Risk assessment for bridge management systems

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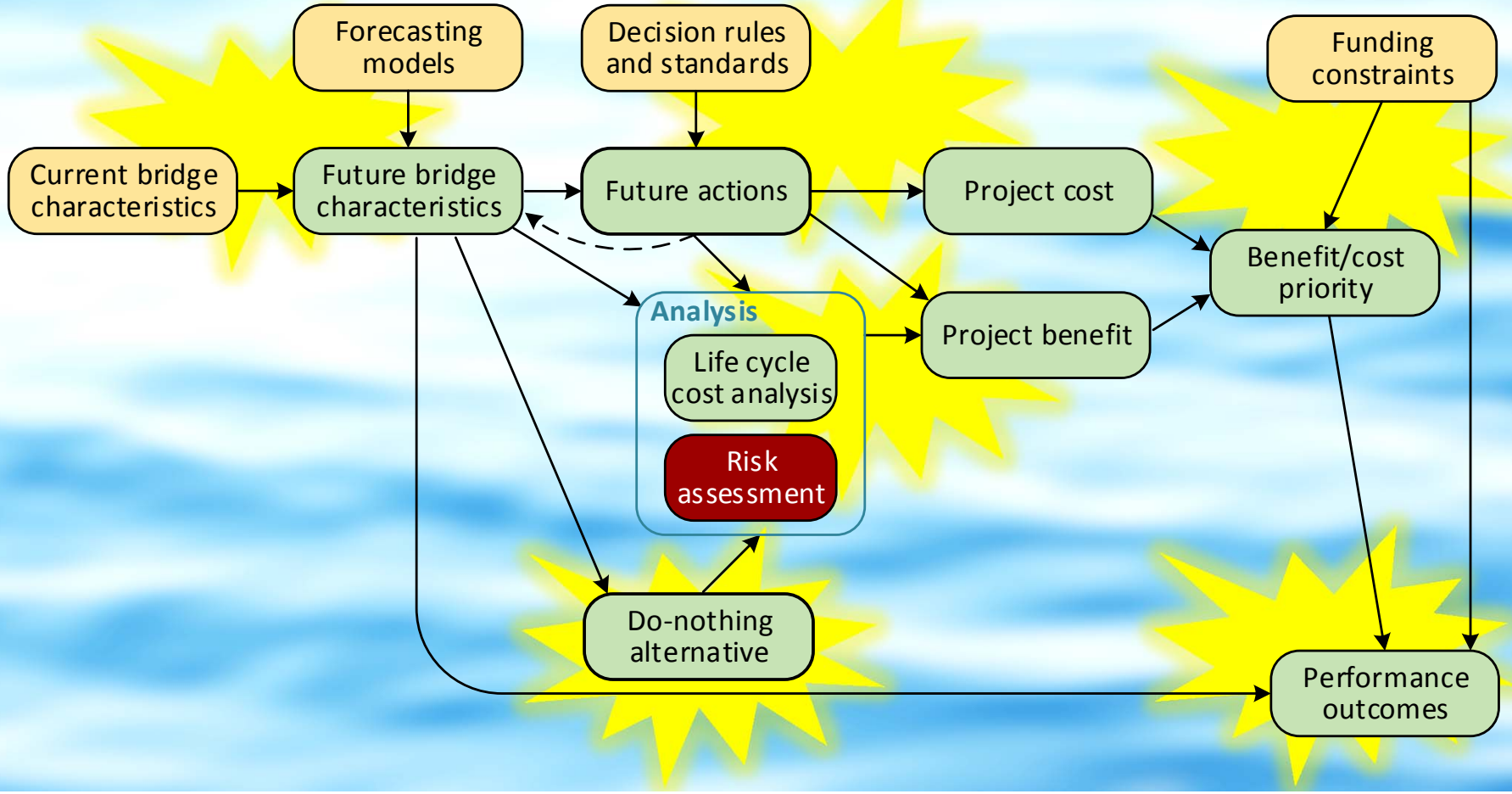
Background – NCHRP 20-07 (378)

Risk assessment for bridge management systems

- Western Management and Consulting LLC, Prime
  - Paul D. Thompson, subcontractor and Guideline primary author
- Project panel consisted of mostly AASHTO SCOBS T-1
  - Subcommittee on Bridges and Structures, T-1 (Security)
- Work completed September 2016
  - Publication decision pending
- Targeted to AASHTOWare Bridge Management
  - But suitable for spreadsheet tools or any other BMS

