



USDOT MARAD - Office of Ports & Waterways

Risk-Based Lifecycle Management of In-Water Structures

American Association of Port Authorities Facilities Engineering Seminar

April 2019

USDOT Strategic Plan FY18 – FY22

Infrastructure - Strategic Objective 2: Lifecycle and Preventative Maintenance

Keep the Nation's transportation infrastructure secure and in a state of good repair by maintaining and upgrading existing systems in rural and urban communities.

DOT has increasingly emphasized a risk-based strategy of infrastructure asset management... DOT will increase its effectiveness in ensuring that infrastructure is resilient enough to withstand extreme weather and security events which could otherwise disrupt the transportation network...

Strategy:

Rebuild: Restore transportation infrastructure and assets to a state of good repair through asset management planning and innovative maintenance strategies.

Risk Management: Provide research, technical assistance, and targeted funding to ensure that transportation infrastructure is planned, constructed, and maintained using the best operational and risk management practices.

Marine Transportation Asset Management Planning (MTAMP) State of Practice

2B TONS ANNUALLY – 17000+ Domestic Commercial Docks

Summary of Findings:

- Planning may not target a *state of good repair* because the priority for limited capital is given to the business objectives of the enterprise.
- “We have a reactionary planning style” that characterizes asset management planning practice. Generally, resilience planning is not undertaken.

Nothing in life is so exhilarating as to be shot
at without result.



What does risk-based asset management look like?

Risk Rating and Scoring

Figure 7.1 Risk Rating Scale

Likelihood		Consequence (Level/Descriptor)				
		1	2	3	4	5
Level	Descriptor	Negligible	Minor	Major	Critical	Catastrophic
1	Low	1	2	3	4	5
2	Medium Low	2	4	6	8	10
3	Medium	3	6	9	12	15
4	Medium High	4	8	12	16	20
5	High*	5	10	15	20	25

Source: CDOT

$$\text{Risk Score} = Ps \times Os \times [(Ss + Ms + Ds + Fs)/4]$$

Where:

Ps = Likelihood Value;

Os = Other Considerations Value = $1 + (0.05 \times [\text{Number of Other Considerations Checked}])$;

Ss = Safety Value;

Ms = Mobility Value;

Ds = Damage (Asset) Value; and

Fs = Financial Value.

The higher the Risk Score, the more important it is for CDOT to develop a risk mitigation strategy to deal with the risk (or formalize the existing strategy).

What does risk-based asset management look like?

Risk Register (Rank 4/5)

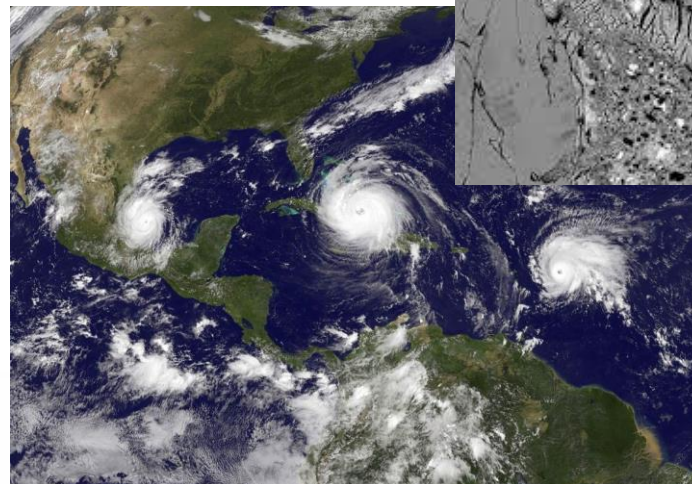
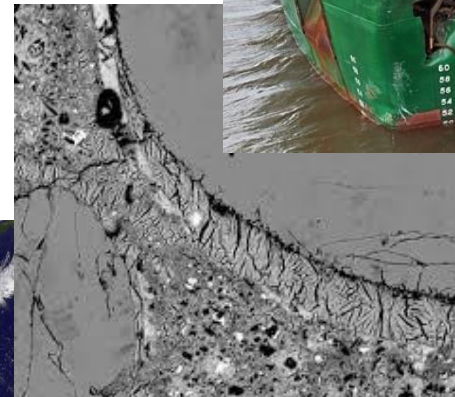
Table 7.1 Initial Risk Register

