Risk and Resilience in the Context of Infrastructure Management

Kongres Zarządzanie Infrastrukturą Drogową

Warszawa, 4-5 Grudnia 2019

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Risk

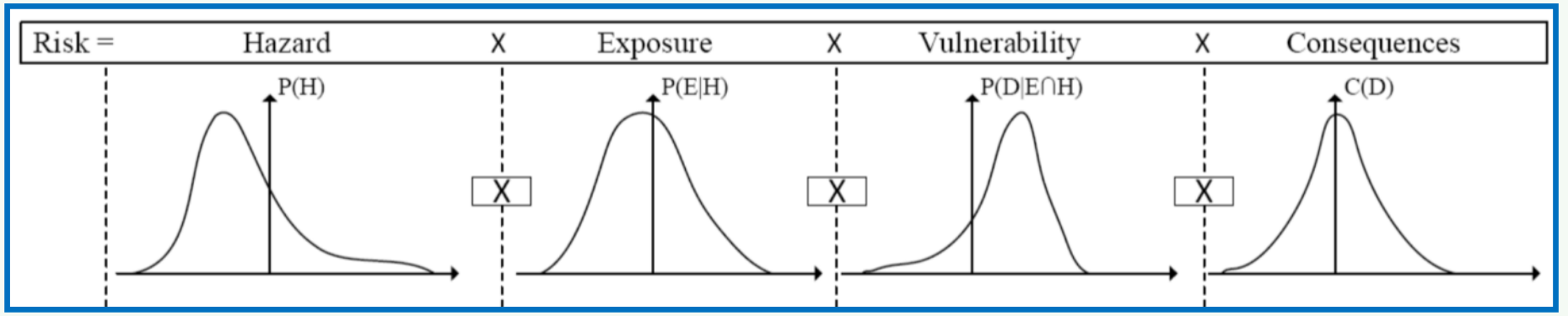
Risk: Effect of uncertainty on objectives

NOTE 4: Risk is often expressed in terms a combination of the consequences of an event and the associated likelihood

Source: ISO Guide 73- Risk Management Vocabulary

Risk

$$R = P(H) \cdot P(E|H) \cdot P(D|E \cap H) \cdot C(D)$$



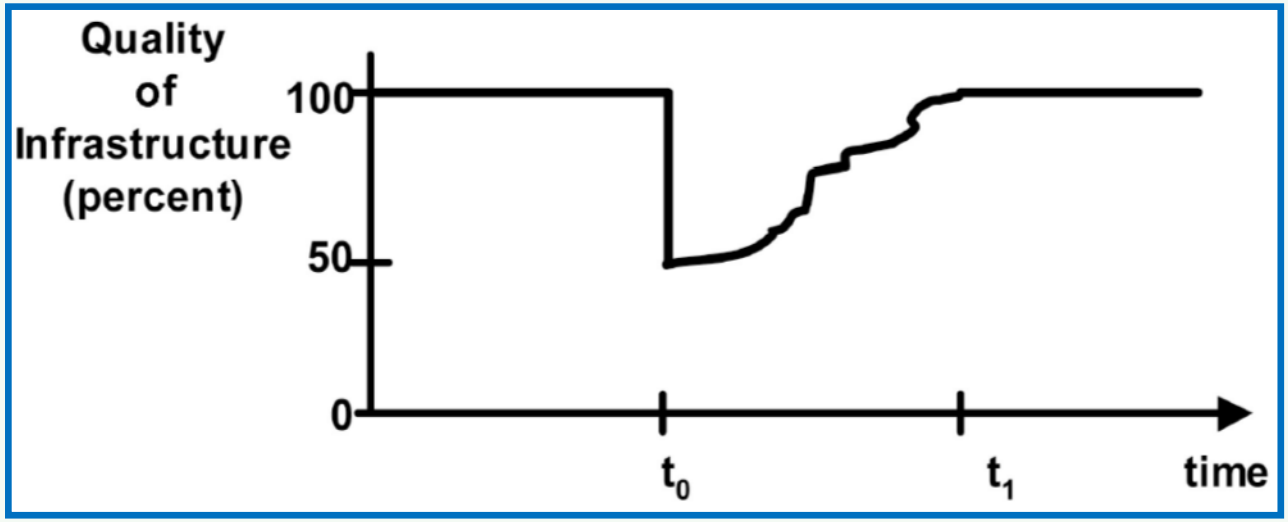
Resilience

Resilience is the ability to anticipate, prepare for and adapt to changing conditions and withstand, respond to and recover rapidly from disruptions

Source: FHWA

Resilience

$$R = \int_{t_0}^{t_1} [100 - Q(t)]dt$$



Source: Bruneau, M.; Chang, S.E.; Eguchi, R.T.; Lee, G.C.; O'Rourke, T.D.; Reinhorn, A.M.; Shinozuka, M.; Tierney, K.; Wallace, W.A.; vonWinterfeldt, D.: A framework to quantitatively assess and enhance the seismic resilience of communities, Earthq. Spectra 19 (4) (2(03) 733-752.

