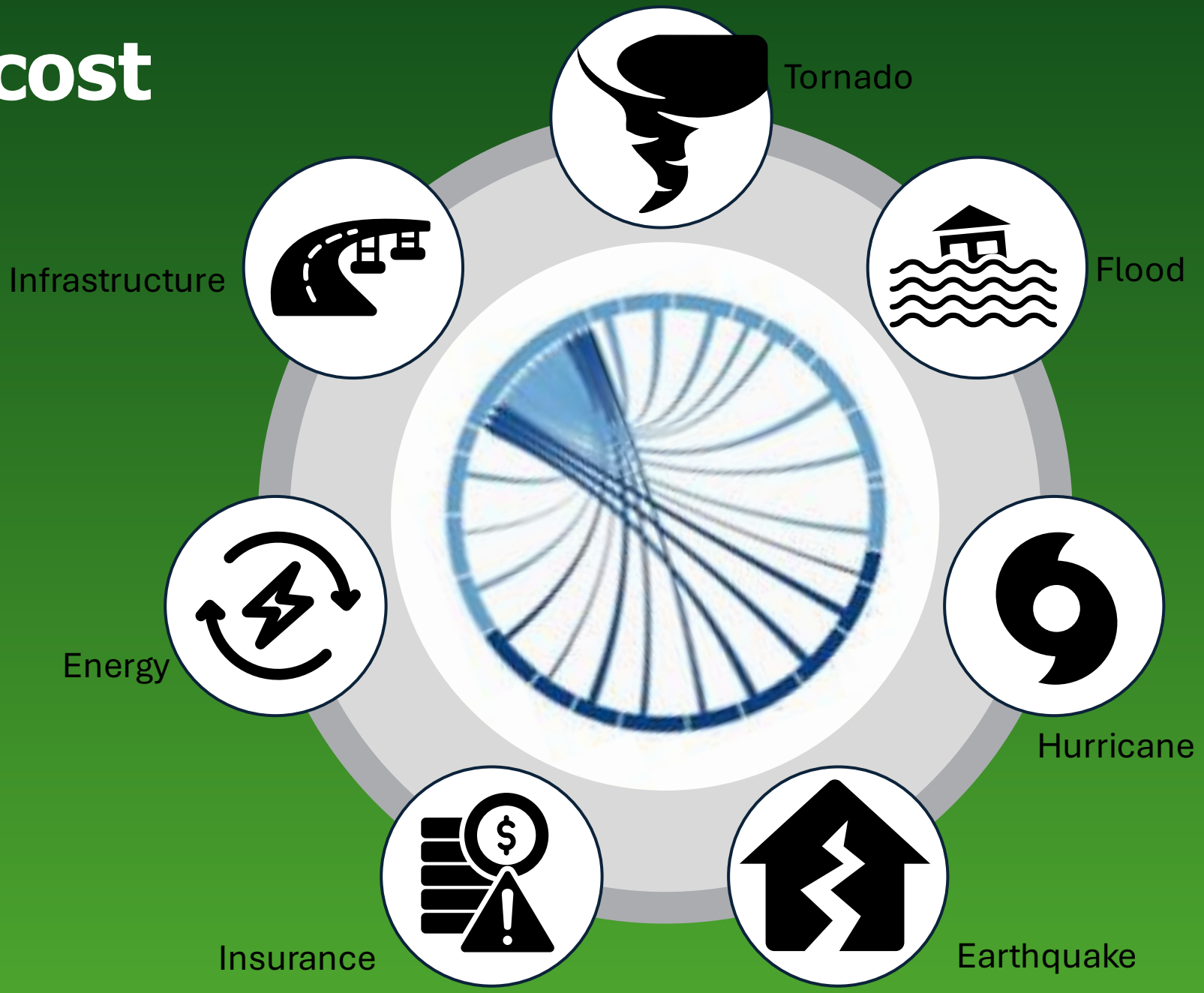
Risk Analysis STEP 2



Communication STEP 3



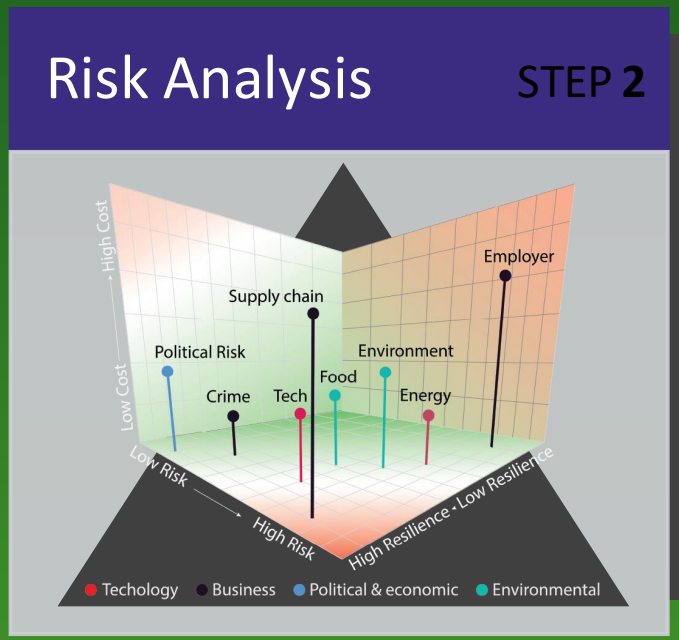
The perceived cost of resilience



The perceived cost of resilience

Without effective Bridge Bumper

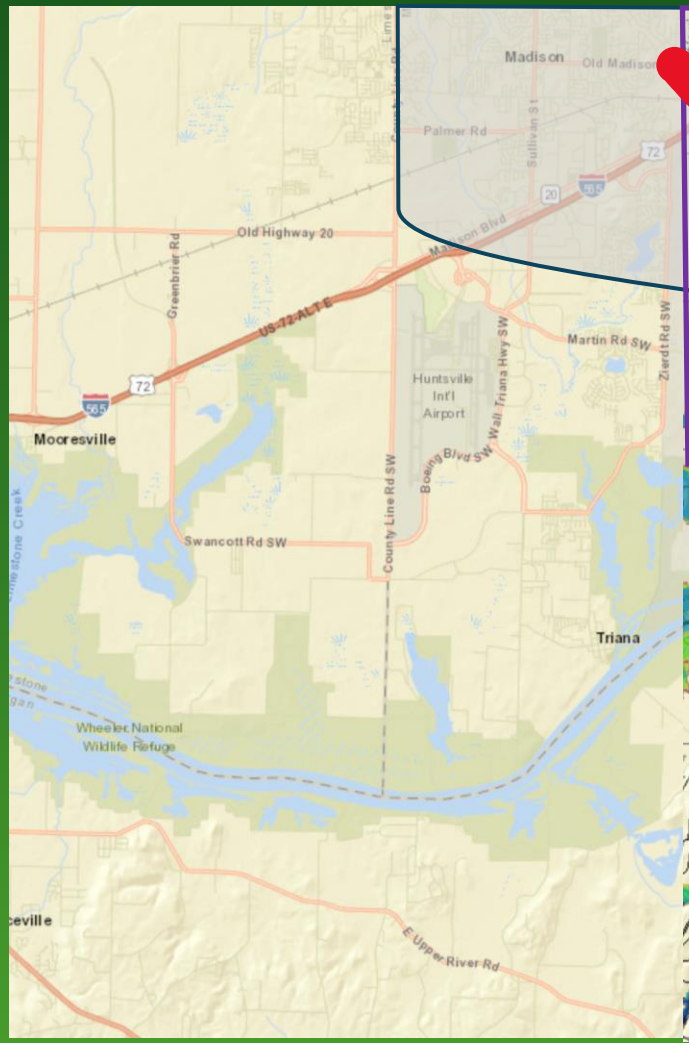
With effective Bridge Bumper

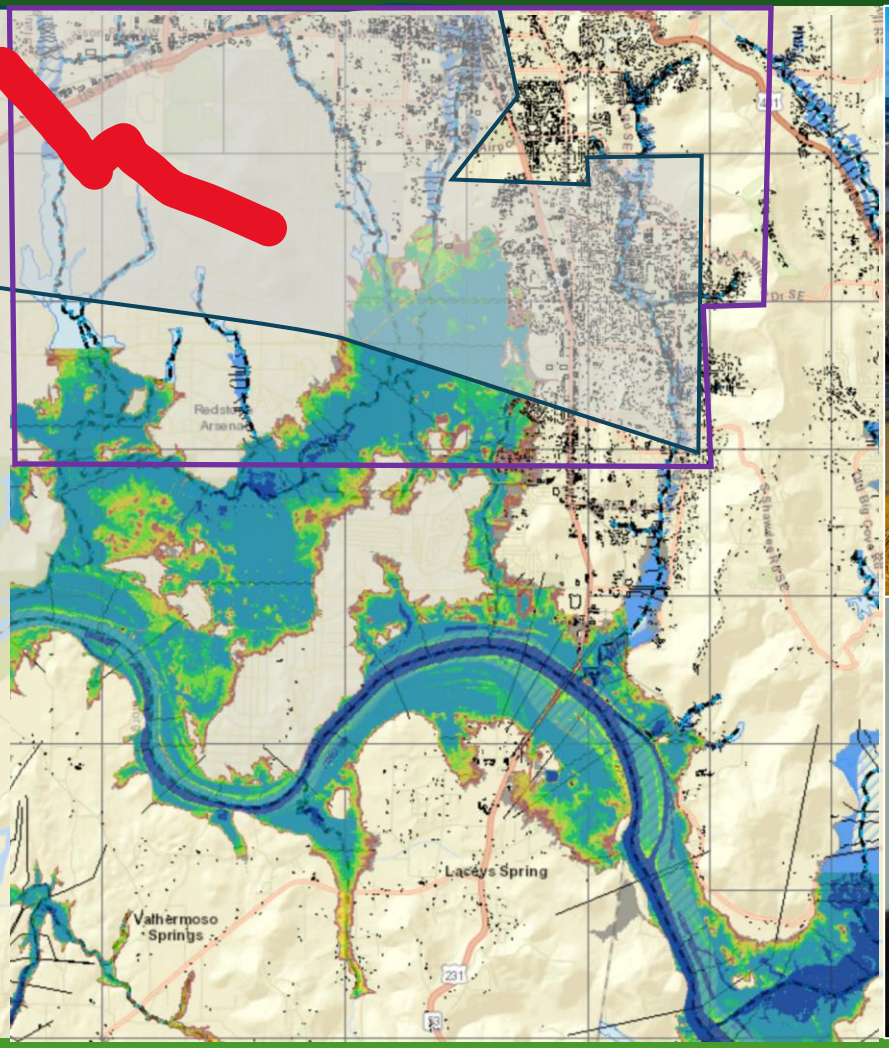


Step 2: Risk Analysis

How Much Risk is Too Much?

How Much Risk is Too Much?





Acceptable risk VS Excess risk

Power & Communication Outage

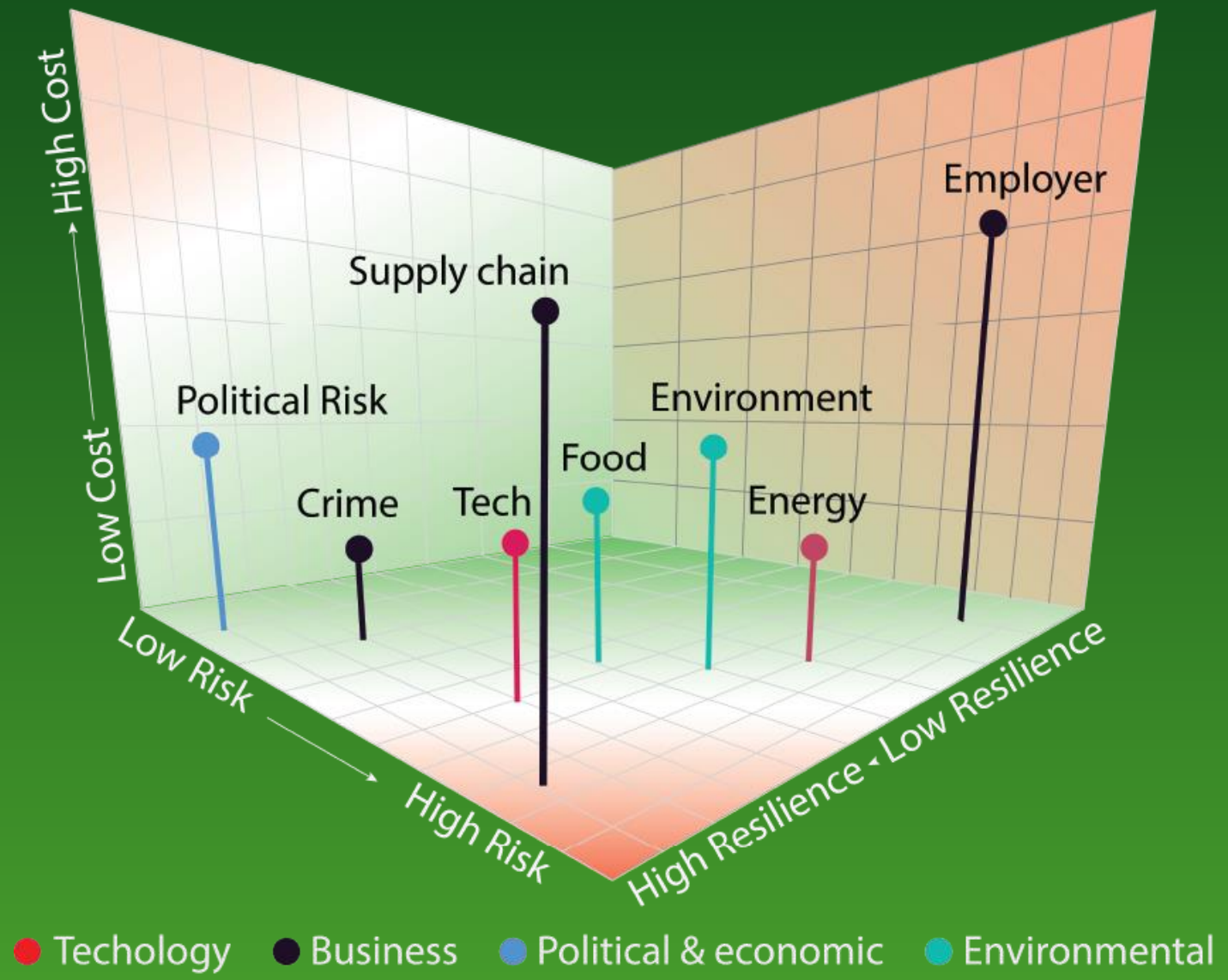
Transportation movement & infrastructure disruption

Tornado damage

Flood Depth (1’ to 16’+)

Risk Analysis

Some types of risk are analyzed	Some types of risk are analyzed
QUANTITATIVELY	QUALITATIVELY



What Are Your Risks?

QUANTITATIVELY

QUALITATIVELY

What are your economic risks?

What are your political risks?

What are your systems risks?

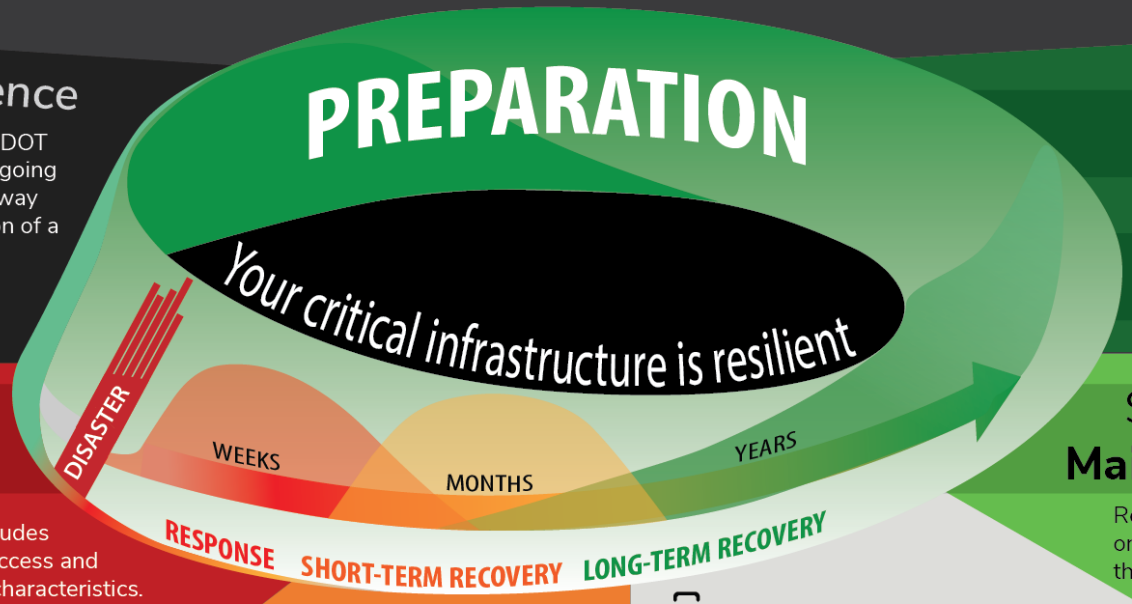
What are risks for which you have no cover?

The Business Case for Resilience and Security In Infrastructure and Continuity of Function

Chris Huffman[MA], Silvana Croope[ATI], Frank Broen[MA] January 2022 B613

The perceived cost of resilience

Resilience and security in the DOT leadership sense requires on-going effort and represents more a way of thinking than the application of a specific tool or technique



Cost of Failure

Infrastructure

Function

Stage 1
Definition

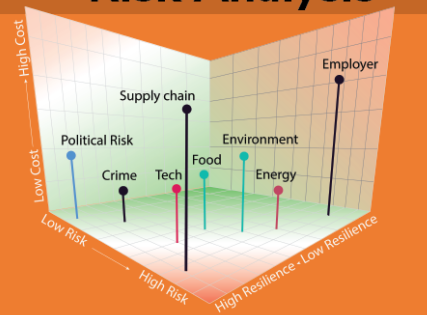
Performance Strategies: Which includes strategies to benchmark communication success and identify needs based on those benchmark characteristics.

Partnership Strategies: Which includes both inter-agency and intra-agency strategies.

Business Case: Which describes the risk tolerance in terms of the costs of disruptions against the costs of preparation

Communication Plans: That identify how the business case is communicated

Stage 2
Risk Analysis

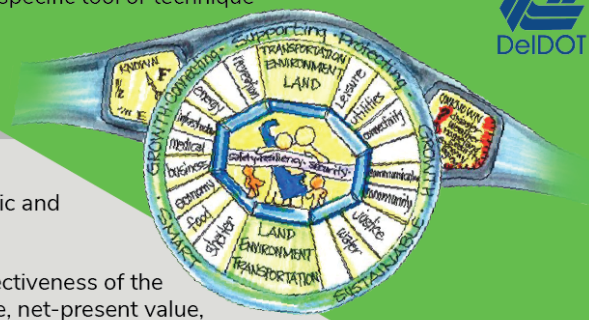


Where are the critical infrastructure elements?
Where are the areas with zero redundancy?
Where are the locations for staging of rescue and recovery?
How are they served?
Where are the plans for calling upon multiple agencies for support?
Where are the triage plans for reconstruction of critical infrastructure?

Stage 3
Mainstreaming the Resilience Program

Resilience and security in the DOT leadership sense requires on-going effort and represents more a way of thinking than the application of a specific tool or technique

DelDOT



Building the Business Case

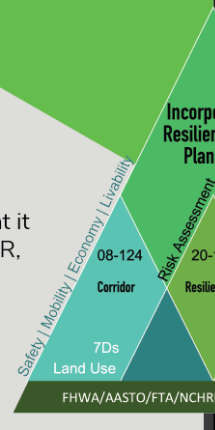
The Strategic Case: That demonstrates how the recommended course of action aligns with the strategic and management objectives of the target audience.

The Economic Case: That demonstrates the effectiveness of the recommended course of action in terms of future value, net-present value, and benefit/cost as described above.

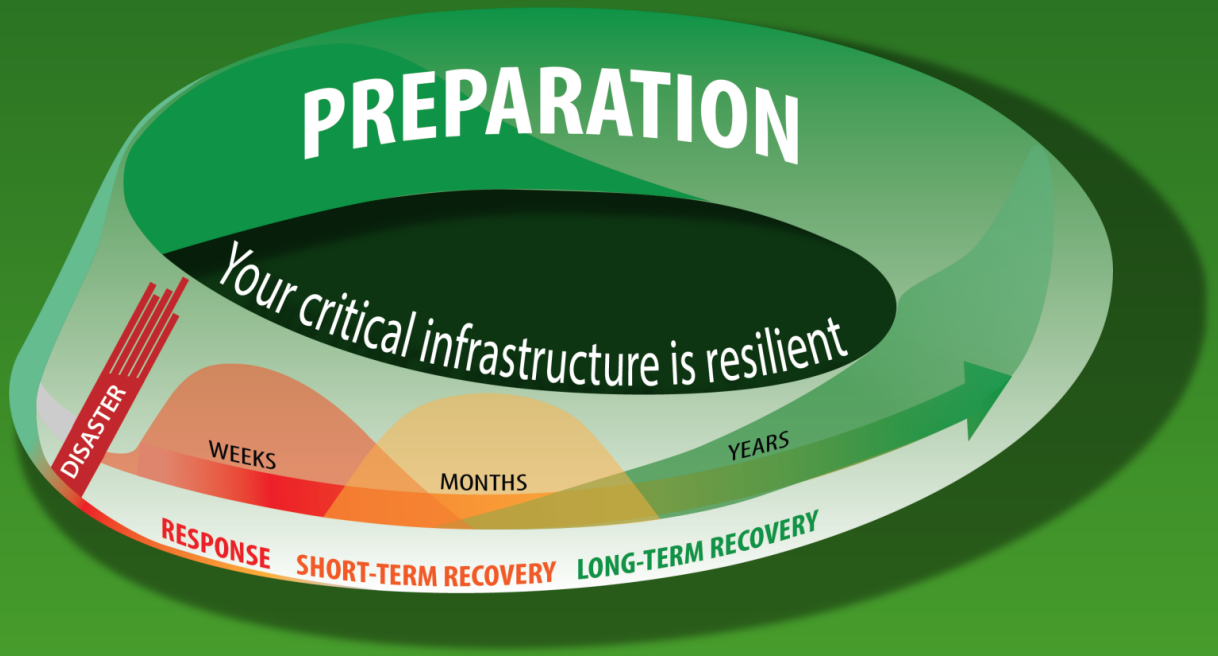
The Commercial Case: That demonstrates how the productions and attractions, and the linkages of compatible activities are available and resilient to support the target audience's objectives in adopting the recommended course of action.

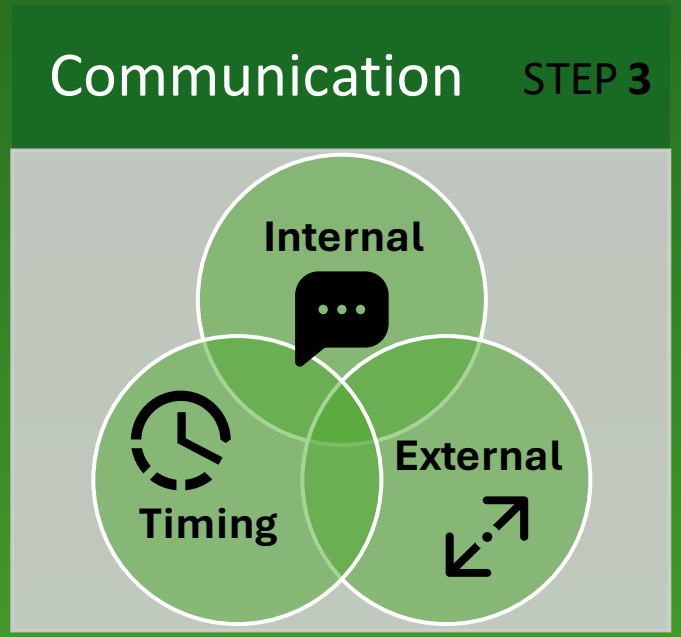
The Financial Case: This is related to the economic case and the commercial case in that it describes what the recommended course of action will cost to achieve in terms of ROI and IRR, as described above.

The Management Case: That demonstrates how the recommended course of action will be integrated into existing statutory, regulatory, or policy frameworks.

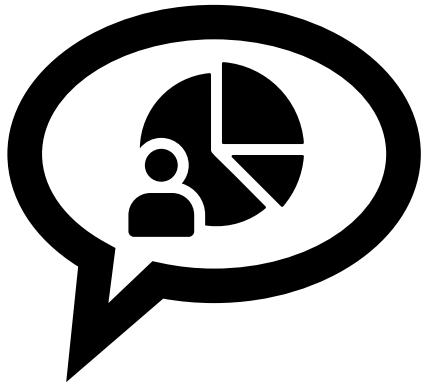


NCHRP Summaries





How resilient is your transportation system?



