



BrM Optimization 101: It's More Than Pushing "Optimize"

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ProMiles

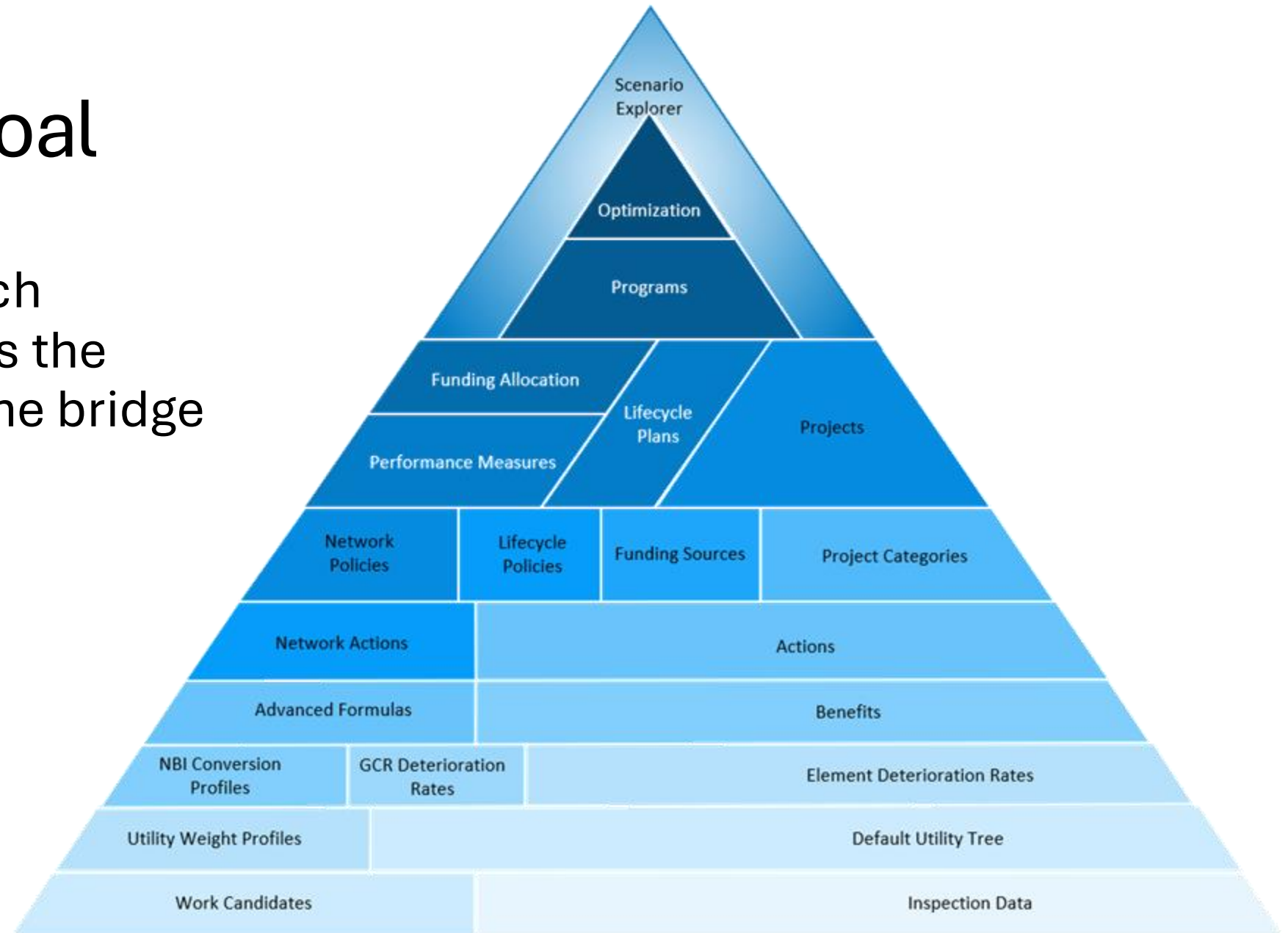
A roadmap for implementing network optimization, lifecycle cost analysis, and performance-based investment decisions.