How does this fit together?

The bigger Picture!

Sustainability

"At its essence, sustainability means ensuring prosperity and environmental protection without compromising the ability of future generations to meet their needs. …."

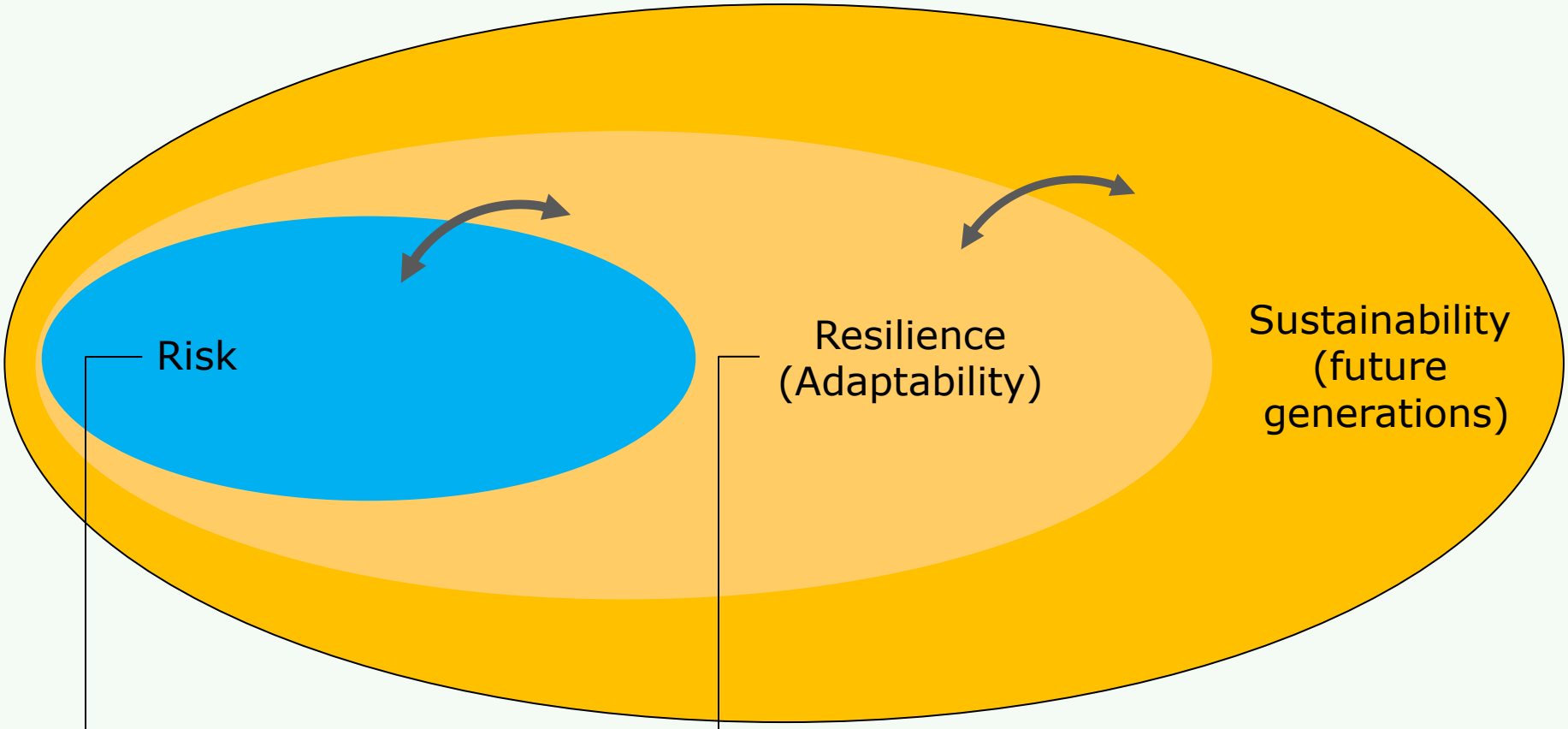
(Ban Ki-moon)


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

Target

9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.

