MISSISSIPPI VALLEY FREIGHT COALITION

MVFC Conference & Annual Meeting

April 27-29, 2010
Cincinnati, Ohio

Critical Sections and Resiliency of Freight Corridors in the MVFC

Teresa Adams

Kaushik Bekkem

Freight System Resilience

pptPlex Section Divider

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Resilience Defined

- Freight transportation system resilience is defined as the ability for the system to absorb the consequences of disruptions, to reduce the impacts of disruptions, and maintain freight mobility.
- Resilience is the measure of how quickly and efficiently a system can recover from a disruption.

Properties of Freight System Resilience

Properties	Physical Infrastructure Dimension	Managing Organization Dimension	User Dimension	Contribution to Freight Transportation System Resilience
Redundancy	Availability of multiple & alternate routing options	Multiple information sources & points of delivery	Multiple parts & materials suppliers; information backed up on distributed servers	Promotes flexibility; supports robustness
Autonomy of Components	The ability of highway system to function when air space closed; independent signal controls for each intersection	Independence of functional units in an organization, e.g. approvals & decision making can be independent of established hierarchies	Independence of functional units in an enterprise, e.g. procurement, billing, manufacturing, & distribution	Supports system operability despite the failure of individual system components; supports robustness
Collaboration	Working partnership between federal, state, regional and local public agencies to plan, construct and operate the full freight transportation network to optimize system use	Good internal communication across divisions & external communication with system users; leadership across all levels of the organization	Public-private partnerships to build relationships between organizations	Supports innovative problem solving, reduces miscommunications, spreads risk across groups Promotes network, versus local, freight system optimization and resiliency.
Efficiency	Network designs that reduce travel time between origin and destination	Use of effective mechanisms to prioritize spending within the organization and on infrastructure	Coordination across the supply chain with relationships built across the different parties	Allows resources to be spent on activities or projects that provide most benefit to the users
Adaptability	Designed with short life-spans & the intent for regular replacement or for the capability to expand capacity without total facility	Familiarity of roles and responsibilities across levels of the organization; cross trained employees; leadership can be engaged at all levels.	Ability to postpone decision making & shipping; build-to order business model	Promotes flexibility & system efficiency; supports robustness
Interdependence	Seamless mode transfers; intermodal facilities	Relationships are established across separate, but related agencies & within agencies; mutual understanding of the value & benefit from interaction	Standardization of parts & interchangeability	Exhibits smooth connections and transitions across parts of the system; promotes system efficiency; spreads risk across the system to reduce risk

Source: Washington State FSR (2008)

Freight System Resiliency Planning

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Jeopardy Clue

… operations plan that covers the time after the first responders have completed their triage until the freight system has been restored.

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What's a Freight System Resiliency Plan?

Developing a Freight System Resiliency Plan

www.wsdot.wa.gov/freight/publications

Phase	Step
Identification	1. Identify and segment customers of the transportation system
	2. Identify and quantify the objectives of the resiliency plan
Assessment	3. Conduct a vulnerability assessment of the transportation network
	4. Create public/private collaboration mechanisms
	5. Determine what regulatory and policy procedures need to be put into place
	6. Agree on priority and trigger setting processes
Implementation	7. Conduct a small-scale in-house simulation
	8. Test the plan with a large-scale simulation

Resiliency of MVFC Freight Corridors

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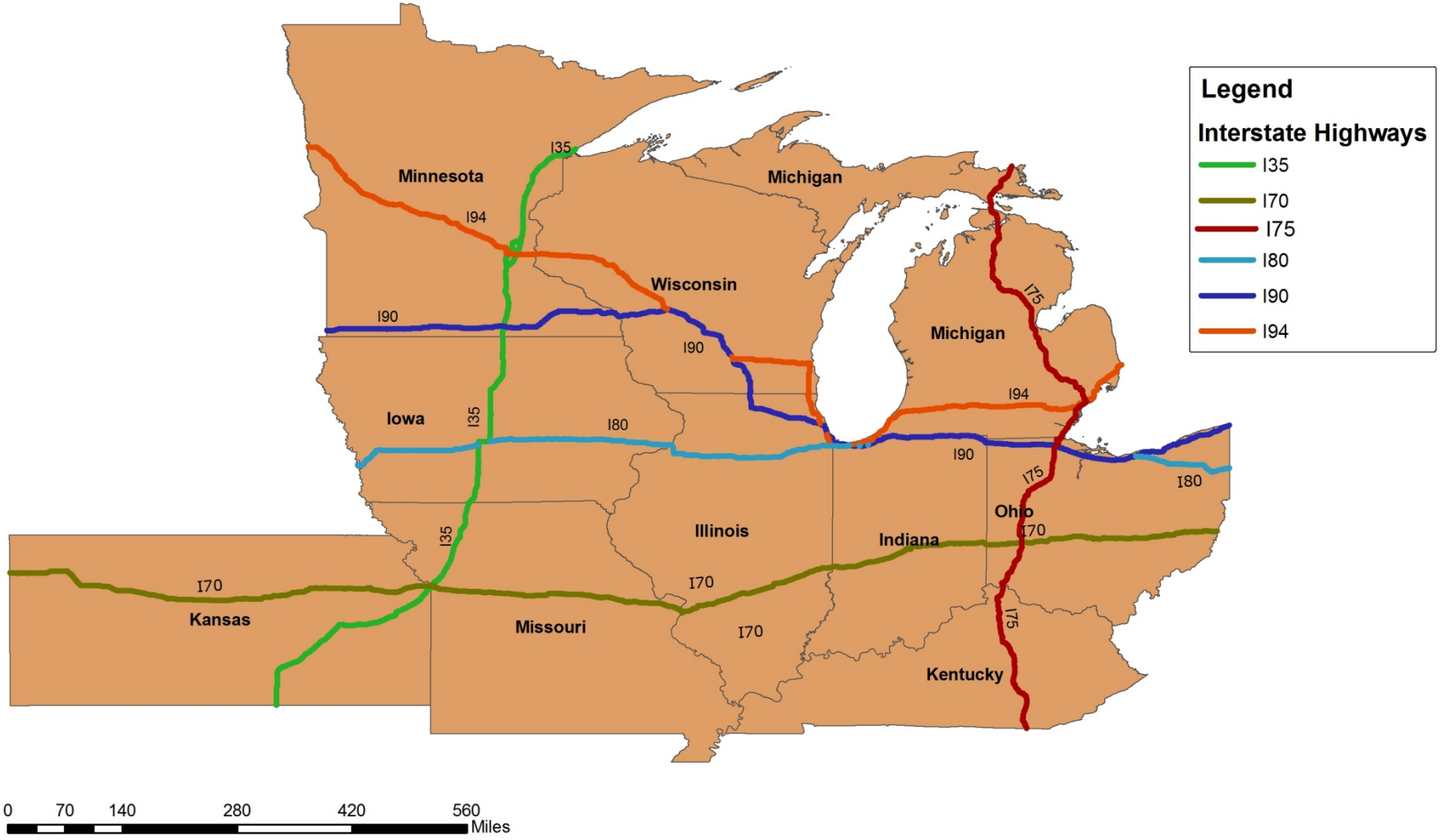
Freight Corridors in MVFC Region



Key Considerations

- Response does not equal recovery.
- DOTs needs strong relationships with the private sector to successfully manage disruptions in freight systems.
- The heart of a recovery plan is found in a reliable, real-time communication system.
- Mechanisms must be in place for fast-tracking recovery before an event happens.
- The States need to decide how to most productively allocate limited freight system capacity during long-term disruptions.
- Most state emergency plans don't include economic recovery.