Optimization

- Optimization is only as good as the Model(s) behind it:
 - Bad Data → Bad Deterioration → Bad Benefits → Bad Projects → Bad Decisions
 - Trusted Data → Realistic Models → Meaningful Benefits → Feasible Projects → Better Decisions

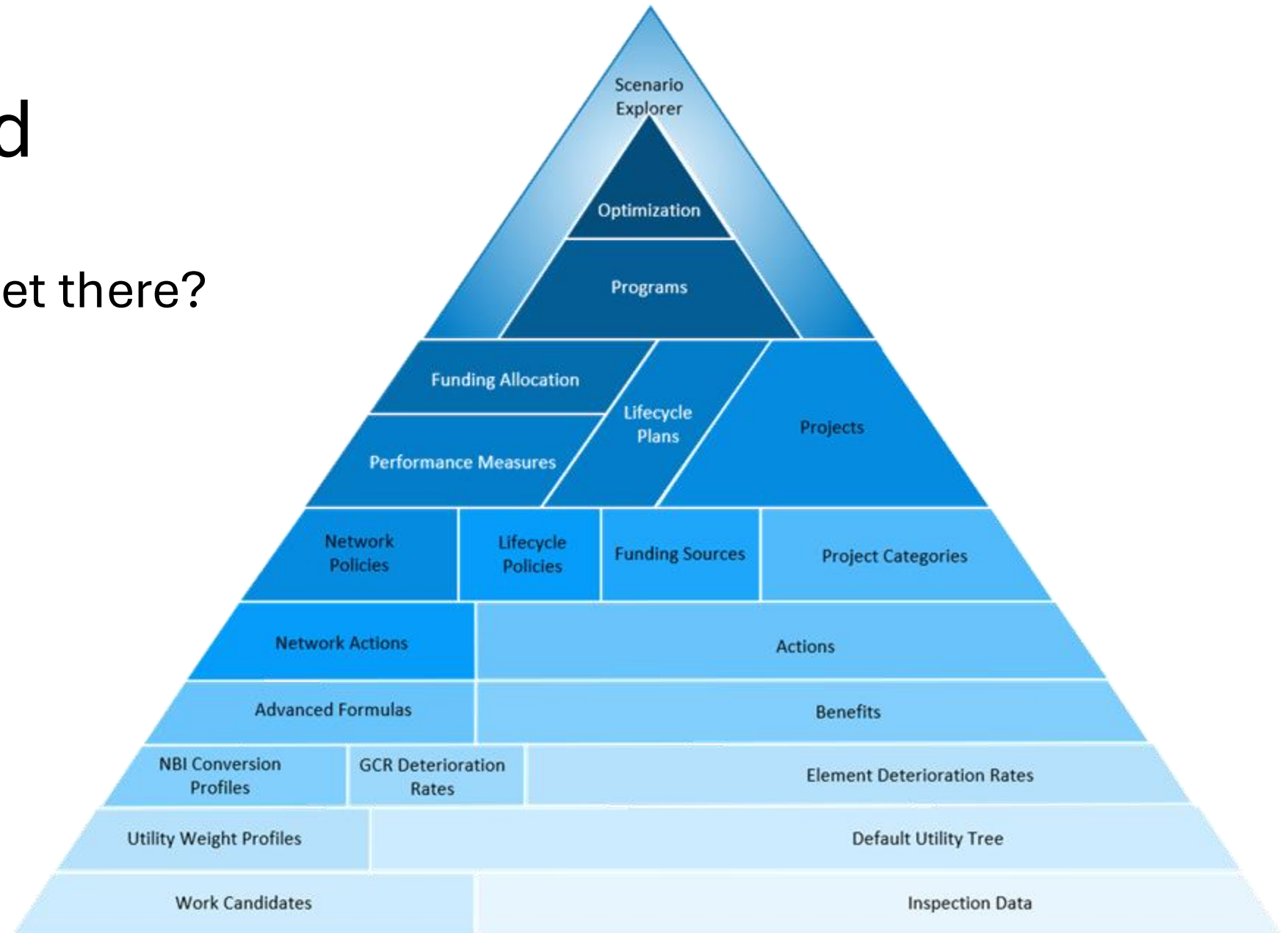
State the Goal

- Determine which project provides the most value to the bridge network.



The Pyramid

- So how do we get there?



Roadmap Overview

- 1 Foundation
- 2 Utility Tree
- 3 Deterioration
- 4 Benefits & Actions
- 5 Network & Lifecycle Policies
- 6 Funding Sources & Project Categories
- 7 Projects, Lifecycle Plans, Performance Measures, & Funding Allocation
- 8 Programs
- 9 Optimization
- 10 Scenario Explorer

Foundation

- Can I trust my data?
 - Inspection
 - Inventory
 - Elements
 - SNBI
 - Work Candidates



Foundation

- Verify inspection & inventory data completeness & accuracy
- Validate element quantities
- Review SNBI consistency
- Review work candidates

Foundation

- Dashboards & Reports can greatly help
- Deliverables
 - Clean database
 - QC/QA Completed
 - A reliable and trusted bridge inventory