Risk – Resilience - Sustainability



Known Knowns
- Variability can be readily described

Known Unknowns
- Limitations, assumptions

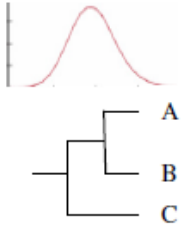
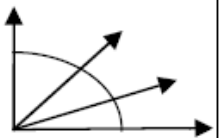
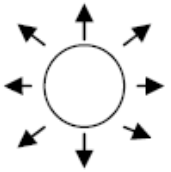
Unknown Unknowns
- Black Swan
- Threats where you have adversary
- Complex system risks with dynamic interdependencies

Based on: Risk, Resilience and Sustainability. Blake, H.: New Zealand Treasury

Uncertainty

Risk

Resilience

Complete Certainty		Level 1	Level 2	Level 3	Level 4	Level 5	Total ignorance
	Context	A clear enough future (with sensitivity) 	Alternate futures (with probabilities) 	Alternate futures (with ranking) 	A multiplicity of plausible futures (unranked) 	Unknown future 	
	System model	A single system model	A single system model with a probabilistic parameterization	Several system models, one of which is most likely	Several system models, with different structures	Unknown system model; know we don't know	
	System outcomes	Point estimates with sensitivity	Several sets of point estimates with confidence intervals, with a probability attached to each set	Several sets of point estimates, ranked according to their perceived likelihood	A known range of outcomes	Unknown outcomes; know we don't know	

Source: Warren E. Walker, Robert J. Lempert, and Jan H. Kwakkel: Deep Uncertainty

So for what Management of Risks and Resilience?

- Ageing transport infrastructure
- Increasing vehicle loads
- Extreme weather – natural hazards
- Threats - natural/man made
- Cyber Security
- …….

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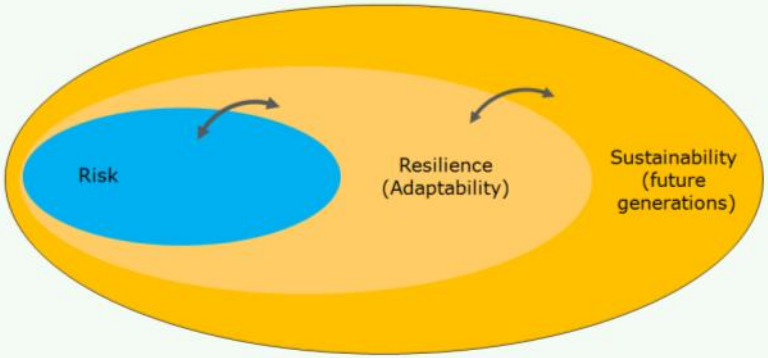
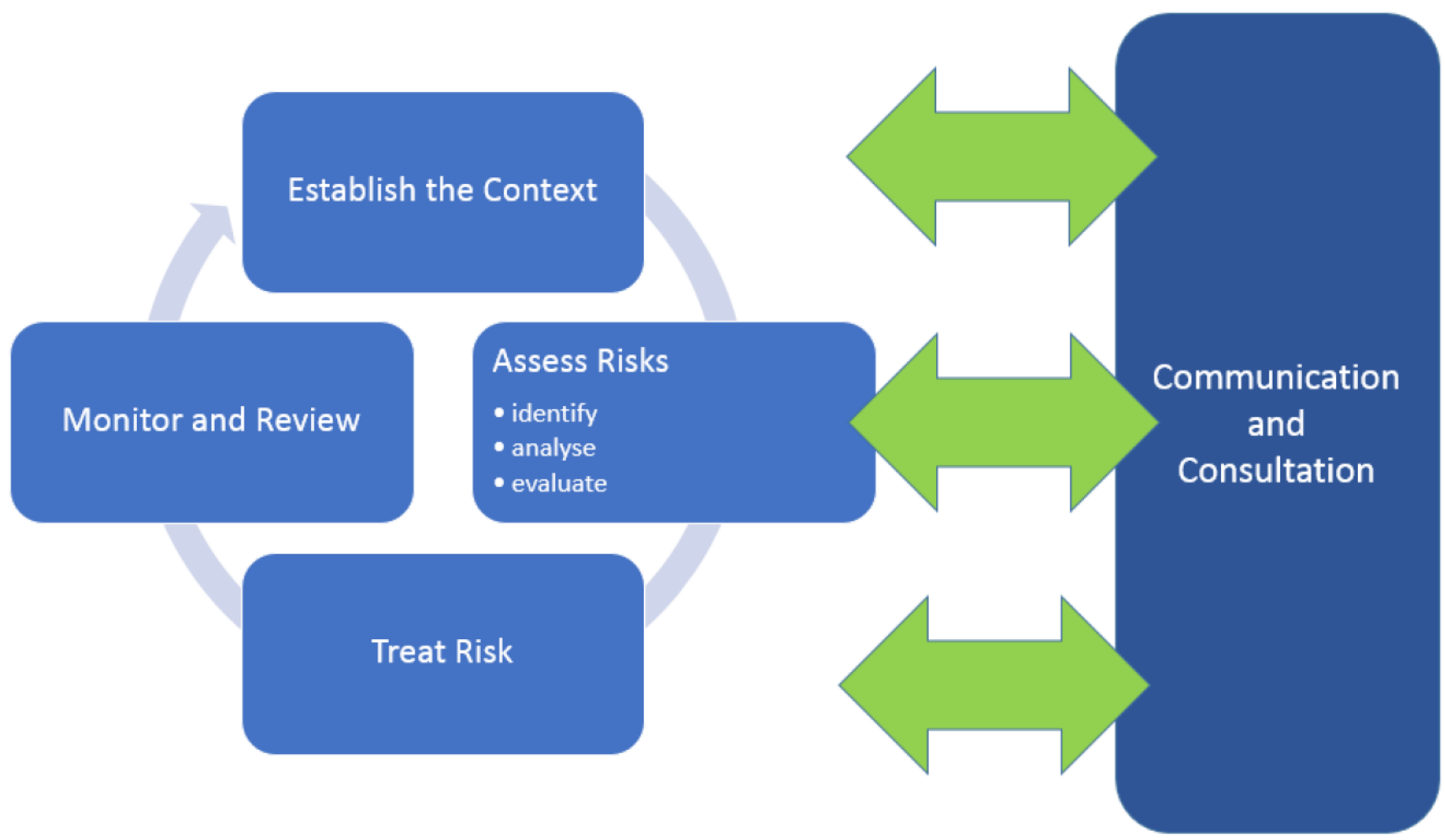