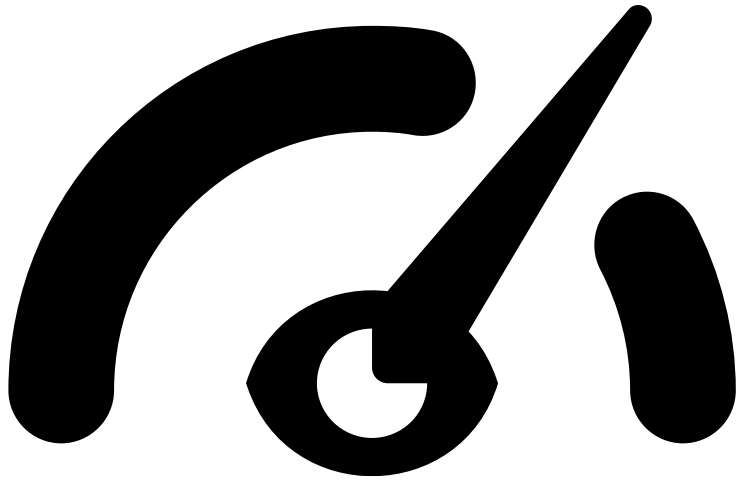
Internal Analysts

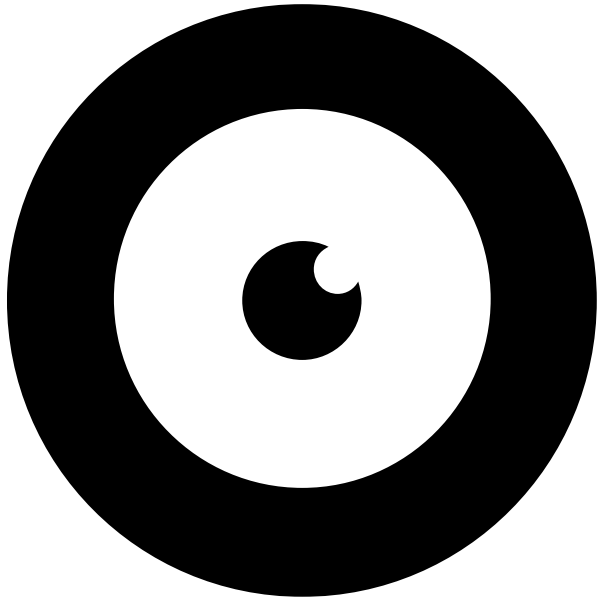
Internal Leadership

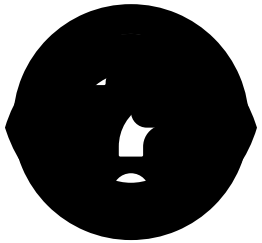
Elected Officials

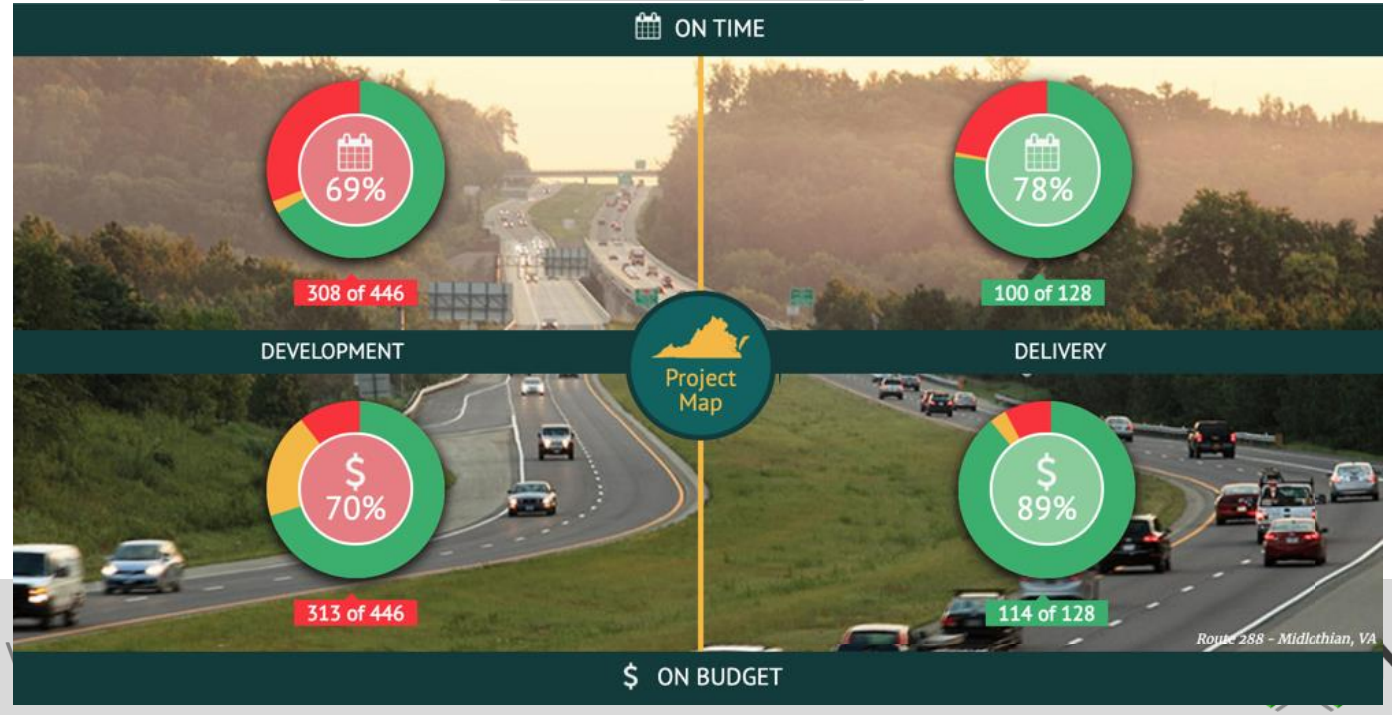
Public

This presentation presents the author's perspective.
Information presented here does not imply an endorsement by the Transportation Research Board, the National Academy of Sciences








ON TIME
69%
308 of 446
78%
100 of 128
DEVELOPMENT
Project Map
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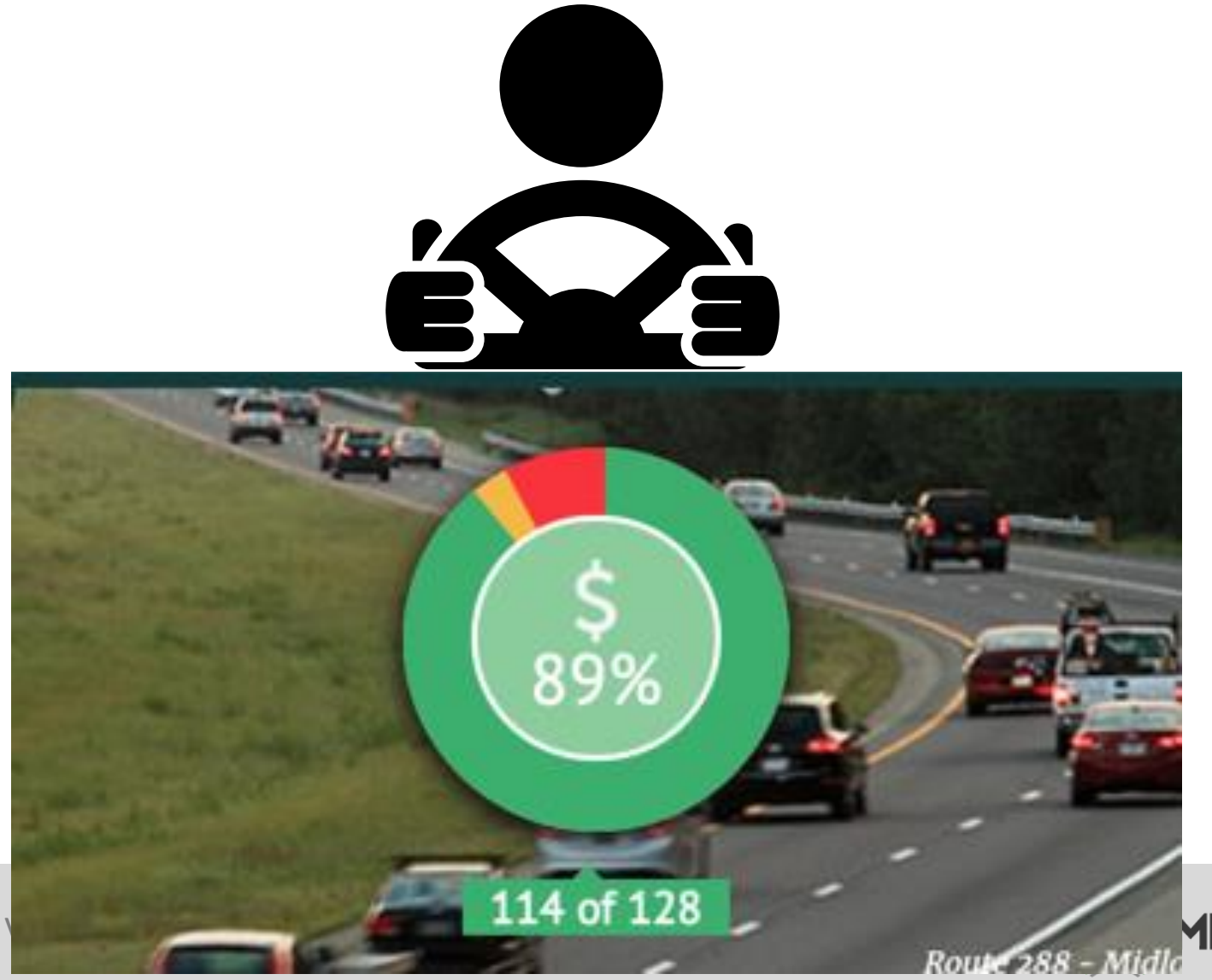
Route 288 - Midlothian, VA
$ ON BUDGET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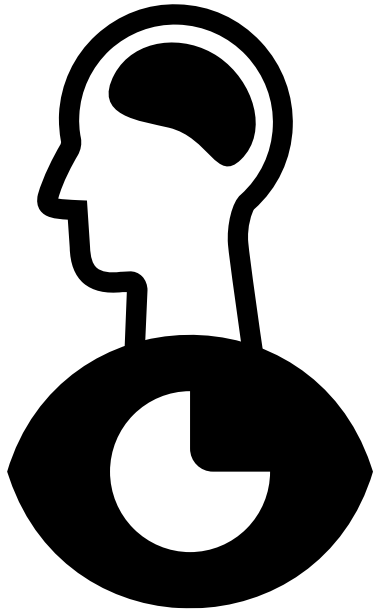
114 of 128

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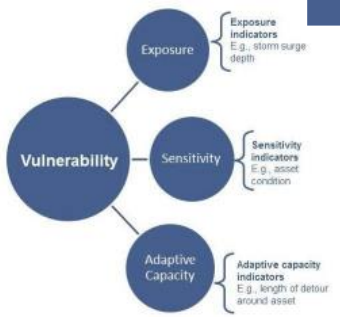
Vulnerable Assets

Vulnerability Assessment (VAST)

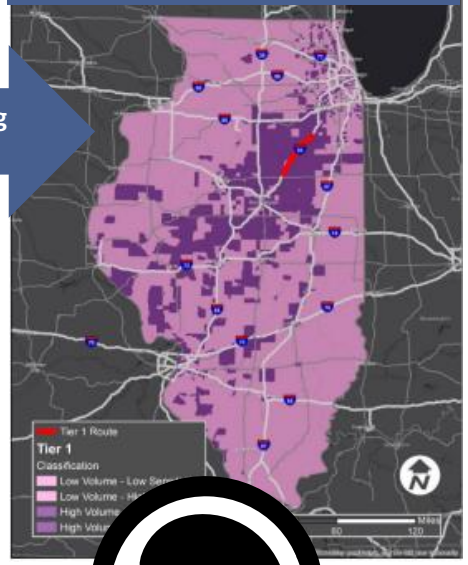


Scenario Planning

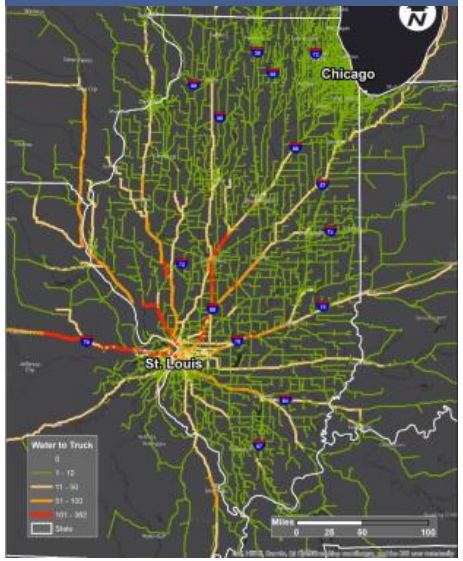
Investment Choices

Cascading Effects

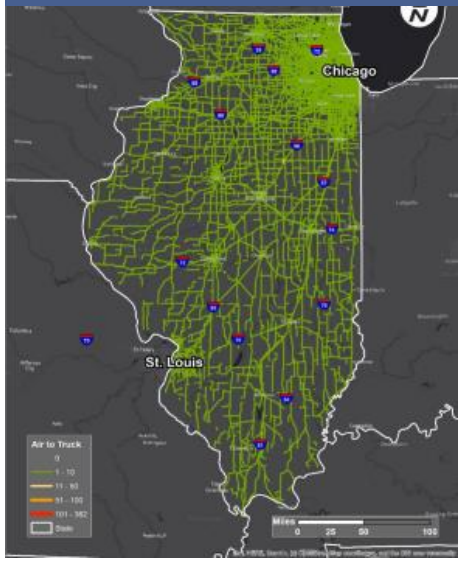
Vulnerability Profile & Protected Markets/Populations

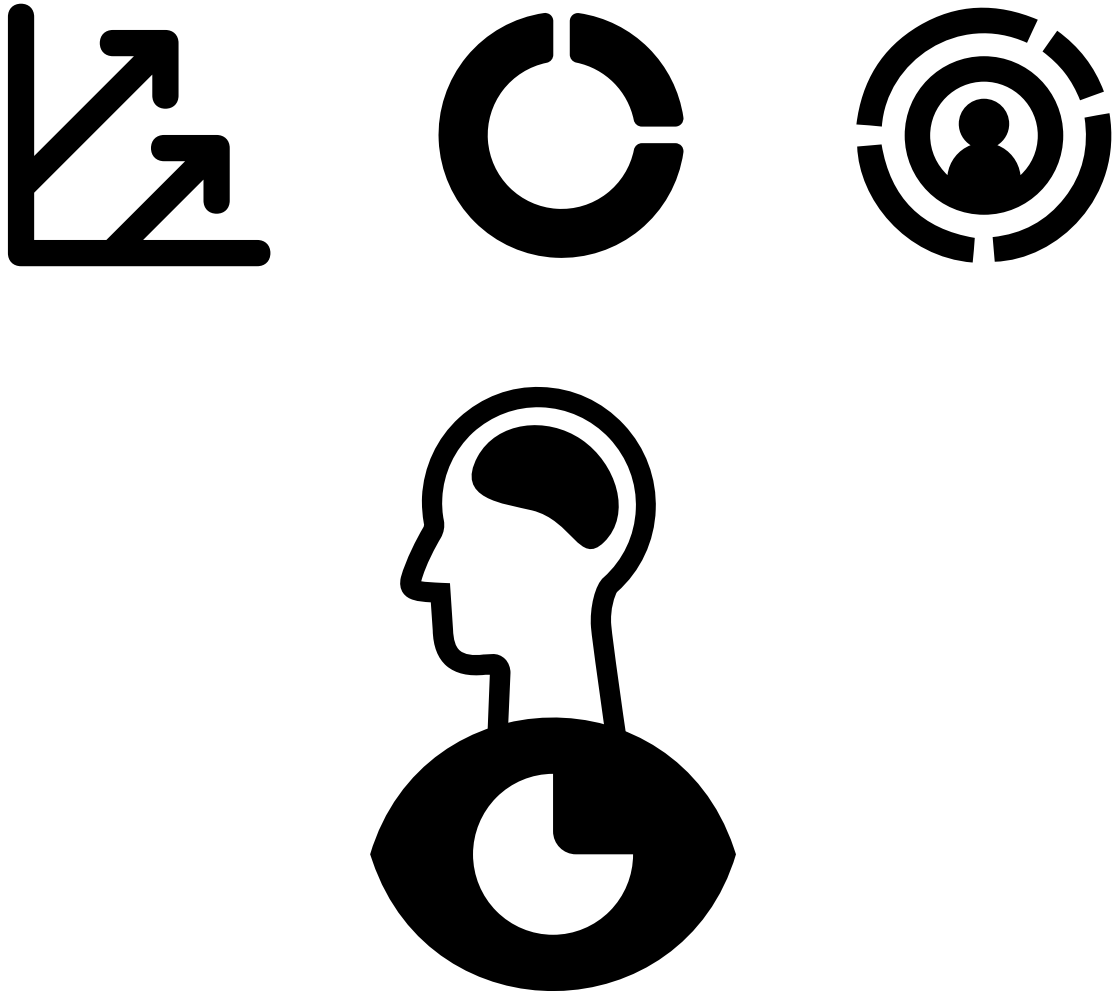


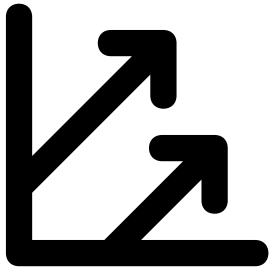
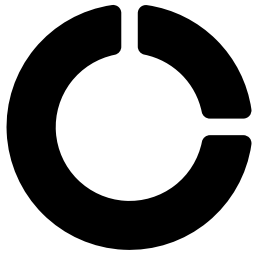
Protected Waterborne Commerce Market (Port of St. Louis)

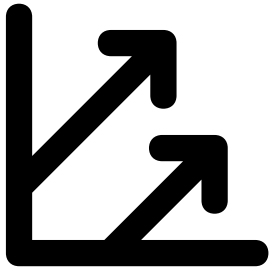
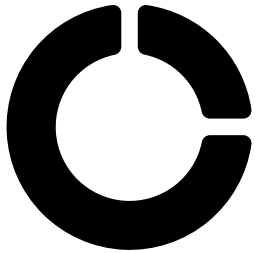


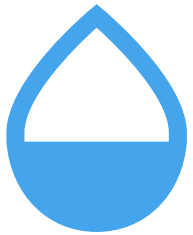
Protected Air Cargo Market (Chicago O'Hare)

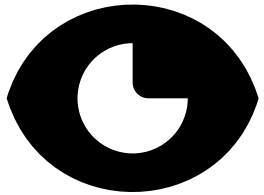


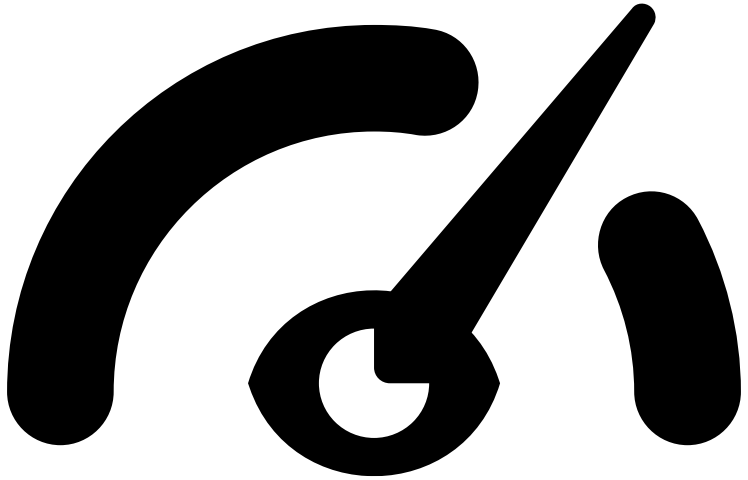






NCHRP Synthesis 584

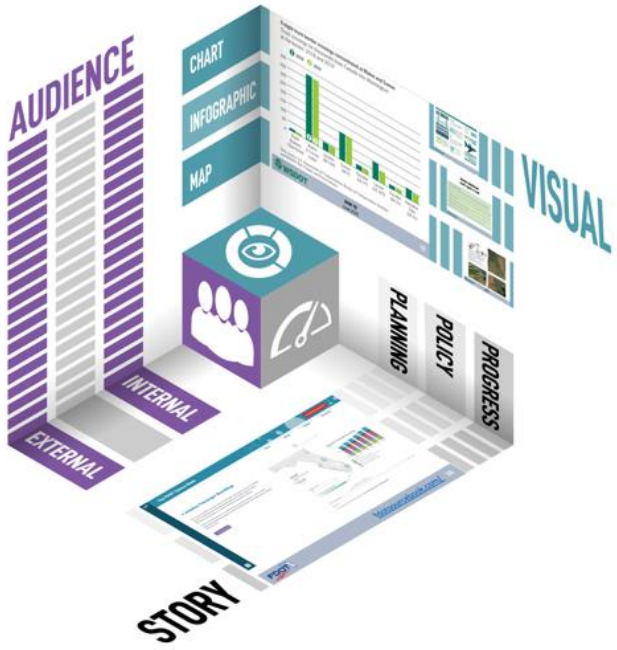
Visualization of Highway Performance Measures

METROANALYTICS

Top Takeaway

Keep it Simple.

VISUALIZING
HIGHWAY
PERFORMANCE
MEASURES

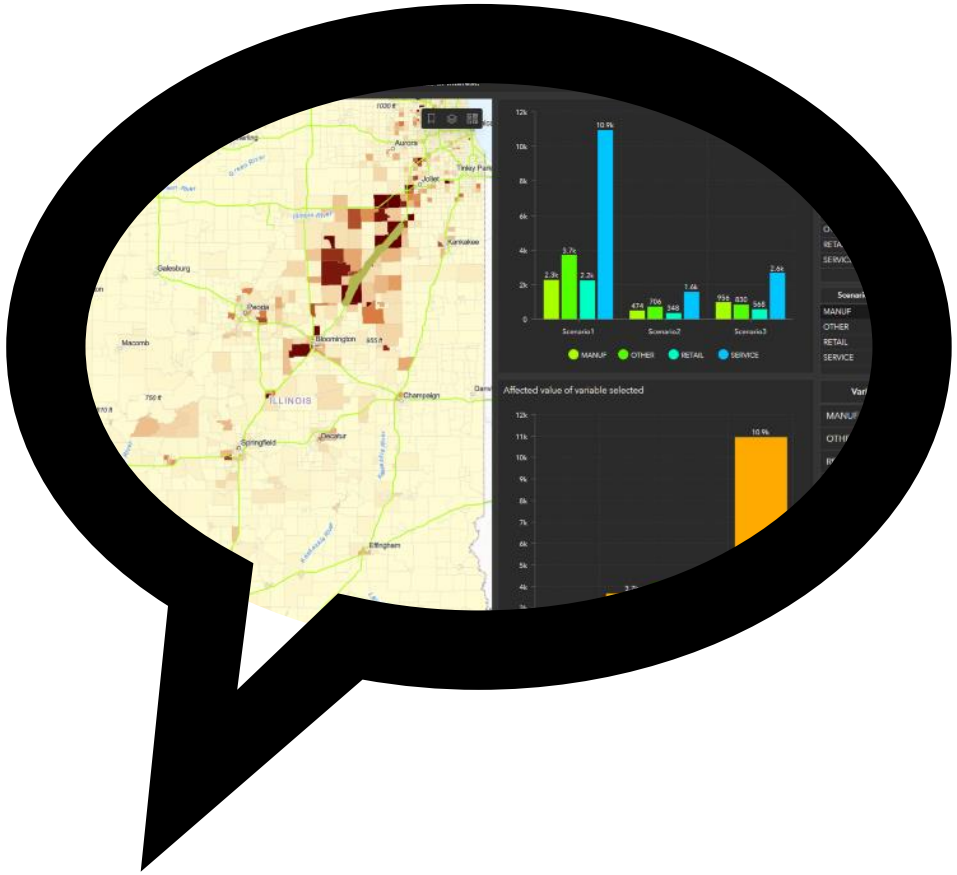


Use pictures to tell a story that resonates.

METRO ANALYTICS

Keep it Simple.

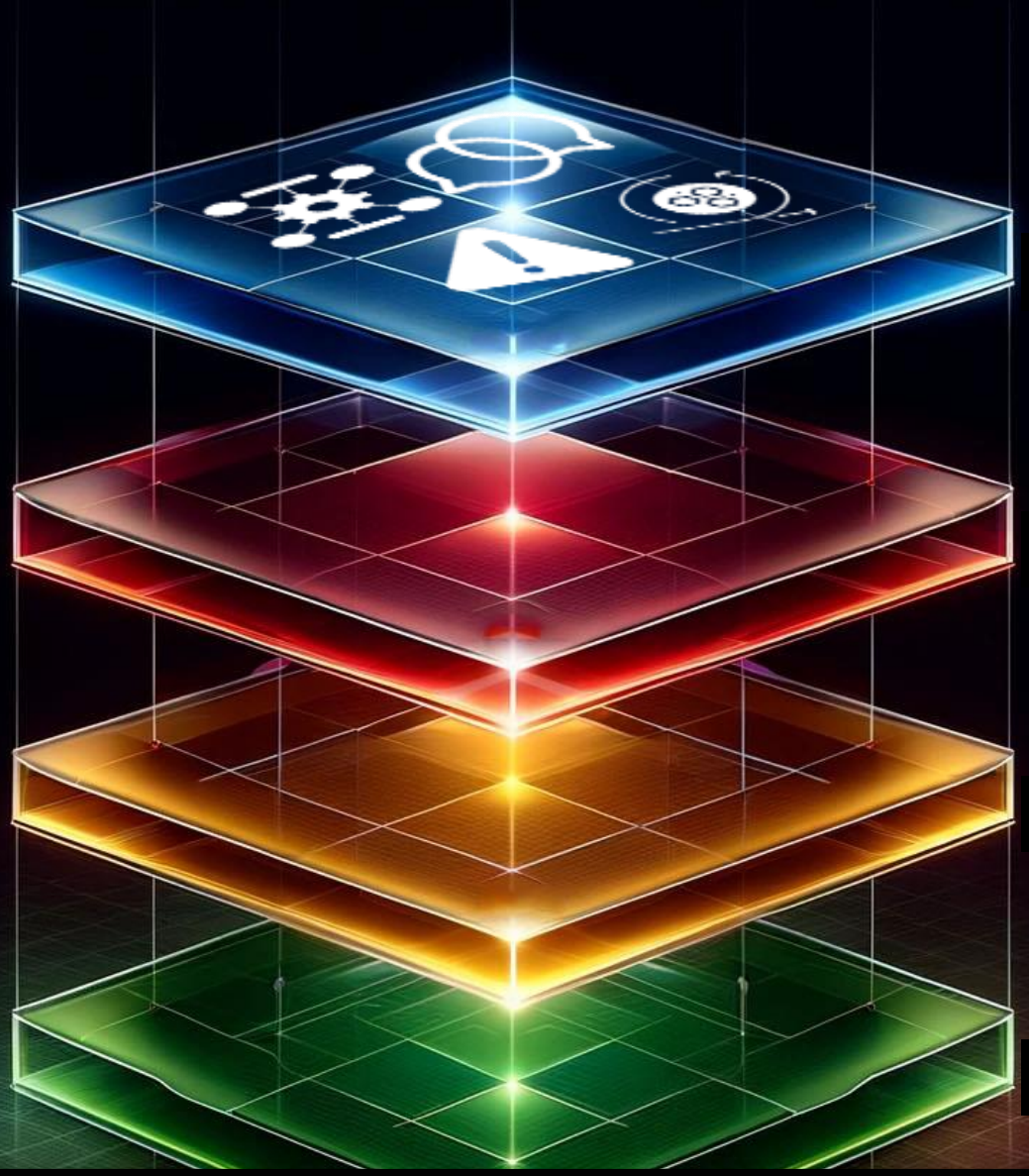
Use pictures to tell a story that resonates.



https://weather.com/safety/floods/news/2019-07-08-washington-maryland-virginia-flooding-leads-to-water-rescues

Web Document NCHRP 385

Business Case and Communications Strategies for State DOT Resilience Efforts (2023)



Best Practices

Tools In A Box

Web Document NCHRP 385

Business Case and Communications Strategies for State DOT Resilience Efforts (2023)

NCHRP RESEARCH REPORT 976

Resilience Primer for Transportation Executives

NCHRP RESEARCH REPORT 1052

Integrating Resilience Concepts and Strategies into Transportation Planning – A Guide

- Agency decision-making
- Collaborating with stakeholders
- Both natural and human-caused

NCHRP 970

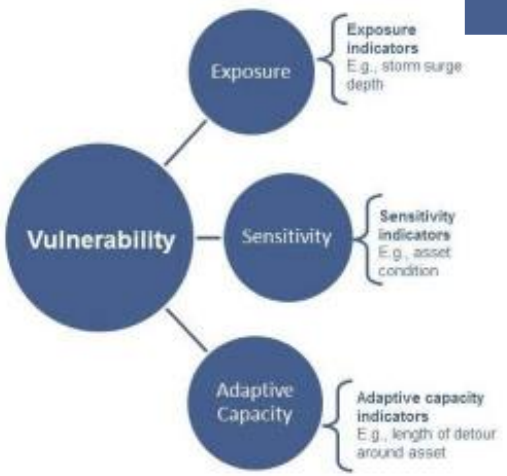
Mainstreaming System Resilience Concepts into Transportation Agencies: A Guide

Resilience Planning

Quantifying the Economic Value of Resilience, Risk Reduction and Asset Protection