Utility Tree



- What am I trying to optimize?
- It might be “minimizing the number of poor bridges, along with eliminating NSTM and SC bridges at the lowest cost”
 - 4 goals in the statement
 - Minimize poor bridges (maximize condition)
 - Minimize risk due to NSTM
 - Minimize risk due to Scour
 - Minimize the long-term cost

Utility Tree

- State your goal
- Identify the key objectives
- Identify the criteria to assess each objective

Key Objectives



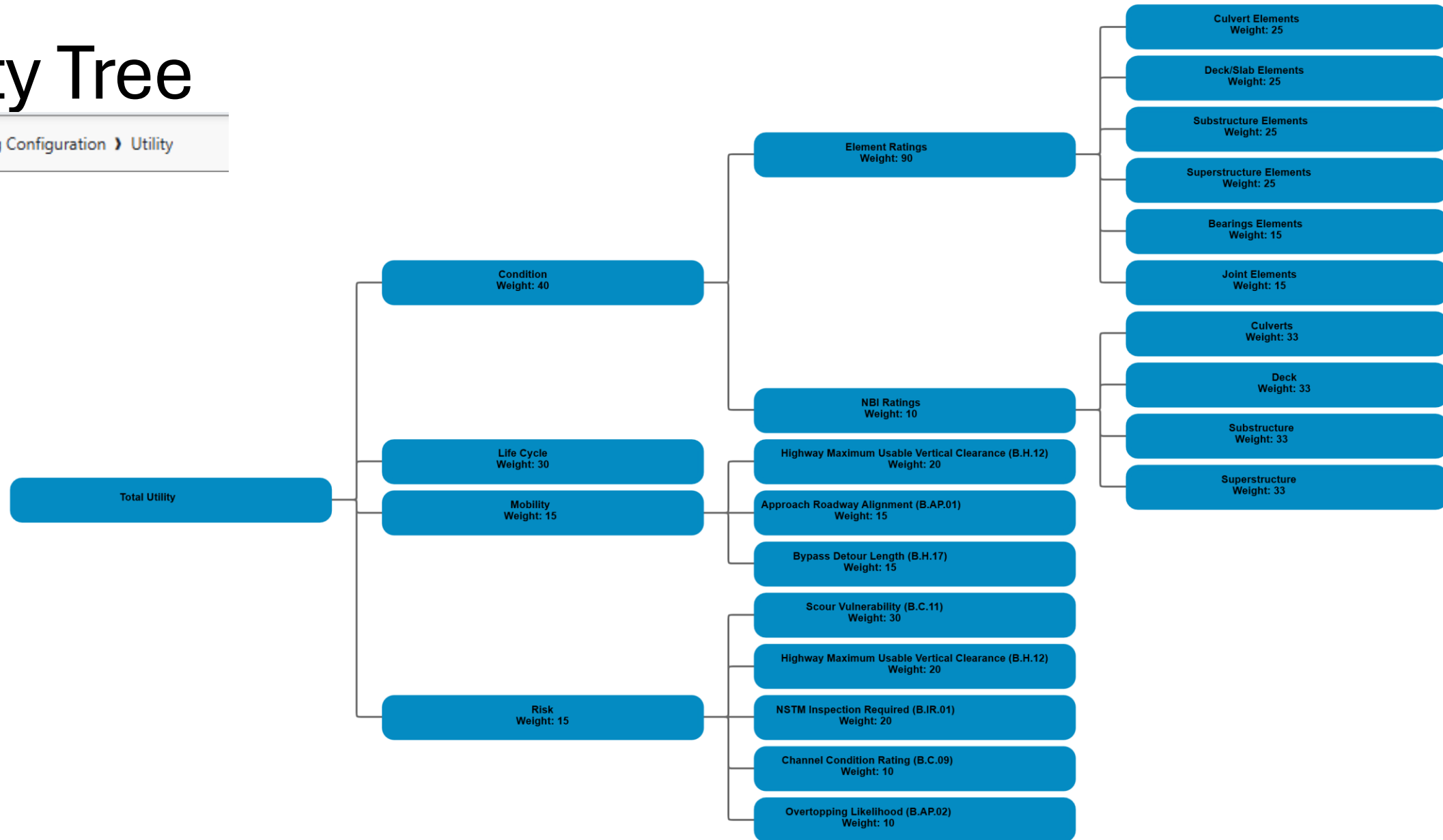
- Maximize Condition
- Maximize Mobility