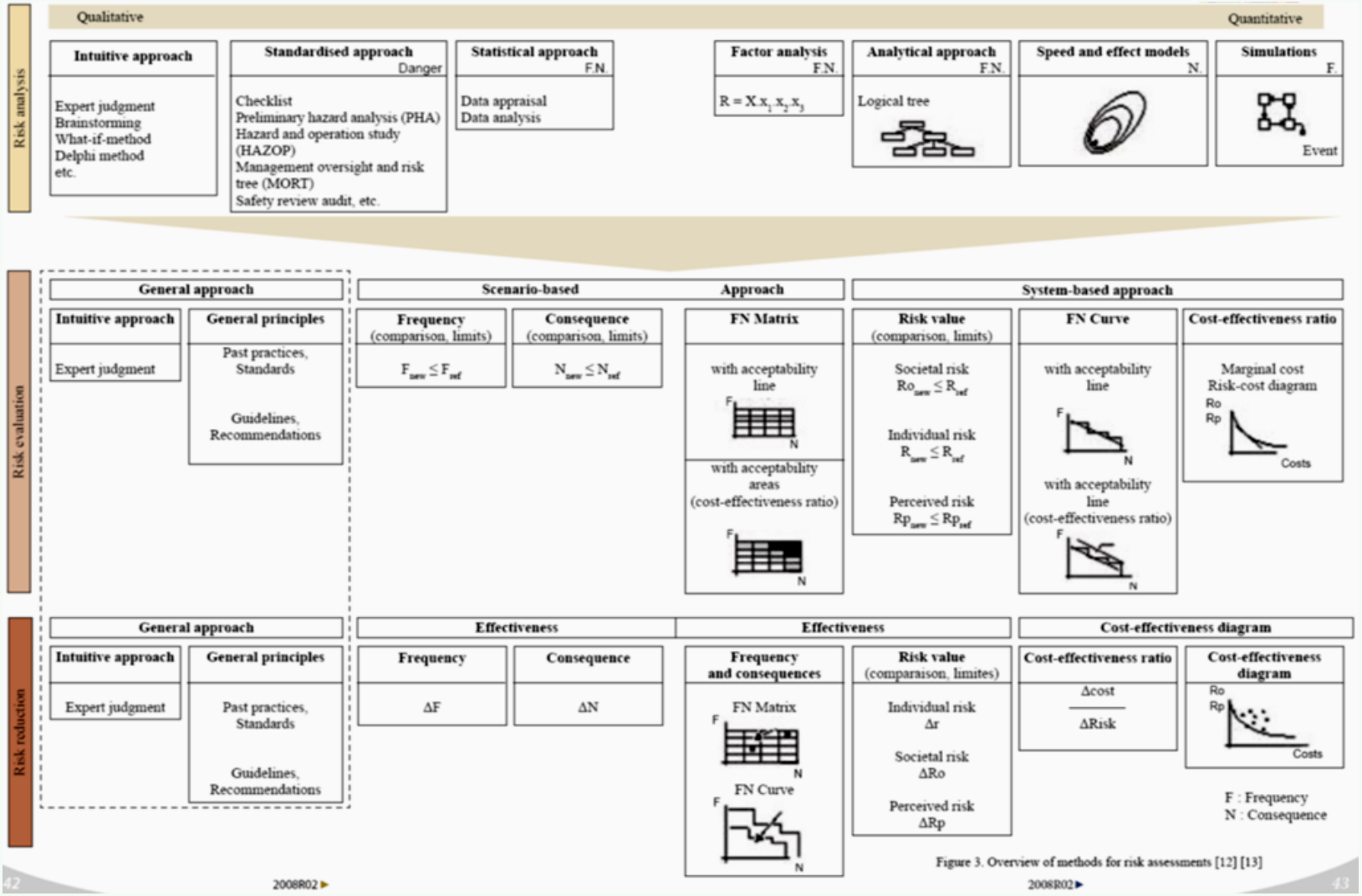
Transport infrastructure: Availability, Safety and Security!