Measures of Freight Resiliency

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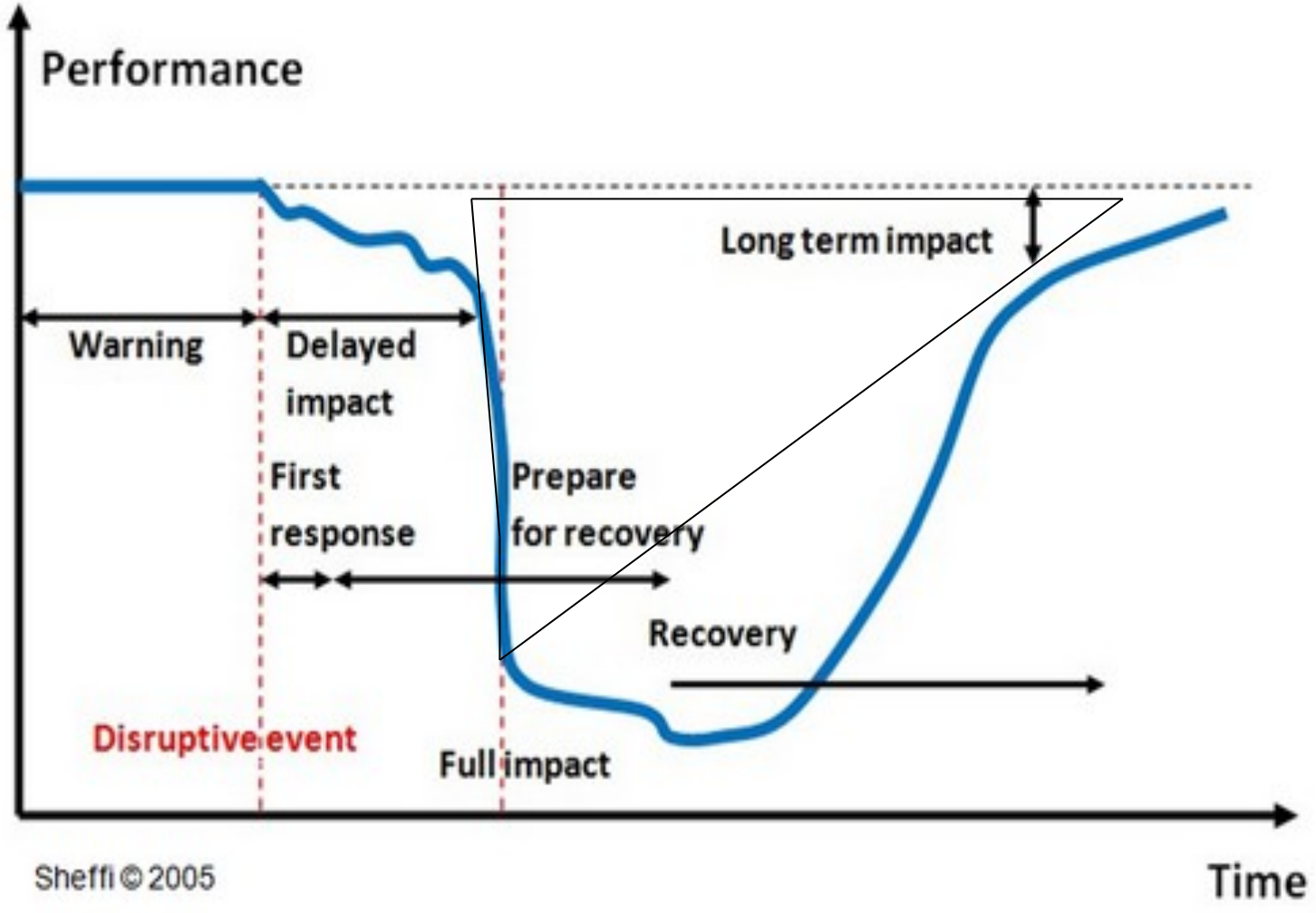
R4 Framework

- **Robustness:** the ability to withstand disaster forces without significant degradation or loss of performance;
- **Redundancy:** the availability of other substitutable units;
- **Resourcefulness:** the ability to diagnose, and prioritize, and mobilizing material, monetary, information, technology and human resources ; and
- **Rapidity:** the capacity to restore function quickly.

Multidisciplinary Center for Earthquake Engineering Research (MCEER)