- Minimize LCC
- Minimize Risk

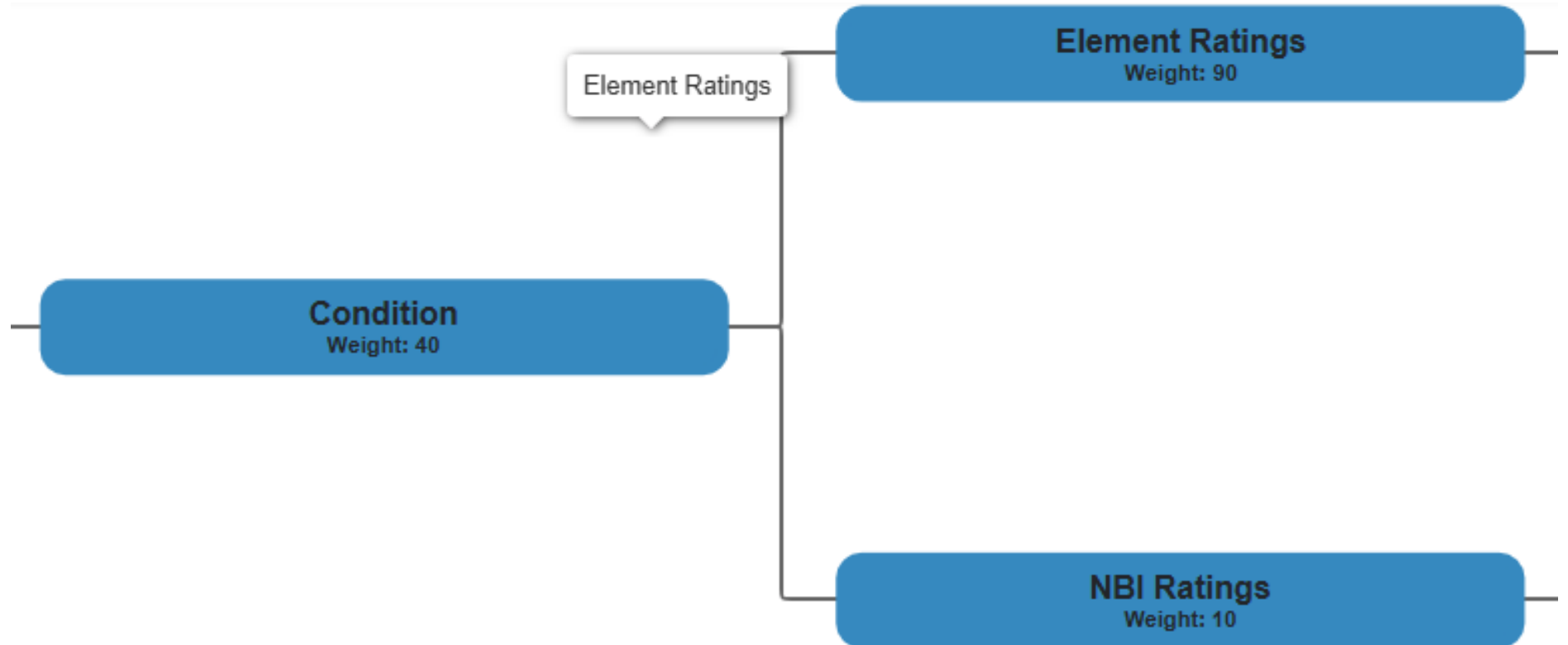
Utility Tree

Settings » Modeling Configuration » Utility



Utility Tree – Condition Objective

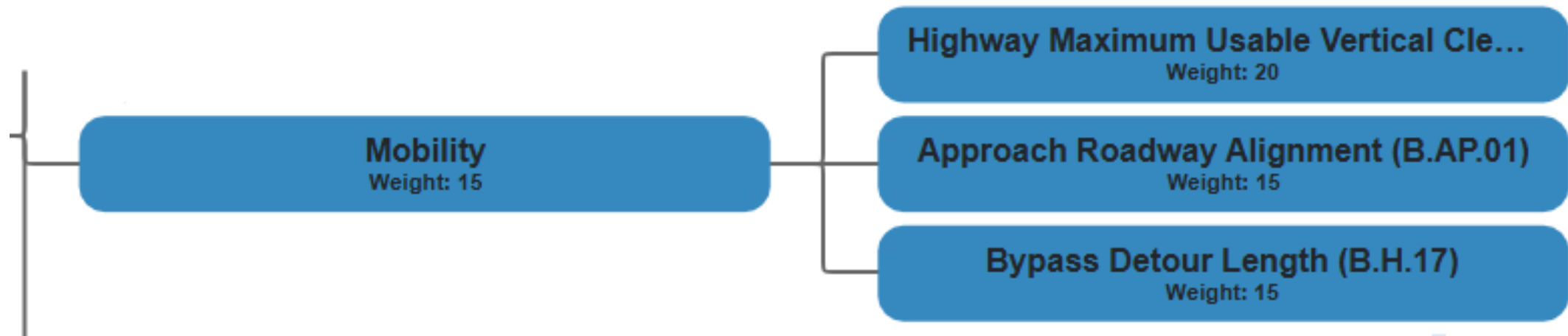
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Utility Tree – Mobility - A