				Consequence Score					Other Considerations					
Risk ID	Voted Priority	Event/Occurrence	Likelihood	Safety	Mobility	Asset Damage	Other Financial Impact	Funding	Insurance	Regulatory	Political	Reputation	Risk Score	
Agency Risks														
1a	11	Not having enough funds to meet targets due to inflation in construction costs	5	3	4	4	2	√		√	√		19.5	
1b	4	Ability to meet MAP-21 targets for NHS segments under local control	5	3	2	3	2	√		√	√	√	15.0	
1c	6	Revenue variations/uncertainties – inability to predict/project total funds available to CDOT	5	1	1	2	3	√	√		√	√	10.5	
1d	9	Politics in general, combined with leadership changes in the Department	4	1	2	1	2	√	√	√	√	√	7.5	
1e	9	Public perception of CDOT (Negative) – resulting in an inability to garner new funds	2	2	4	3	2	√			√	√	6.3	
1f	11	Not communicating to and getting buy-in at the appropriate levels in CDOT how the RB AMP works	3	1	1	1	1	√			√	√	3.5	
Program Risks														
2a	8	Unfunded maintenance requirements – e.g., regulatory	5	3	3	2	3	√		√		√	15.8	
2b	9	Will I-70 viaduct pull funding from other projects	4	2	3	3	2	√	√		√	√	12.0	
2d	9	Retirement of key people, loss or turn-over of staff, resulting in loss of critical knowledge	4	3	2	2	3				√	√	11.0	
2e	9	Data management (that impacts ability of CDOT to document accomplishments)	5	1	2	2	3			√		√	11.0	
2f	9	Project delivery risks due to organizational or systemic issues, e.g., communication, etc.	3	2	1	1	4	√	√		√	√	7.2	

What does risk-based asset management look like?

Potential Risk Events/Occurrences for In-Water Structures Condition

Extreme weather/earthquake
Overloading
Corrosion/Stray Currents
ASR/DEF
Age
Insufficient maintenance
Aggressive (corrosive) soils
Failing condition of adjacent structures
Inadequate funding for min lifecycle cost
Scour
Overdredging
Vessel allision
Regulation
Staff turnover
Data management



What does risk-based asset management look like?
Potential Consequence Areas for In-Water Structures Condition

Human safety

Operations/Logistics

Freight movement

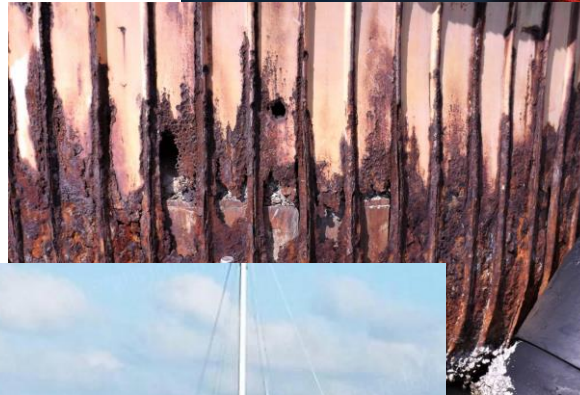
Tenant Impact

Assets Damage

Environmental

Regulatory

Reputation



What does risk-based asset management look like?
Investment Strategies & Lifecycle Optimization

INVESTMENT STRATEGIES

1. Conduct preventative maintenance based on observed sources of deterioration at unit cost
2. Prioritize treatments to prolong service life, reduce risk of failure
3. Consider the cost-effectiveness of maintenance for aged structures
4. Progress in all areas but not all performance targets will be met and condition may decline
5. Most revenues go to maintenance
6. Optimize resources to achieve multiple purposes

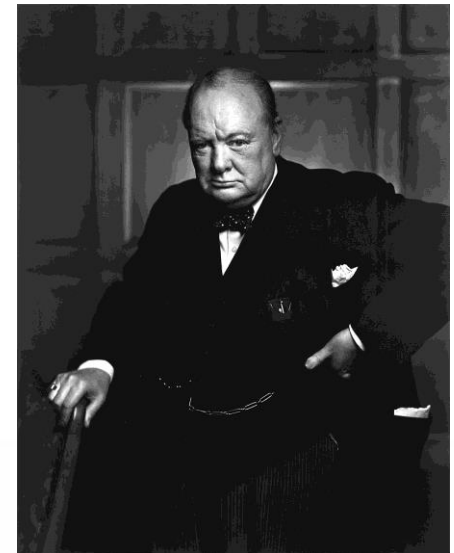
INVESTMENT OBJECTIVES AND OUTCOMES

1. Defer replacement of aged structures
2. Reduce risk
3. Reduce commerce impact caused by load restrictions
4. Maintain existing system with limited improvements