Vulnerable Assets

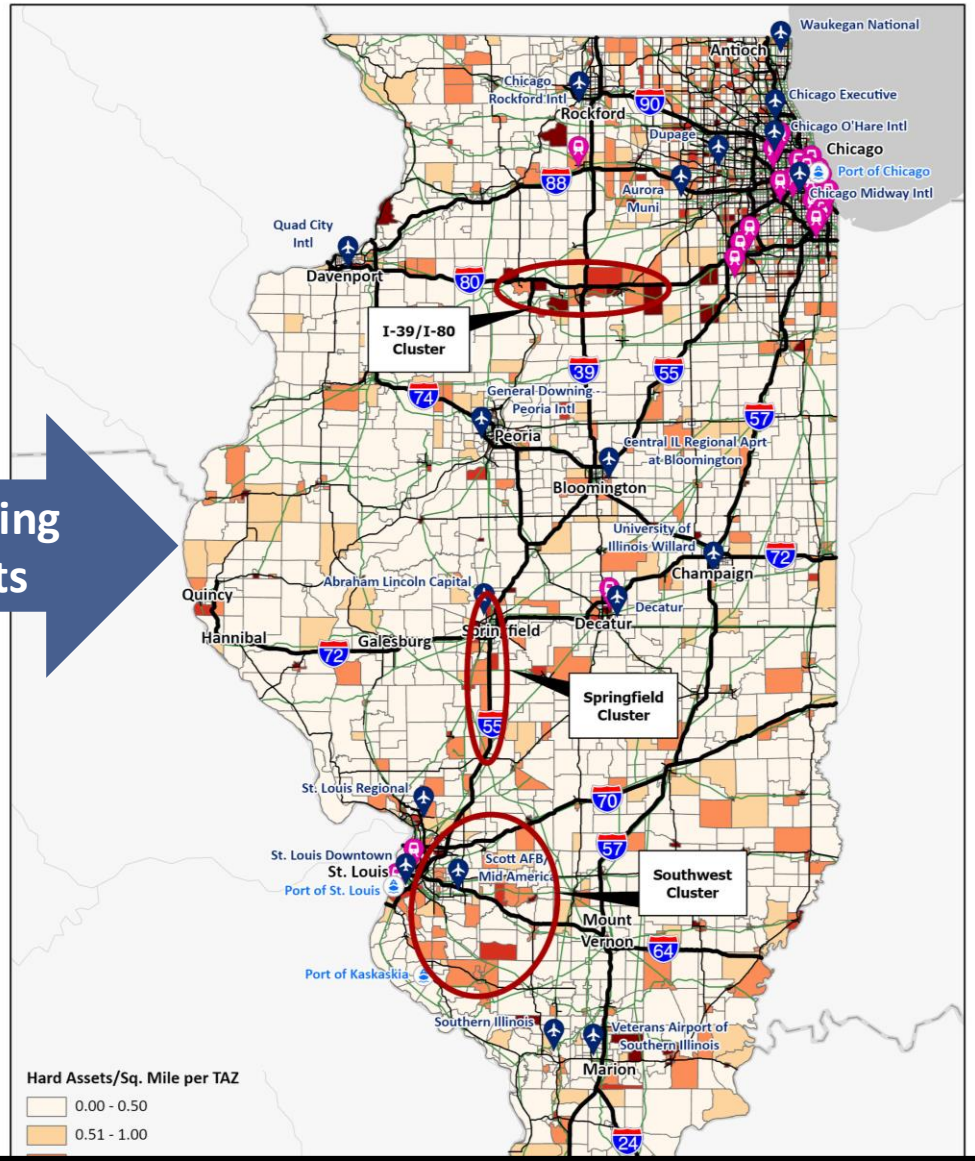
Vulnerability Assessment (VAST)



Scenario Planning

Investment Choices

Cascading Effects



NCHRP 20-125
Incorporating Resilience Into Transportation Networks

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1000+ documents

4 PLAYS

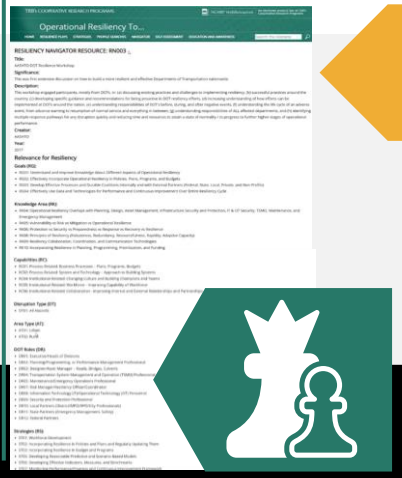
- **RP1** Resilience Team and Roles
- **RP2** Collaborative Technology
- **RP3** Integrating Data
- **RP4** Continuous Improvement

Use **4 Plays** to Achieve **4 Goals**

4 GOALS

RESILIENCY GOALS (RG)

- **RG1** Understand and improve knowledge
- **RG2** Incorporate in policies, programs, and budgets
- **RG3** Durable coalitions
- **RG4** Continuous improvement



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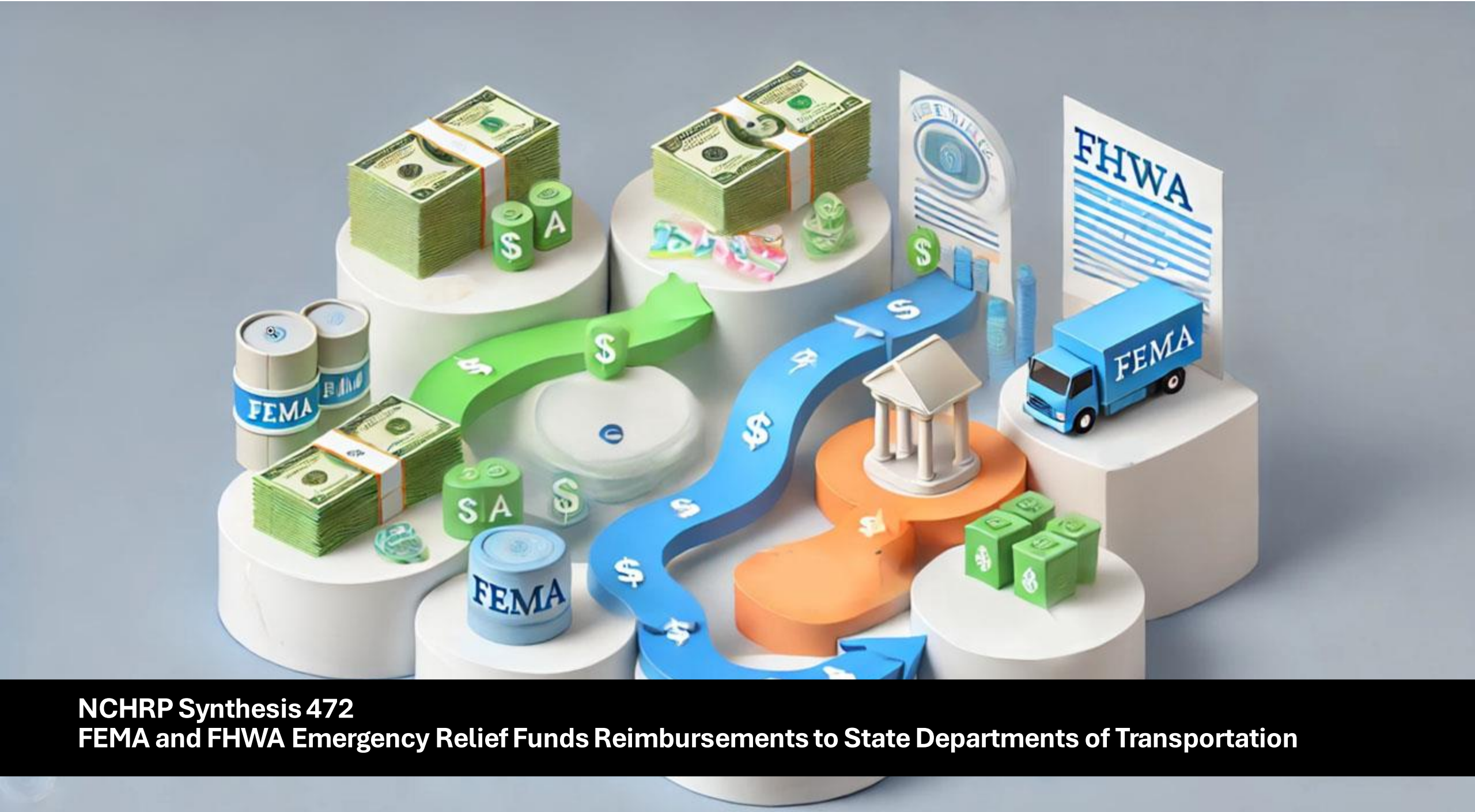
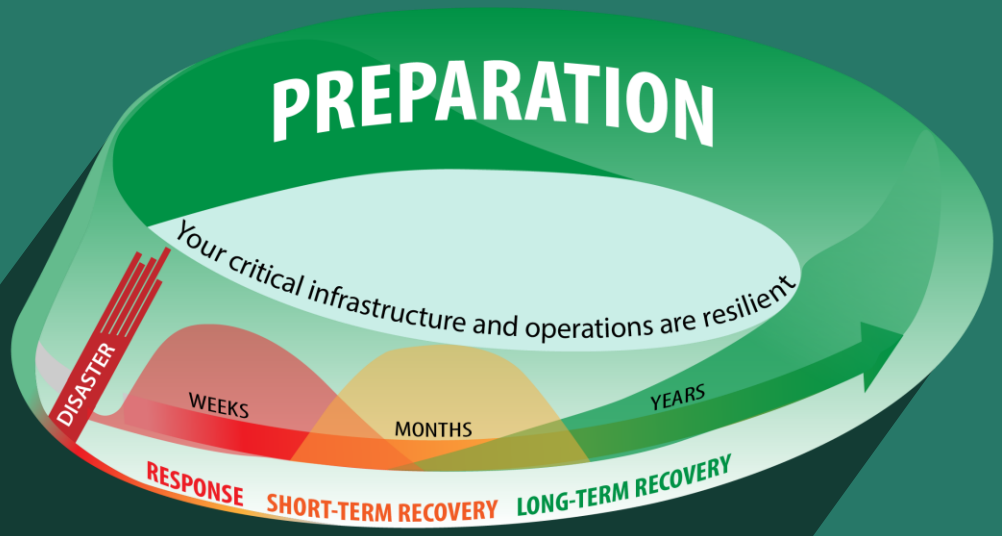
2 Area Types
10 Knowledge Areas
6 Capabilities
13 Roles
18 Disruption Types
16 Strategies

NCHRP 08-146
Resilience Operations



NCHRP Synthesis 472
FEMA and FHWA Emergency Relief Funds Reimbursements to State Departments of Transportation


PREPARATION
Your critical infrastructure and operations are resilient
DISASTER
WEEKS
MONTHS
YEARS
RESPONSE
SHORT-TERM RECOVERY
LONG-TERM RECOVERY

Examples

Risk Resilience Matrix

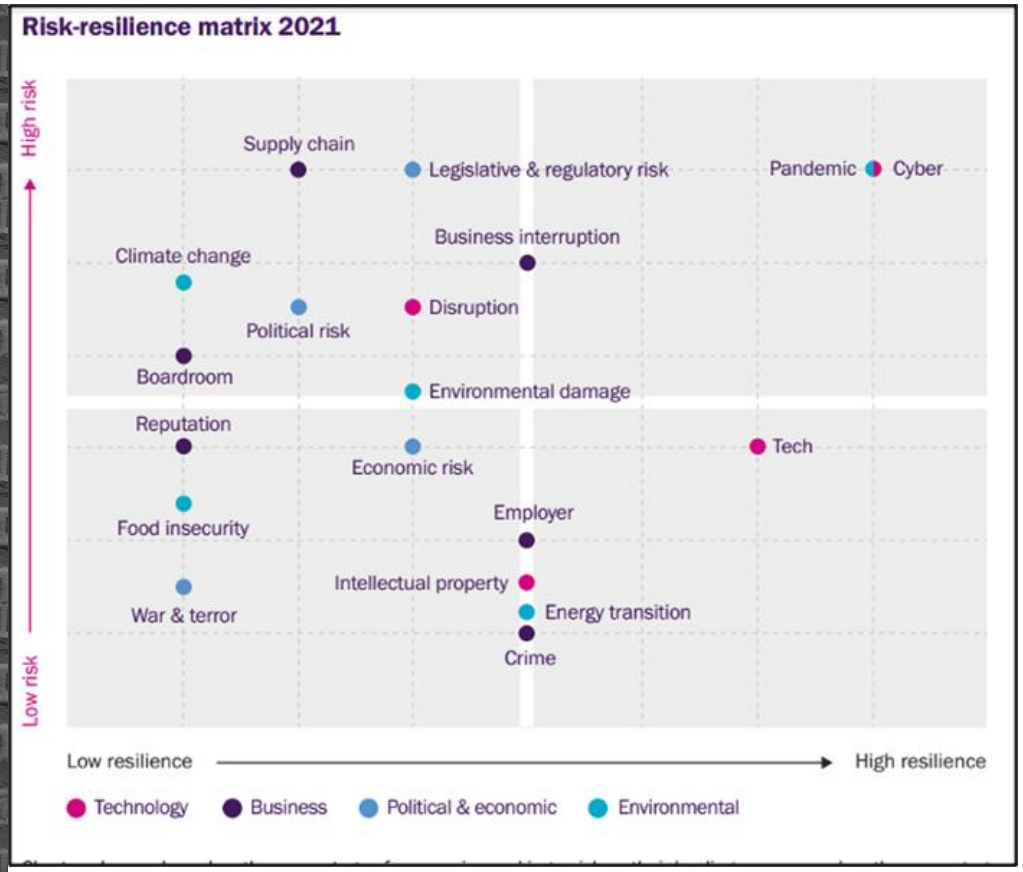
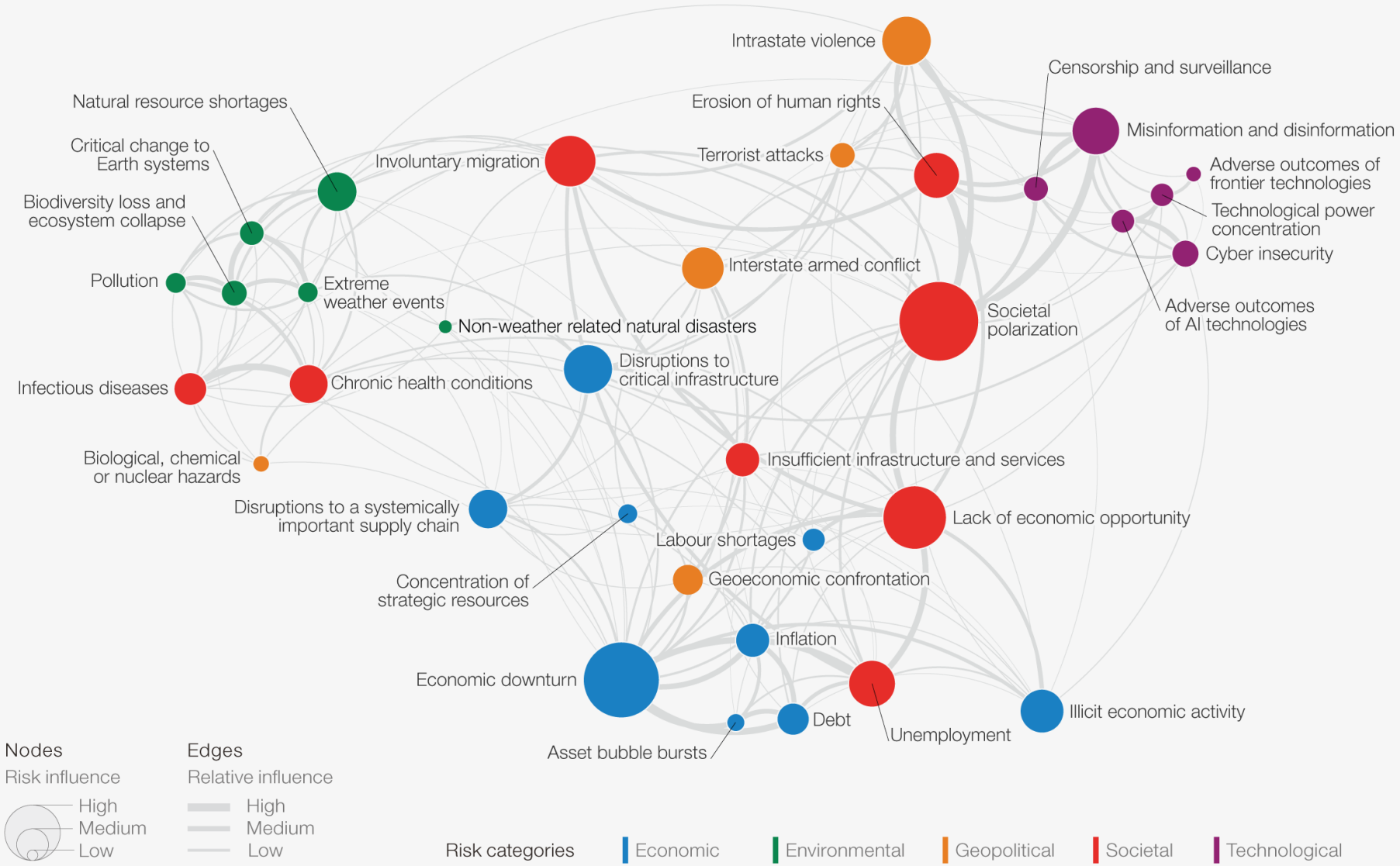


FIGURE D **Global risks landscape: an interconnections map**

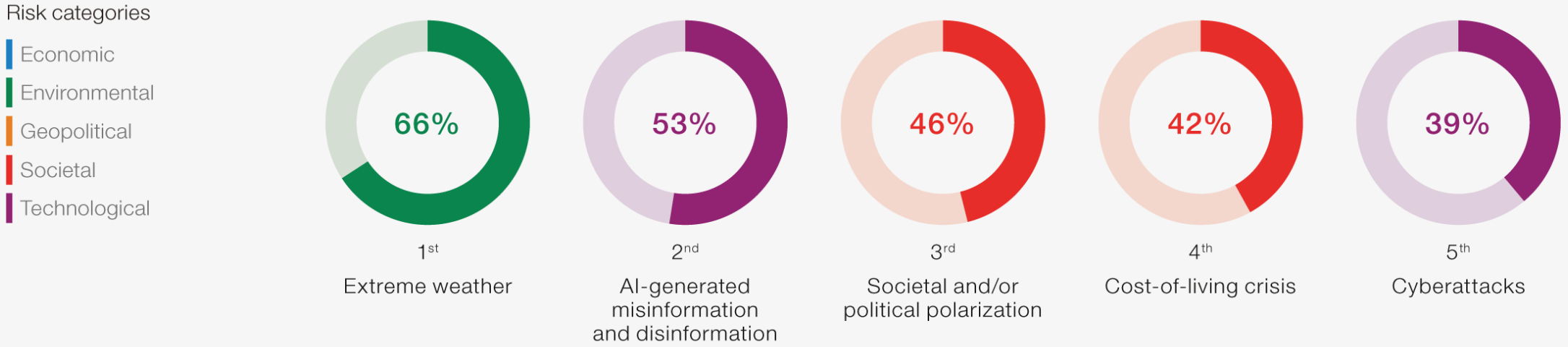


Source

World Economic Forum Global Risks Perception Survey 2023-2024.

FIGURE B **Current risk landscape**

"Please select up to five risks that you believe are most likely to present a material crisis on a global scale in 2024."

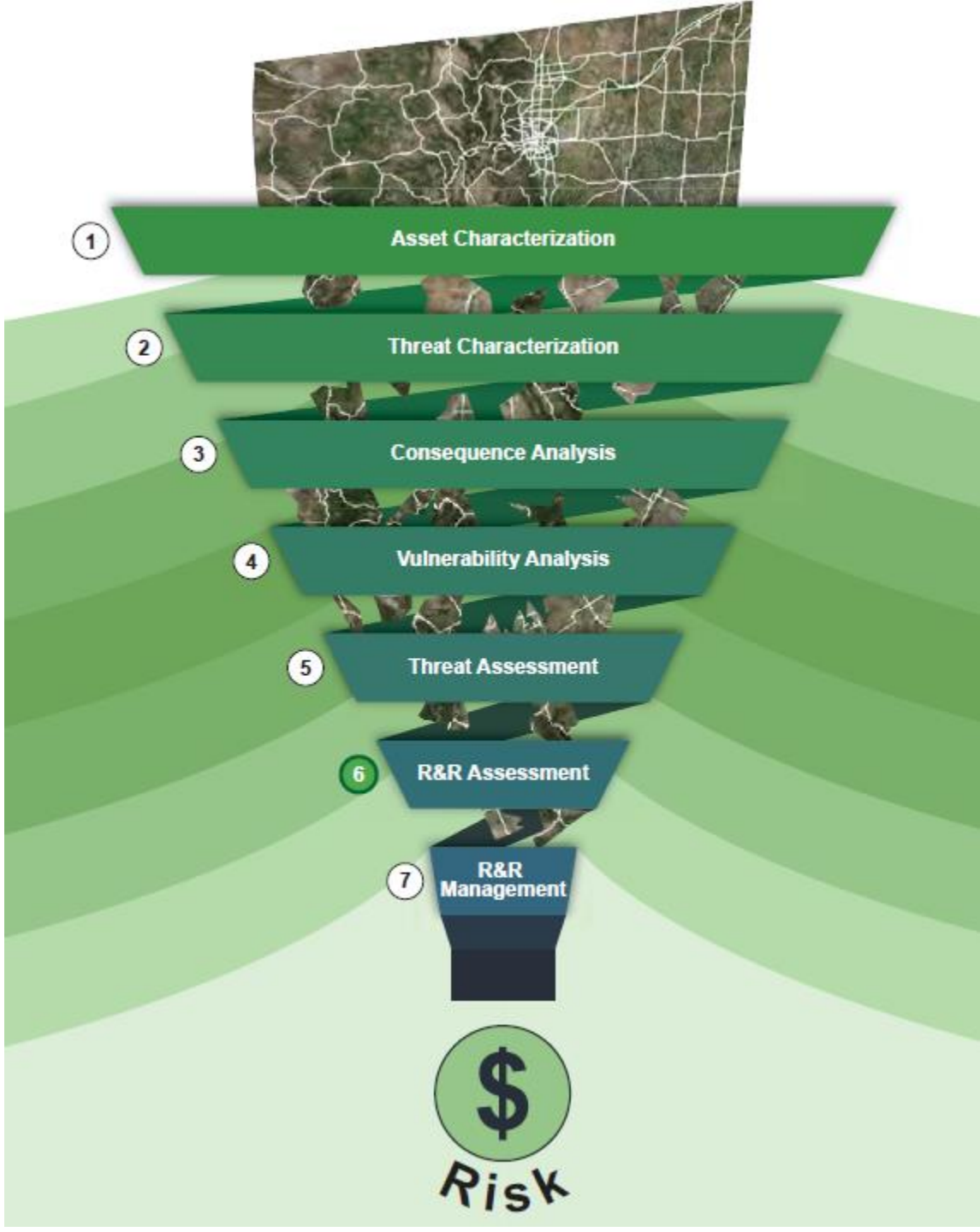


Source

World Economic Forum Global Risks Perception Survey 2023-2024.

AEM 2020

- CDOT RnR Analysis



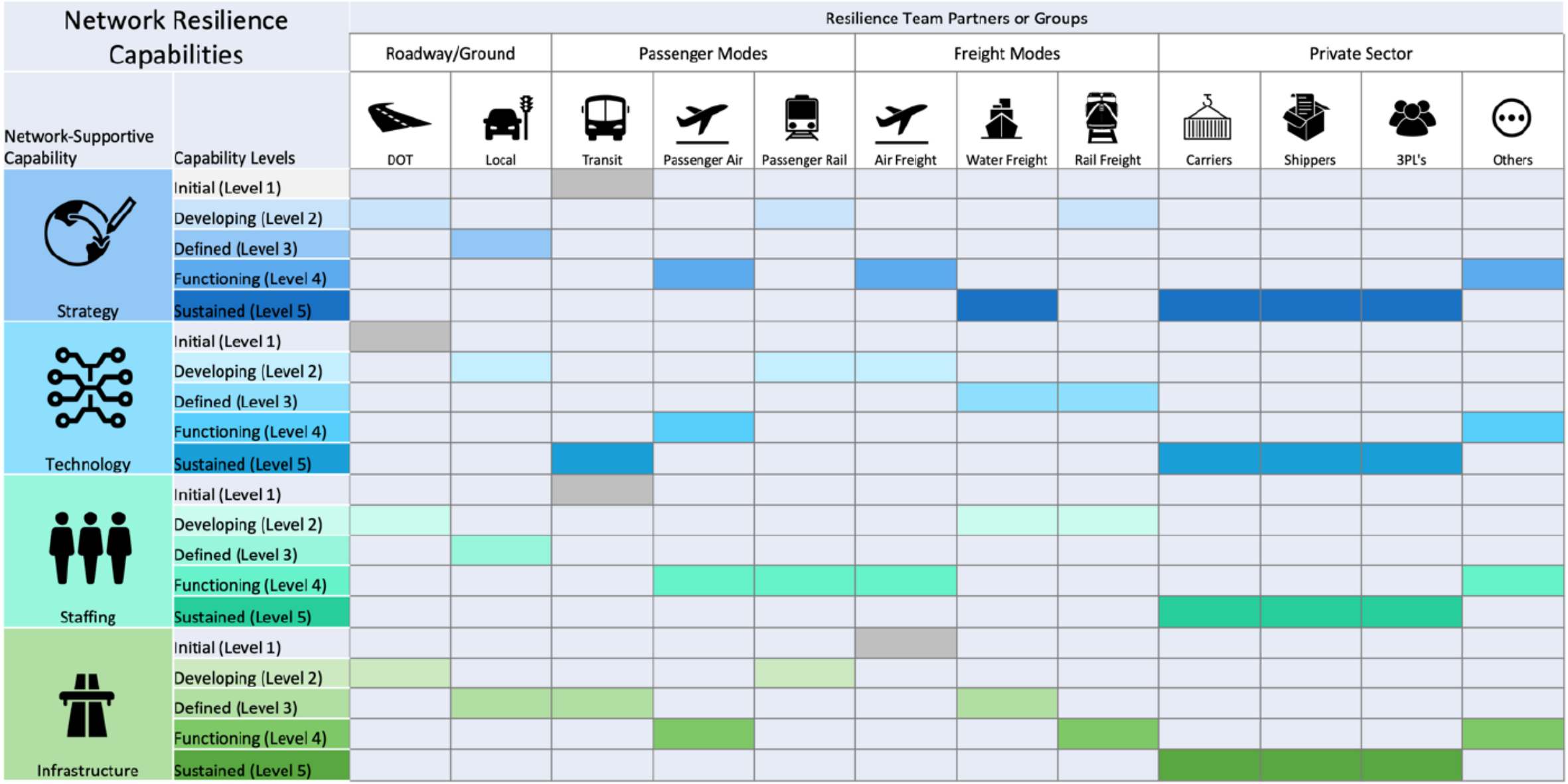
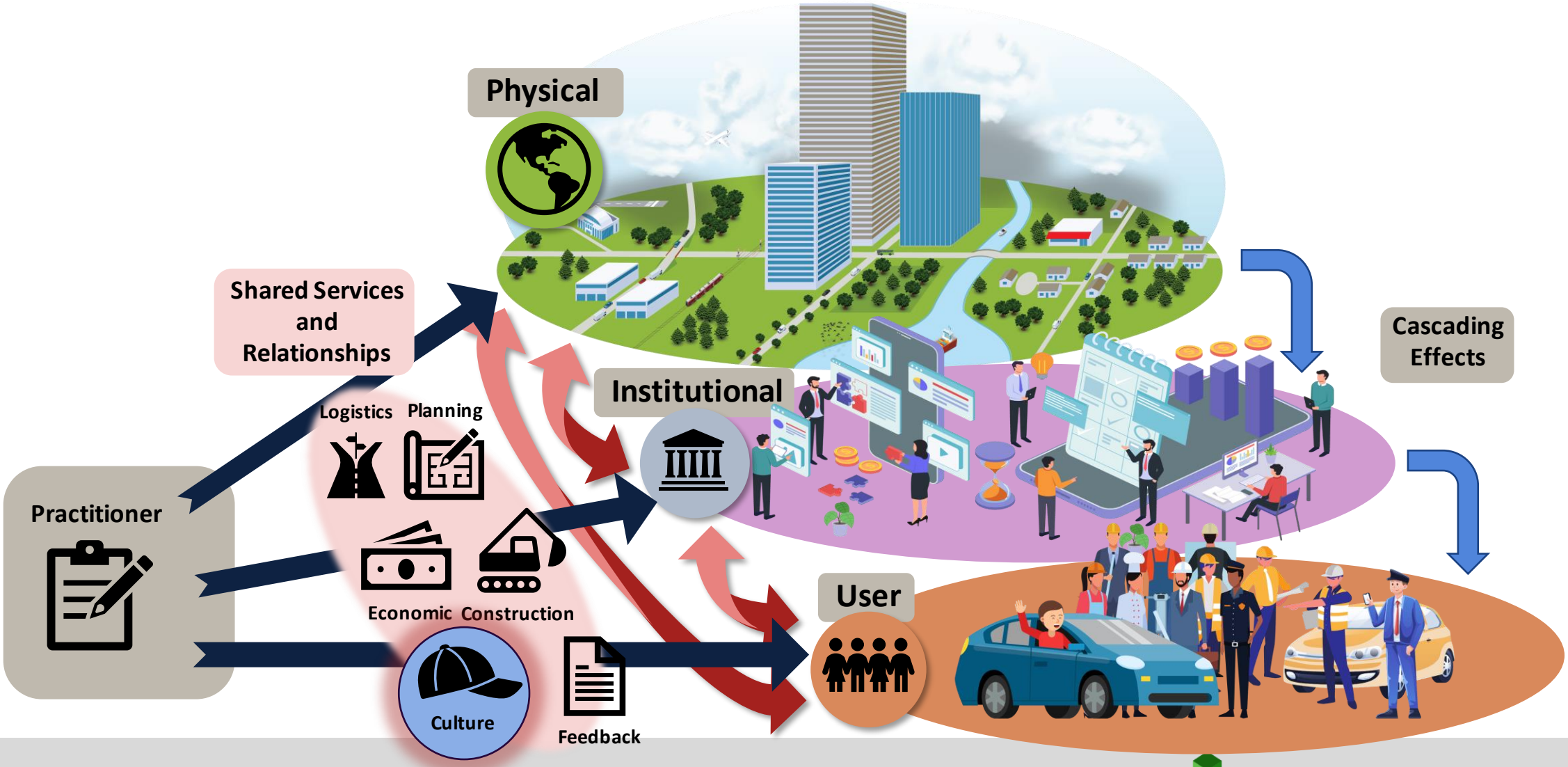