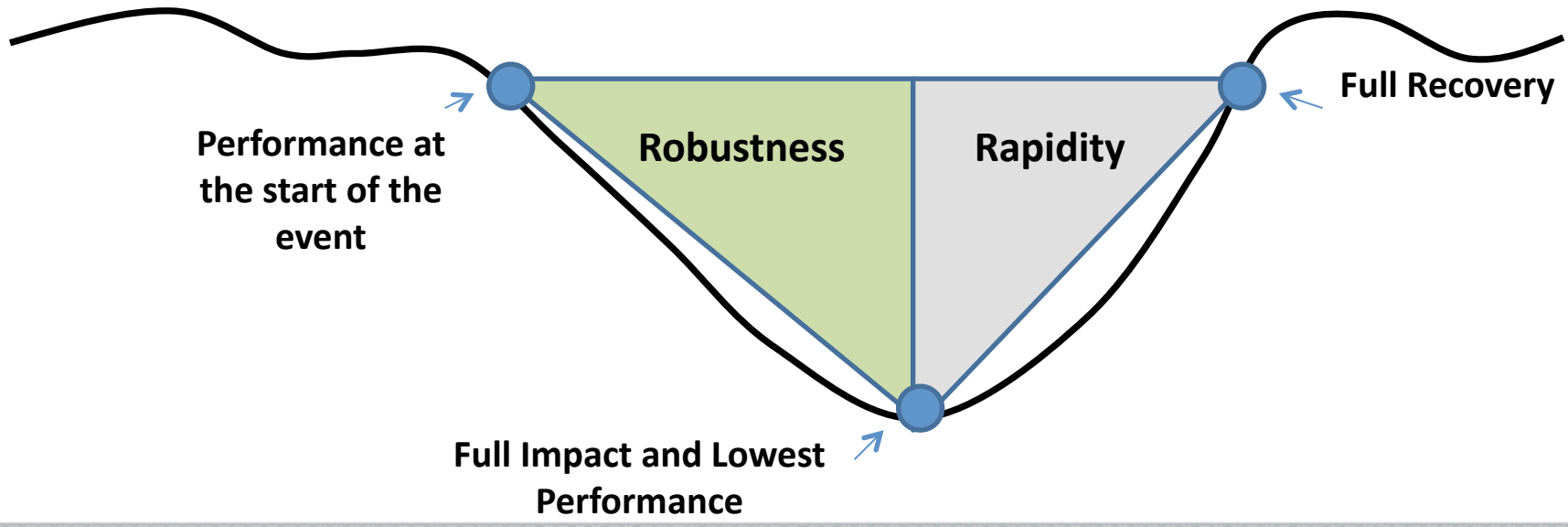
Resiliency Triangle

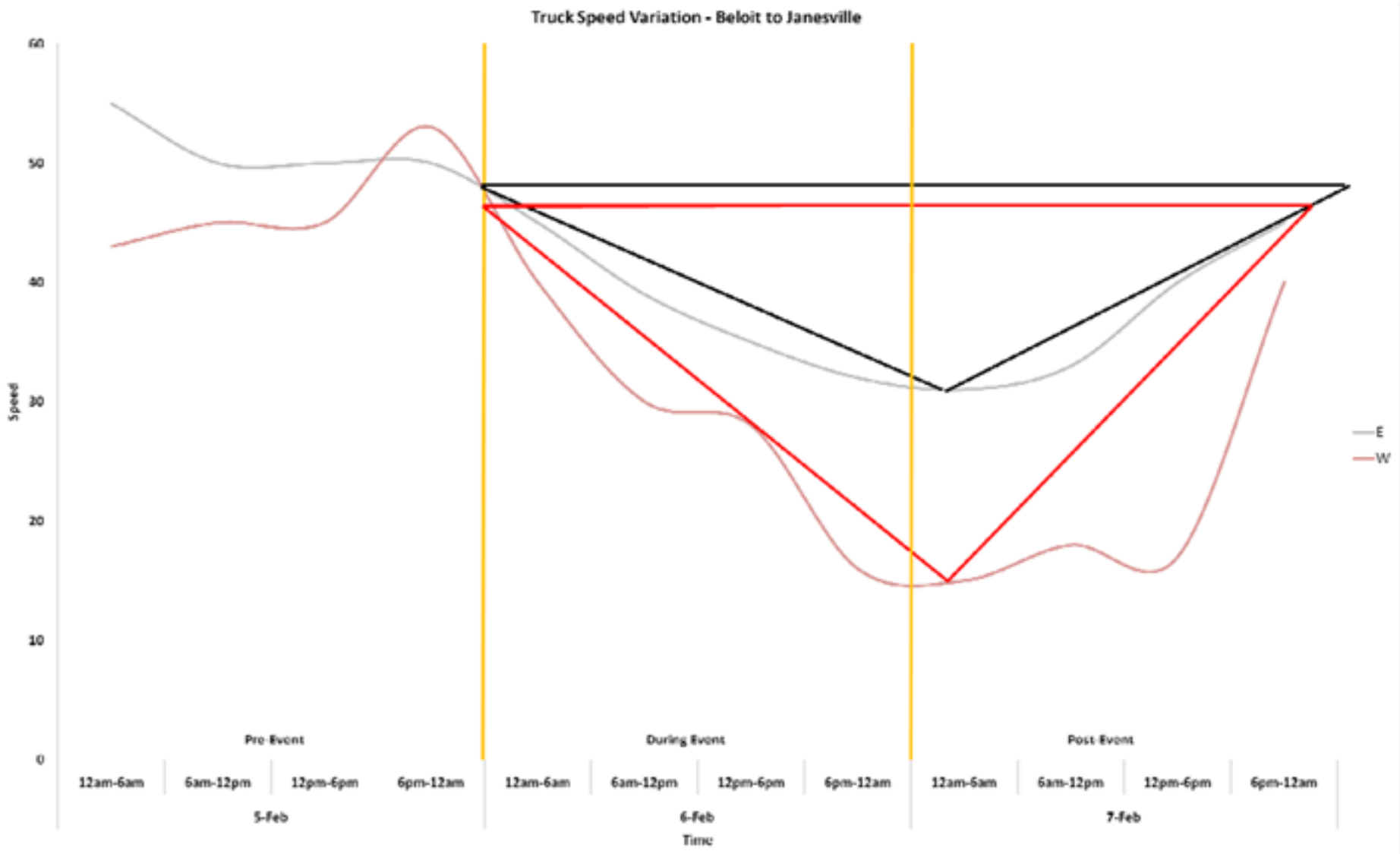


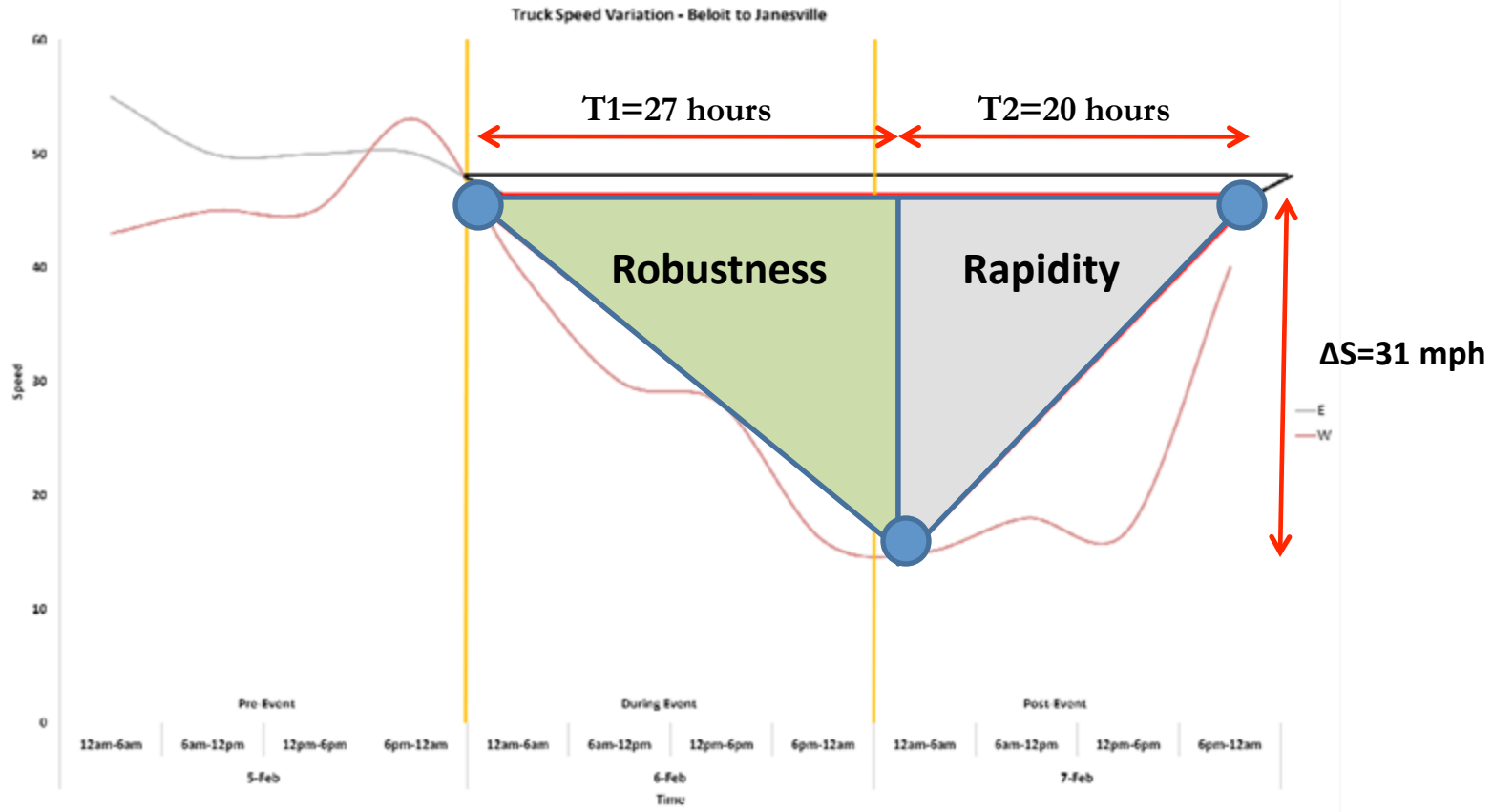
Resiliency defined as performance with time (Sheffi, 2005, Tierney & Bruneau,2007)

Freight Resiliency Performance Measures

- Robustness - ability to withstand disasters without significant performance loss
- Rapidity - capacity to restore function quickly




Truck Speed Variation - Beloit to Janesville
Speed
60
50
40
30
20
10
0
E
W
Pre Event
During Event
Post Event
12am-6am
6am-12pm
12pm-6pm
6pm-12am
5-Feb
6-Feb
7-Feb
Time



Example: Speed resiliency on the Janesville to Beloit section as affected by the February 2008 snow event (speeds before, during and after)

Robustness (Westbound):

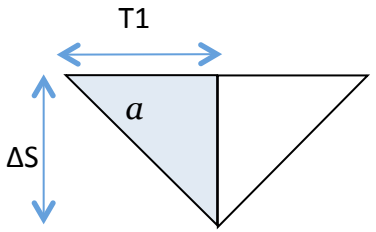
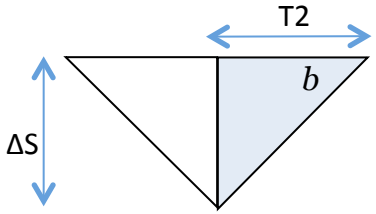
$\Delta S/T1$: 31/27 = 1.148 = 48.9 degrees

Rapidity (Westbound):

$\Delta S/T2$: 31/20 = 1.55 = 57.2 degrees

Freight Resiliency Performance Measures

- We criteria to qualify the computed resiliency measures.
- These criteria have empirical threshold values reflecting observed behavior during the disruptive events.
- More research is needed to determine threshold values.

Criteria	Figure
High Robustness: No loss or gradual minor loss of truck speed (ΔS) over time period (T1). $\Delta S/T1 \leq 0.20$ mph/hr $a \leq 11.3^{o}$ **Moderate Robustness:** Significant loss in truck speed (ΔS) occurs over long period of time (T1) 0.20 mph/hr < ΔS/T1 < 0.50 mph/hr $11.3^{o} < a < 26.6^{o}$ **Low Robustness:** Rapid loss in truck speed (ΔS) occurs over short time period (T1). $\Delta S/T1 \geq 0.50$ mph/hr $a \geq 26.6^{o}$	
High Rapidity: Rapid increase in truck speed (ΔS) occurs over short time period (T2). $\Delta S/T2 \geq 0.50$ mph/hr $b \geq 26.6^{o}$ **Moderate Rapidity:** Significant increase in truck speed (ΔS) occurs over long period of time (T2) 0.20 mph/hr < ΔS/T2 < 0.50 mph/hr $11.3^{o} < b < 26.6^{o}$ **Low Rapidity:** Gradual increase in truck speed (ΔS) over a long time period (T2). $\Delta S/T2 \leq 0.20$ mph/hr $b \leq 11.3^{o}$	

Assessing Vulnerability: A Case Study

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Operational Resiliency of Hudson-Beloit Interstate Highway Corridor

Dec. 2008-Apr. 2010

Teresa Adams
Kaushik Bekkem and Edwin Toledo
WISDOT Policy Research Program
John Corbin, Wisconsin State Traffic Engineer