LIFECYCLE OPTIMIZATION STRATEGIES

1. Frequent and regular inspection
2. Preventative maintenance
3. Rehabilitate appropriately in the lifecycle
4. Identify improvements that decrease lifecycle costs

**Gentlemen, we have run out of
money; now we have to think.**



What does risk-based asset management look like?
State of the Inventory (Rank 5/5)

Exhibit 3-9: Distribution of Remaining Structural Life for All WSDOT Owned Bridges.^{1,2}

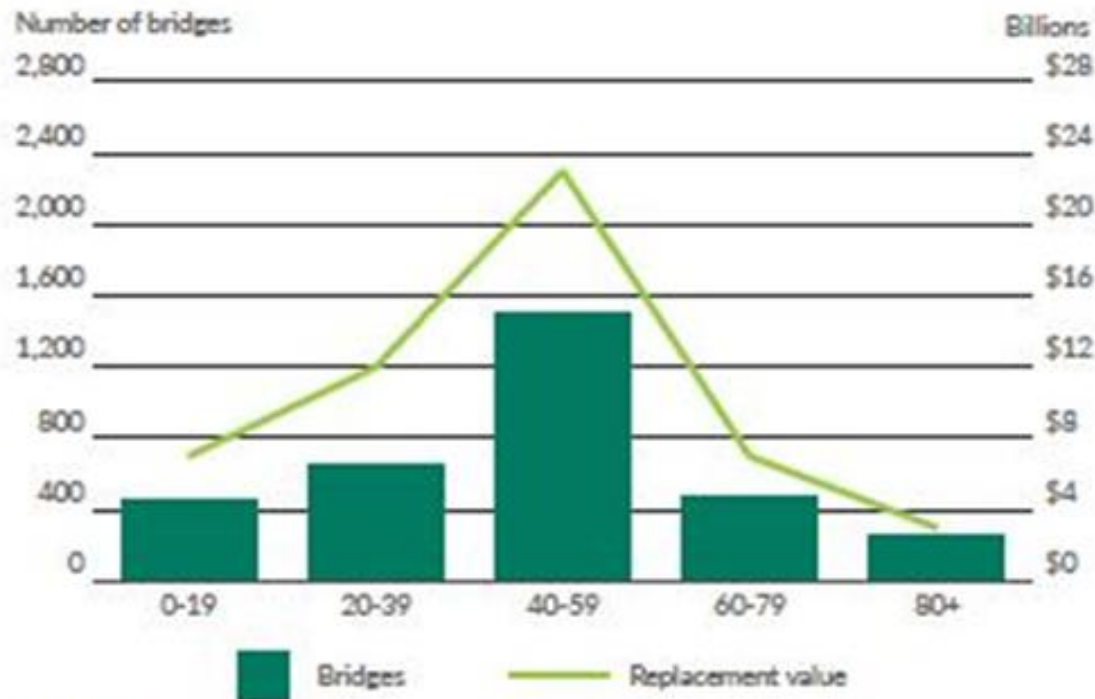


Exhibit Notes:

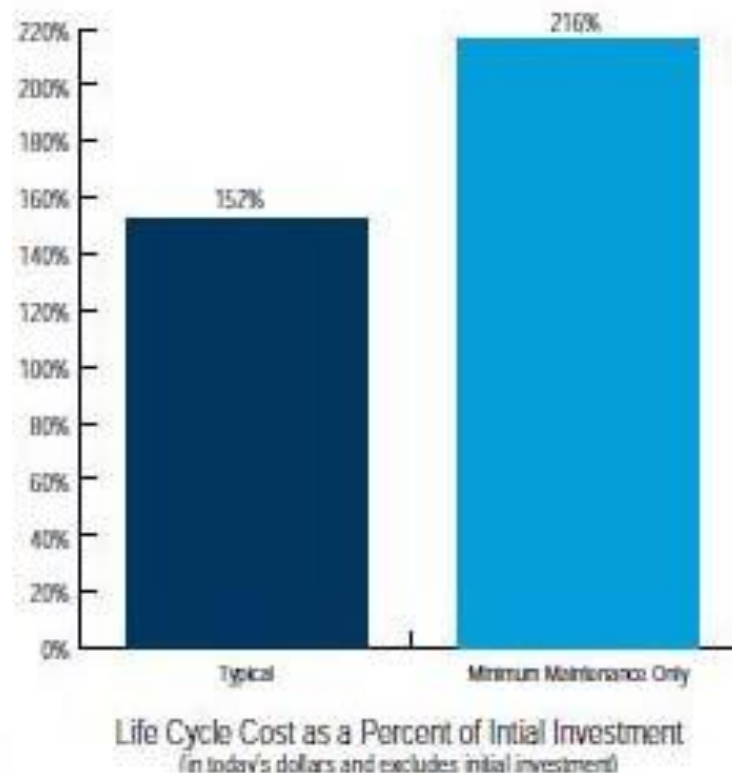
- ¹ Source is from WSDOT Bridge and Structures Office; prepared for June, 2017 [Gray Notebook 66th Edition](#).
- ² Replacement value describes the cost to replace all bridges in each age range.