Figure 16. Suggested structure for a network team capability maturity profile

METRO ANALYTICS

Transportation Network Resilience Ecosystem Cascading Effects



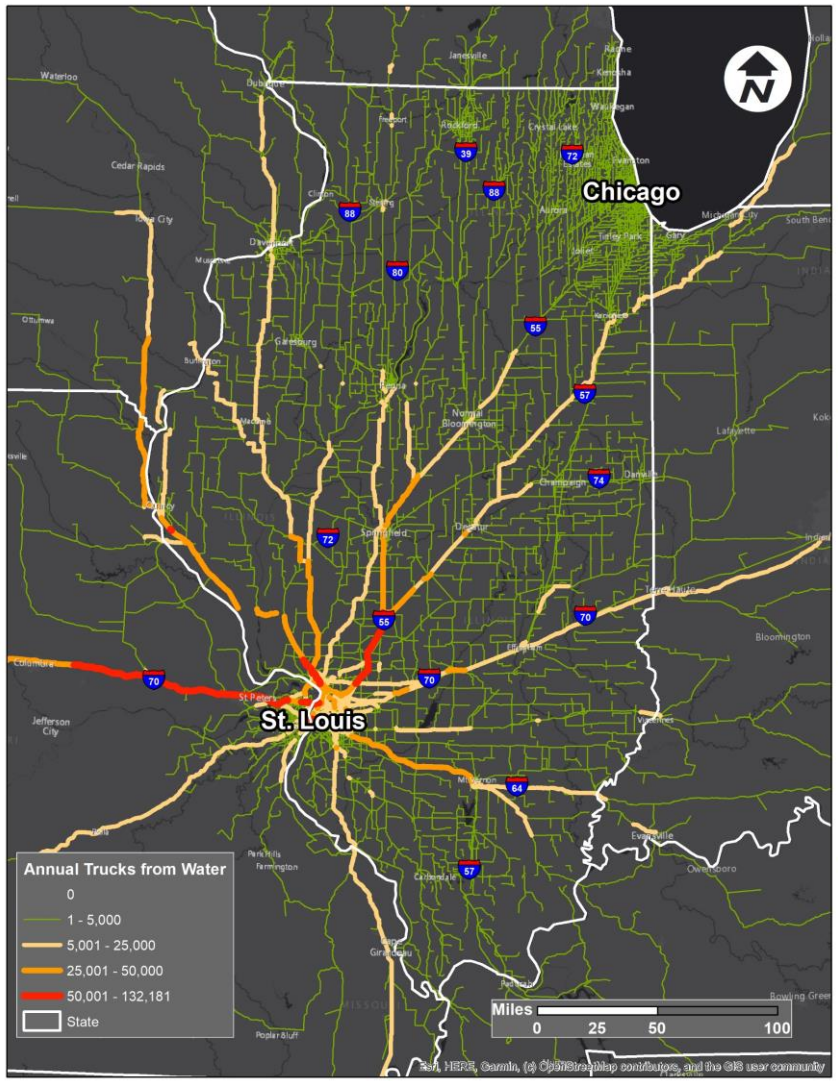
METRO ANALYTICS

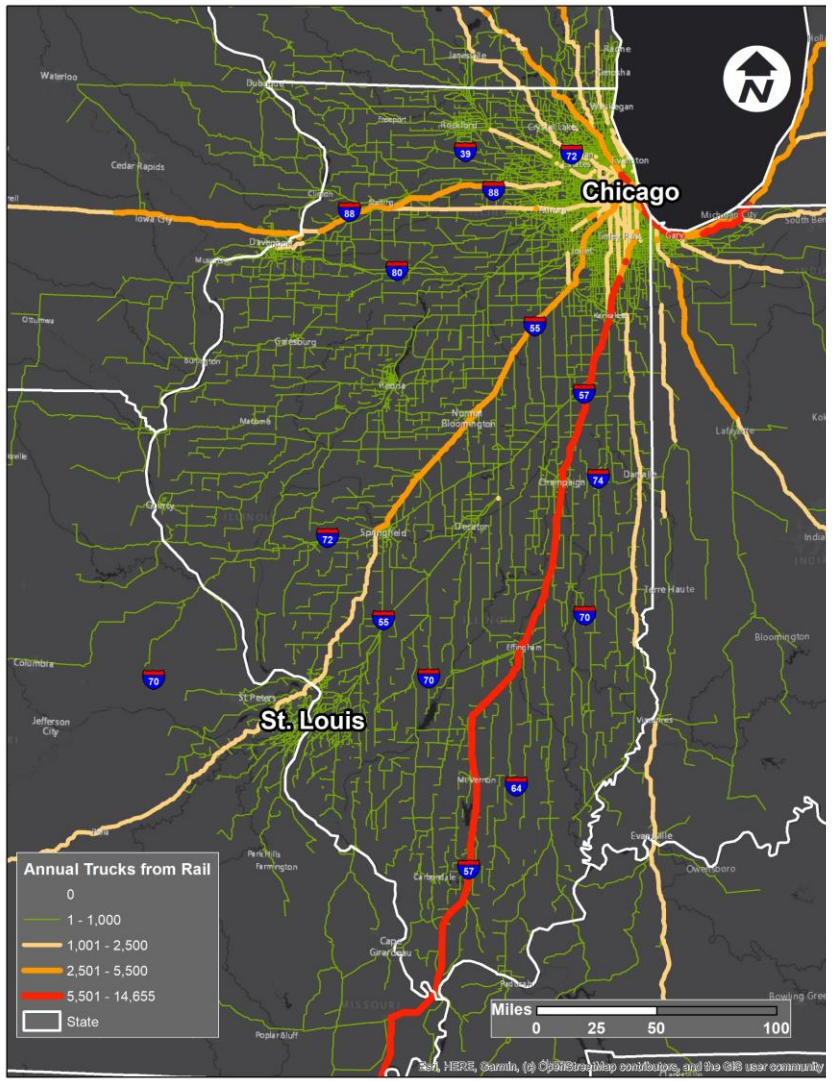
Illinois Routes Serving

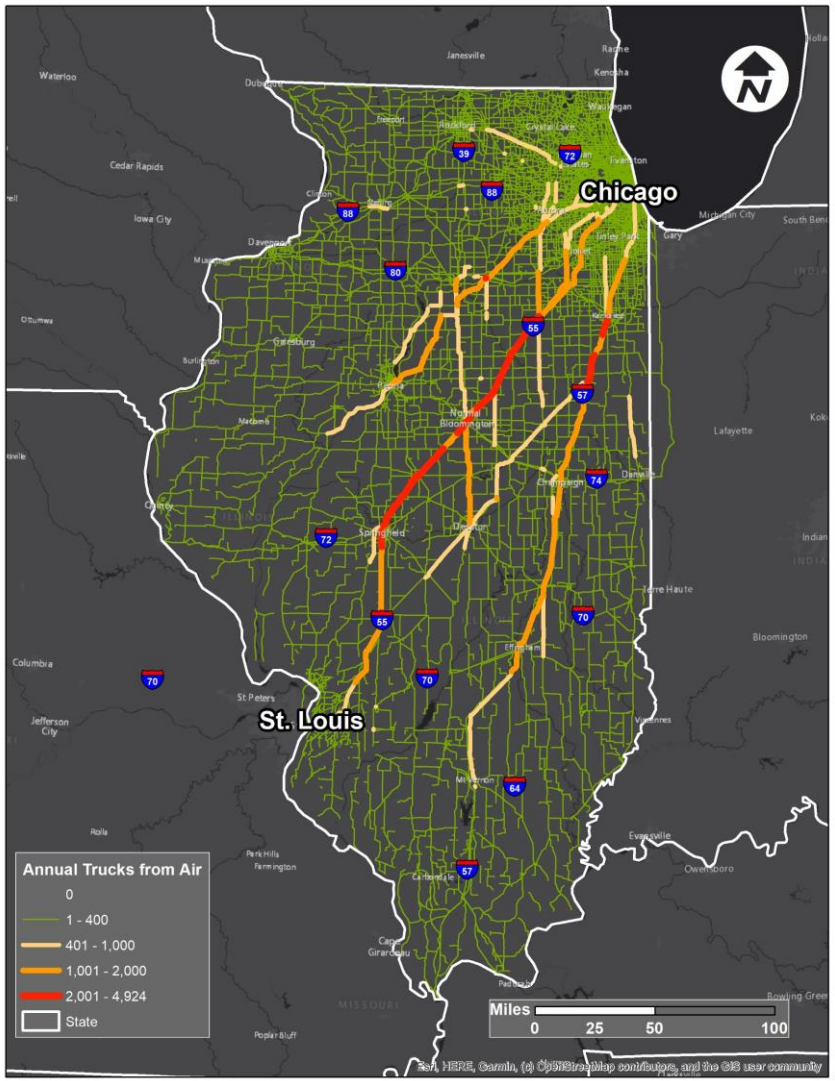
Waterborne Commerce:
Madison County/IL

Inter-Modal Rail:
Chicago Trade Center

Inter-Modal Air Cargo:
O'Hare & Chicago

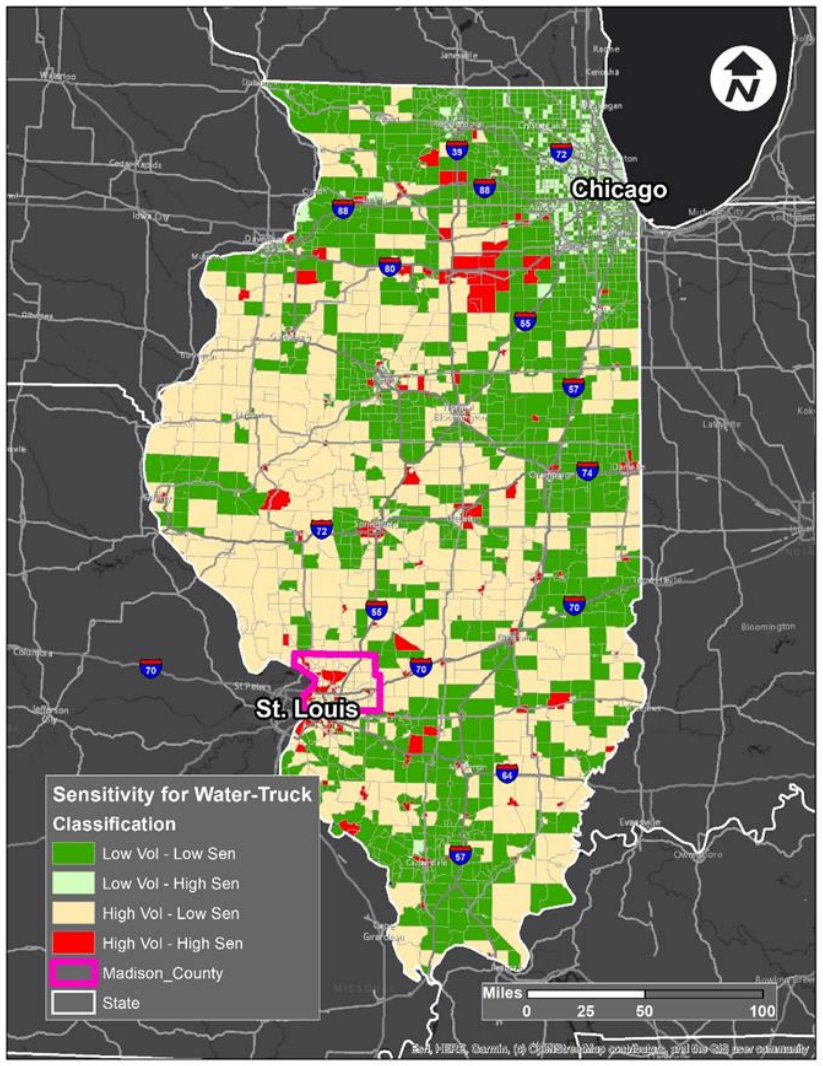




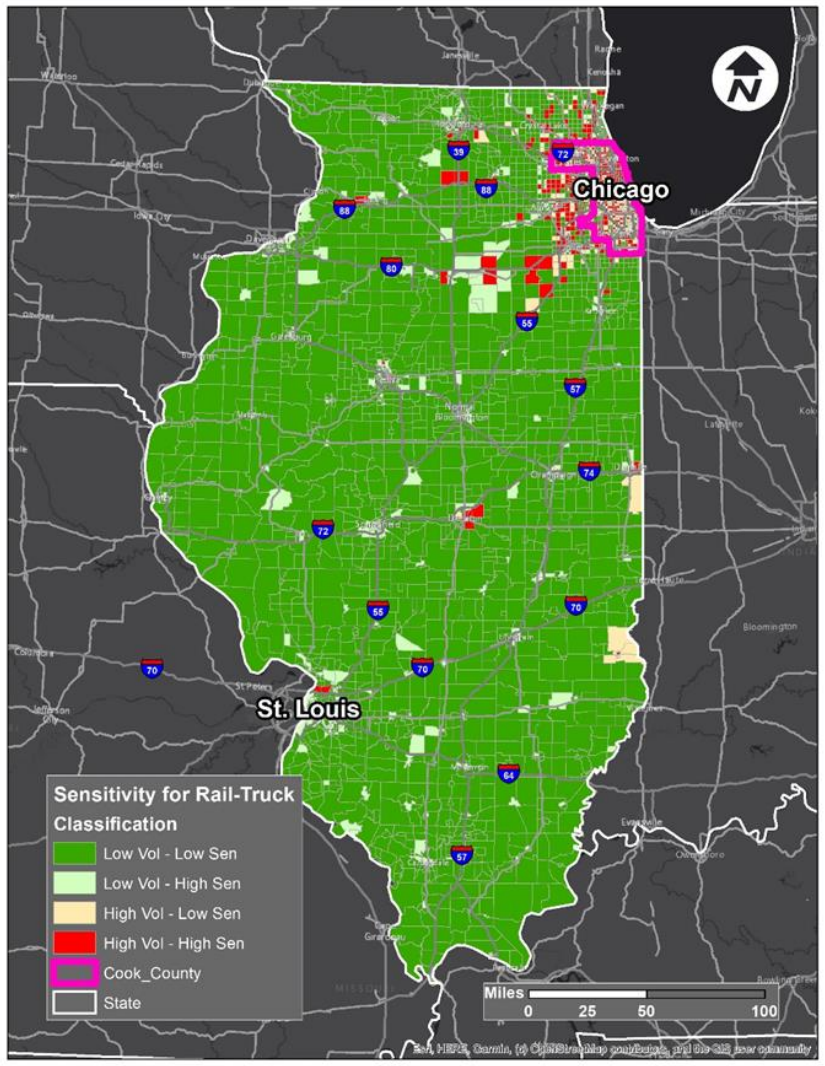


Illinois Routes Serving

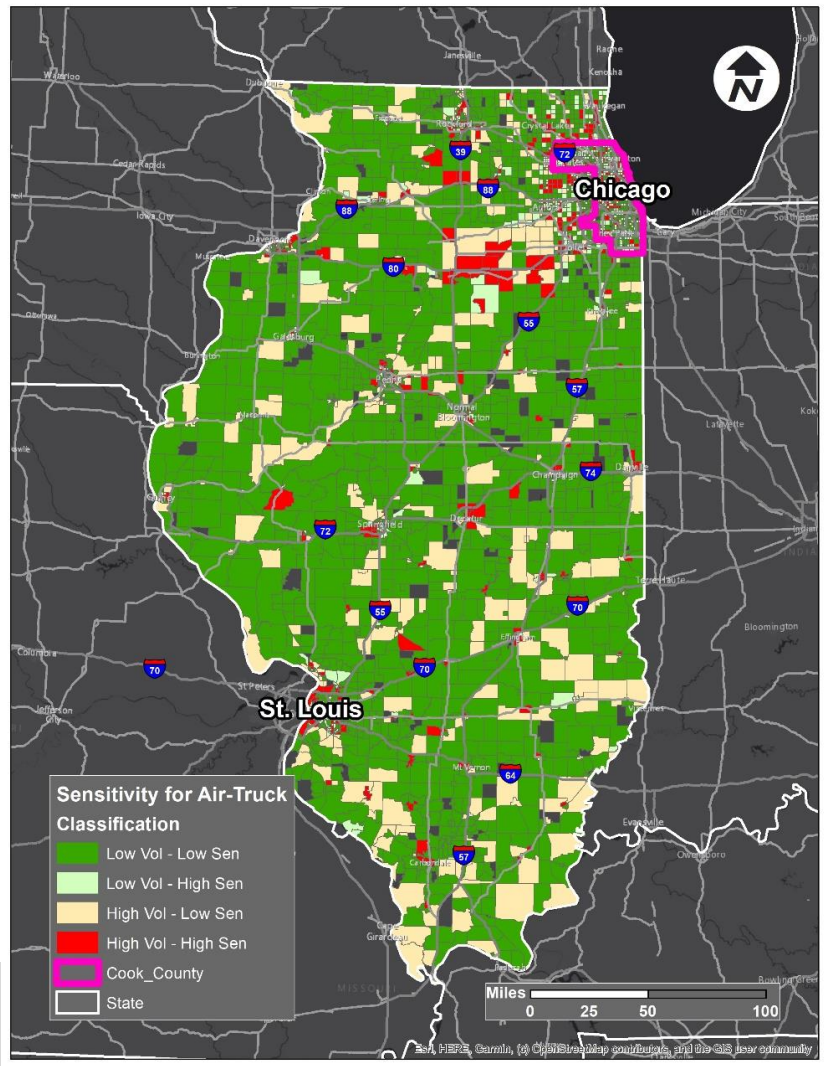
Waterborne Commerce:
Madison County/IL



Inter-Modal Rail:
Chicago Trade Center

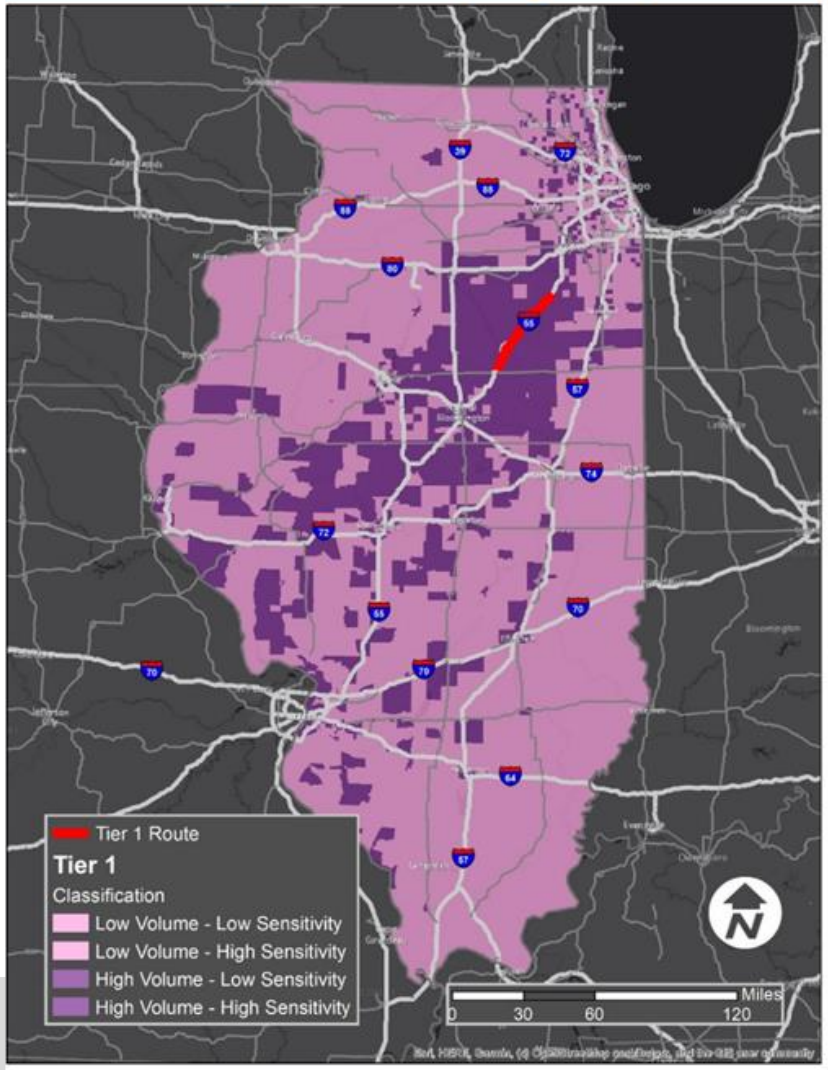


Inter-Modal Air Cargo:
O'Hare & Chicago

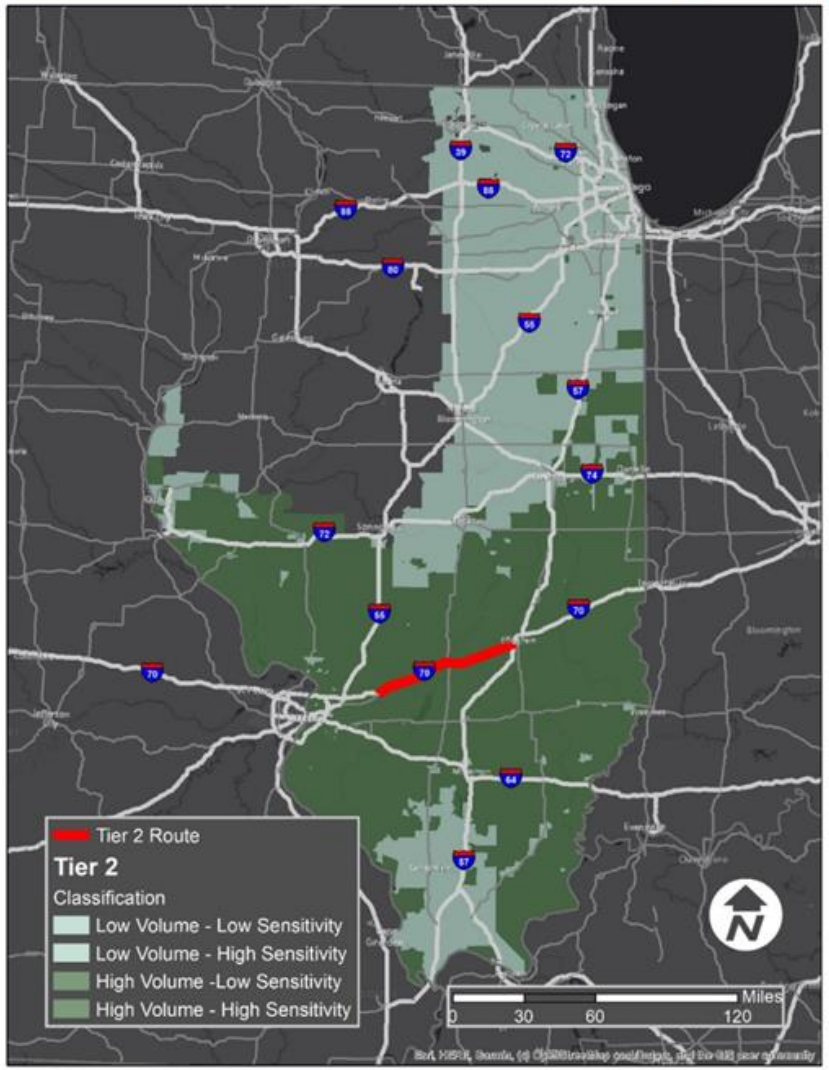


Comparing 3 Projects

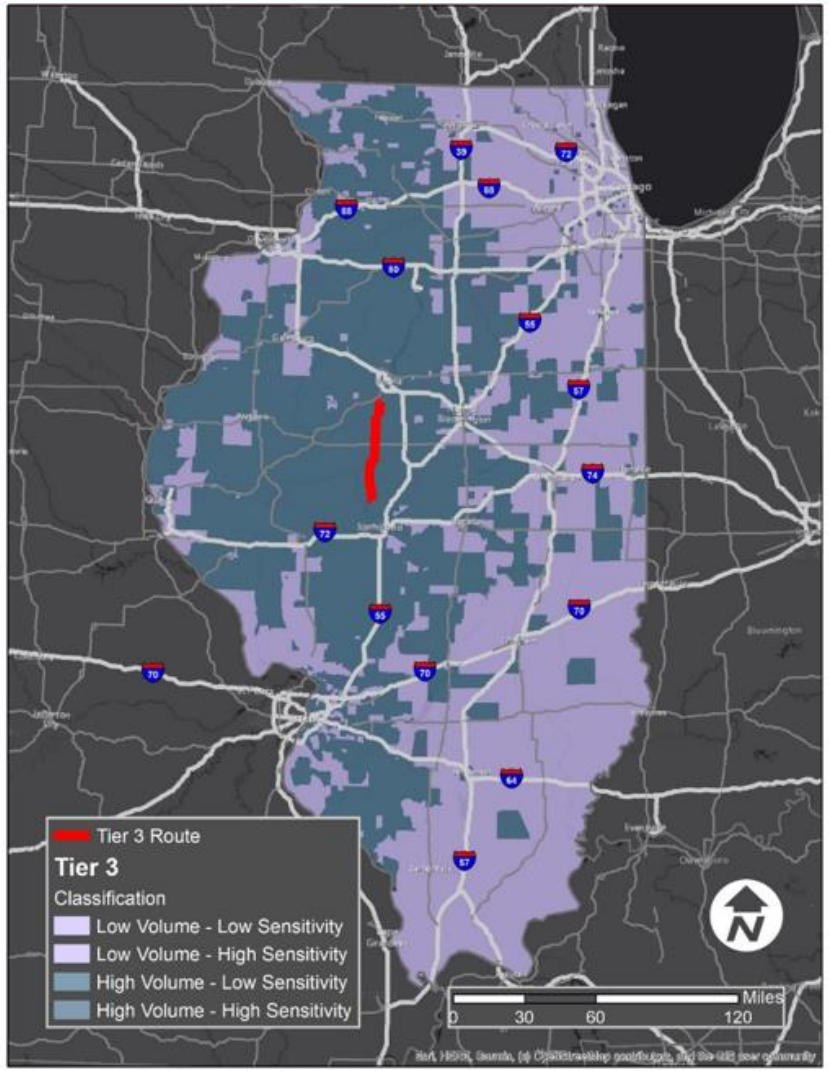
I-55 South of Chicago:
Tier 1 – High Volume, High Impact