Risk Management Process*



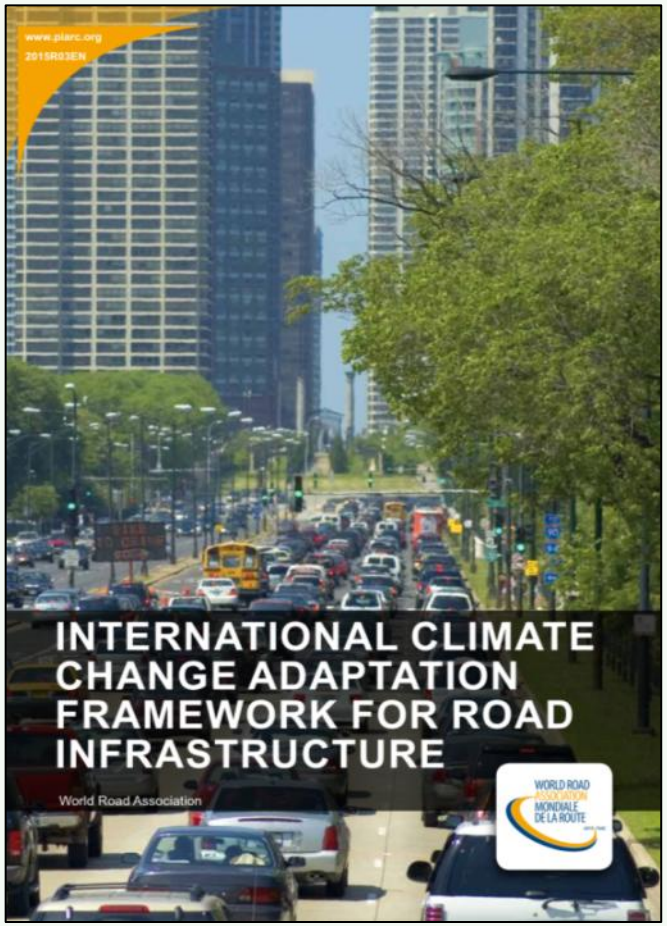
*ISO 31000

Risk Management



PIARC TC C3.3 - Risk Analysis for Road Tunnels, 2008

PIARC - Climate Change Adaptation Framework



www.piarc.org

The framework guides road authorities through the process of increasing the resilience of their networks and assets through the following stages:

- Stage 1 - Identifying scope, variables, risks and data
- Stage 2 - Assessing and prioritising risks
- Stage 3 - Developing and selecting adaptation responses and strategies
- Stage 4 - Integrating findings into decision making processes

PIARC - Climate Change Adaptation Framework

TABLE 6 - RISK SCORE MATRIX					
Likelihood	Severity				
	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

TABLE 7 - RISK CATEGORIES AND RESPONSES	
Extreme ≥ 20	• Extreme risks demand urgent attention at the most senior level and cannot be simply accepted as a part of routine operations without executive sanction. • These risks are not acceptable without treatment.
High ≥ 12	• High risks are the most severe that can be accepted as a part of routine operations without executive sanction but they are to be the responsibility of the most senior operational management and reported upon at the executive level. • These risks are not acceptable without treatment.
Medium ≥ 5	• Medium risks can be expected to form part of routine operations but they will be explicitly assigned to relevant managers for action, maintained under review and reported upon at the senior management level. • These risks are possibly acceptable without treatment.
Low < 5	• Low risks will be maintained under review but it is expected that existing controls will be sufficient and no further action will be required to treat them unless they become more severe. • These risks are can be acceptable without treatment.