Run-to-Failure Management of Waterfront Structures

What does risk-based asset management look like?
Lifecycle Management Strategies
Markov Chain Network Level

Minimum Maintenance Model → Run-to-Failure Management

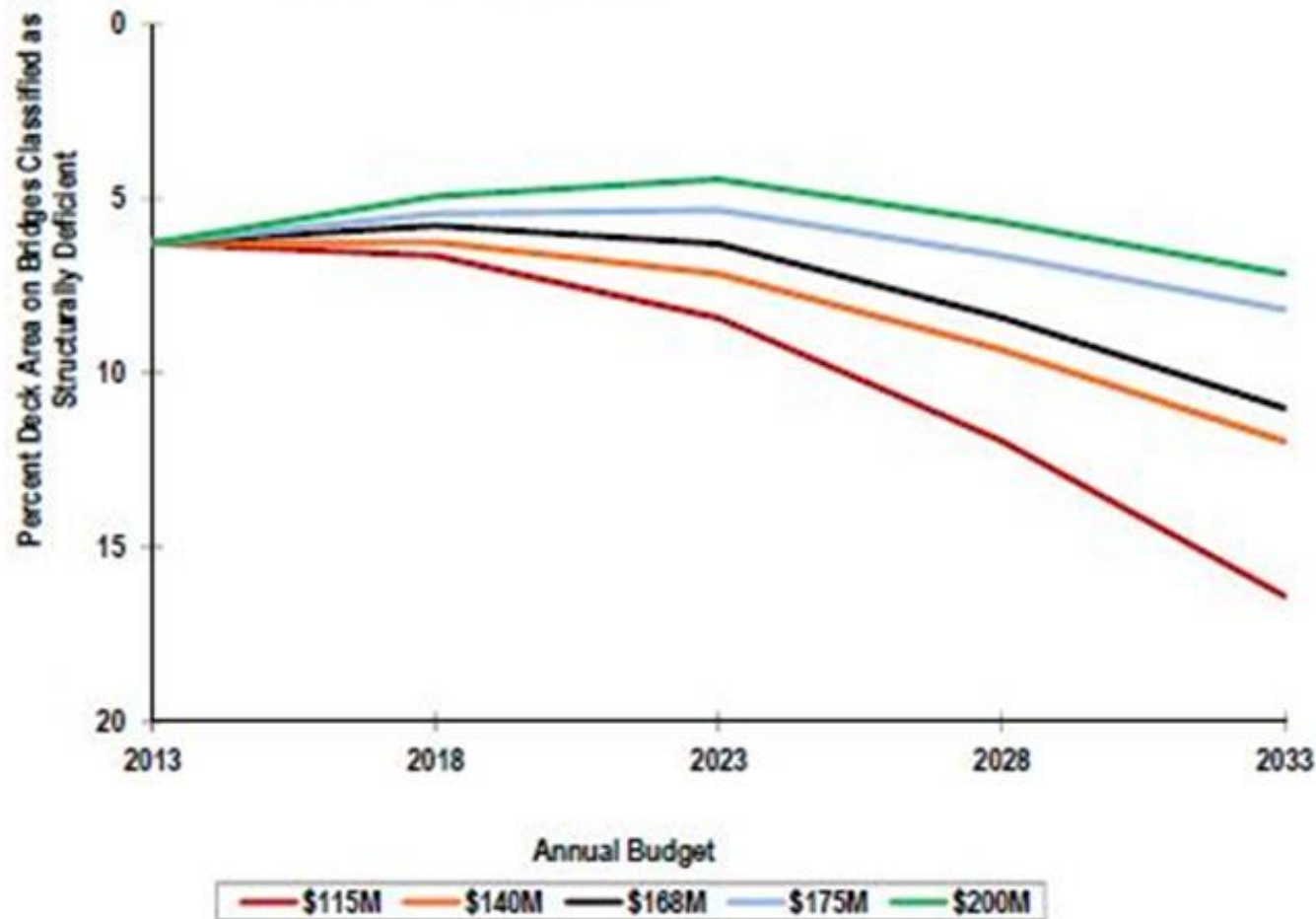


Management of Derelict Waterfront Structures



What does risk-based asset management look like?
Trade-Off Analyses (Rank 5/5)

Figure 4.2 Bridge Performance versus Funding



What does risk-based asset management look like?