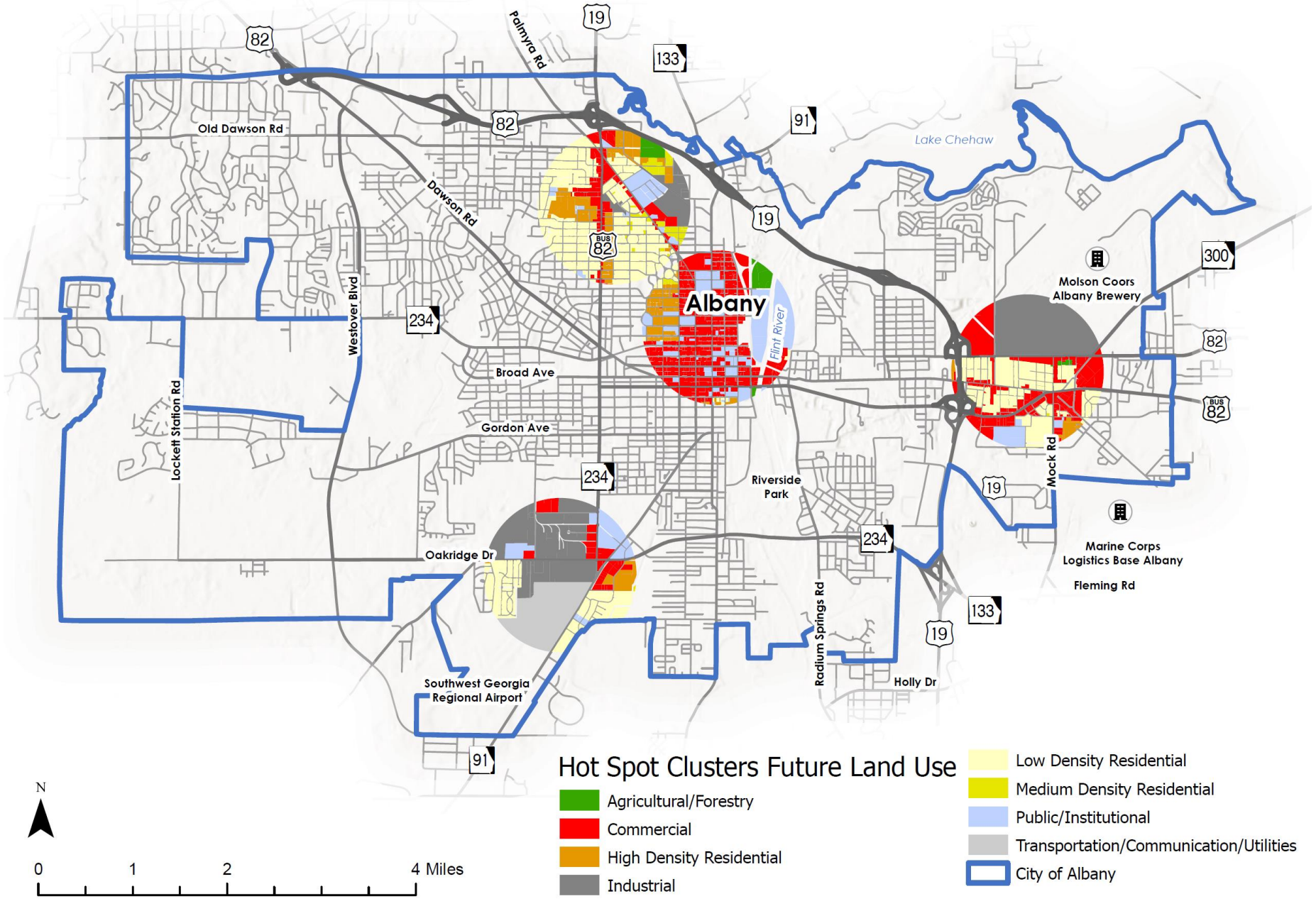
I-70 East of St. Louis
Tier 2 – Moderate Volume & Impact



SR-29 Central Illinois
Tier 3 – Modest Impact



Hot Spot Clusters Future Land Use



METRO ANALYTICS

Illinois Resilience Dashboard

Use the selectors to the right to explore the effects of different tiers of disruptions for different geographies and variables of interest.

Disruption Scenario
Scenario 1 (I-55)

Mapping Variable
Sensitive Employment

Graph/Table Variable
Employment

Disruption Location
- 1
- 2
- 3

Sensitive Employment

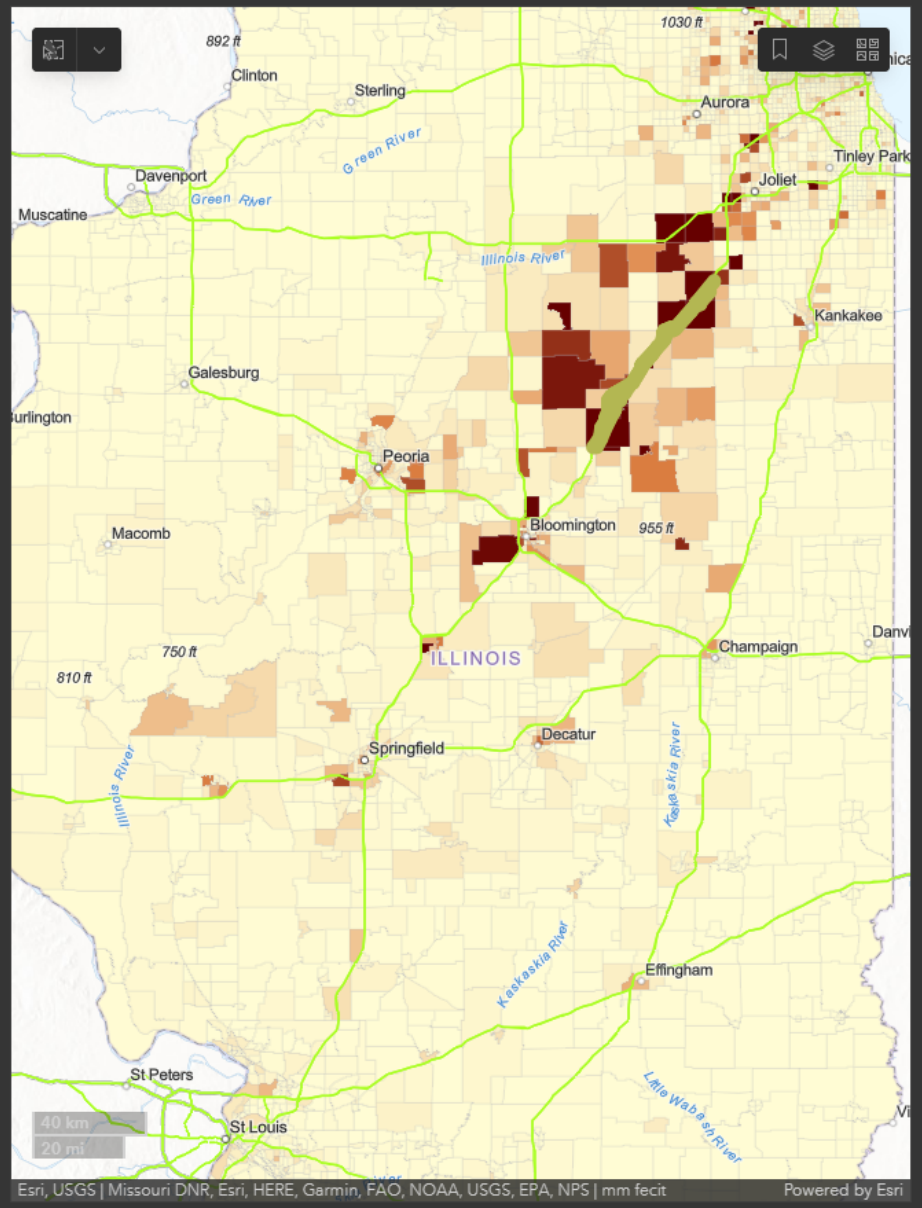
Employment
- > 67
- 33.8
- < 0

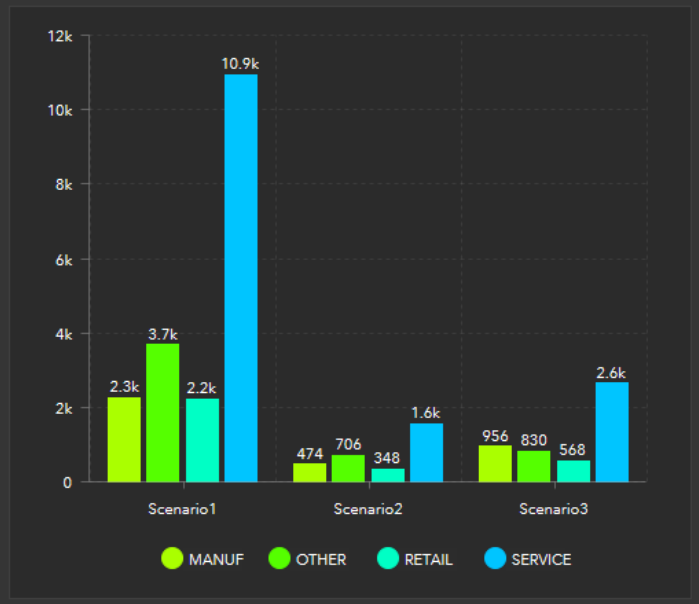
Importance - Volume & Emp Sensitivity
- Low Vol, Low Emp
- Low Vol, High Emp
- High Vol, Low Emp
- High Vol, High Emp

Low Income Households

Income
- > 41
- 20.6
- < 0

Trips



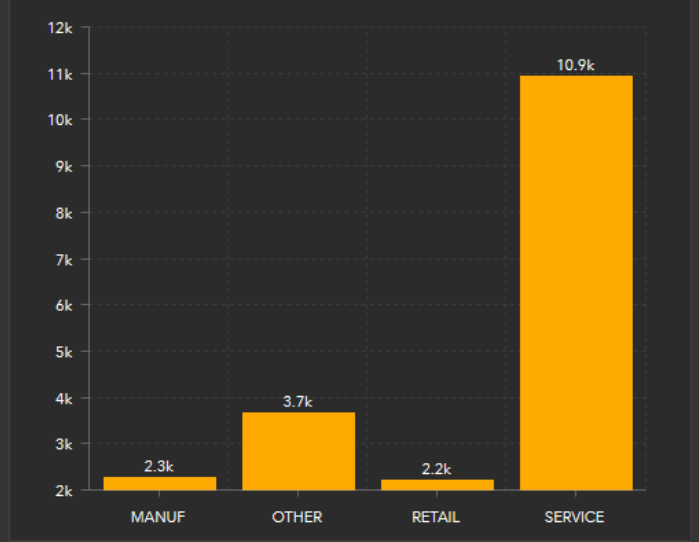


Scenario 1	Affected	Total	Aff_Share
MANUF	2,269	579,849	0.39%
OTHER	3,675	837,300	0.44%
RETAIL	2,219	619,830	0.36%
SERVICE	10,941	3,845,057	0.28%

Scenario 2	Affected	Total	Aff_Share
MANUF	474	579,849	0.08%
OTHER	706	837,300	0.08%
RETAIL	348	619,830	0.06%
SERVICE	1,564	3,845,057	0.04%

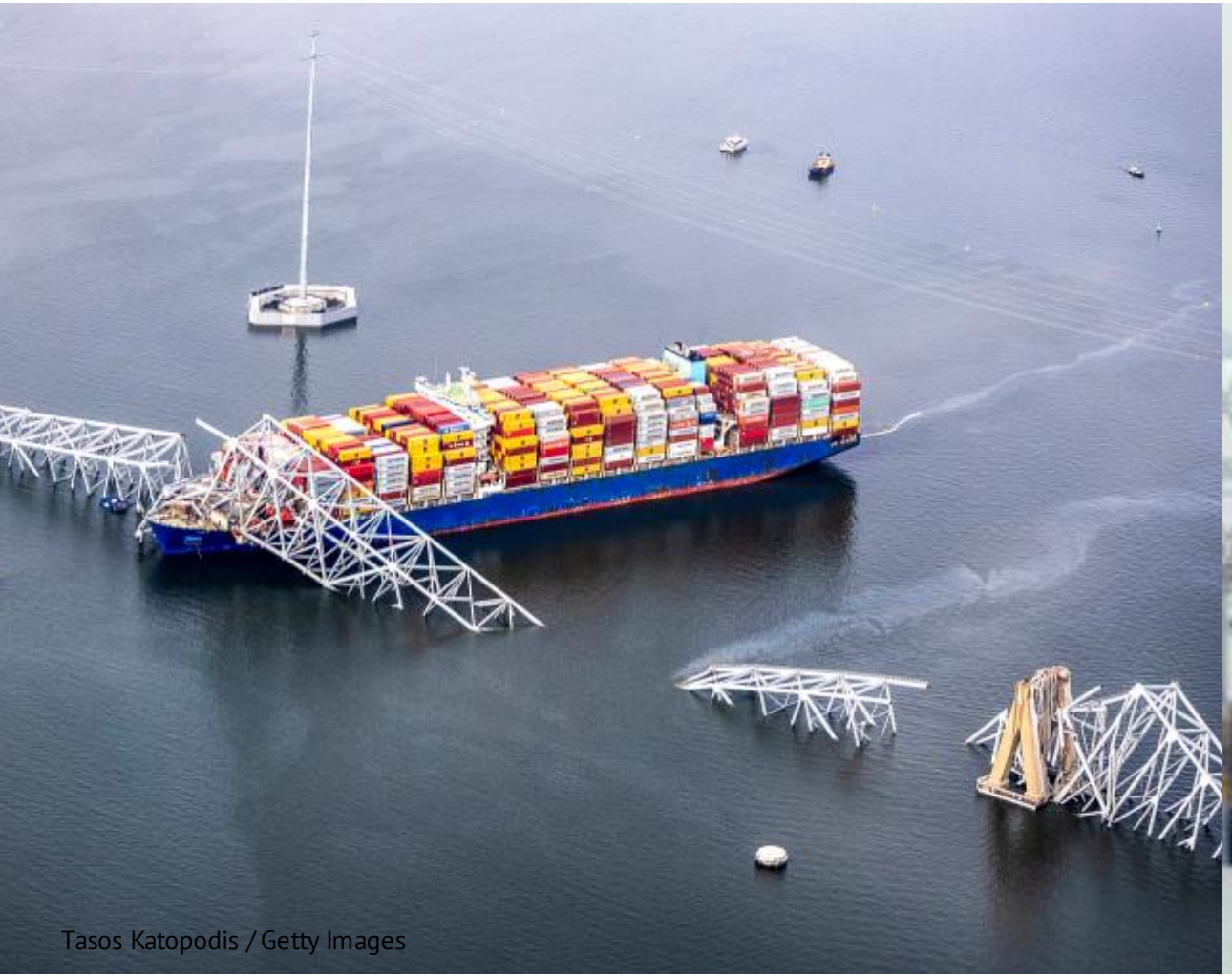
Scenario 3	Affected	Total	Aff_Share
MANUF	956	579,849	0.16%
OTHER	830	837,300	0.10%
RETAIL	568	619,830	0.09%
SERVICE	2,645	3,845,057	0.07%

Affected value of variable selected



Variable	Affected	Total
MANUF	2,269	579,849
OTHER	3,674	837,300
RETAIL	2,219	619,830
SERVICE	10,940	3,845,057

METRO ANALYTICS



Tasos Katopodis / Getty Images

Without effective Bridge Bumper

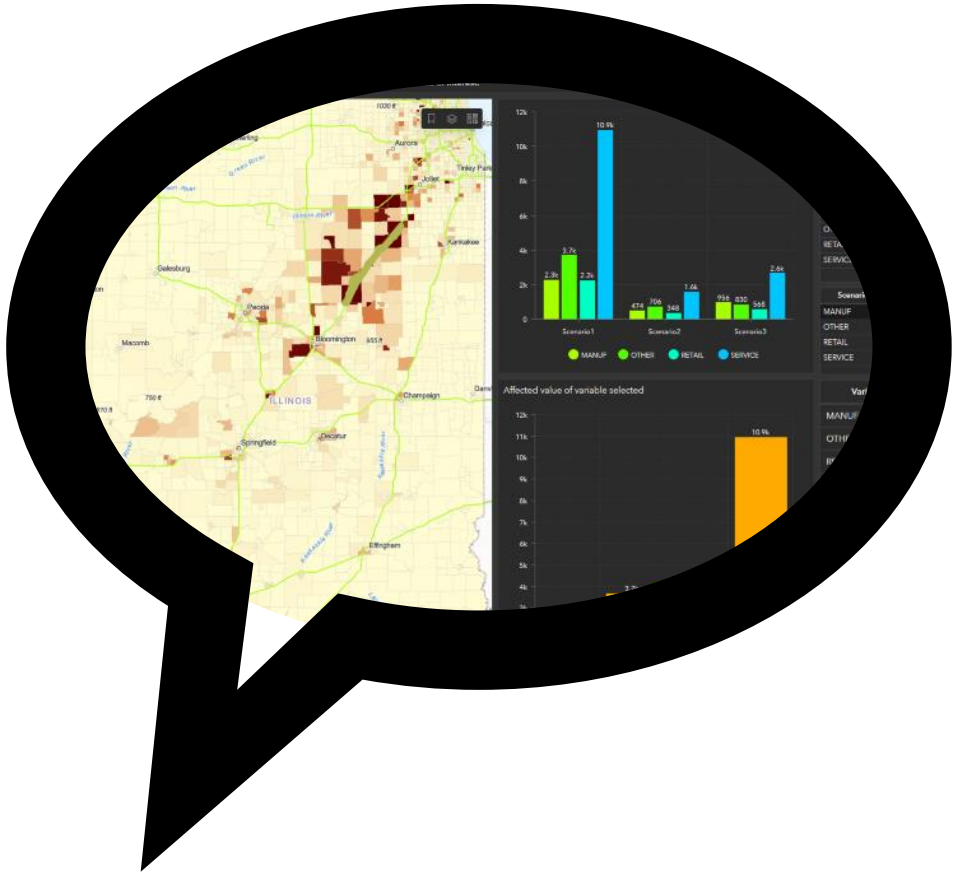
AP file photo The cargo ship oil spill accident at Oakland Baby Bridge

With effective Bridge Bumper

METRO ANALYTICS

Keep it Simple.

Use pictures to tell a story that resonates.



Frank Broen **frank@metroanalytics.com**

https://weather.com/safety/floods/news/2019-07-08-washington-maryland-virginia-flooding-leads-to-water-rescues

ANALYZING AND VISUALIZING RISK FOR RESILIENCE

National Academies of Science
Transportation Research Board Webinar
Visualizing Risk for Resilience

Silvana V Croope, PhD, ENV SP, E.W. 105198790
Post-Doctor in Law
UniCuritiba, ANIMA Group, Brazil
Delaware Department of Transportation (DelDOT) - Retired

- NEED FOR RISK AND RESILIENCE COMMUNICATION
- EXAMPLES
- ANTHROPOLOGIC PERSPECTIVES AND EVOLUTION
- TECHNOLOGY
- CHALLENGES

“PROBLEMS CANNOT BE SOLVED BY THE SAME LEVEL OF THINKING THAT CREATED THEM”

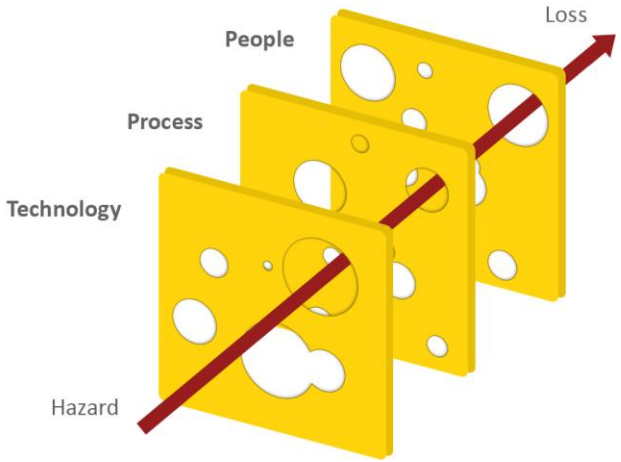
- ALBERT EINSTEIN

KNOW YOUR RISK

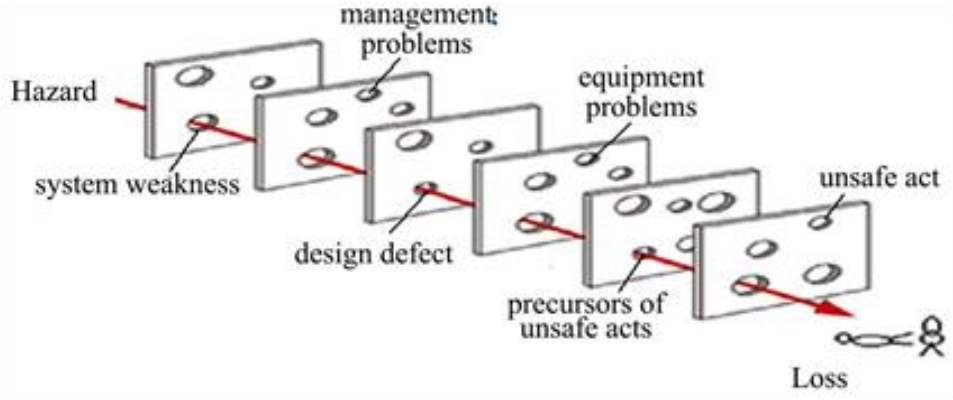
- EXPERIENCE (HISTORIC EVENTS AND FORECASTING INSIGHTS)
- ANALYSES
- COMMUNICATION
- ACTIONS

RISK IS PART OF RESILIENCE DEVELOPMENT

- Traditional Risk…
- Enterprise/holistic Risk Management
- Disruption and failure can be a type of risk, where failure is the opposite to resilience



- Resilience: 4Rs + Adaptation + Altruism
- Resilience: customized approach
- Resilience for security comes in second development organization

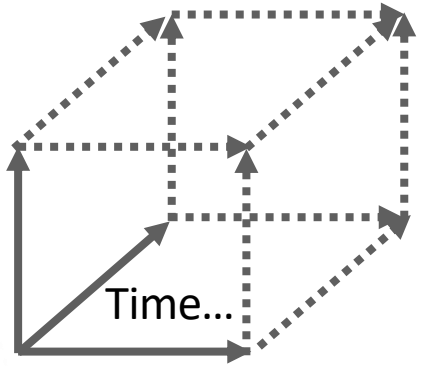


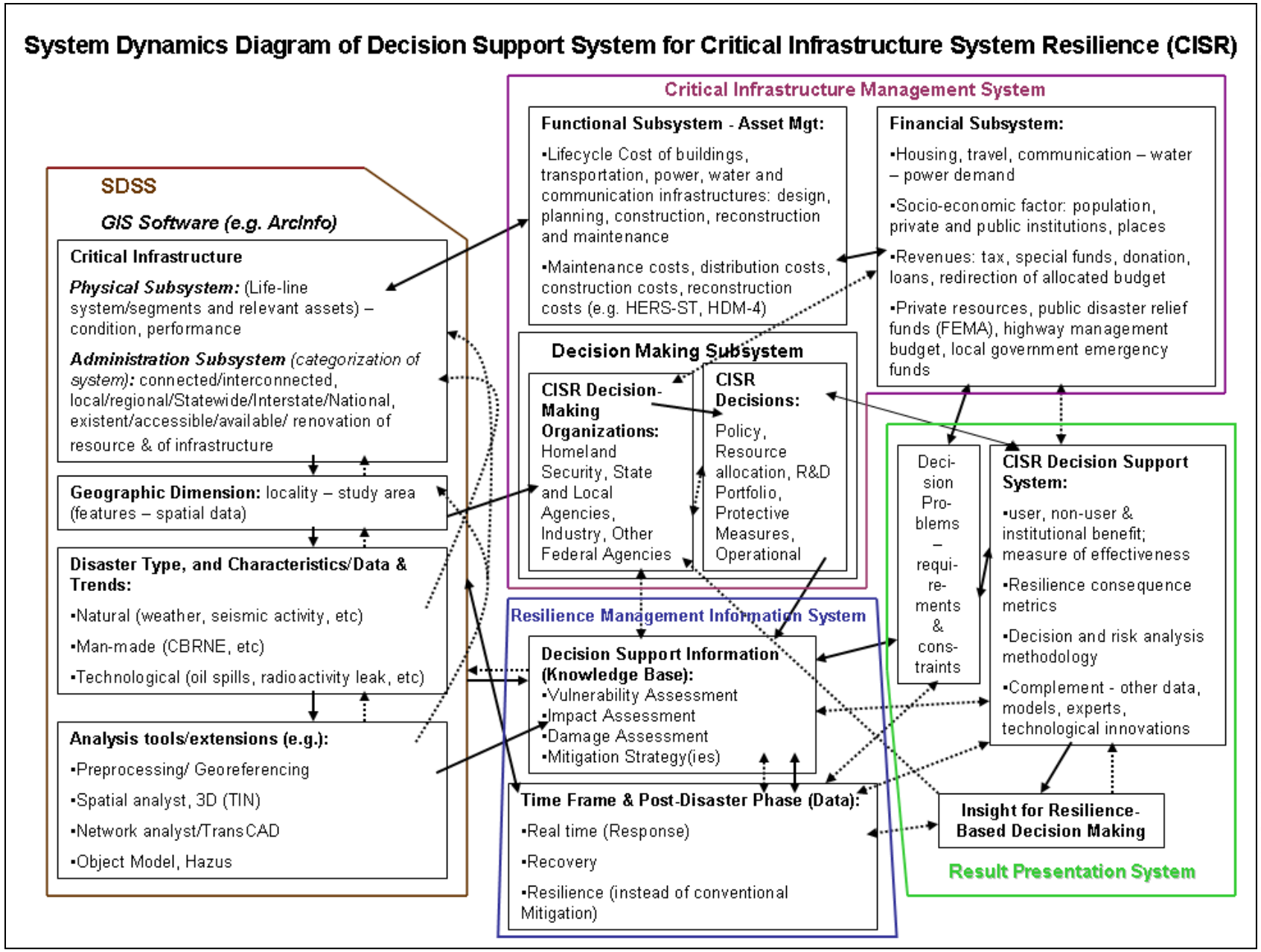
CIR-DSS

(DR. CROOPE)