WISCONSIN DEPARTMENT OF TRANSPORTATION

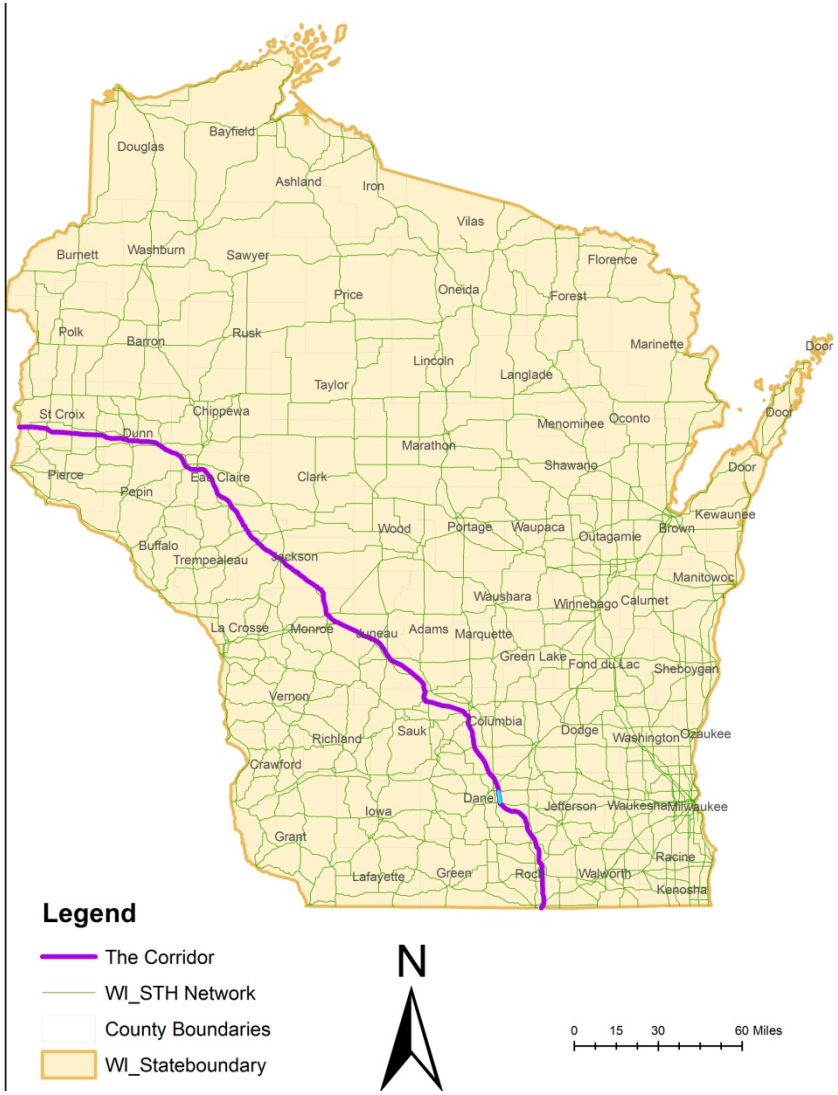
THE UNIVERSITY of WISCONSIN MADISON

2008

Figures from presentation of "All-Hazards Transportation Security and Infrastructure Protection," Jeff Western, Western Consulting Inc

I-90/94 Hudson to Beloit Interstate Corridor

- Commodities
- Highway Traffic
- Usage
  - E-E traffic
  - I-I traffic
  - I-E traffic
  - E-I traffic



Project Methodology

Development of a Statewide Resiliency Plan

Identification

- Identify and segment customers of the transportation system
- Quantify the objectives of the resiliency plan

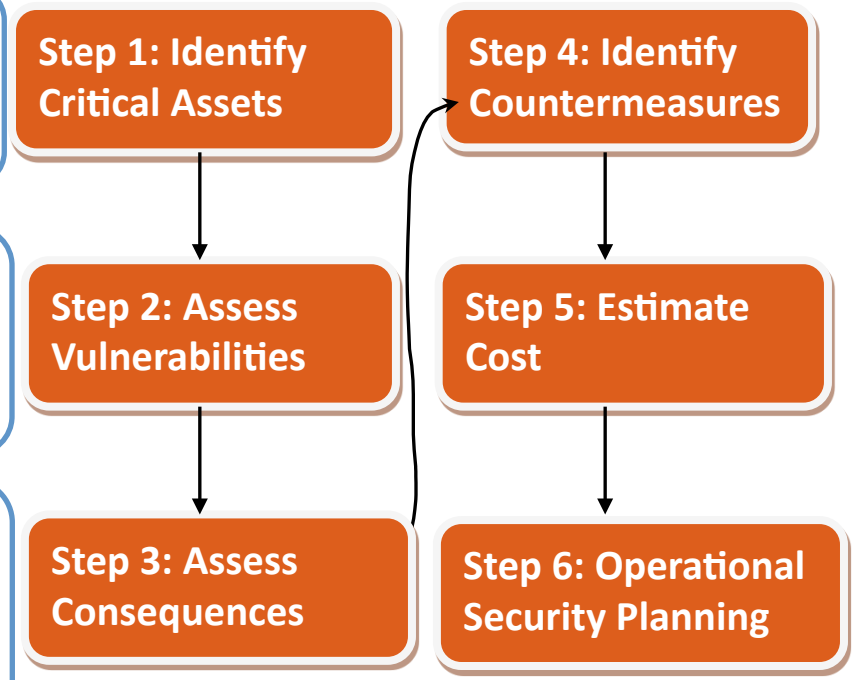
Assessment

- Develop the network inventory for the critical sections of the network.
- Conduct a vulnerability assessment of the transportation network

Implementation

- Recommend the responding strategies in terms of traffic control and incident management.
- Conduct a small scale simulation for a few customer groups

Vulnerability Assessment Overview



* MIT Center for Transportation and Logistics for WSDOT

www.wsdot.wa.gov/freight/publications

*SAIC , 2002

Commodities

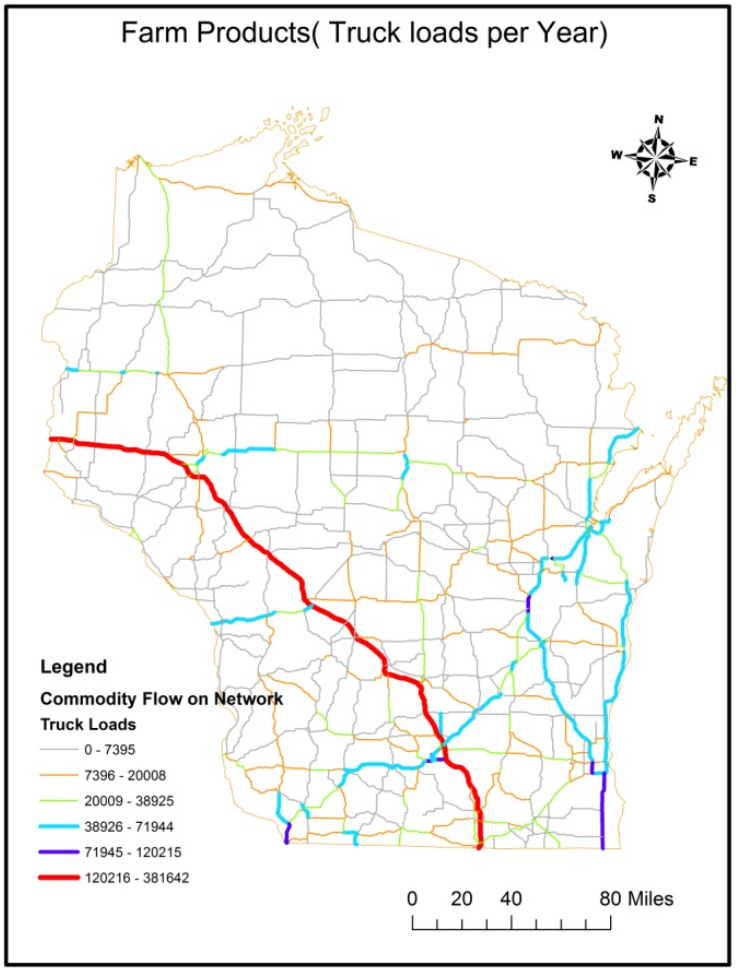
List of commodities moving on Highways, ranked by value (TRANSEARCH data)