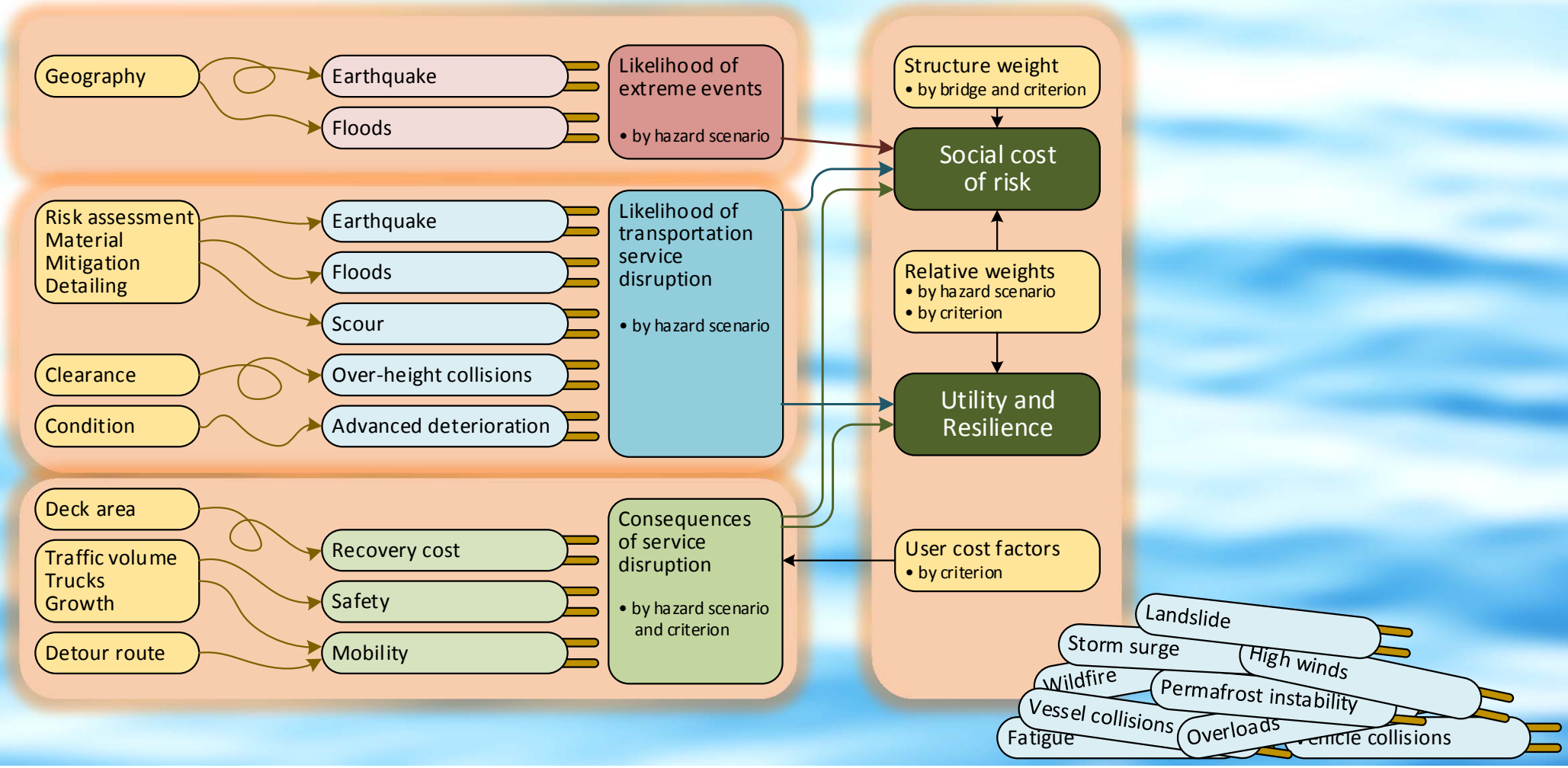
Integrating risk into BMS



Hazards considered

- Earthquake
- Landslide
- Storm surge
- High wind or tornado
- Flood
- Scour
- Wildfire
- Temperature extremes
- Permafrost instability
- Overload
- Over-height collision
- Tanker truck collision
- Vessel collision
- Sabotage
- Advanced deterioration
- Fatigue

Plug-in risk models



Worksheet for social cost of risk

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Sheet B - Project summary

Bridge ID	**010001**		
Alternative	**Do nothing**	Deck area (sq.ft)	20,000
Program year	**2017**	Program cost ($000)	12,345

Roadways	On structure				Under structure			
Func class	11 - Urban interstate				14 - Urban other principal arterial			
Utilization	ADT	54,000	Trucks	5.50%	ADT	21,000	Trucks	3.00%
Roadway	Length (ft)	200	MPH	55	Length (ft)	100	MPH	45
Detour	Miles	2.1	MPH	45	Miles	1.0	MPH	45

From BMS data. If multiple roadways, use the total ADT and most significant roadway, projected to program year.
Length on-structure is bridge length. Length under-structure is bridge width..