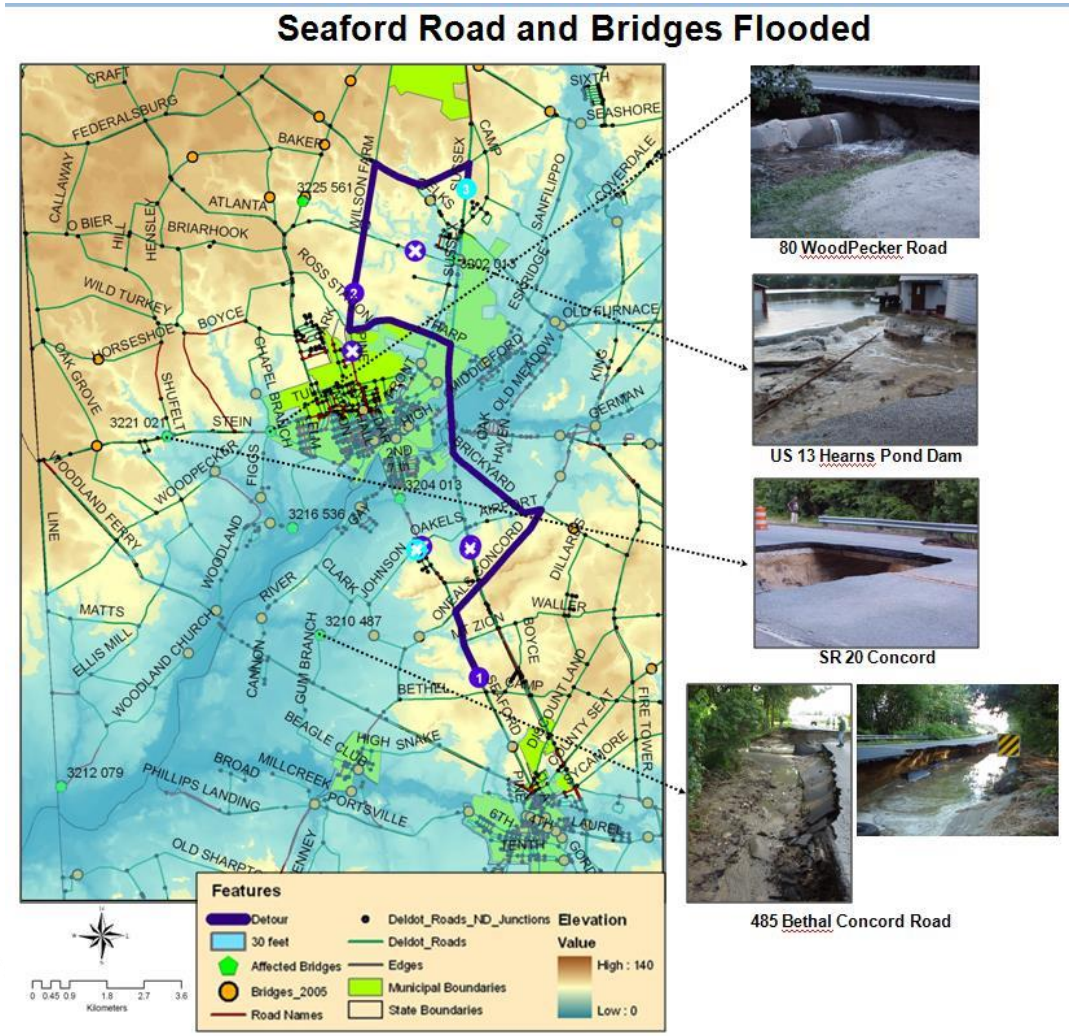
Includes software development to test and simulate hypothesis for resilience outcomes.

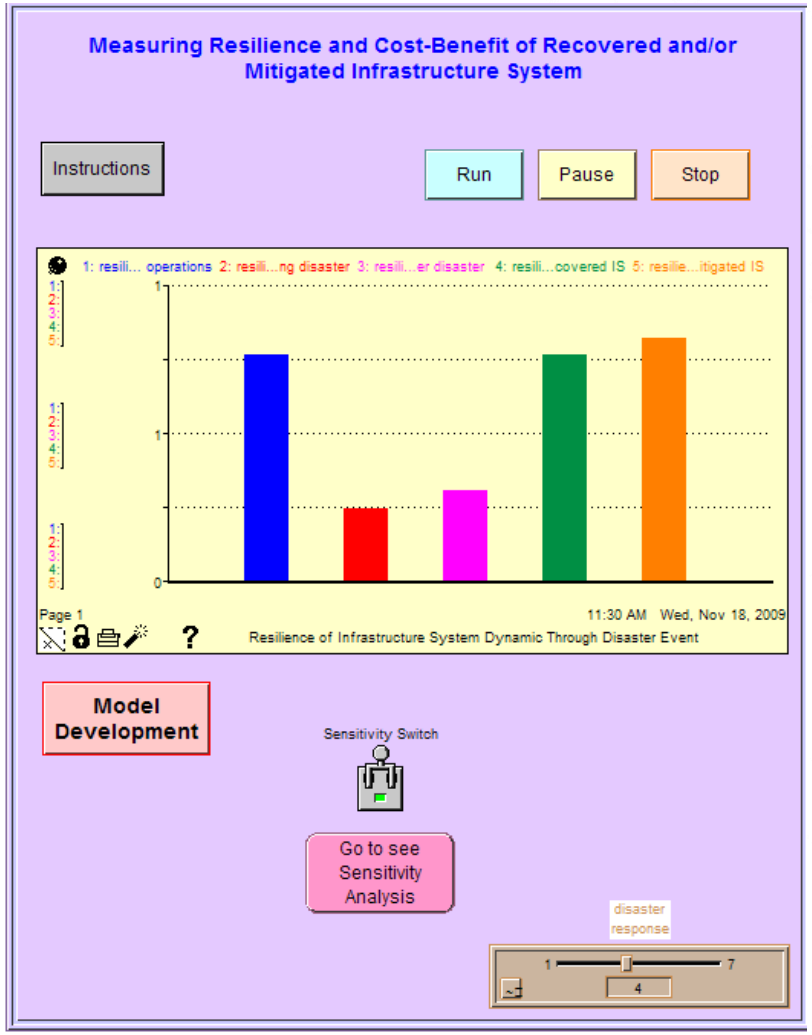
http://dx.doi.org/10.13140/2.1.3395.9044





CIR-DSS WAS TESTED… AND ADJUSTED TO TRANSFER IT TO PRACTICE…

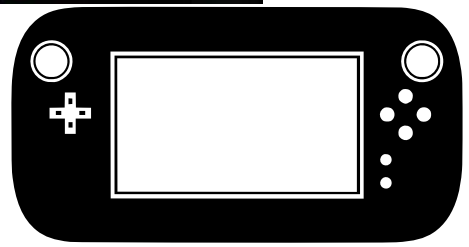




DISASTERS CONTROL AND MANAGEMENT:
MULTI AND INTERDISCIPLINARY PERSPECTIVE FOR RESILIENCE

Control → Management

- Antonym: lack off/ uncontrol



DELAWARE DOT

Transportation Strategic Enterprise Resilience for Facing Climate Change

TRB Webinar:
Economic and Financial Dimensions to a Climate Resilient Transportation Infrastructure

Silvana V Croope, Ph.D., ENV SP
DelDOT – Delaware Department of Transportation
May 12, 2016

DELDOT RISK AND RESILIENCE MANAGEMENT FRAMEWORK

Seminar 1: The Delaware Floodplain Impacts of Severe Storms on Infrastructure in a Low-Lying State

Delaware Department of Transportation AECOM RMS

Enterprise Resilience Management Strategy

2 Flood
8 Hurricane
1 Coastal Storm
5 Snow
1 Drought
4 Severe Storm

21 Natural Disasters since 1953

https://www.fema.gov/data-visualization-disaster-declarations-states-and-counties

Delaware Department of Transportation vision:

Every Trip | Every Mode | Every Dollar | Everyone

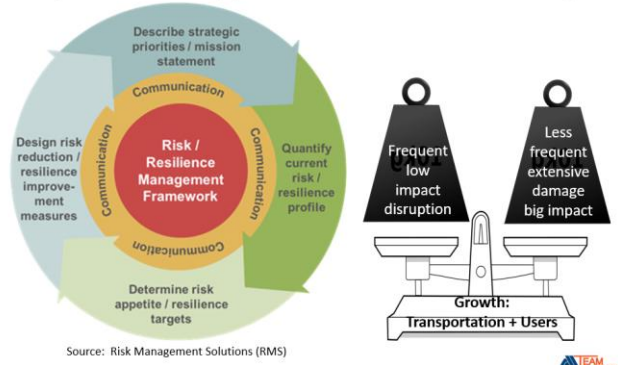
" Any potential hazardous impacts should be assessed and benchmarked against DelDOT's safety, service level, financial and environmental tolerances."

Align with
- DelDOT's Climate Change Strategic Implementation Plan
- Enterprise Resilience Management Strategy

Delaware Department AECOM RMS

Risk & Resilience Management Framework:

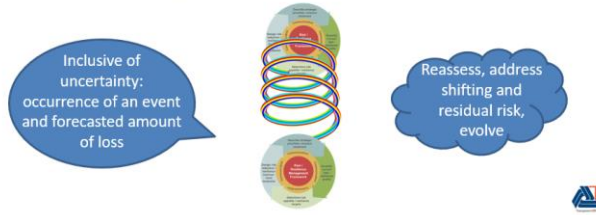
A cycle-based approach to decision-making



Source: Risk Management Solutions (RMS)

DelDOT Resilience Strategy

Maintain business as usual during an event
&
Restore timely, decreasing disruption through effective investments



RECENT EXAMPLES

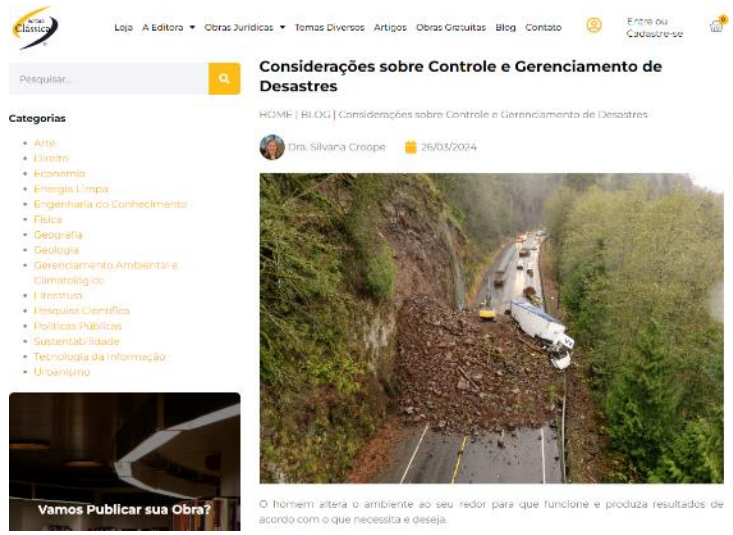
- Flooding Monitoring Systems (direct sensing)

Dams' Risk of Failure

https://editoraclassica.com.br/produto/um-estudo-de-caso-de-resiliencia/

Catastrophe Law: Public and Private Responsibility to Protect Human Rights in Natural Disasters Events (in Portuguese)

https://revista.grupofaveni.com.br/index.php/dialogospossiveis/article/view/1723



https://editoraclassica.com.br/consideracoes-sobre-controle-e-gerenciamento-de-desastres/

ANTHROPOGENIC PERSPECTIVE

- Post-doctorate research:
- Regulations for construction and economic development
  - Construction standards and processes, support by technological monitoring, and the cycle of disasters due to intentional, historic/natural, or negligence failure

- Issues:
  - Know your risk
  - Communicate the risk (censure and access/dissemination or real information)
  - Use and management of knowledge for decision making, investments, transfer of risk
    - To the public
    - To backstop government programs

DELAWARE ROADWAY AND SURROUNDING LAND FLOODING PROJECTIONS

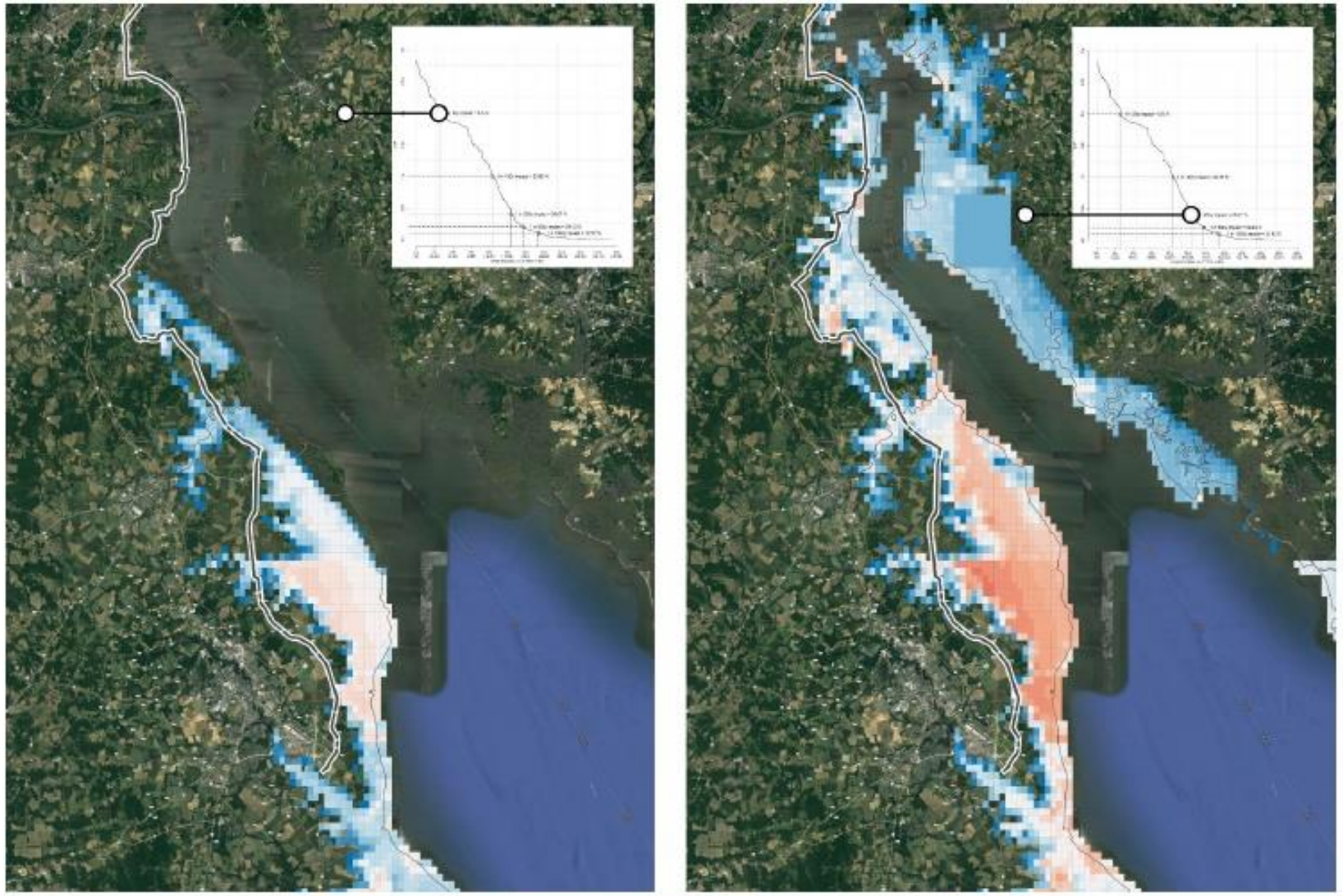


FIGURE 10 STORM SURGE FOOTPRINTS FOR SELECT STOCHASTIC EVENTS[16]

- Develop and transfer the risk?
- Retreat?
- Adopt to stand ground and retrieve?

[16] The stochastic events on the left (Event A) and right (Event B) impact 6.5% and 26.0% of the total length of SR9 respectively, the corresponding probabilities of occurrence of events of this magnitude are 2.0% and 0.4%. These events have been selected to provide examples of the type of stochastic event that make up the OEP curve. While the OEP curve describes the full range of severity and loss, event 'scenarios' such as this are a useful tool to add real-world context when communicating the types of event that can impact SR9, and their probabilities of occurrence.

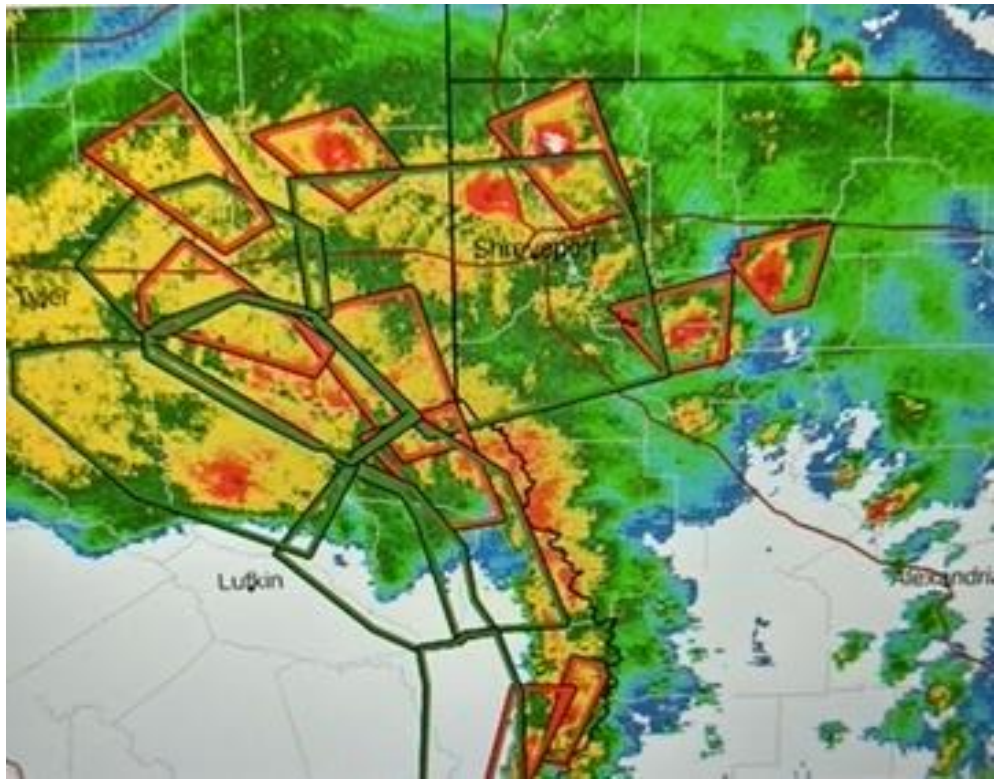
RESILIENCE PROJECTS EXAMPLES

(DR. CROOPE)

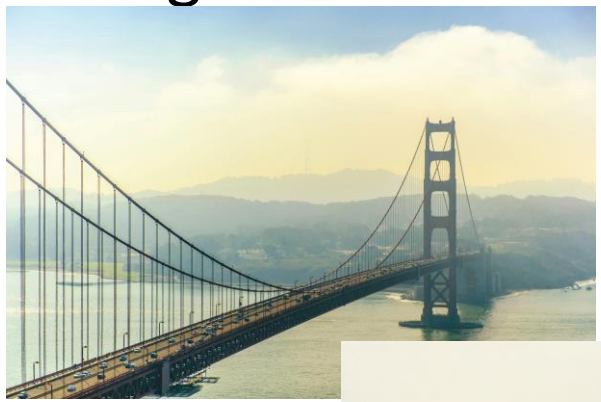
- NAS-TRB NCHRP "FloodCast"
  - https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4914
  - http://floodcast.info/wordpress/
- World Bank: rail transportation capacity increase with resilience network approach, Rio de Janeiro, Brazil.
- UFSC-LabTrans: PARF
  - http://www.naestradaro.com.br/2015/11/dnit-discute-prevencao-de-desastres.html
- Outros
  - https://onlinepubs.trb.org/onlinepubs/webinars/170816.pdf
- UN: Global Sustainable Development Report (2016), Chapter 2
  - https://sustainabledevelopment.un.org/content/documents/10822Chapter2_GSDR2016_booklet.pdf
- DelDOT SIP
  - https://deldot.gov/Publications/reports/SIP/pdfs/SIP_FINAL_2017-07-28.pdf
- Climate Justice for Wilmington
  - https://www.delawarenaturesociety.org/wp-content/uploads/2018/10/DNS-Climate-Change-Summary-Report-Final.pdf
- UAS NOS-T (Tráfico humano)
  - https://www.unitedagainstslavery.org/nost-2021
- NCHRP 20-121 (NAS)

RESILIENCE TO CLIMATE AND SECURITY

Hurricane with tornadoes

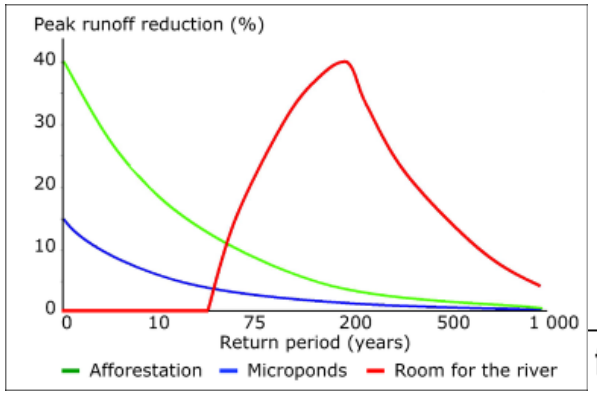


Bridge nodes for network

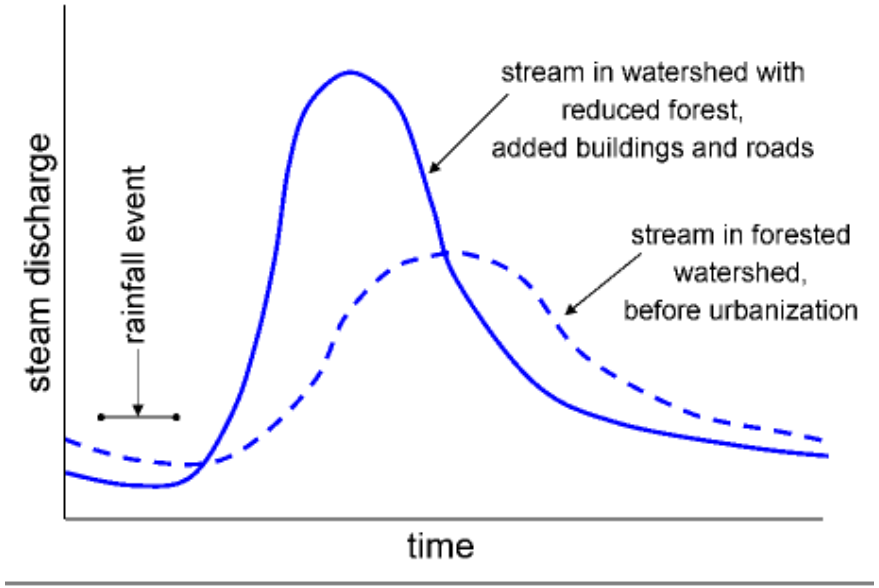


Multiple concrete dolphins (left) protect the 1987 span of the Sunshine Skyway Bridge from ship collisions.

COMPARISON OF FLOOD IMPACTS AND POLICY CHANGES



flooding before and after urbanization of a watershed



FEMA's Implementation of the Federal Flood Risk Management Standard

On July 11, 2024, FEMA published a Final Rule to revise its floodplain management regulations at Title 44 Part 9 of the Code of Federal Regulations (CFR): Floodplain Management and Protection of Wetlands. This final rule is available for public inspection (viewing) as of July 10, 2024.

The rule revises regulations to fully implement the FFRMS - increased flood risk minimization requirements for federally funded projects that incorporate consideration of anticipated changes in future flood risk.

FEMA is Publishing Final Rule on Federal Flood Risk Management Standard

On July 11, 2024, FEMA published a Final Rule and Policy to implement the FFRMS which addresses increased flood risk.

The FFRMS is designed to make communities more resilient and help reduce damage caused by flooding. The Final Rule amends Title 44 Code of Federal Regulations Part 9: Floodplain Management and Protection of Wetlands and will be effective on Sept. 9, 2024. In addition, FEMA is publishing a Notice of Availability of the new FEMA policy that also will take effect on Sept. 9.

TRANSPORTATION (TRADITIONAL) RESIDUAL RISK

- Roadways are usually fixed location built
- Federal agencies coordination to enable increased capacity and elevation still a challenge to scope projects for exact investment and augment return of investment in adaptation (more than US$4 per US$1 invested)
- New technologies exist, but not market and public known and maybe not affordable
- Altruism and corruption control necessary to achieve true resilience.

SOME TECHNOLOGIES…

- Top-bottom: NOAA's forecasting system (in development)
- Bottom-up: part of IIoT, smart cities, only local water body limited investments for flood monitoring (not in the list for NOAA)
- Floating bridges and roadways (different for mud and water): Washington State, Florida, …
- Temporary floating pathways (DoD)
- Flood walls, flood vents,…
- AI…

https://www.youtube.com/watch?v=7-t4QcXQChI

COURAGE AND INSIGHT INSTEAD OF RISK PROBABILITY

DOES MORE INTELIGENCE SOLVE **ALL** TYPES OF PROBLEMS?

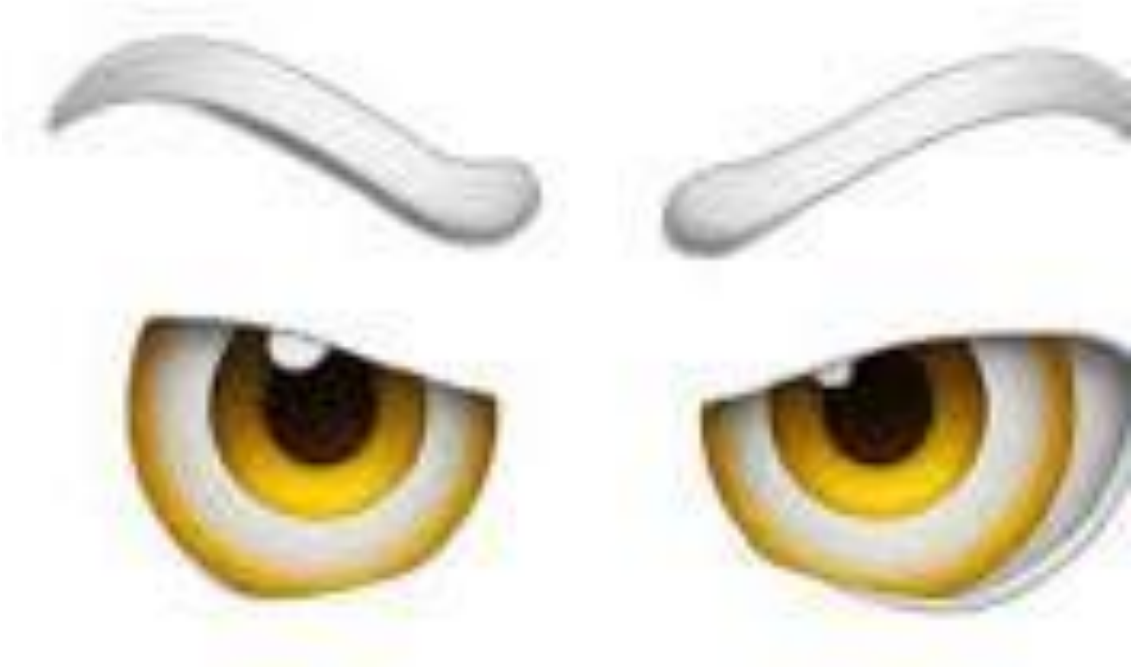
- Redefinition and application of humans' capabilities, abilities, and time for dealing with risk, increasing and becoming resilient, producing a sustainable economic development and world.
- Change is the only real constant.
- Sustainable and resilient economic development requires new new and balanced investment and political strategies to enable an inclusive and equitable place for all in an evolved civilization.