Trade-Off Analyses – Why AM gets a bad rap?

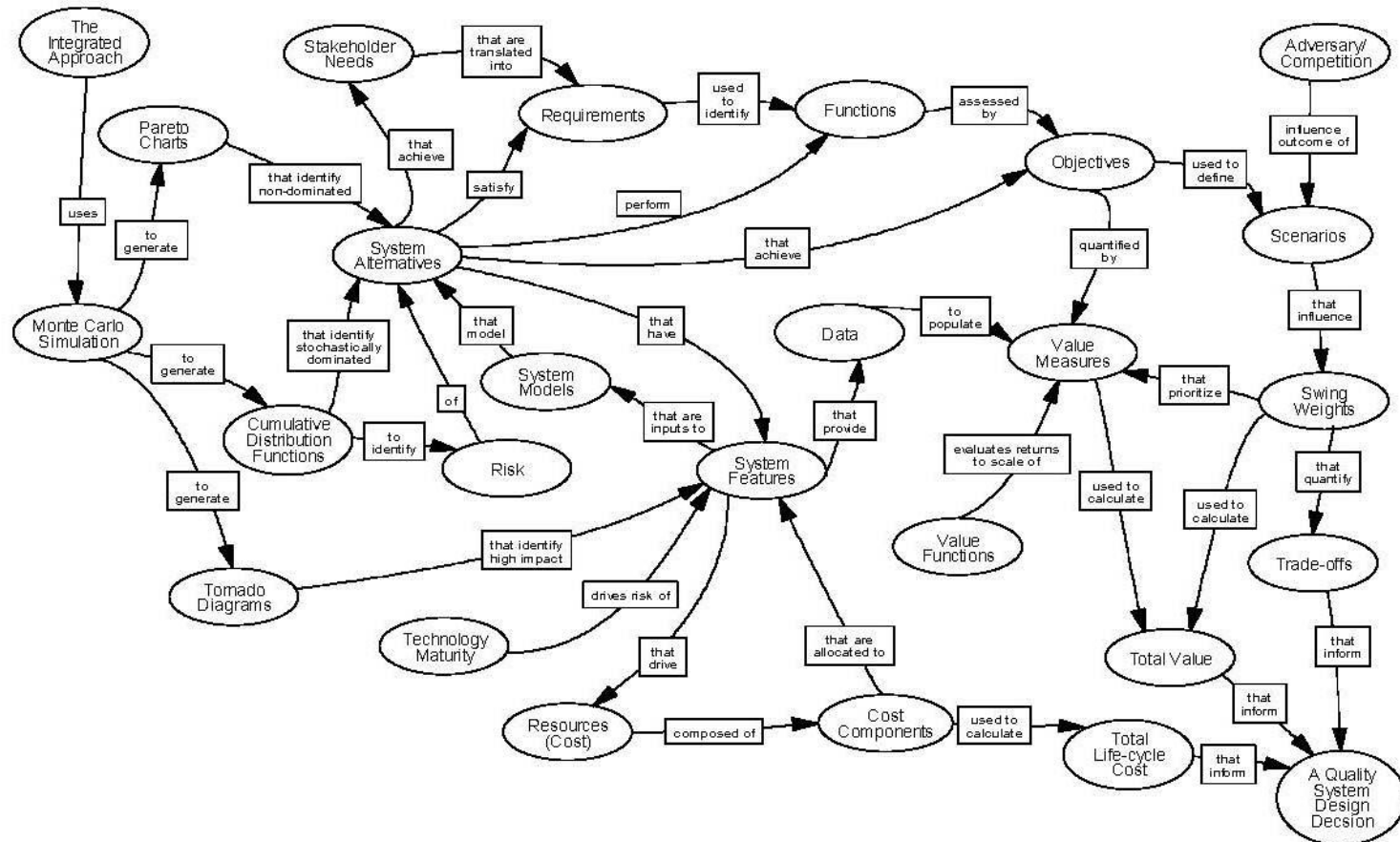
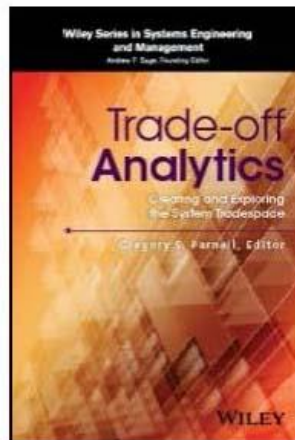


Figure 9.1. Concept diagram for the integrated trade-off analysis.