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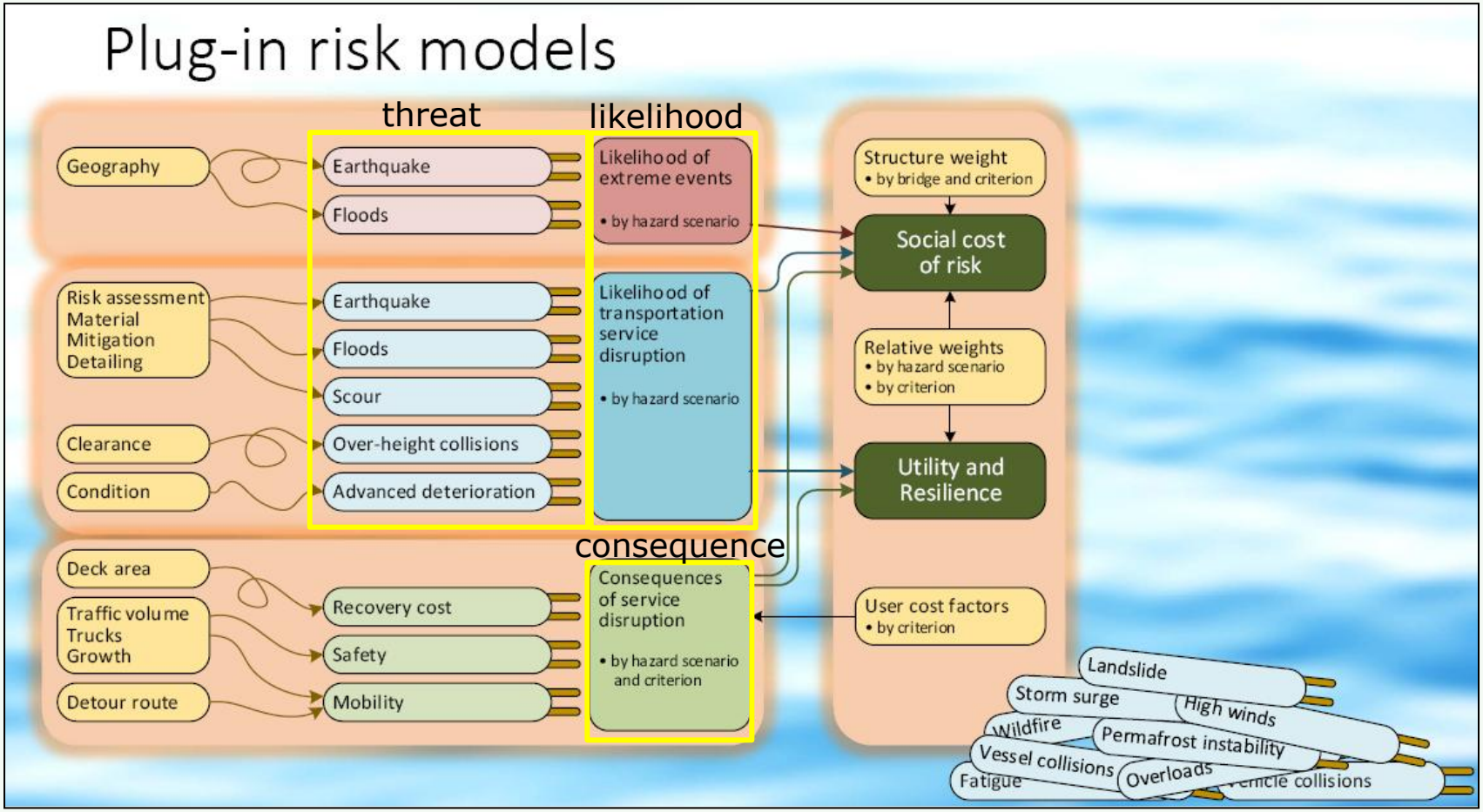
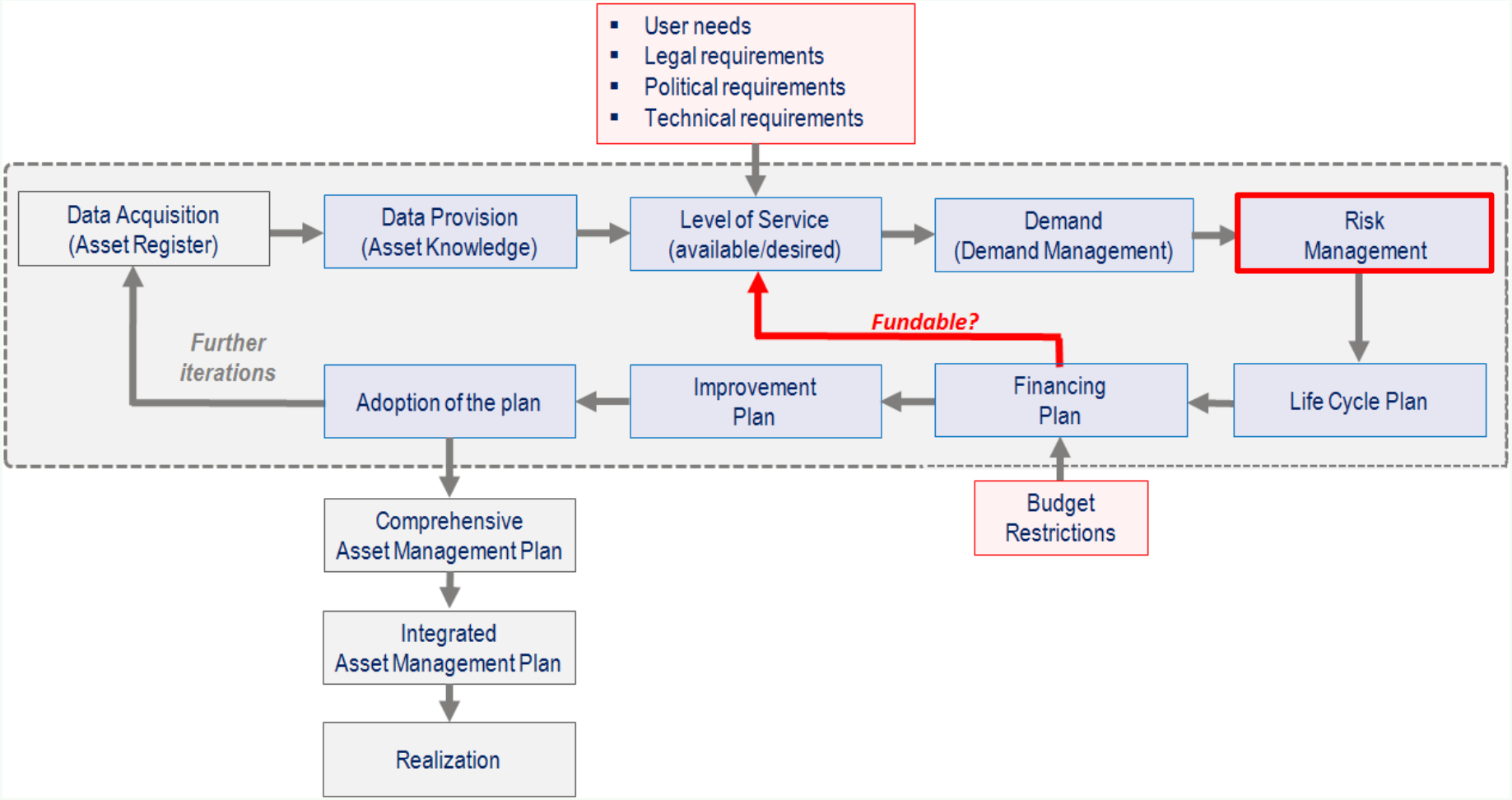
Risk-based Bridge Management (U.S.)