Settings » Modeling Configuration » Utility

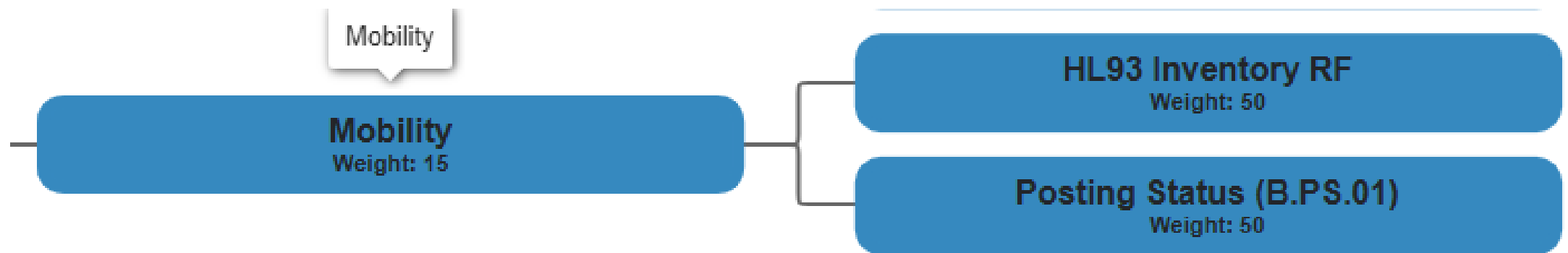
Roadway centric approach



Utility Tree – Mobility - B

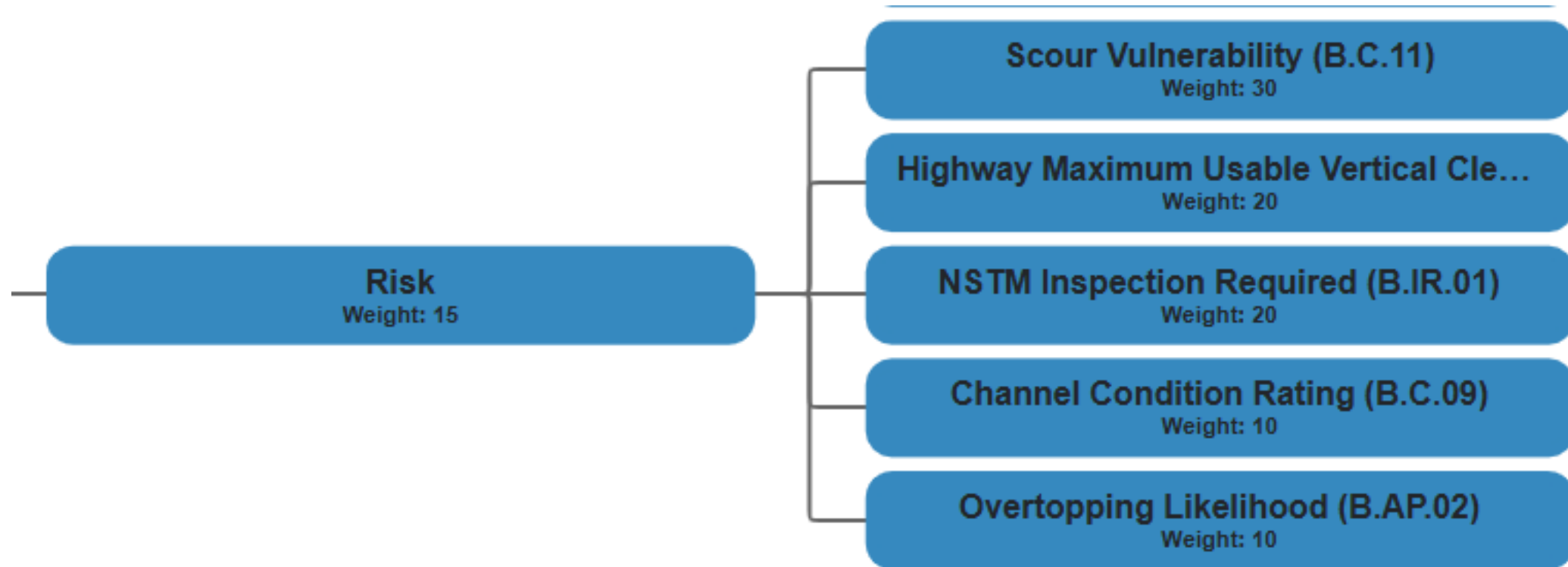
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Load Rating centric approach