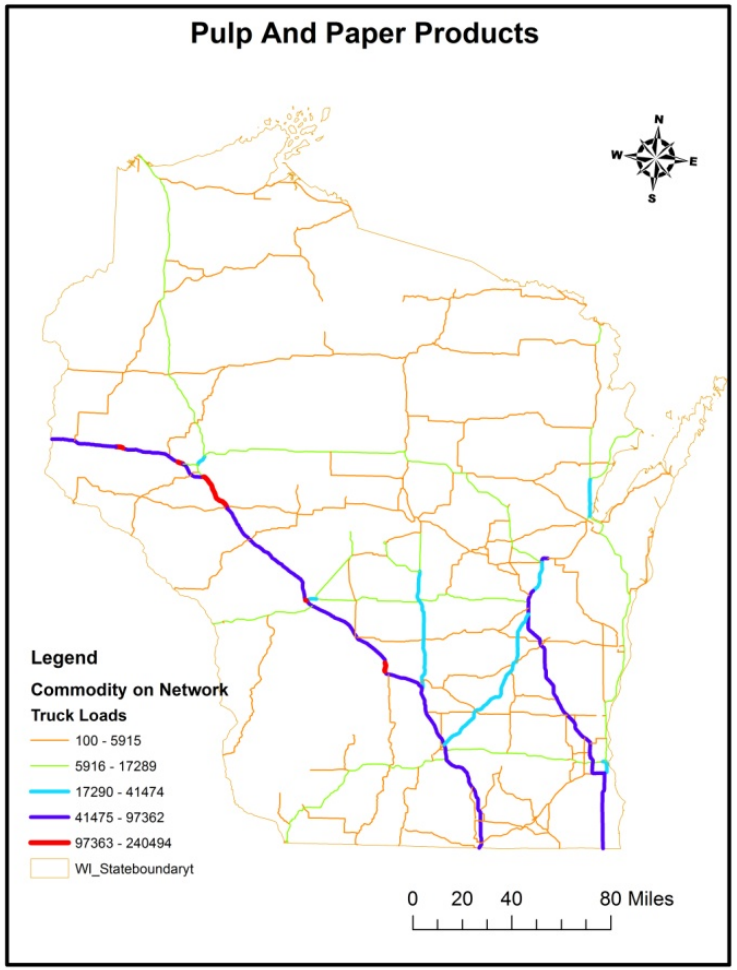
Commodity	No of Truck Loads (000's per year)	Truck Tons (000's per year)	Total Goods Value (in Mill. Dollars/year)
Drayage	2260.88	46358.24	359820.00
Electrical Mach/Equip/Su	458.95	7096.14	94212.06
Machinery Excl. Electrical	547.98	7363.05	77647.52
Transportation Equipment	817.76	11314.39	64225.84
Fabricated Metal	630.06	11289.72	52601.61
Primary Metal	737.50	18053.15	48355.54
Chemicals/Alllied	840.10	17221.74	46552.25
Miscellaneous Manufactu	94.84	1837.30	38271.33
Food/Kindred	1513.43	34360.09	38152.50
Farm	2461.33	39363.78	23705.93
Instr/Optical/Watches	54.80	690.55	21897.00
Printed Matter	224.02	3991.55	20773.25
Lumber/Wood	1015.93	26027.18	20366.98
Rubber/Plastics	394.56	5251.62	20069.18
Pulp/Paper/Allied	556.48	13172.84	17656.65

Top 10 Commodities
- Economic value
- Truck Loads
- Flow on the Corridor

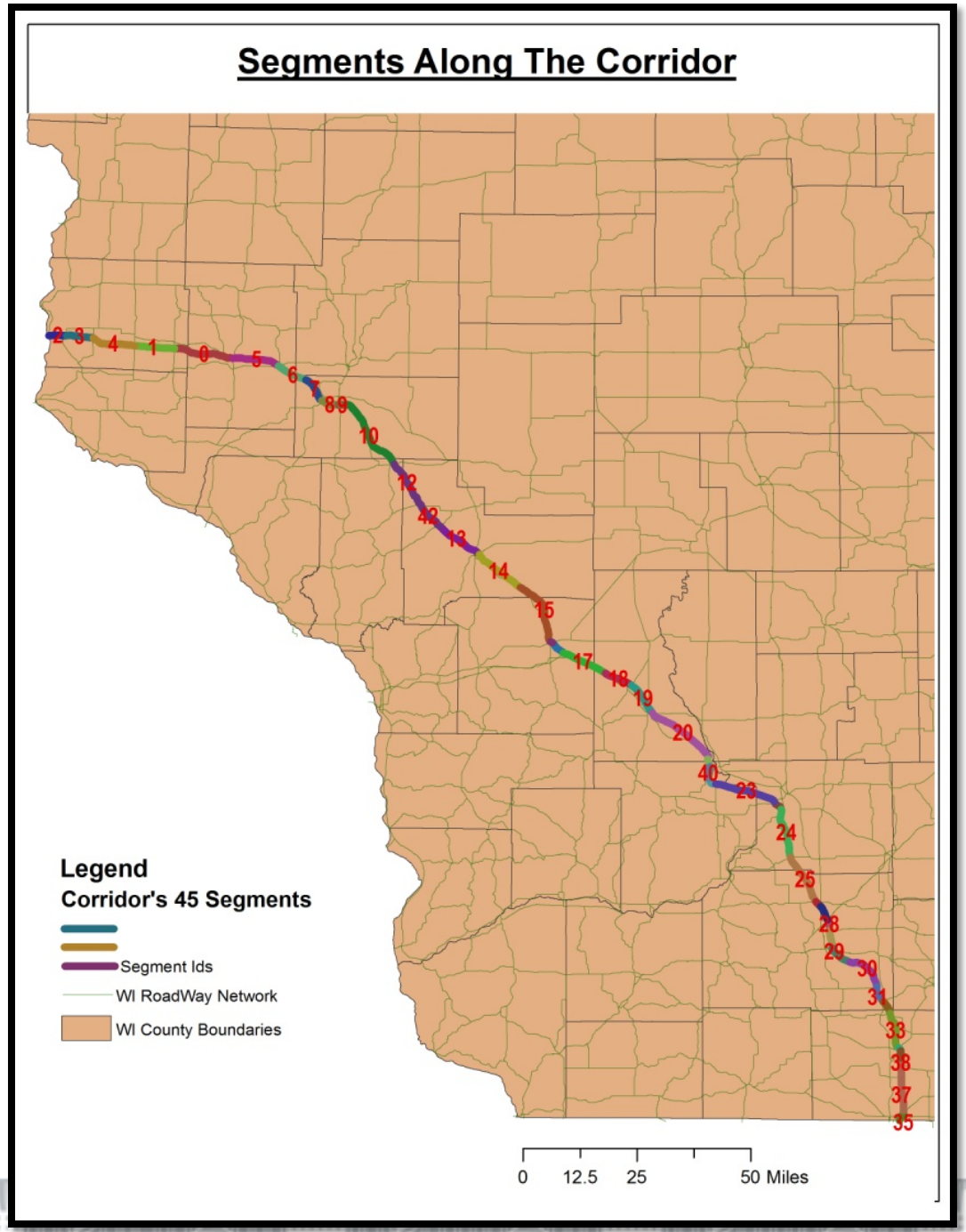
STCC2 CODE	COMMODITY
14	Non metallic minerals
01	Farm products
24	Wood & lumber products
20	Food & kindred products
32	Clay, concrete, glass or stone
26	Pulp, paper or allied products
29	Petroleum or coal Products
30	Rubber or plastic products
33	Primary metal products
28	Chemicals

Commodity Flows

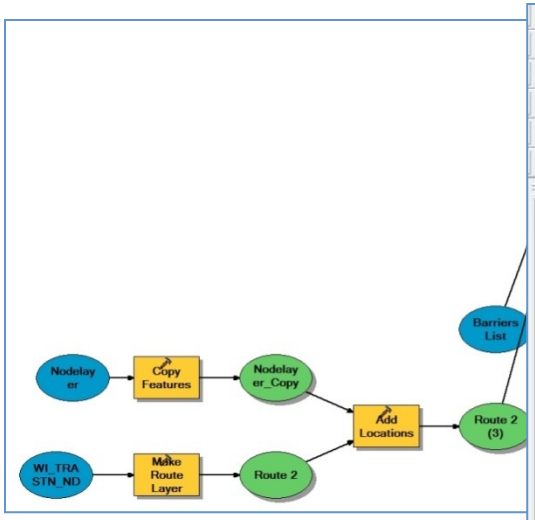




- List of data used:
  - Route Sign
  - Length
  - One Way
  - County
  - AADT
  - % Trucks
  - Direction/Heading
  - Commodity flows