Paul D. Thompson: Risk assessment for bridge management systems, Int. Bridge and Structure Management Conference, April 25-27, Meza, Arizona, USA

Implementation of Risk and Resilience within Asset Management



Heller, S.: Grundlagen des Asset Managements, Straße und Autobahn, in publication

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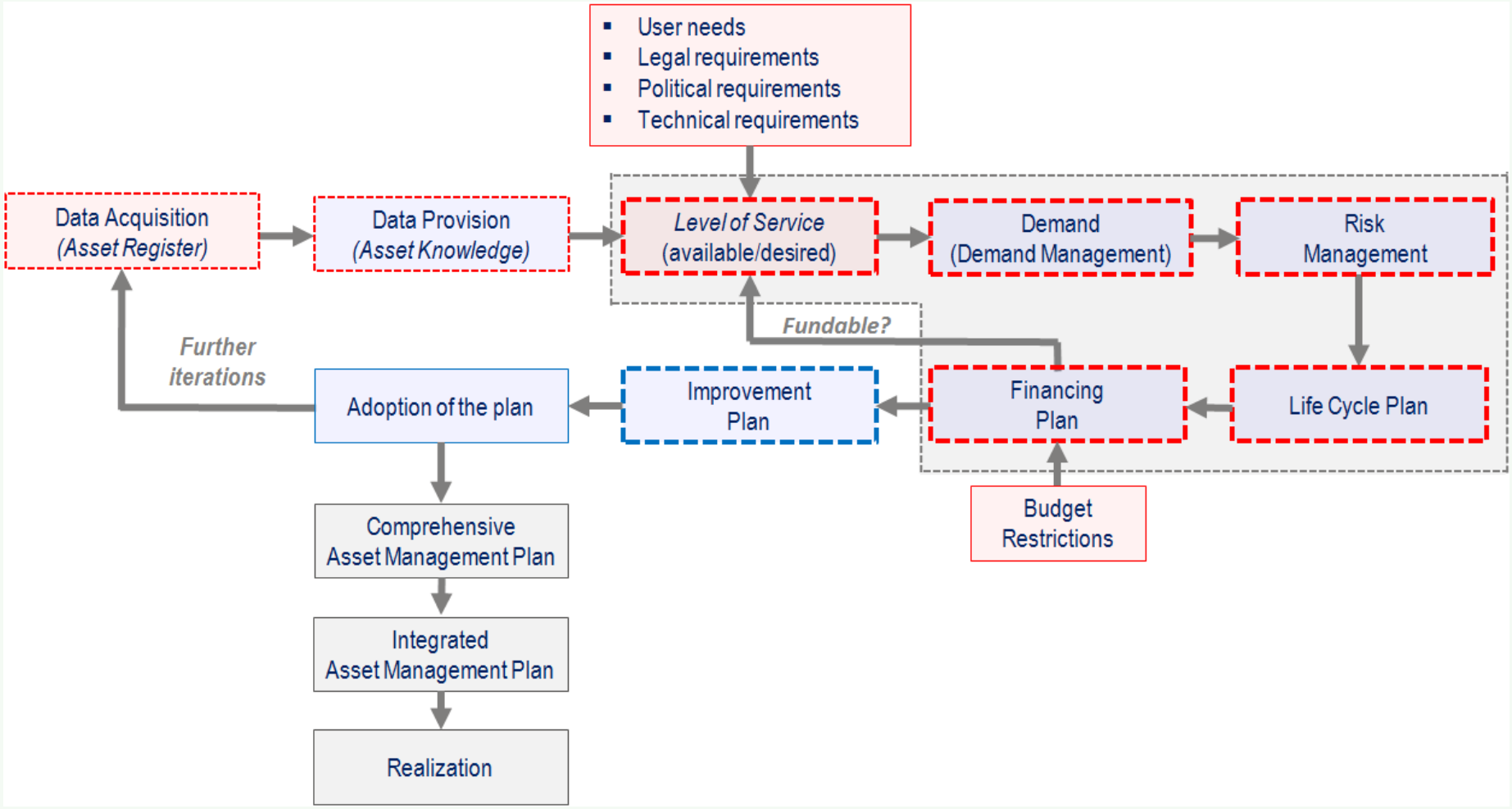