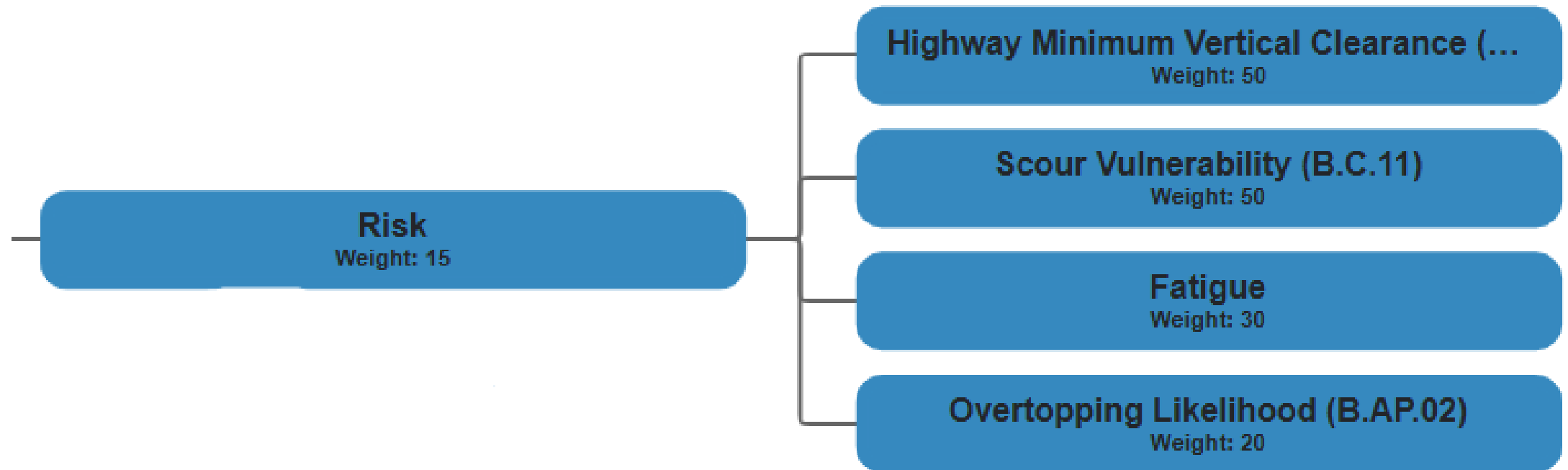
Utility Tree – Risk - A

Settings » Modeling Configuration » Utility



Utility Tree – Risk - B

Settings » Modeling Configuration » Utility



Utility Tree

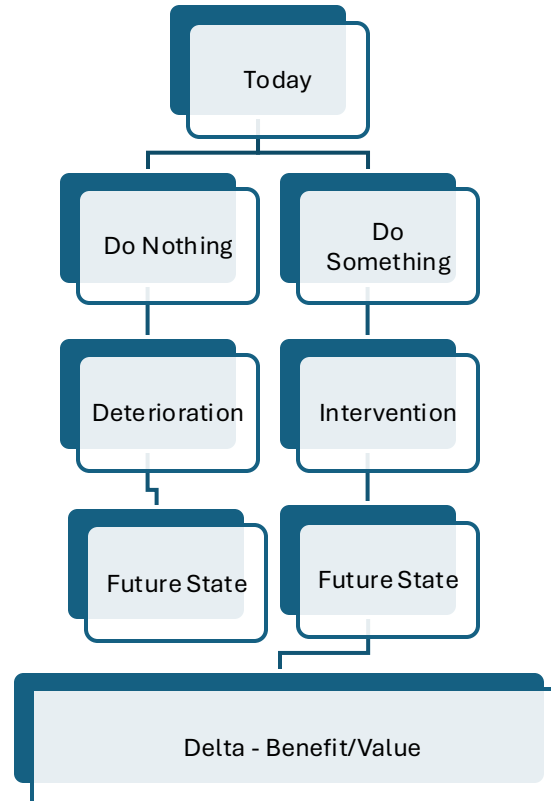
- NCHRP Report 590 (2007) provided the foundation for the multi-objective approach
 - NCHRP Report 590 - [nchrp_rpt_590.pdf](#)
- You can have different objectives – Condition, Life Cycle, Mobility and Risk
- Set different values and/or weights for the different objectives you have.
 - You can then do a Condition only
 - Or Risk Only
 - Or various combinations
- Pontis 5.2 (2009) was the first version to incorporate multi-objective optimization.