Hazard scenarios		Consequences ($000)				Likelihood			Risk
ID	**Scenario**	**Cost**	**Safety**	**Mobility**	**Environment**	**Extreme**	**Disruption**	**Weight**	**Cost ($k)**
1	Eq-100	12,345	50	6,000	600	1.00%	5.00%	1.00	9.50
2	Fl-100a	12,345	50	6,000	600	1.00%	10.00%	1.00	19.00
3	Fl-100b	100	0	2,000	200	1.00%	20.00%	1.00	4.60
4	Fl-500	12,345	50	6,000	600	0.20%	50.00%	1.00	19.00
5	OH-13.5	100	70	200	40	--	5.00%	1.00	20.50
6	AD-0.9	50	0	200	40	--	10.00%	1.00	29.00
7	Fracture	12,345	0	6,000	600	--	0.50%	1.00	94.73
8								1.00	0.00
9								1.00	0.00
10								1.00	0.00

Use worksheet A to define the hazard scenarios and performance criteria.
See Section 3.5 for supporting computations of consequences.
See the Sections 3.3 and 3.4 for likelihood computations.

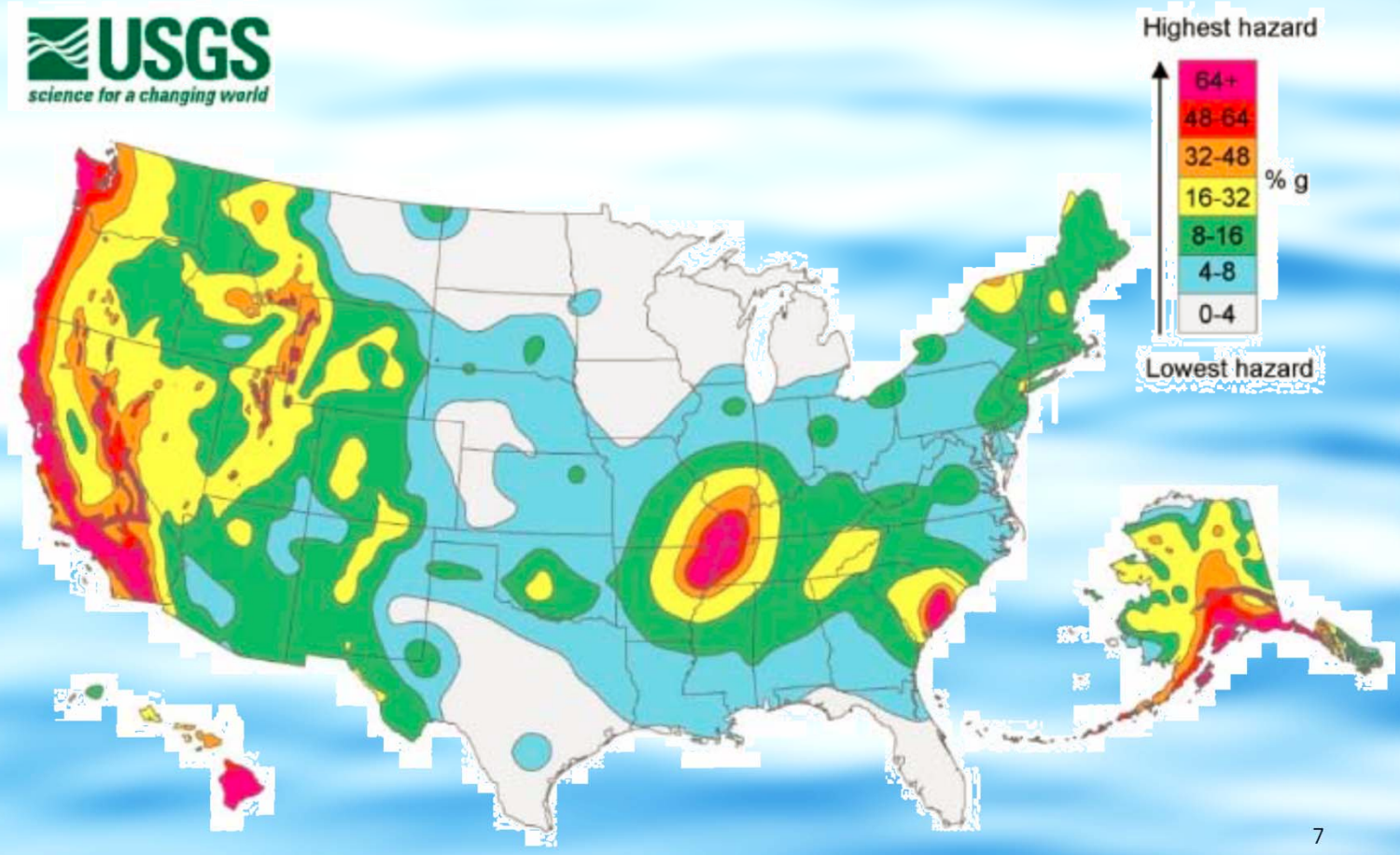
Risk cost and vulnerability	Cost	Safety	Mobility	Environment
Struc weight	20,000	75,000	134,400	134,400
Criteria weight	1.00	1.00	1.00	1.00
Risk cost ($k)	102.79	3.63	79.00	10.90
Vulnerability	5.1394	0.0483	0.5878	0.0811