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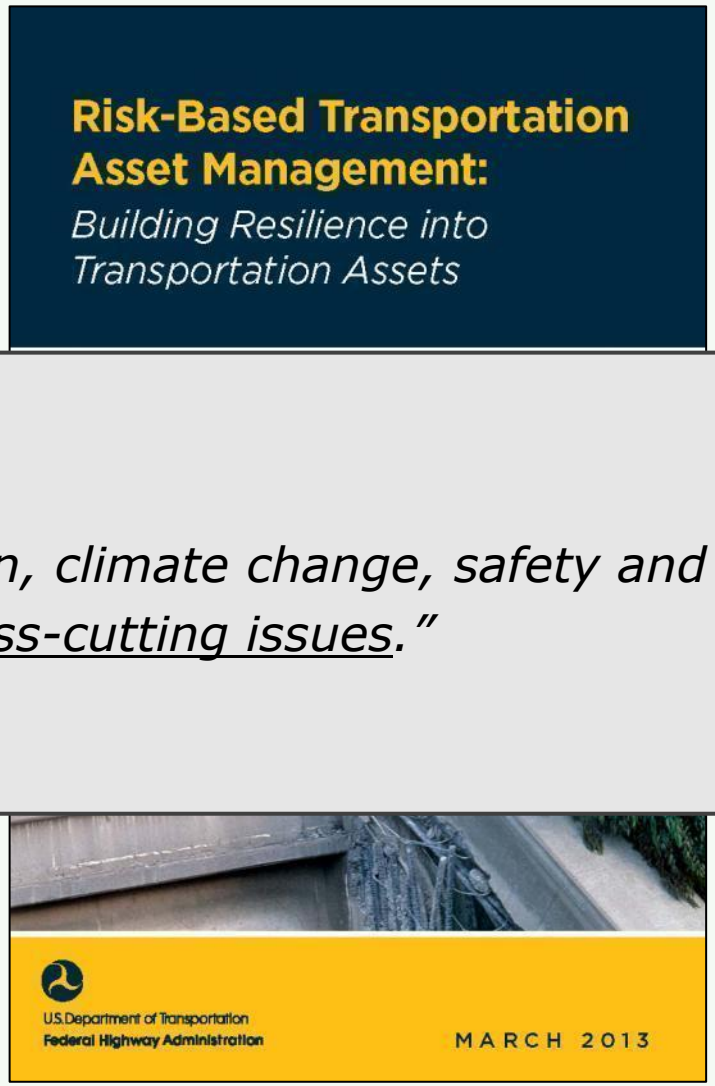
Risk-based Asset Management (U.S.)



<u>PIARC Strategic Plan 2020-2023:</u>

"Incorporate issues, such as innovation, climate change, safety and resilience of road infrastructure as <u>cross-cutting issues</u>."

http://www.fhwa.dot.gov/asset/pubs.cfm

Summary and Conclusions

- Future challenges for owners and operators require more risk- and resilience based approaches.
- Risk- and Resilience Management contribute to quality, reliable, sustainable and resilient transport infrastructure.
- Risk and/or resilience-based approaches shall be implemented into lifecycle management systems.
- Risk and Resilience must be considered holistically as cross-cutting issues.

Thank you very much for your kind attention!