Deterioration

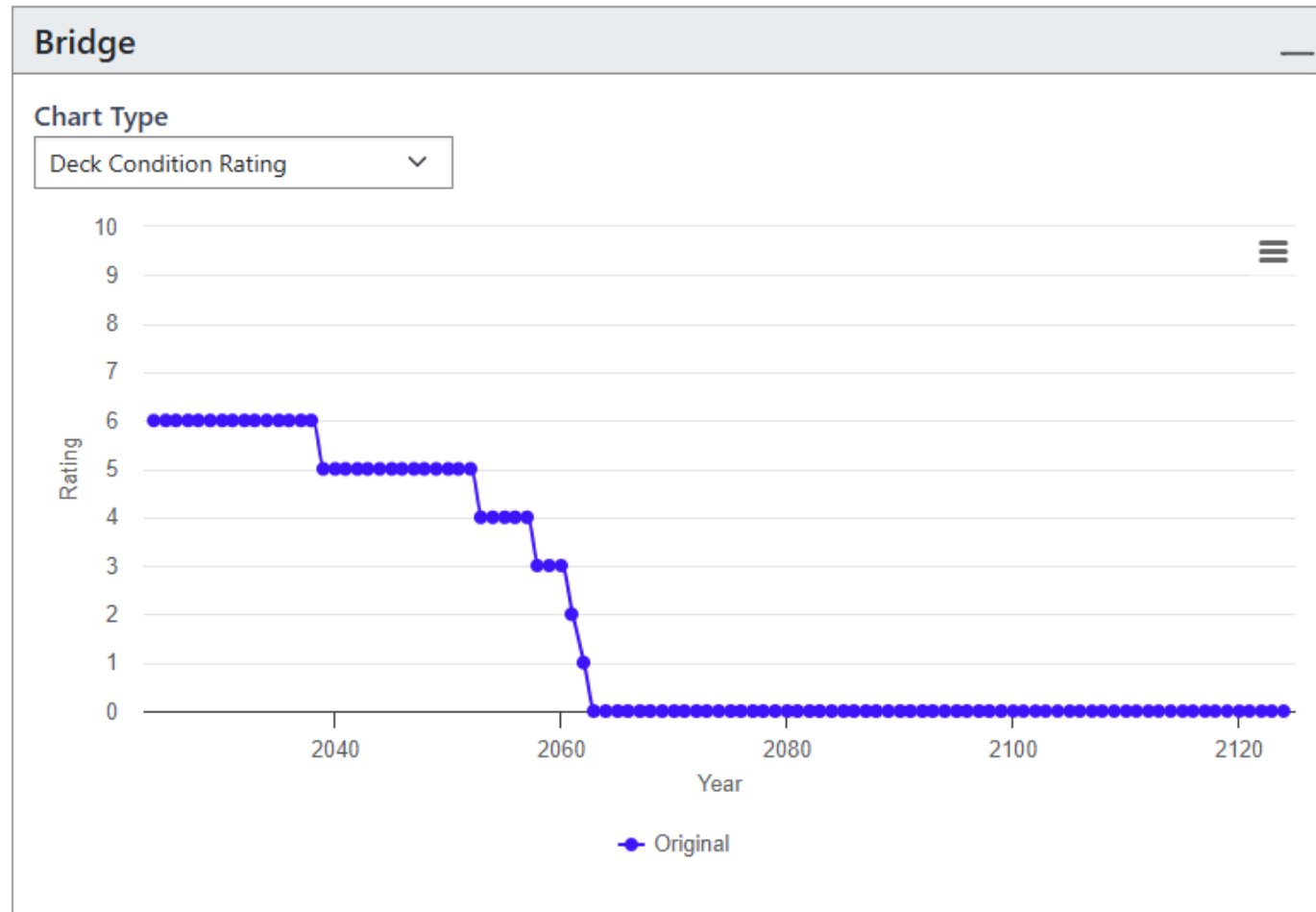
- What happens if I do nothing?
 - Both GCR and Elements