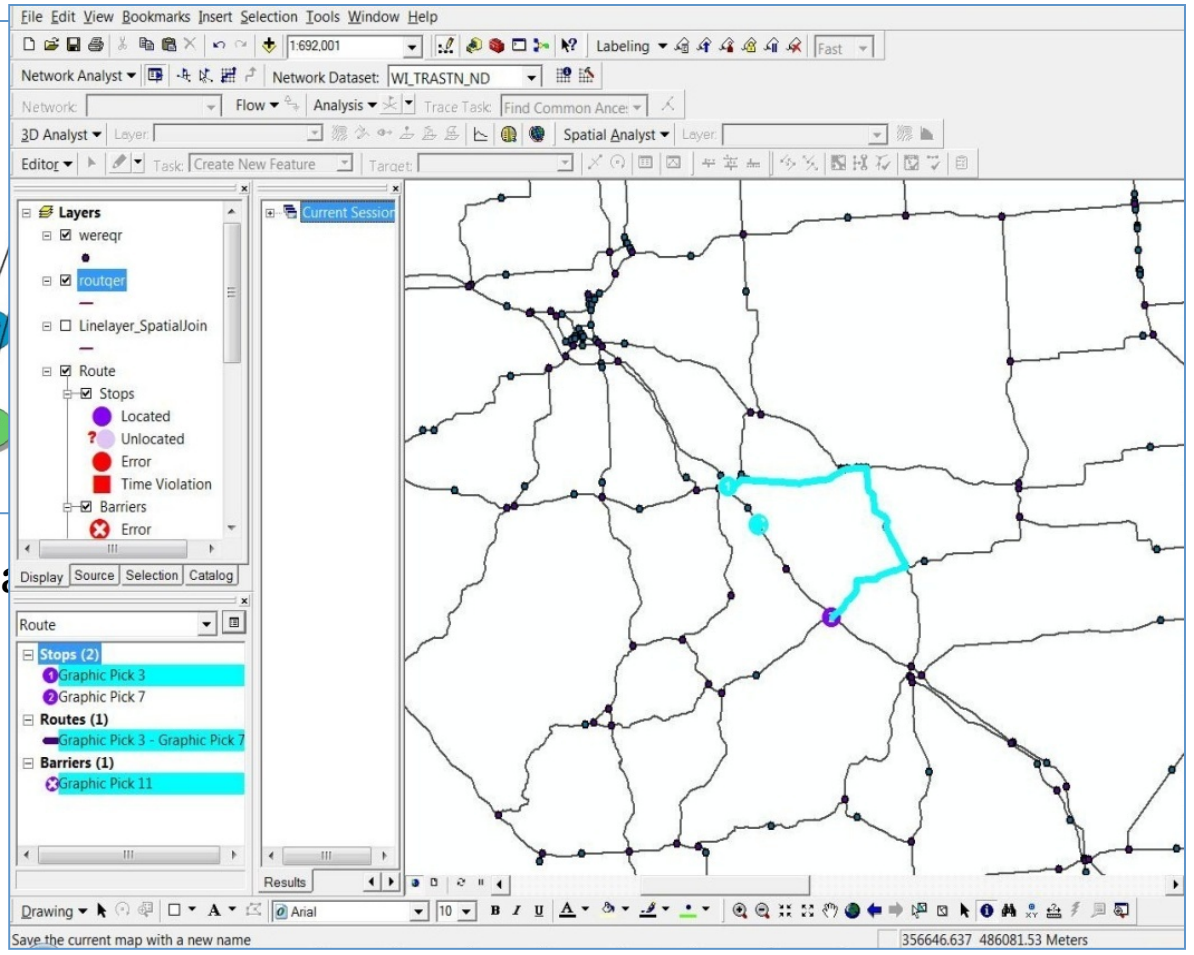


Network Analysis



Algorithm to obtain the a
Corridor

Python scripting is used for batch processing of the alternate routes. The script automates the process for multiple segment disruptions- dis-contiguous or contiguous.



The ArcMap® Illustration of alternate route analysis

Alternate Routes for Sample Segments

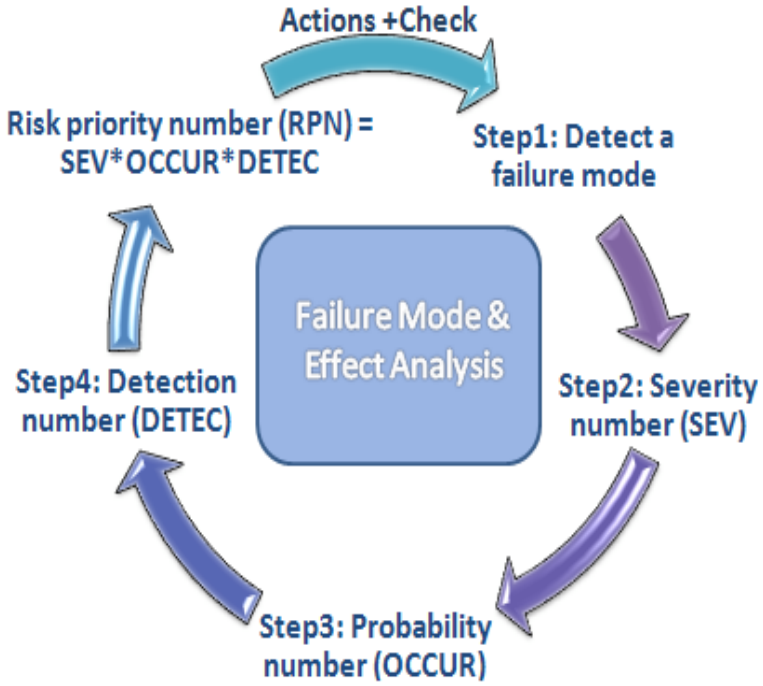
Corridor Segment ID	Alternate Routes	Alternate Route ID	TRK % per Year	AADT	Length In Feet	Minutes in mins	Total Truck Tons	Total Truck Loads	Total Truck Value
3			0.127	40201	9041.762	5.188	4287648 7	2254299	2.40E+11
	1	55000581	0.0988	18557	11648.05	6.684	0	0	0
		55010960	0.0505	11395	3481.624	1.997	626956	34469	2611872 993
		2	0.0842	31032	802.2121	0.460	4365392 8	2300945	2.42E+11
	Net for Alternative 1		**0.0988**	**31032**	**15931.88**	**9.142**			
	Betterment		**0.02813**	**9169**	**-6890.12**	**-3.953**			
	% change			**22.808**	**-76.203**	**-76.203**			
	2	55000601	0.17066	28773	10601.1	6.0833	289593	19426	1836231 58.3
		55011690	0.08422	13306	11338.74	6.506	39502	2694	8557139. 485
	Net for Alternati		**0.171**	**28773**	**21939.84**	**12.590**			

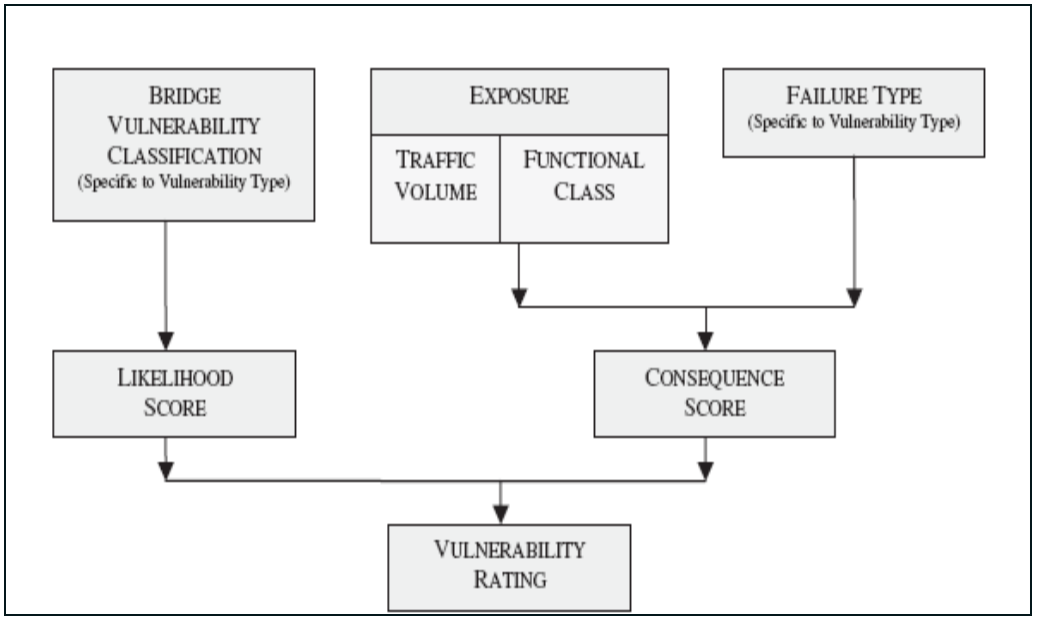
Resiliency Criteria

- Alternate route distance not more than 2X the route distance on the disrupted segment
- Alternate route travel time not more than 2X the travel time on the disrupted segment
- Increased traffic volumes on the alternate route does not exceed the capacity

Assessing Vulnerability

- FMEA (Failure Mode and Effect Analysis)
- Each corridor segment is assigned a RPN (Risk Priority Number) based on failure modes and disruption events.
- For bridges, Bridge Vulnerability Assessment procedure adopted from NYSDOT (1996a)