Source: Trade-off Analytics: Creating and Exploring the System Tradespace, 1st Edition

What does risk-based asset management look like?
Trade-Off Analytics Short Course – Maritime and Highway AM

Textbook



Parnell, Gregory S. Editor, Trade-off Analytics: Creating and Exploring the System Tradespace. John Wiley & Sons, 2017.

Course Topics

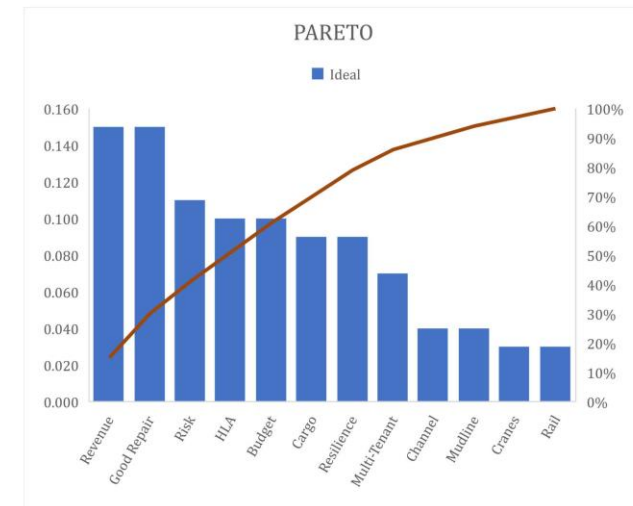
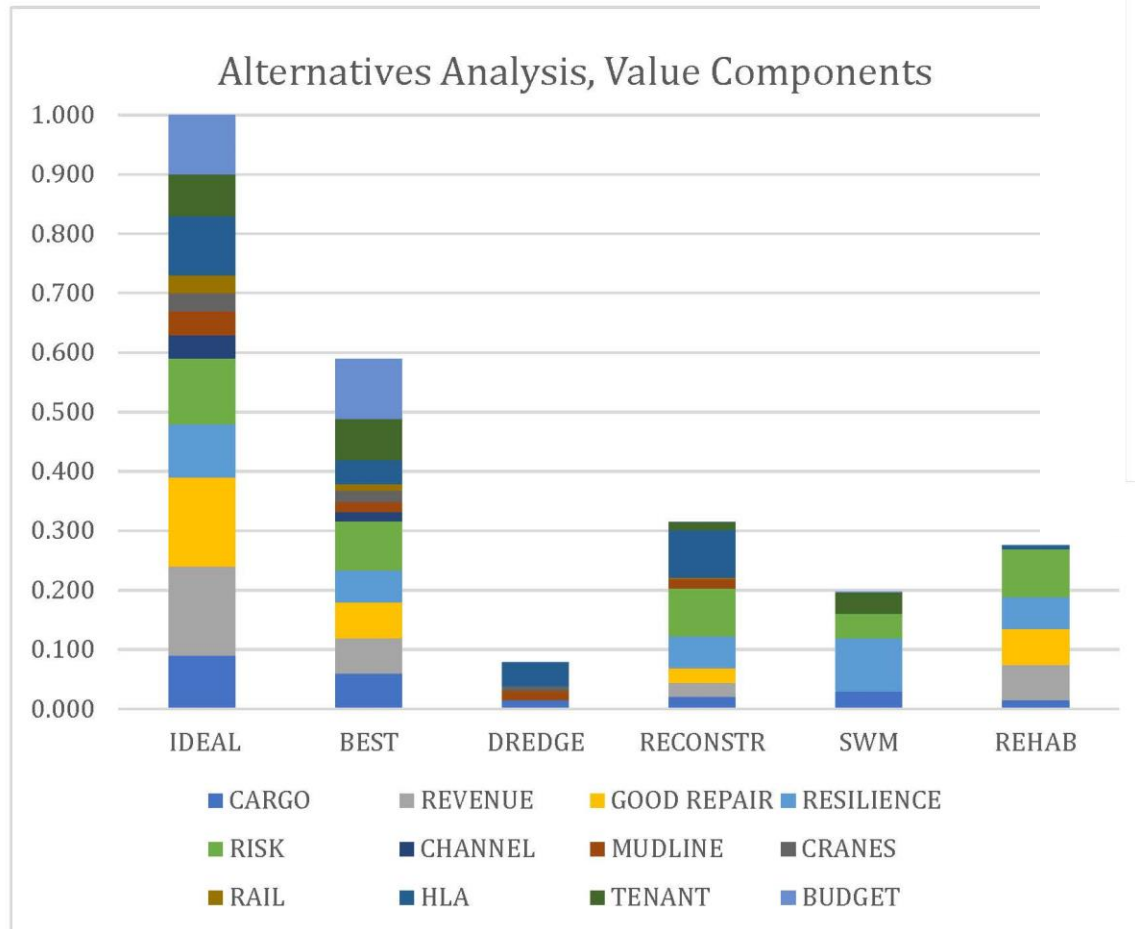
Introduction to trade-off analytics and decision analysis
Introduction to maritime and multimodal infrastructure life cycles
Conceptual framework of infrastructure trade-off analysis
Framing the infrastructure decision
Identifying infrastructure improvement opportunities
Overview of Benefit Cost Analysis
Identifying infrastructure benefits and measures
Developing infrastructure benefit models
Developing infrastructure cost models
Developing an integrated model for benefit and cost trade-off analytics
Developing and evaluating alternatives
Exploring and evaluating the decision space
Developing an asset portfolio decision model
Understanding sources of uncertainty and analyzing uncertainty
Communicating analysis results to decision-makers