TECHNOLOGY AND LAW (FOCUS ON RISKS)

- Cyber Governance (Zwitter, 2024)
- Neurotechnology and privacy (Guercio, 2024)
- AI for weather forecasting (GraphCast, 2023)
- AI for disasters risk (NIH, AIDR, Texas A&M)
- Detection of threats (Everbridge)
- **Eficiency level: almost 90%…**
- **Applications: System of systems, administrative processes, industrial control processes, financial investments, research, automation for decision making…**

LAWS FOR AI USERS NEGLIGENCE OR INTENTIONAL HARM AND MISUSE (RISK FOCUS)

- Selbst, 2020
- Accidents: CIGI, 2023
- Risks due to AI: Stein, 2022
- Medical Risks due to AI: Jorstad, 2020
- Criminal Act using AI
- Negligence Crime related to AI
- Risk Management with AI
- AI and economic development
- AI and economic impact
- Transportation big data and AI?...



TECHNOLOGICAL DISASTERS, INNOVATION, AND REGULATION

Do you know the transportation risk and resilience with AI?

RESILIENCE FUNDED MANDATE

Bipartisan Resilience Infrastructure Bill

a. White House: https://www.whitehouse.gov/build/guidebook/#:~:text=The%20Bipartisan%20Infrastructure%20Law%20is,and%20the%20safety%20of%20our

b. FHWA ($350 billion) : https://www.fhwa.dot.gov/bipartisan-infrastructure-law/climate.cfm

c. FEMA: https://www.fema.gov/press-release/20231115/president-bidens-bipartisan-infrastructure-law-two-years-later-fema-makes

d. NOAA: https://www.noaa.gov/infrastructure-law

e. DOI: https://www.doi.gov/priorities/investing-americas-infrastructure/ecosystem-restoration/projects

THANK YOU!

Dr. Viviane Coelho de Sellos Knoerr

Silvana Croope, PhD

Expert Witness License 105198790

Pós-Doutora pela UniCuritiba

scroope.posdocunicuritiba@gmail.com

Visualizing Risk for Resilience

Herby G. Lissade, P.E.

Traffic Engineering Manager
Interwest Consulting Group
California Department of Transportation
(Caltrans) – Retired)

August 2024

Interwest Overview

THOUGHTFUL SOLUTIONS. THRIVING COMMUNITIES.

22

YEARS

SERVING

CA

MORE THAN

400

FULL TIME CALIFORNIA EMPLOYEES

415+

JURISDICTIONS SERVED IN CA

8

LOCATIONS

- ✓ Irvine
- ✓ Elk Grove
- ✓ Fremont
- ✓ Fresno
- ✓ Rosemead
- ✓ Ontario
- ✓ San Diego
- ✓ San Jacinto

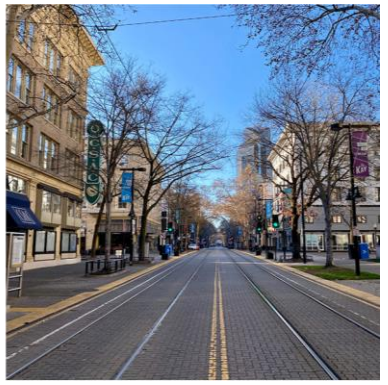
OUR PROJECT APPROACH

Understand the hazards of climate change

- Flooding
- Wildland urban interface fires
- Drought
- Heat
- Excessive snowfall

Understand the diverse community's needs

- public health
- natural ecosystems
- social equity
- the economy
- GHG emissions



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Disaster Resilience: A National Imperative (2012)

THOUGHTFUL SOLUTIONS. THRIVING COMMUNITIES.

Defines "national resilience," describes the state of knowledge about resilience to hazards and disasters, and frames the main issues related to increasing resilience in the United States.

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Analyzing And Visualizing Risk For Resilience

By making risks visible,
we can better understand their impact and devise strategies to mitigate or capitalize on them.

Statewide Vulnerability Assessments

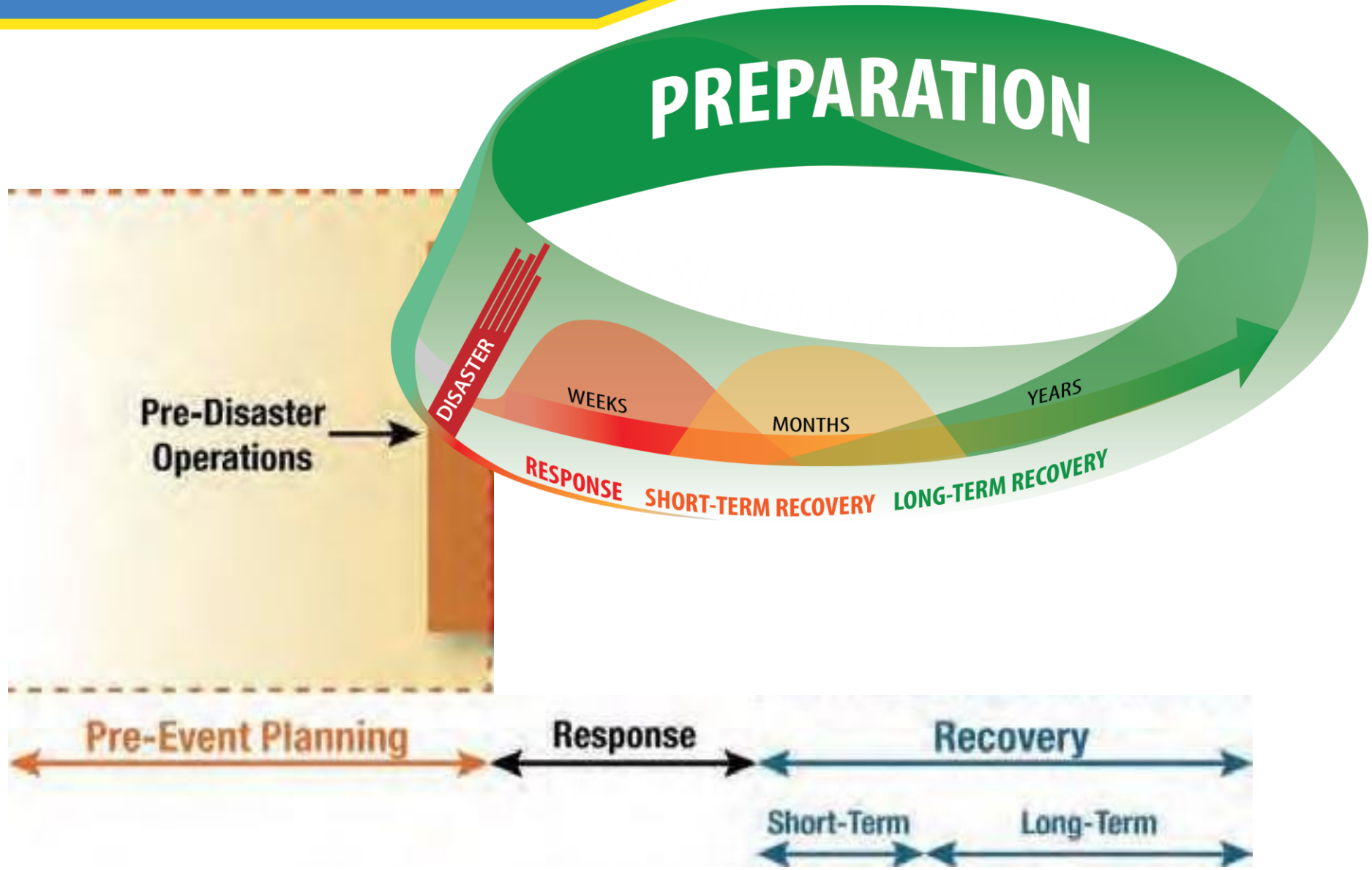
Sea Level Rise Adaptation Options

All Hazards Planning Fundamentals for Resilience

Prevention	• Capabilities necessary to avoid, prevent, or stop a threatened or actual act of terrorism.
Protection	• Capabilities necessary to secure against acts of terrorism and manmade or natural disasters.
Mitigation	• Capabilities necessary to reduce loss of life and property by lessening the impact of disasters.
Response	• Capabilities necessary to save lives, protect property and the environment, and meet basic human needs after an incident has occurred.
Recovery	• Capabilities necessary to assist communities affected by an incident to recover effectively.

Source: AASHTO. Fundamentals of Effective All Hazards Security and Resilience for State DOTs, 2015.

Pre-Event Recovery Planning



Prioritizing Risks

Not all risks are equally important.

Prioritizing them allows for more informed decision-making.

FEMA Recognized Types of Disasters

1. Chemical Emergencies
2. Dam Failure
3. Earthquake
4. Fire or Wildfire
5. Flood
6. Hazardous Material
7. Heat
8. Hurricane
9. Landslide
10. Nuclear Power Plant Emergency
11. Terrorism
12. Thunderstorm
13. Tornado
14. Tsunami
15. Volcano
16. Wildfire
17. Winter Storm

Highlighting Relationships:

Visualize the relationships between risks.

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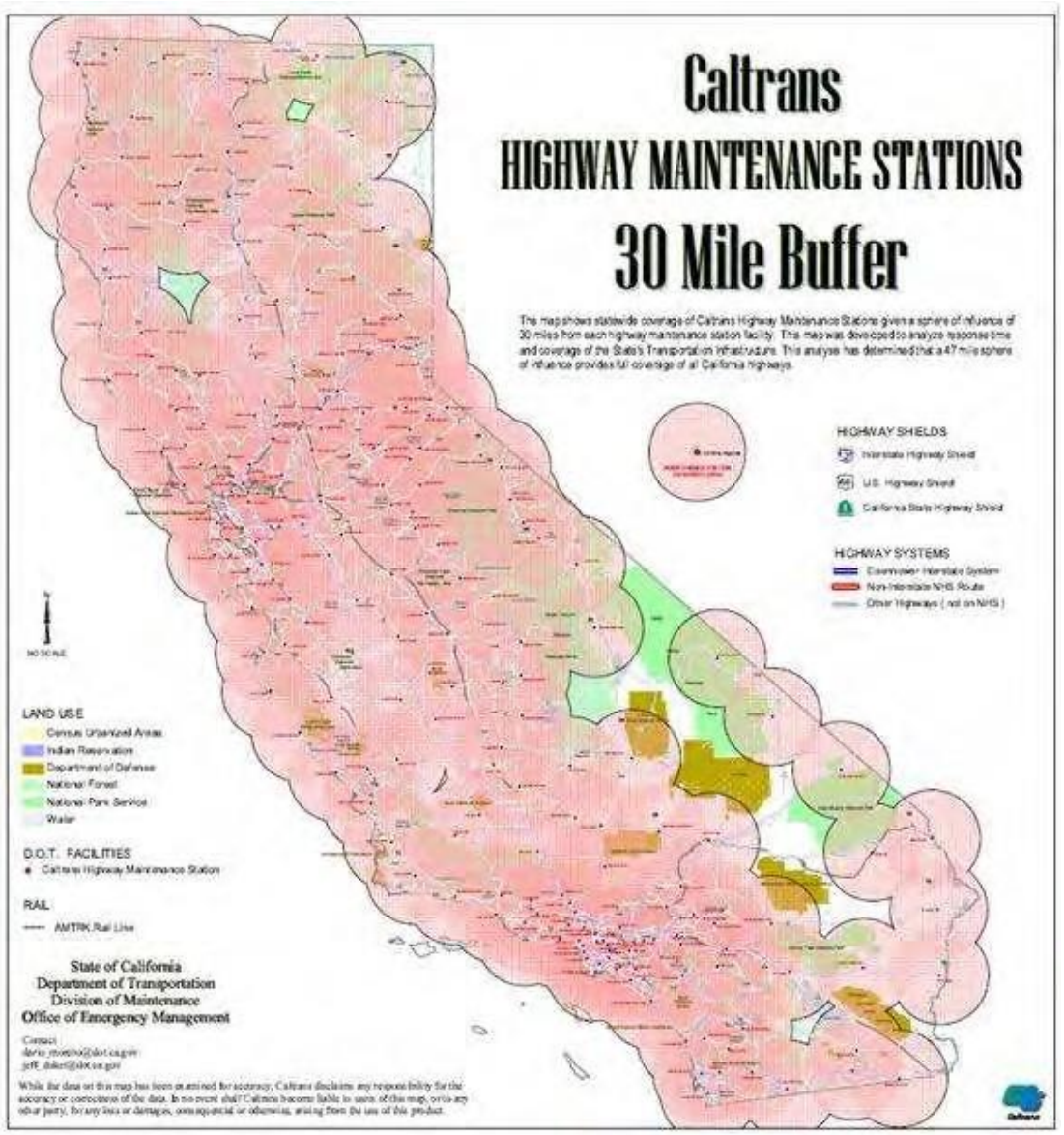
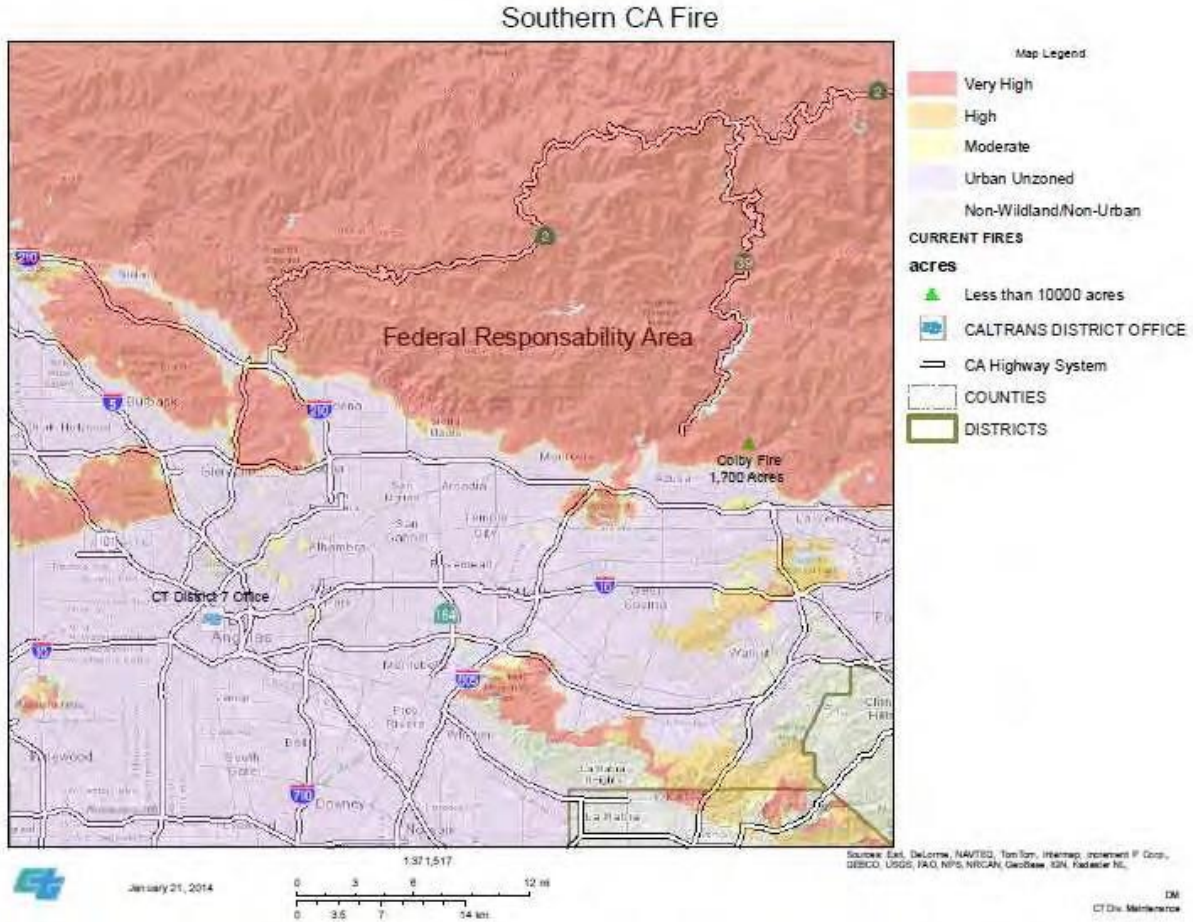
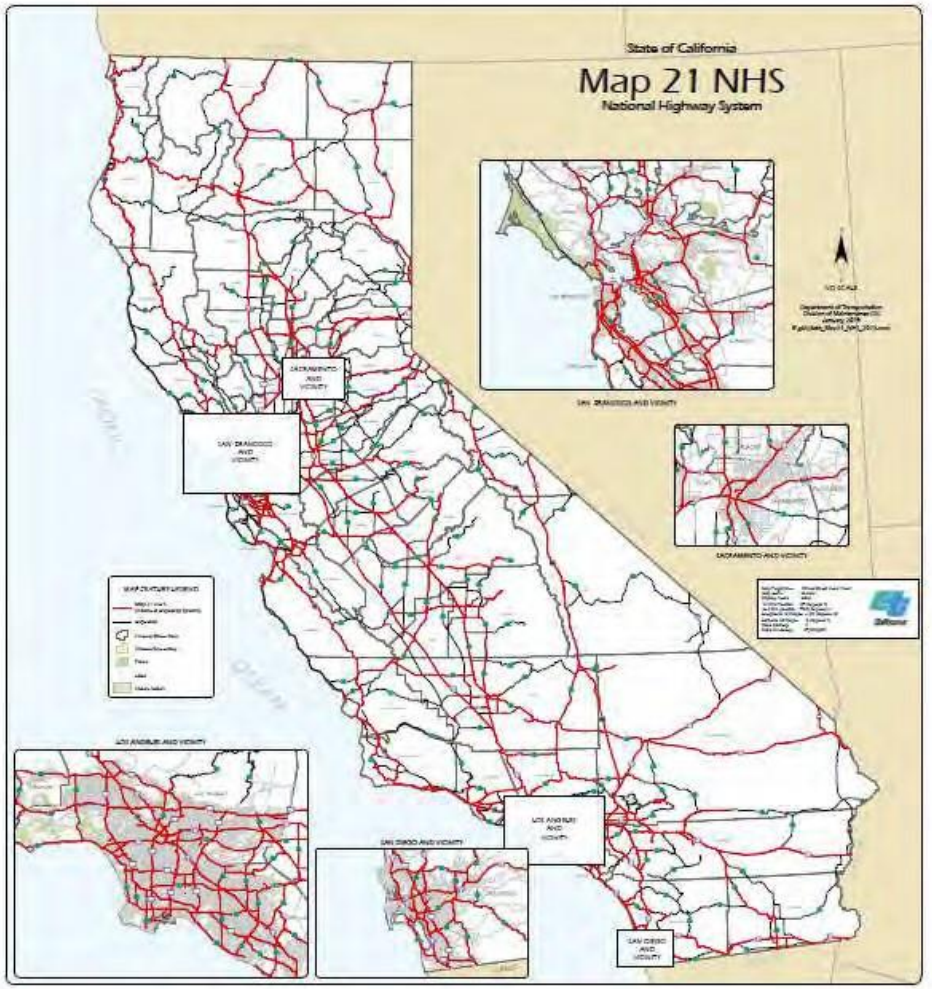
Highlighting Relationships



Caltrans Maps

- Earthquake + Fire Maps
- Flood + Landslide Maps
- Supply Chain Maps
- Traffic Flow Maps





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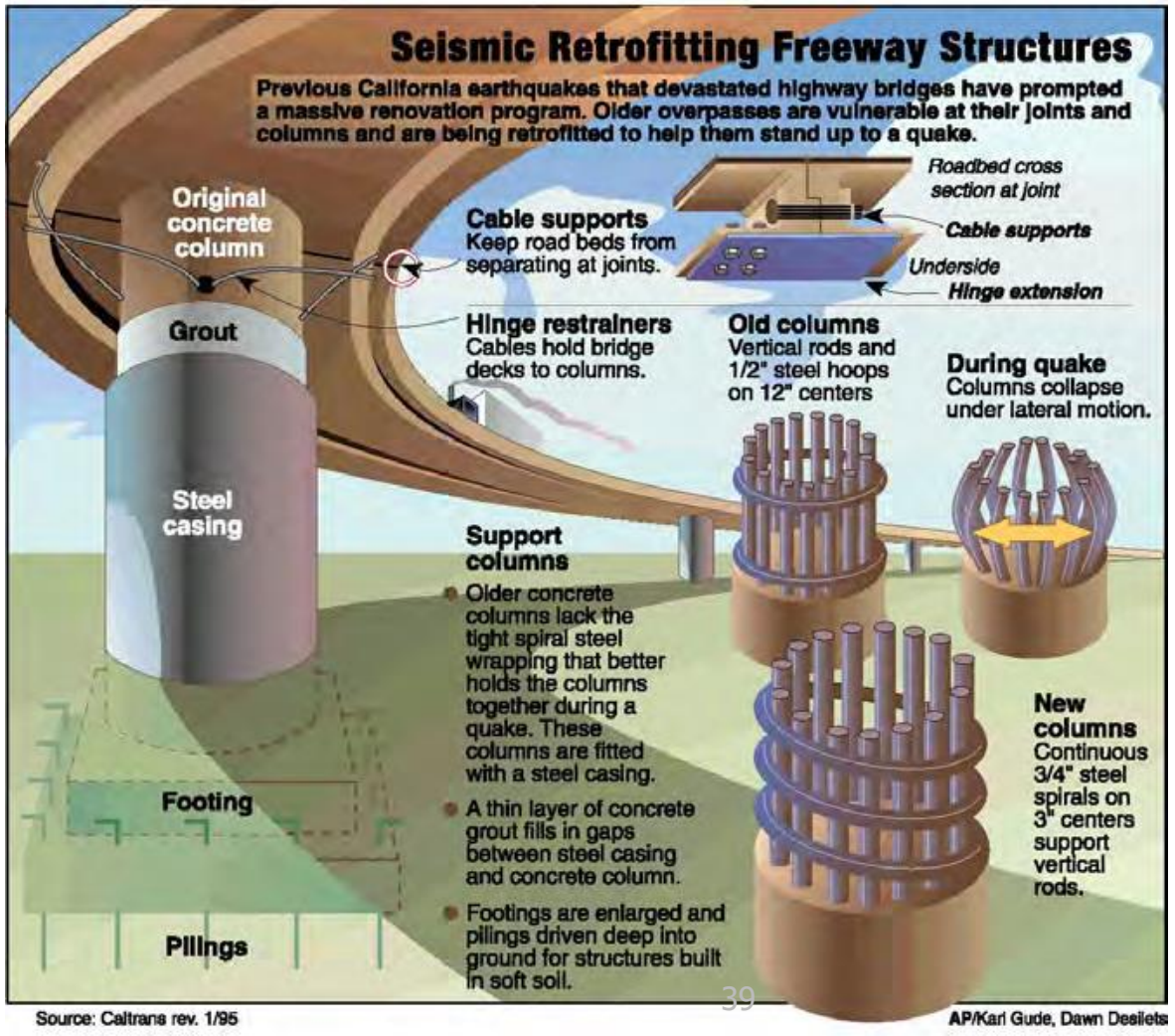
Communicating Relative Risk:

Instead of a lengthy risk register, use visual representations to communicate relative risk levels.

Assessing Disaster Risk



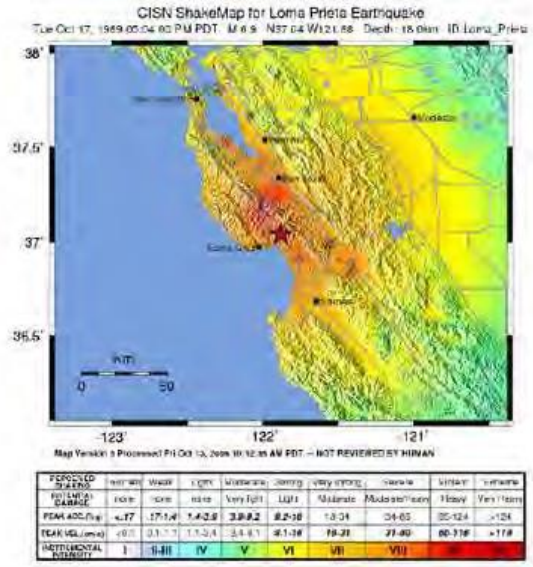
Economic Study: Regional Resiliency Assessment Program (RRAP)

Inspection Prioritization

Caltrans ShakeCast Server (C) <Loren.Turner@dot.ca.gov>
05/09/2008 11:18 AM
To Caltrans-ShakeCastAdmin@dot.ca.gov
cc
bcc
Subject BRIDGE ASSESSMENT: 6.9, 7 km NNE of Aptos, CA (Loma_Prieta_scte Version 1)

Caltrans ShakeCast Preliminary Earthquake Bridge Impact Report

This report supersedes any earlier reports about this event. This is a computer-generated message and has not yet been reviewed by an Engineer or Seismologist. Information about the epicenter, magnitude, location, date, and time are provided by the California Integrated Seismic Network (CISN). The analysis of potential bridge damage in this report is based upon an initial ShakeMap (unverified) and estimated fragilities for Caltrans bridges. Bridge fragility models were adopted from HAZUS and Basoz & Mander (1999). This report is intended to be used as a first response tool to assist in identifying Caltrans bridges most likely impacted by the event.



Event Summary
Name: (Unnamed Event) , Version 1

Magnitude: 6.9
ID: Loma_Prieta_scte-1
Location: 7 km NNE of Aptos, CA
Latitude: 37.04
Longitude: -121.88
Time: 1989-10-18 00:04:00 GMT

Downloads & Resources
Caltrans Intranet Links:
Caltrans ShakeCast Intranet
Caltrans ShakeMap Products

GoogleEarth KML files:
ShakeCast Bridge Assessment
Statewide Bridge Inventory
Caltrans Real-time Traffic
USGS Real-time Earthquakes

Bridge Assessment Summary
Maximum Peak 1.0 sec Spectral Acceleration: 105.3903%g
Maximum Acceleration: (not measured)
Total number of bridges assessed: 2030
Summary by inspection priority:

High	22	High Priority for full engineering assessment
Medium-High	107	Medium-High Priority for full engineering assessment
Medium	106	Medium Priority for full engineering assessment
Low	1795	Low Priority for full engineering assessment; quick visual inspection likely sufficient.