Vulnerability Assessment

Three network components
- Bridges
- Culverts
- Roadways

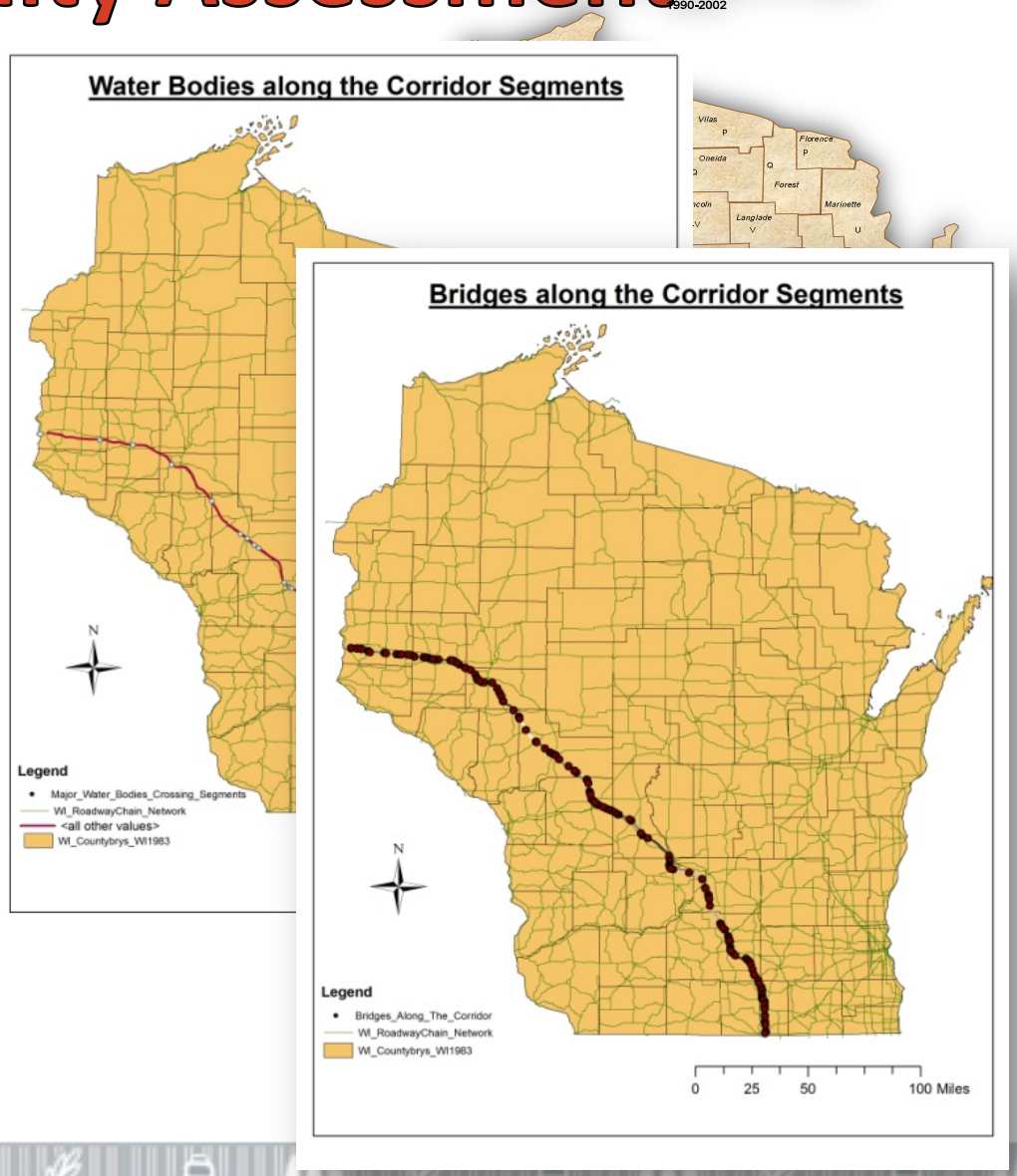
FMEA for:

Hydrologic
- Scouring
- Scouring due to Floods

Overload
- Traffic volumes
- Functional class of bridges

Weather related
- Snow/Ice accumulation
- Snow Storms
- Tornadoes
- Severe winter storm

The segment risk rating (RPN) is averaged over the failure modes.

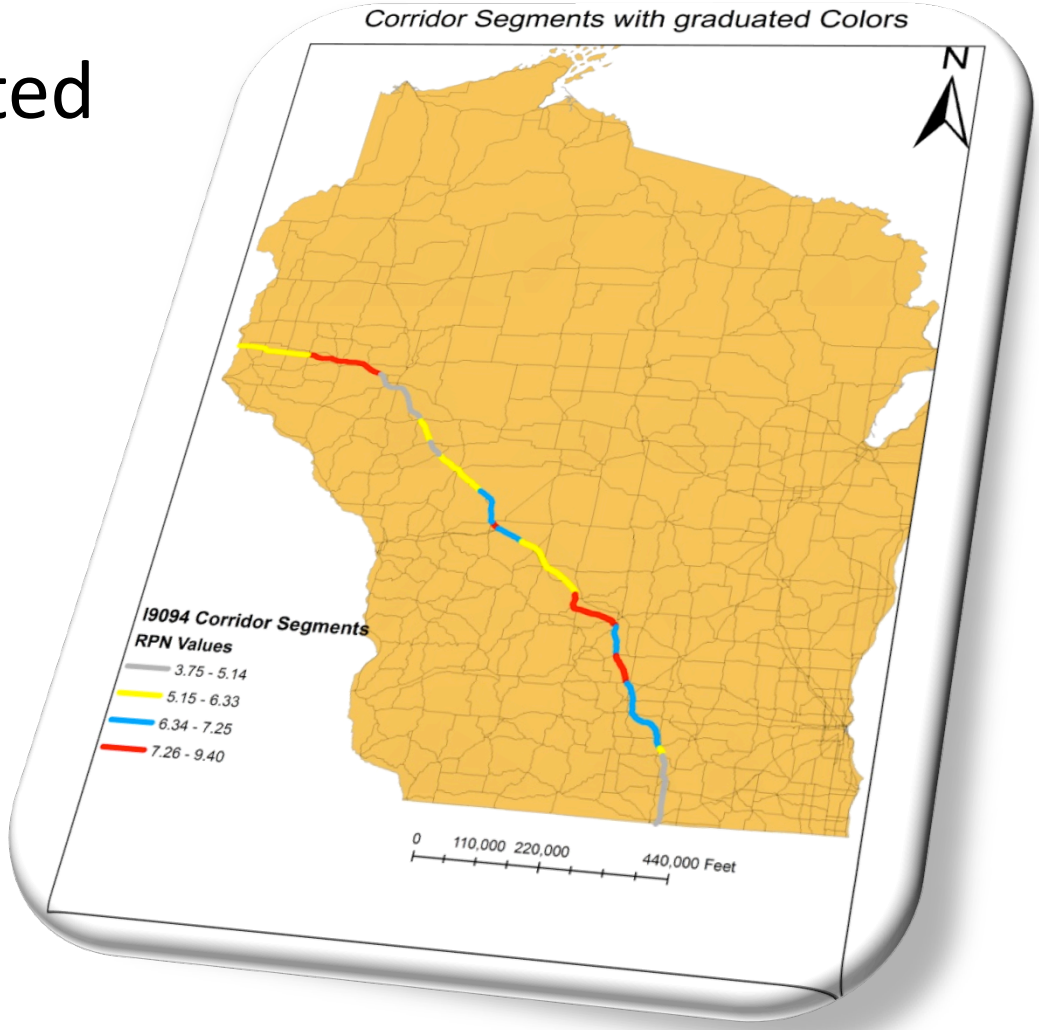


Computing Risk Priority Number (RPN)

- Failure Event type
  - Probabilities
    - Major disaster events from Wisconsin Emergency Management
    - Flooding data from FEMA maps of Wisc DNR
    - Winter Maintenance Report findings
  - Severity
    - Winter Maintenance Report findings
    - Snow Severity Index
    - Water bodies location GIS layers
    - NBI Bridge ratings from Wisconsin HSI
  - Detectability
    - *Assumed to be 1 , for post disaster