See Section 3.2 for these computations.

Risk analysis results	
Maximum unit risk cost:	100.00
Vulnerability index:	0.0586
Utility:	**94.14**
Social cost of risk ($000):	**196.31**

Likelihood of extreme event

- Example: Earthquake



Likelihood of service disruption

- Example: Risk allocation using MnDOT methodology

Bridge scour susceptibility					
		Defect reduction			
Code	Description	None	2	3	4
A	Not a waterway	100	100	100	100
E	Culvert	100	100	100	100
M	Stable; scour above footing	90	90	70	40
H	Foundation above water	90	90	70	40
N	Stable; scour in footing/pile	80	80	60	30
I	Screened; low risk	70	70	50	30
L	Evaluated; stable	70	70	50	30
P	Stable due to protection	60	60	40	20
K	Screened; limited risk	60	60	30	20
F	No eval; foundation known	50	50	40	20
C	Closed; no scour	50	50	25	20
J	Screened; susceptible	40	40	30	10
O	Stable; action required	40	40	20	10
G	No eval; foundation unknown	20	20	15	10
R	Critical; monitor	10	10	5	0
B	Closed; scour	0	0	0	0
D	Imminent protection reqd	0	0	0	0
U	Critical; protection required	0	0	0	0

Smart flag reduction:

Use worst condition state of defect 6000, Scour

Consequences of service disruption

- Example: Mobility
- Also considered:
  Safety
  Life cycle cost
  Environmental sustainability

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Sheet CQ - Mobility

1	Bridge ID	**010001**
2	Forecast year	**2018**
3	Hazard scenario	**Earthquake**

Prediction of traffic volume		
4	Average daily traffic (NBI 29)	23,000
5	Year of average daily traffic (NBI 30)	2010
6	Future average daily traffic (NBI 114)	29,000
7	Year of future average daily traffic (NBI 115)	2030
8	Growth rate (g)	1.17%
9	Projected average daily traffic (ADT)	25,235

Cost of detoured traffic		
10	Funct class (26)	14 - Urban other principal arterial
11	Duration of the disruption (DD) (hours)	5.0
12	Detour length (DL, NBI 19) (miles)	2.2
13	Vehicle operating cost (VOC$) ($/mile)	0.208
14	Detour speed (DS) (mph)	45
15	Travel time cost (TT$) ($/hour)	30.62
16	Vehicle occupancy (VO) (persons/vehicle)	1.30
17	Total Social Cost	**12,637**
18	Worst case duration (hours)	720
19	Consequence ratio (CR)	**0.69%**

Performance measures for BMS

- **Social cost**: Used in benefit/cost ratio for priority setting
- **Utility**: Used for comparing bridges and tracking resilience over time

Conclusions

- Existing methods can be adapted to quantify a wide variety of hazards for BMS use
- Monetization of risk is a feasible and simple solution to the problem of integrating risk with life cycle management
- The methodology provides well defined opportunities for future research.

Thank you!