Bridge Assessment Summary
Maximum Peak 1.0 sec Spectral Acceleration: 188.76%g
Maximum Acceleration: (not measured)
Total number of bridges assessed: **3133**
Summary by inspection priority:

High	119	High Priority for full engineering assessment
Medium-High	156	Medium-High Priority for full engineering assessment
Medium	152	Medium Priority for full engineering assessment
Low	2706	Low Priority for full engineering assessment; quick visual inspection likely sufficient.

Bridge Assessment Details
Bridges presented in the table below are sorted in order of severity of impact to bridges.

Bridge Name	Bridge Number	Dist-Cty-Rte-PM	Inspection Priority	1sec Peak Spectral Acceleration (%g)	Exceedance Ratio
Ralston Avenue OC	35 0114	04-SM-101-9.55-BMT	High	105.3903	2.934
Via Del Oro OH	37 0477L	04-SCL-085-1.22-SJS	High	49.2711	2.472
San Mateo-Hayward Bridge	35 0054	04-SM-092-R14.44-FSTC	High	49.6514	2.167
Constitution Way OC	33 0513K	04-ALA-260-R.86-ALA	High	68.2755	1.415
Meridian Road Underpass	37 0258	04-SCL-280-R3.89-SJS	High	59.9229	1.122
Campbell Underpass	37 0135	04-SCL-017-12.22-CMB	High	70.2112	1.087
East Hillsdale Blvd OC	35 0138	04-SM-101-11.15-SM	High	68.3762	1.071
Redwood Creek	35 0145	04-SM-101-6.2-RDWC	High	61.0924	1.064
Sfobb-Approach Lower Deck	34 0118R	04-SF-080-4.95-SF	High	33.2578	1.057
Holly Street OC	35 0037	04-SM-101-8.4	High	65.904	1.048
Route 13/80 Separation (North)	33 0191G	04-ALA-013-13.92-BER	High	66.6766	1.046
Race Street Overcrossing	37 0260	04-SCL-280-R3.76-SJS	High	59.9229	1.045
Presidio Viaduct	34 0019	04-SF-101-9.14-SF	High	68.3123	1.035
South Delaware Street UC	35 0158L	04-SM-092-R11.61-SM	High	35.1822	1.030
South Delaware Street UC	35 0158R	04-SM-092-R11.61-SM	High	35.1822	1.030
Powell Street UC	33 0020	04-ALA-080-3.79-EMV	High	66.6766	1.020
Redwood Harbor Overhead	35 0065	04-SM-101-5.5-RDWC	High	56.8606	1.018
Macarthur Avenue OC	37 0100	04-SCL-280-L5.18-SJS	High	54.4613	1.012
N101-S84 Connector OC	35 0081G	04-SM-101-5.39-RDWC	High	56.8606	1.009
N17-N85 Connector Separation	37 0515G	04-SCL-017-9.24-LGTS	High	86.2137	1.008
San Francisquito Creek	35 0013	04-SM-101-.01	High	55.3678	1.007
N&S87-S280 Connector Separation	37 0396H	04-SCL-087-5.1-SJS	High	50.5564	1.001
Blossom Hill Road OC	37 0345	04-SCL-082-R.35-SJS	Medium-High	49.4998	0.951
Harkins Slough Road OC	36 0089	05-SCR-001-R2.27-WAT	Medium-High	56.0768	0.938
Sunol Street Rr UC	37 0263L	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909
Sunol Street Rr UC	37 0263R	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909
Winchester Boulevard OC	37 0195	04-SCL-280-4.57-SJS	Medium-High	55.327	0.898
Lincoln Avenue UC	37 0262L	04-SCL-280-R3.51-SJS	Medium-High	52.8878	0.896
South Gilroy OH	37 0305L	04-SCL-101-R5.1	Medium-High	43.2728	0.896

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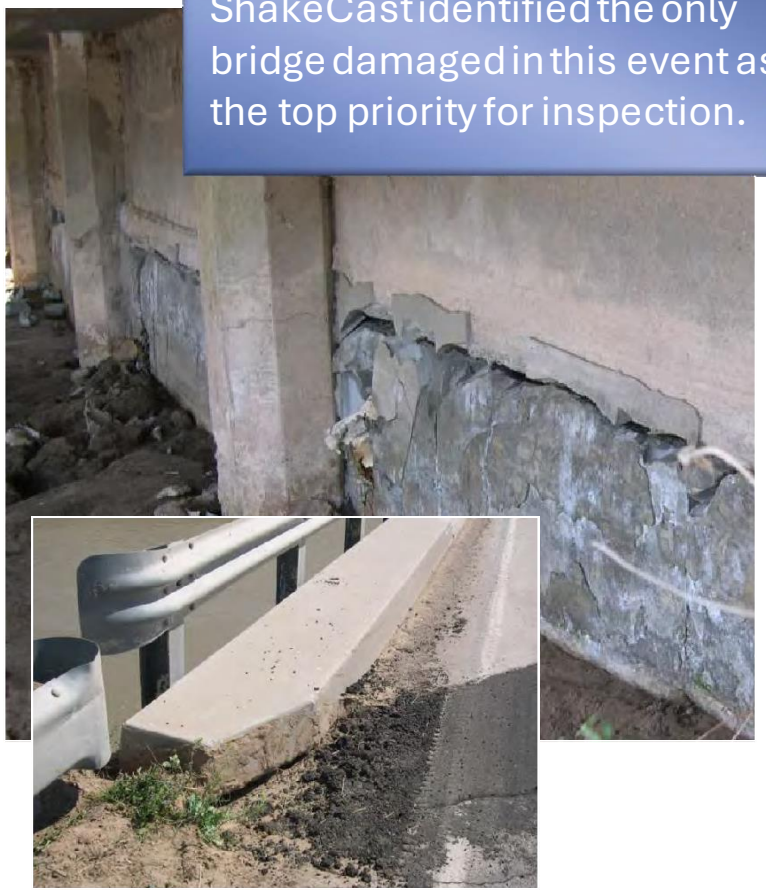
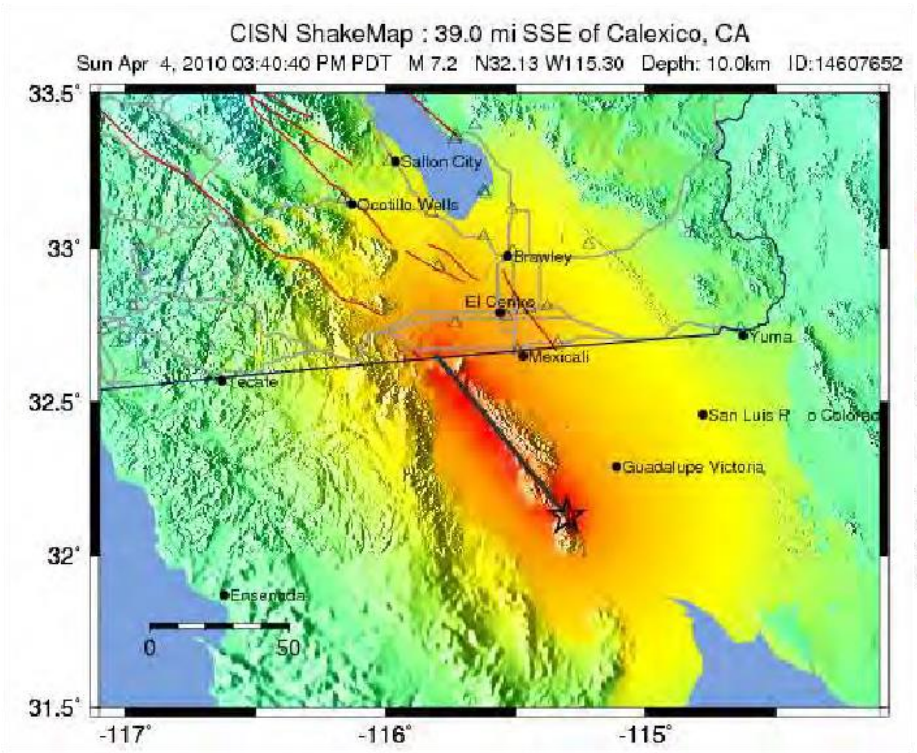
ShakeCast at Work

7.2 Calexico April 2010

ShakeCast identified the only bridge damaged in this event as the top priority for inspection.





Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 48.5782%g
Maximum Acceleration: (not measured)
Total number of bridges assessed: **219**
Summary by inspection priority:

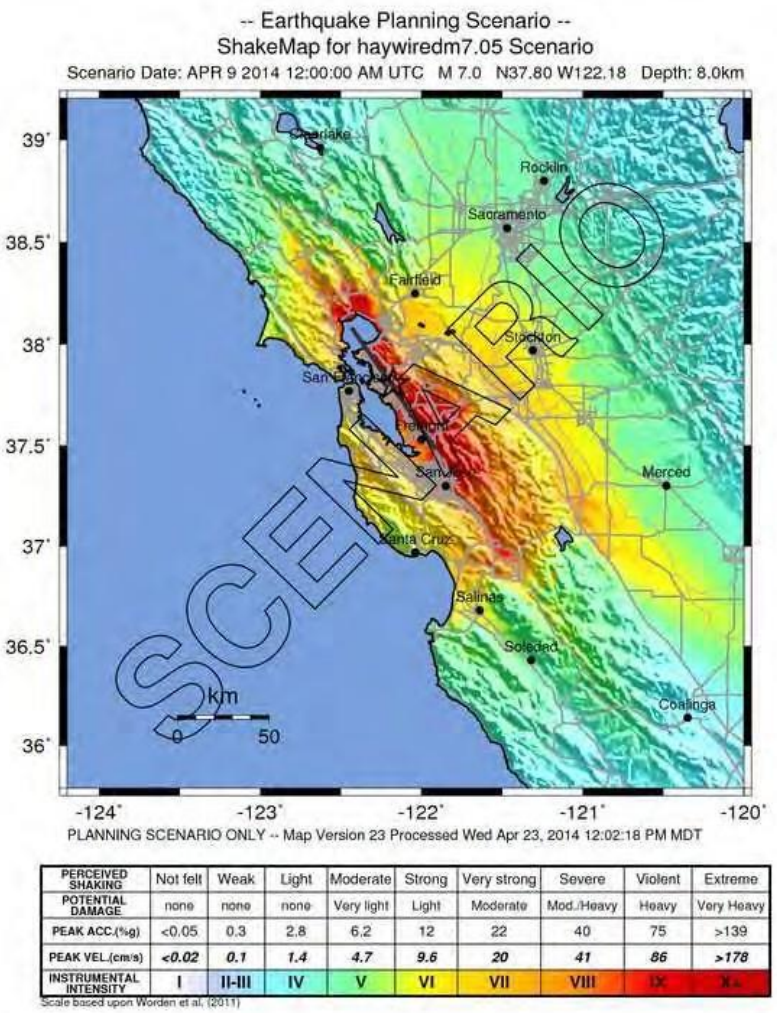
High	|NULL|	High Priority for full engineering assessment
Medium-High	|NULL|	Medium-High Priority for full engineering asses
Medium	|NULL|	Medium Priority for full engineering assessmen
Low	219	Low Priority for full engineering assessment; g

Bridge Assessment Details

Bridges presented in the table below are sorted in order of severity of impact (exceedance ratio). The lis
Acceleration exceeds 10% g.

Bridge Name	Bridge Number	Dist-Cty-Rte-PM
58 0274 - WESTSIDE MAIN CANAL	58 0274	11-IMP-098-22.02
58 0275 - WORMWOOD CANAL	58 0275	11-IMP-098-22.07
58 0212L - COYOTE WELLS OH	58 0212L	11-IMP-008-R13.97
58 0212R - COYOTE WELLS OH	58 0212R	11-IMP-008-R13.93

Assessing Disaster Risk



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2011)

Economic Study: U.S. Geological Survey

SAFRR – Science Application for Risk Reduction Haywired Scenario

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Being Dynamic and Data-Rich:

Use dynamic visualizations that update in real-time.

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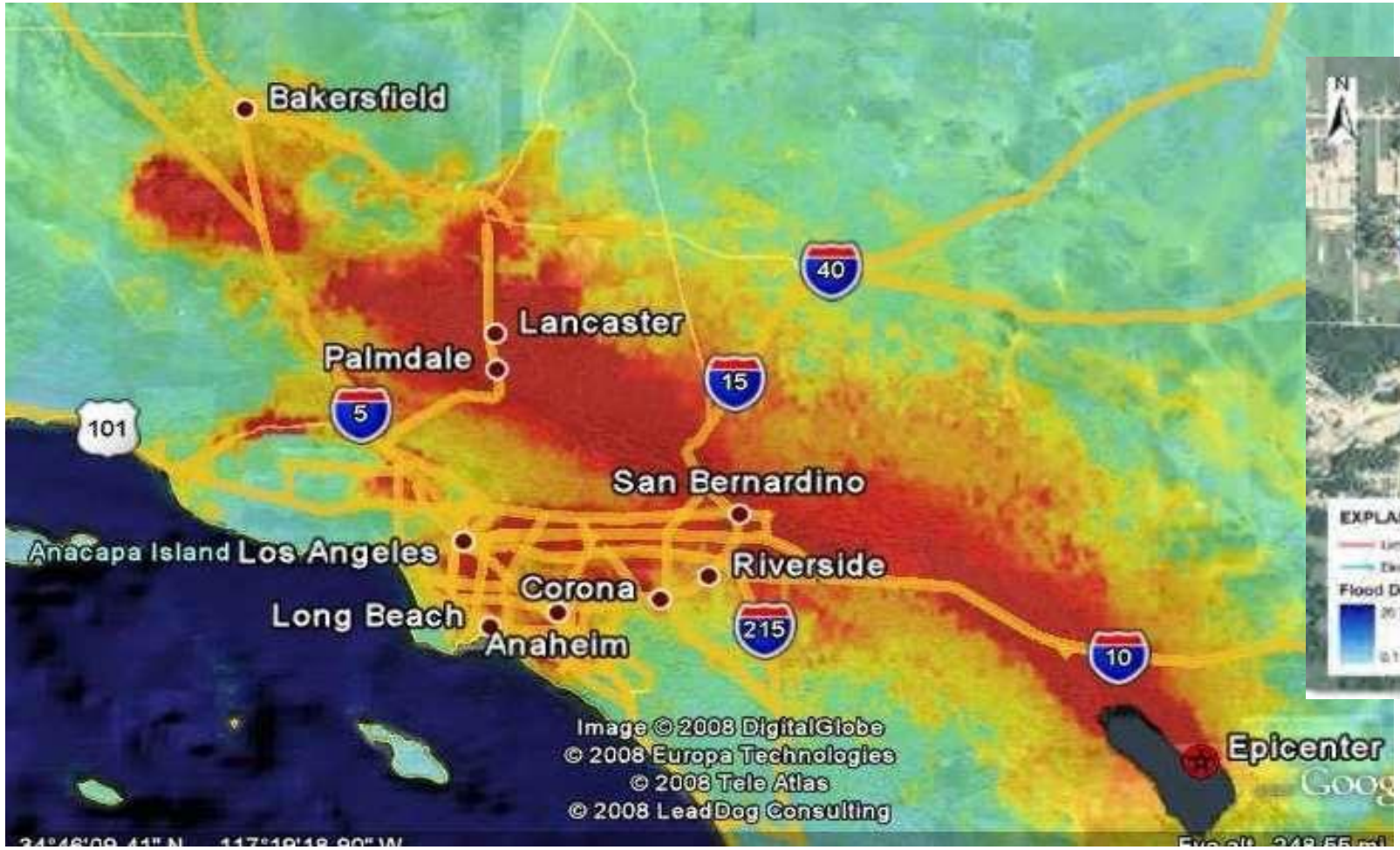
Dynamic Visualization



The effective use of Hazard Maps decreases the magnitude of disasters

Hazard Maps provide information on the range of possible damage and disaster prevention activities

Keeping It Current:

Regularly update risk visualizations to reflect changes in the project or business environment.

nbrace New Technologies – Implementation of Research

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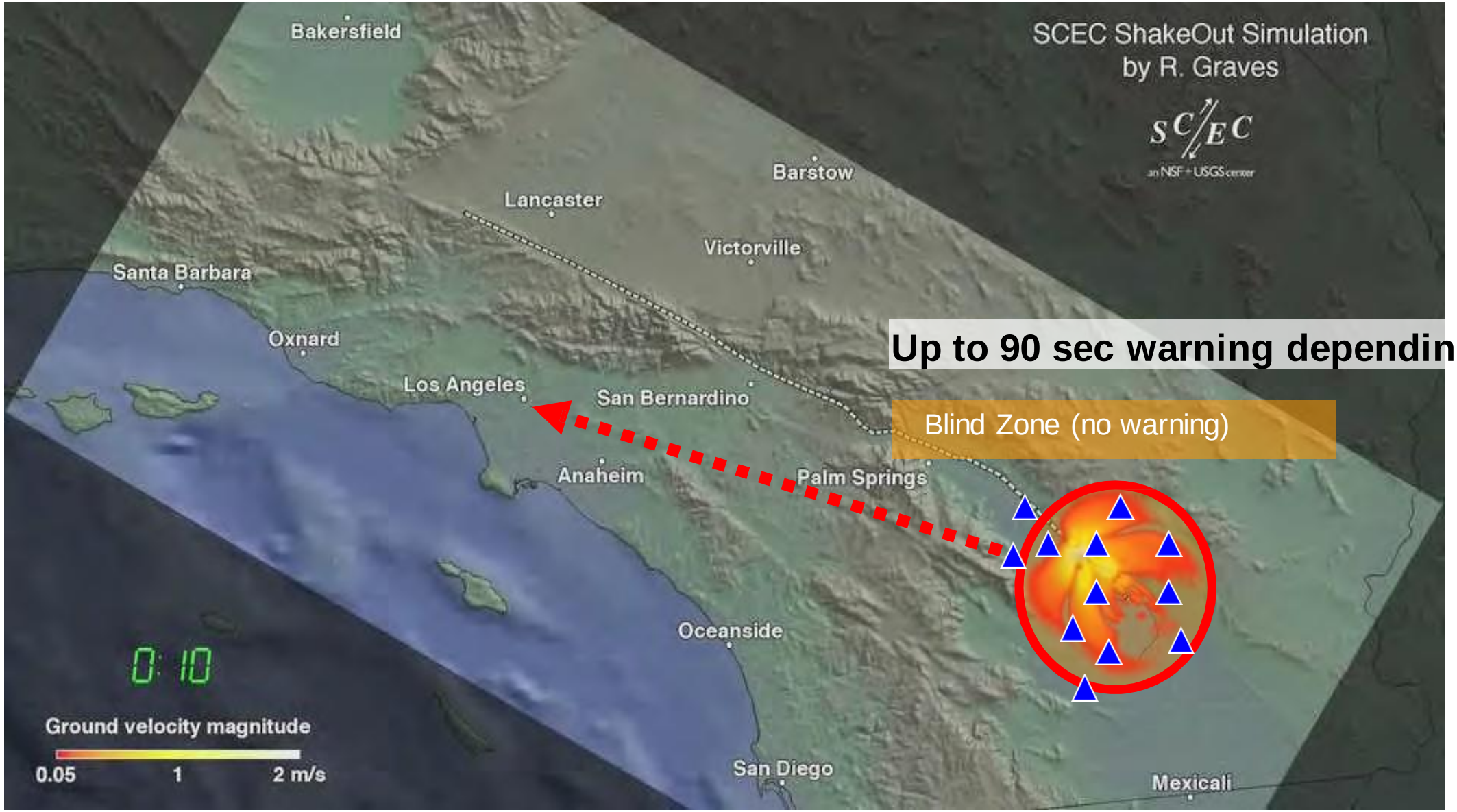
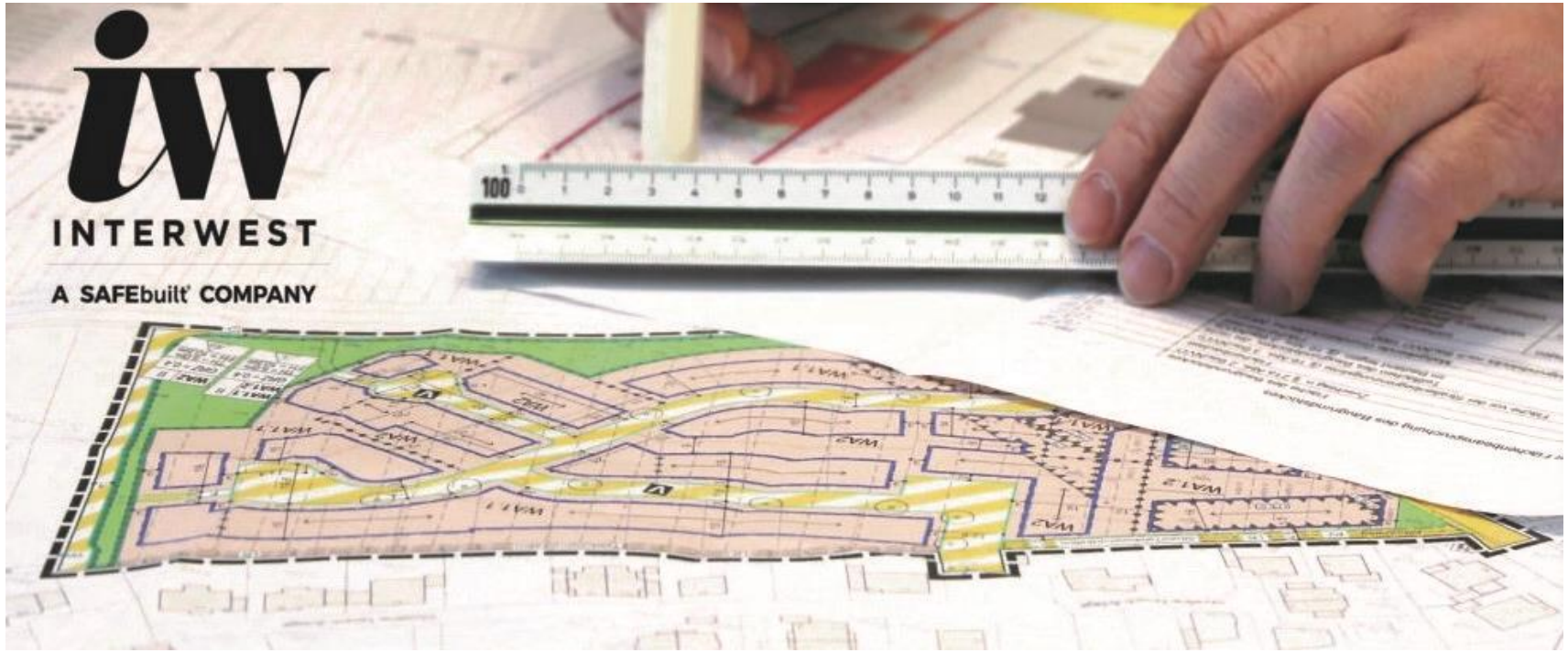
Implementing New Technology

Earthquake Early Warning



Up to 90 sec warning depending on distance.

Blind Zone (no warning)



Herby G. Lissade, P.E.
Traffic Engineering Manager
Interwest Consulting Group

Email: HLissade@InterwestGrp.com

"Without Engineers, Science is Just Philosophy – HGL"

Thank you for the opportunity to present to the Transportation Research Board of the National Academies..

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Today's presenters

Matt Haubrich
matthew.haubrich@hdrinc.com

Frank Broen
Metro Analytics

frank@metroanalytics.com

Dr. Silvana Croope
Systems & Technology Resilience Solutions LLC

Sil.Croope-STRS@protonmail.com

Herby Lissade
Consultant
hlissade@interwestgrp.com

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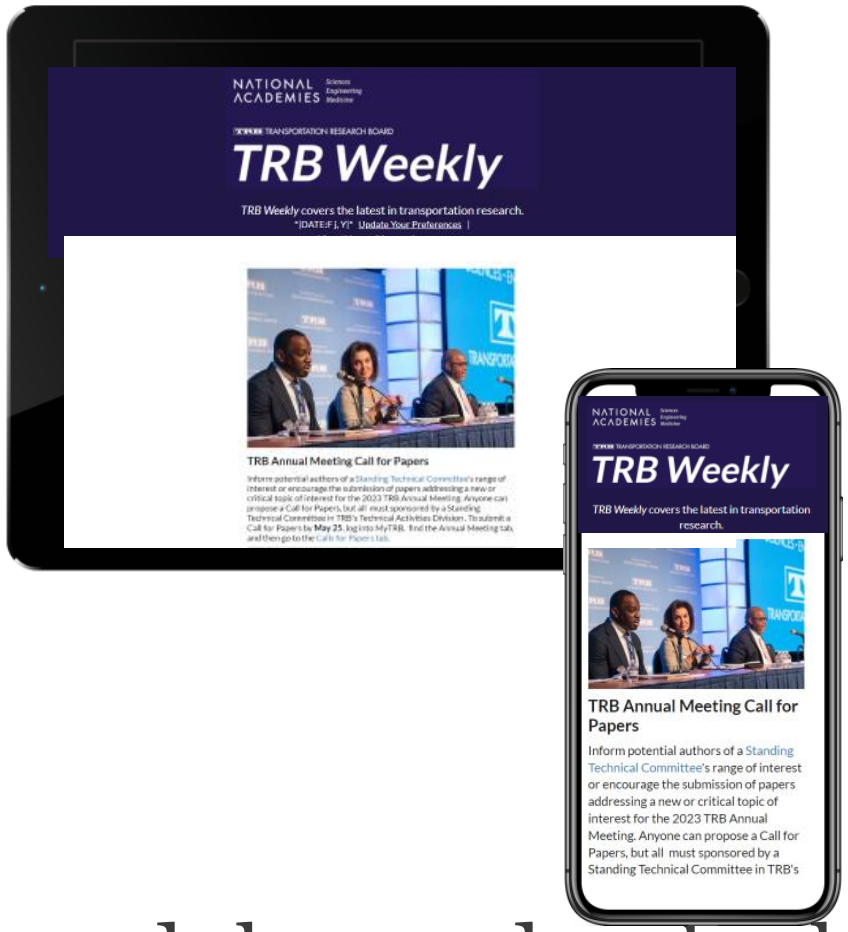

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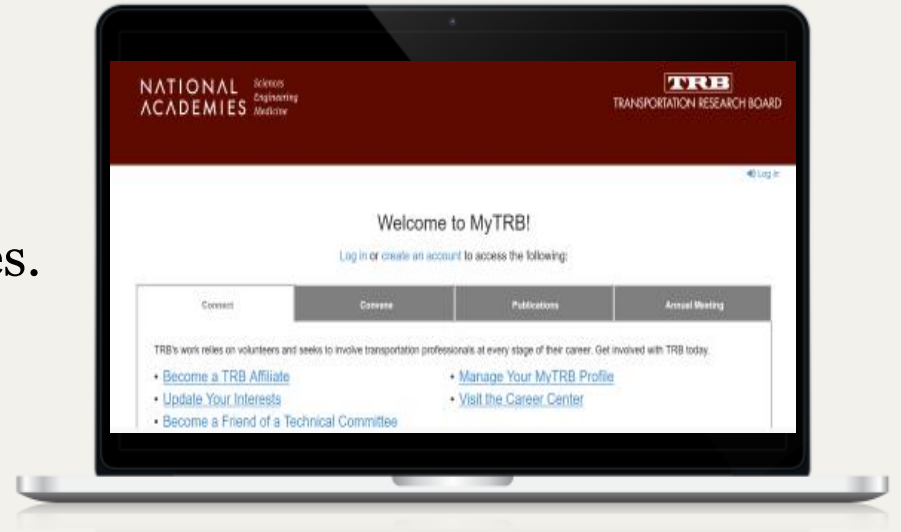

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