Projects and Assessment

2 x Infrastructure related student projects
2 x Comprehensive exams

What does risk-based asset management look like?

Trade-Off Analytics – Alternatives Analysis



What does risk-based asset management look like?
Asset Funding Plan (Rank 2.5/5)

Table 8.1 10 Year Asset Management Planned Funding

10 Year Estimate (Millions)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Total CDOT Estimated Revenue	\$1,104.8	\$1,110.8	\$1,132.7	\$1,099.2	\$975.9	\$981.4	\$986.8	\$974.6	\$977.3	\$978.9
MLOS	\$251.3	\$254.4	\$262.0	\$269.9	\$277.9	\$286.3	\$294.9	\$303.8	\$312.9	\$322.3
Surface Treatment	\$235.2	\$235.9	\$240.0	\$240.0	\$240.0	\$240.0	\$240.0	\$240.0	\$240.0	\$240.0
Bridge	\$53.3	\$49.1	\$55.3	\$41.5	\$41.5	\$41.5	\$41.5	\$41.5	\$41.5	\$41.5
Culverts	\$9.6	\$8.2	\$9.5	\$7.1	\$7.1	\$7.1	\$7.1	\$7.1	\$7.1	\$7.1
Tunnels	\$12.4	\$5.2	\$12.2	\$9.1	\$9.1	\$9.1	\$9.1	\$9.1	\$9.1	\$9.1
Walls	–	\$2.4	\$3.0	\$2.3	\$2.3	\$2.3	\$2.3	\$2.3	\$2.3	\$2.3
Bridge Enterprise	\$114.9	\$115.0	\$132.3	\$134.6	\$136.9	\$139.3	\$141.8	\$144.5	\$147.2	\$149.9
Rockfall Mitigation	\$9.1	\$9.2	\$9.0	\$5.1	\$5.1	\$5.1	\$5.1	\$5.1	\$5.1	\$5.1
Fleet (Road Equipment)	\$20.9	\$18.4	\$18.7	\$14.0	\$14.0	\$14.0	\$14.0	\$14.0	\$14.0	\$14.0
Buildings (Property)	\$20.8	\$12.9	\$15.5	\$7.2	\$7.2	\$7.2	\$7.2	\$7.2	\$7.2	\$7.2
ITS Maintenance	\$27.6	\$21.4	\$27.3	\$14.8	\$14.8	\$14.8	\$14.8	\$14.8	\$14.8	\$14.8
Asset Management Total	\$755.1	\$732.1	\$784.8	\$745.6	\$755.9	\$766.7	\$777.8	\$789.4	\$801.2	\$813.3

Source: CDOT

Port Planning & Investment Toolkit Module

Risk-Based Asset Management Module for In-Water Structures

Who should I contact in my region to talk about the MARAD waterfront asset management tool?

Please contact your local Maritime Administration (MARAD) Gateway Office for more information, or e-mail the Ports & Waterways Planning at patricia.gaynor@dot.gov.