RPN Vulnerability Rating

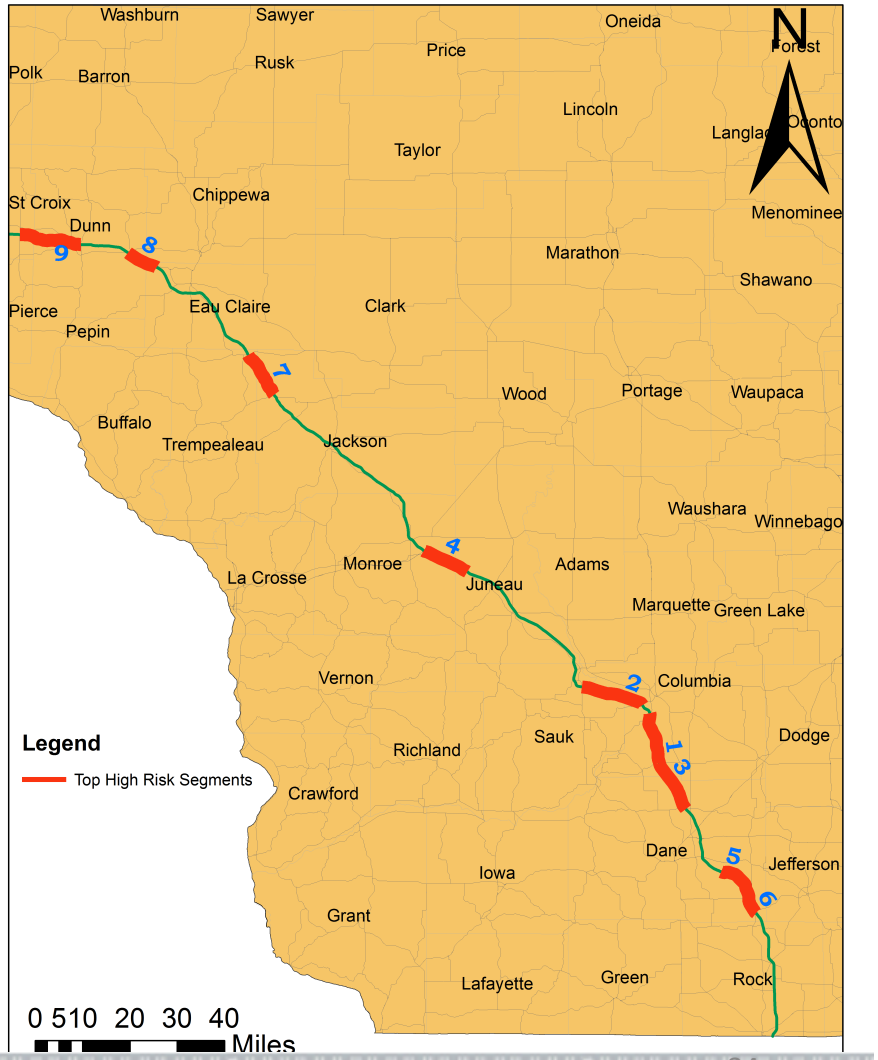
- RPN values calculated
- Scale of 1 – 10
  - 10 – high
  - 1 – low



Top 10 High Risk Segments

- Risk number= *f*(
  - Economic Value of Commodity flow,
  - Extra VMT due to detour,
  - Risk Priority Number)

Corridor Segment ID	From Intersection	To Intersection	Rank (1= High)
24	I90E:39N, M115, Columbia County	I90E: 60E, M108A, Columbia County	1
23	I90E: 60E, M108A, Columbia County	Lake Delton: SW, Sauk County	2
25	90E: 60E, M108A, Columbia County	I90E:19E, M115, Dane County	3
30	I94E:I90E, Tomah Monroe County	I90E:12E, Newlisbon, Juneau County	4
31	I90E:12E, M156, Dane County	I90E:51N,M147, Dane County	5
12	I90E:51N,M147, Dane County	I90E:73N, M156, Dane County	6
6	I94E: 10E,M098, Trempealeau County	I94E: 121E,Ossea, Jackson County	7
0	I94E:12E, M90, Dunn County	I94E:12E,Elk Mound, Eau Claire County	8
17	I94E:128N,M041, Menomonie, St.Croix Co	I94E:12E,M028, Spring Valley, Dunn County	9
28	I90E:I94E, M142, Madison, Dane County	I90E:12E, M138, Madison, Dane County	10



Logical Next Steps for Implementation

- Review existing and pending plans of agency, and the emergency procedures of trucking companies.
- Discussion with agency personnel at traffic management and emergency response centers.
- Identify and recommend countermeasures for future network enhancements on weak segments.
- CBA of infrastructure resiliency improvements

Future Studies

- Multi-segment disruptions (traffic detours depend on the entry and exit points)
- O-D network model – disruption along various segment of the path
- Commodity-based economic analysis – need O-Ds for each commodity
- CBA of infrastructure resiliency improvements
- Calibrate TRANSEARCH data for observed truck traffic counts on alternative routes
- Validate results by comparing alternate routes and travel speeds during disruption events with truck GPS data collected by ATRI (American Transport Research Institute)

Resiliency of MVFC Freight Corridors

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Implementation	7. Conduct a small-scale in-house simulation
	8. Test the plan with a large-scale simulation

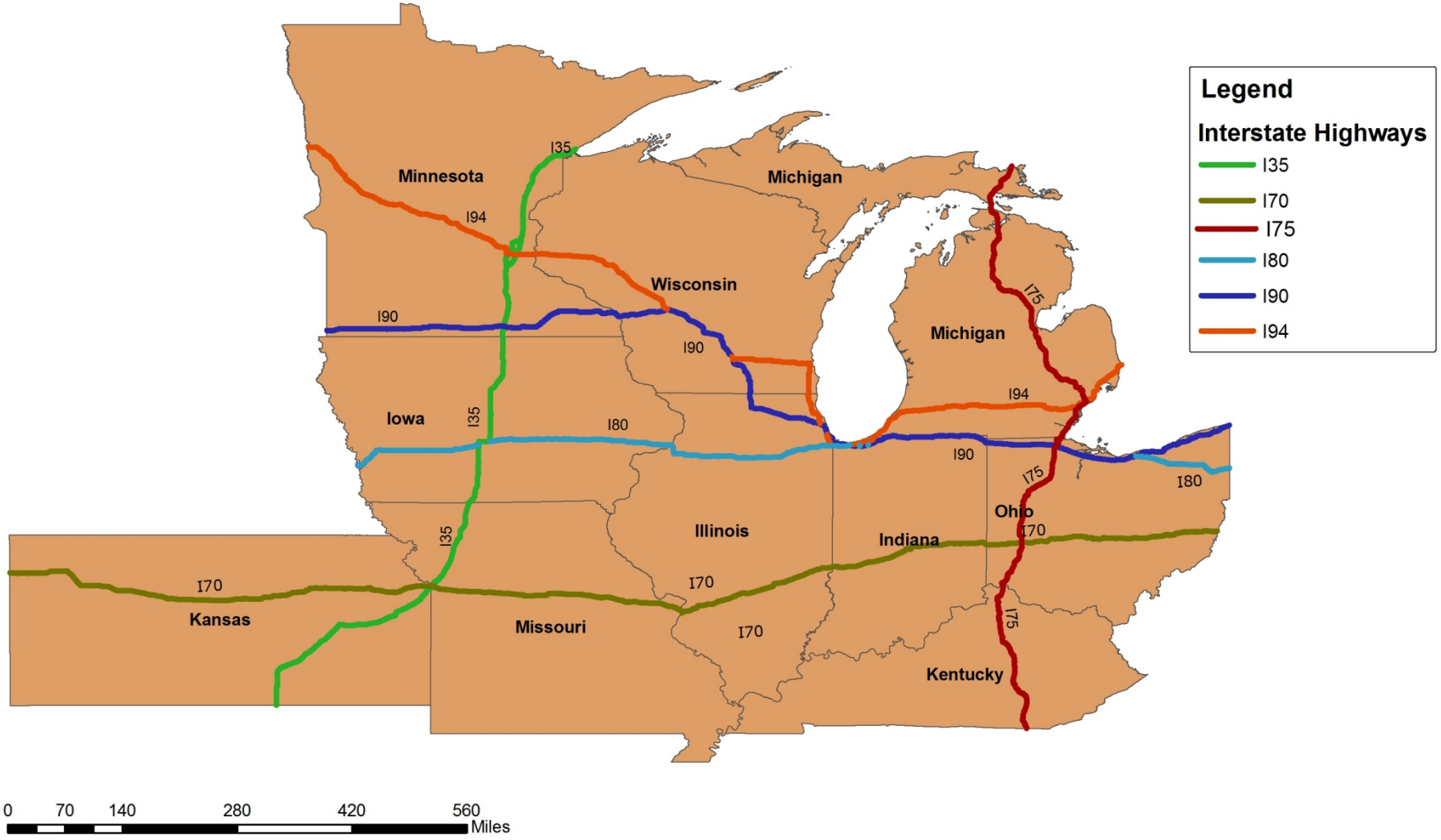
MVFC Work Plan

- Survey of freight companies and State DOTs & HAS, for
  - mitigating critical nodes,
  - segmentation of corridor user groups and
  - quantifying better objectives of FSR plans.
- In assessment phase, additionally
  - Current capacity constraints
  - Determine the critical nodes and segments
  - Public/private collaboration mechanisms
  - Regulatory and policy procedures to be put in place
- Incorporating resiliency study in to state/local freight planning efforts.

Goal

- Identify key nodes and sections, including intermodal connectors, on the freight network within the MVFC region with the greatest system impact if they partially or completely lose their capacities.
- This project will involve risk assessments and include key components of the roadway infrastructure and intermodal connections.

Freight Corridors in MVFC Region



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- Mechanisms must be in place for fast-tracking recovery before an event happens.
- The States need to decide how to most productively allocate limited freight system capacity during long-term disruptions.
- Most state emergency plans don't include economic recovery.

- List of data used:
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  - Length
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  - % Trucks
  - Direction/Heading
  - Commodity flows