TRANSPORTATION SYSTEM BENEFITS

In the last 10 years, DOT has invested approximately \$1.1B in grant funds leveraging \$2.25B in port projects. In FY19, another \$300-400 M in grant funding will likely be awarded to leverage an additional \$1B in port construction. Publicly-available asset management tools are encouraged to protect this public investment.



ASSET MANAGEMENT BENEFITS

- ✓ Increased system reliability & decreased lifecycle cost.
- ✓ Increased asset service levels at decreased cost.
- ✓ Ability to facilitate trade-offs between maintenance & capital projects.
- ✓ Strategic lifecycle management of risk & revenue requirements for the entire asset base.
- ✓ Asset investment plans that explain why a portfolio of investments is the most appropriate course of action.
- ✓ Increased visibility of long-term spending requirements.
- ✓ Enhanced ability to communicate and defend decisions

Port Planning & Investment Toolkit

Waterfront Asset Management



OPTIMIZED DECISION-MAKING

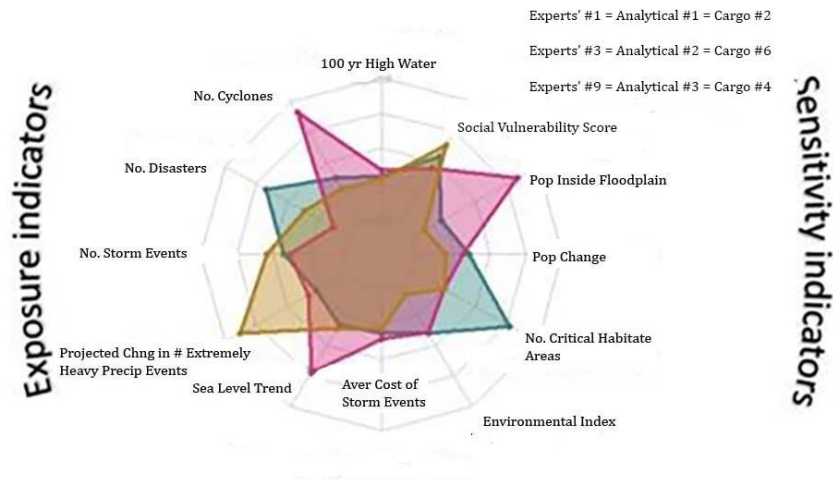


Optimizing capital budgets and leveraging federal grant & loan programs for the resources you need to grow your port.

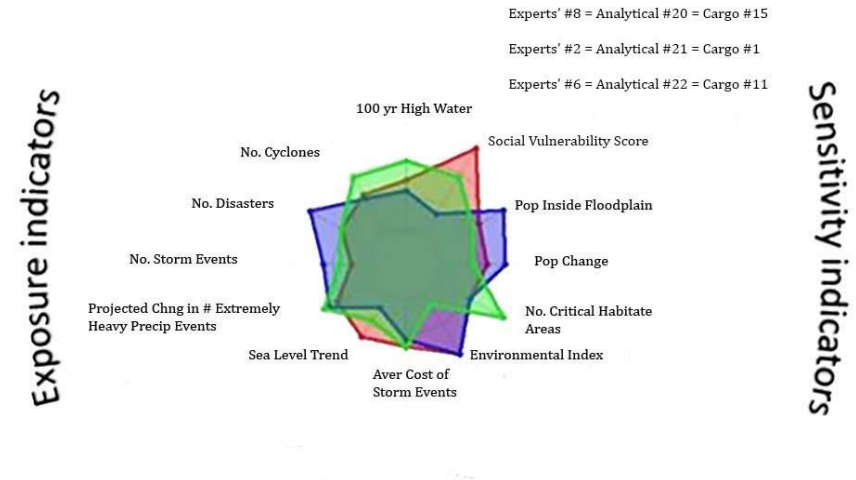
Resilience Research and In-Water Structures Asset Management

Port asset managers' expectations about the vulnerability of their port may not align with objective indicators of coastal port vulnerability. Port adaptability is expected to significantly influence vulnerability. For the most vulnerable ports, resilience can be a critical component of in-water structures asset management planning.

Most Vulnerable Ports in CENAD



Least Vulnerable Ports in CENAD



In-Water Structures Risk-Based Lifecycle Decisions

Reconstruct
Rehabilitate
Routine Maintenance
Decommission
Retrieve (from river bottom)

How will you decide?



Patricia J. Gaynor, PE

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