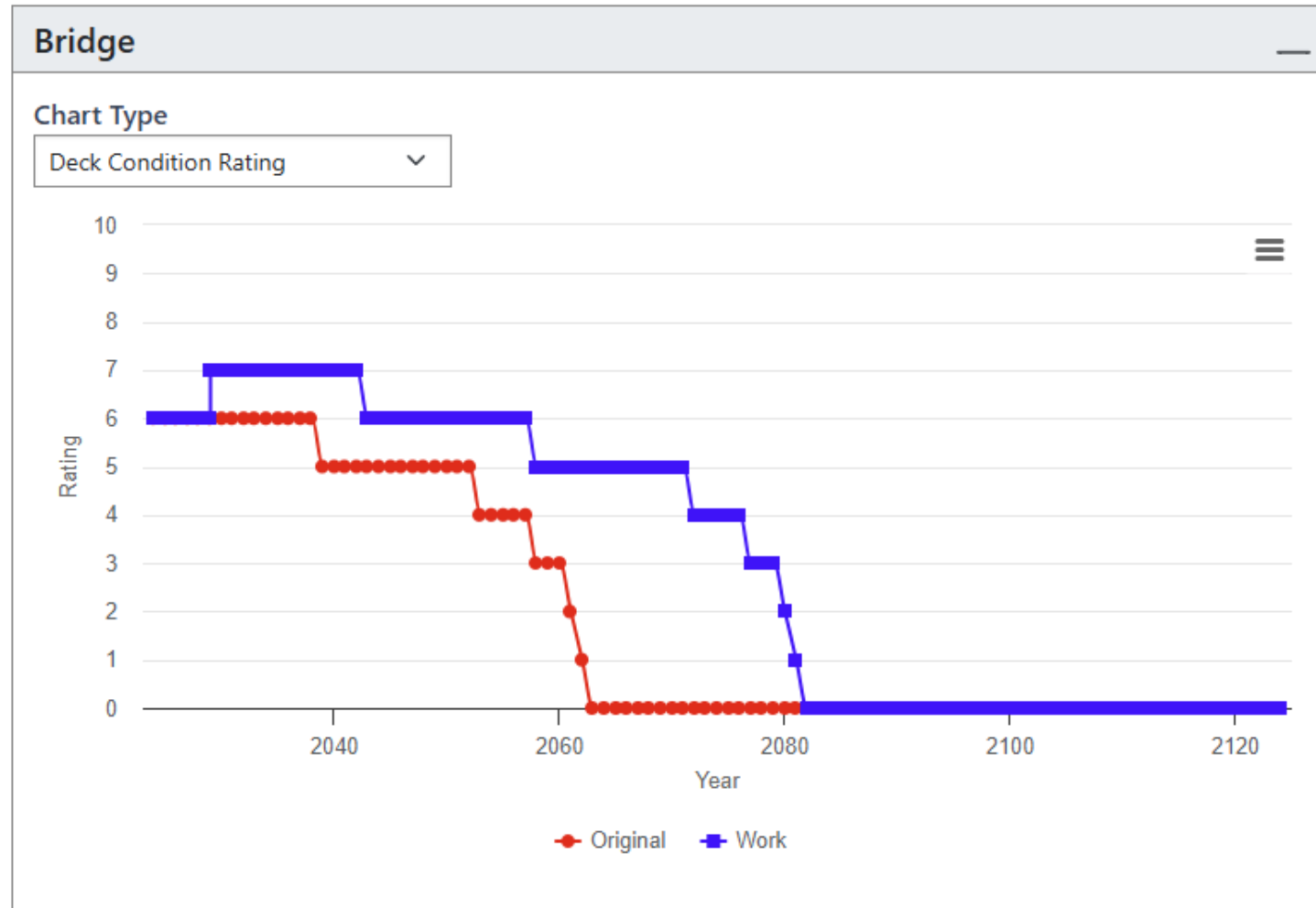
Optimization Requires Two Futures



Do nothing



Do Something



Deterioration

- Do Nothing
 - Condition – worse
 - Risk – same or worse
 - LCC – higher future cost
 - Reduced mobility
- Do Something
 - Condition – better
 - Risk – lower or same
 - LCC – lower future cost
 - Improved mobility
- Benefit is the modeled difference in value/outcome between the two futures

Deterioration

- Can you trust your Deterioration Models?
 - Default model might be close or might be way off
 - It's a good starting point
 - Minnesota vs Arizona – much different environments
 - Initially concentrate on the items you most commonly do work on

Deterioration - GCR

Settings » Modeling Configuration » GCR Deterioration Profiles

Culvert Deterioration Profile

Settings » Modeling Configuration » GCR Deterioration Profiles

☒ Active

 Standard

Transition Times

NBI Rating 9 *

2	Years
---	-------

NBI Rating 8 *

18	Years
----	-------

NBI Rating 7 *

20	Years
----	-------

NBI Rating 6 *

20	Years
----	-------

NBI Rating 5 *

12	Years
----	-------

NBI Rating 4 *

8	Years
---	-------

NBI Rating 3 *

5.8	Years
-----	-------

NBI Rating 2 *

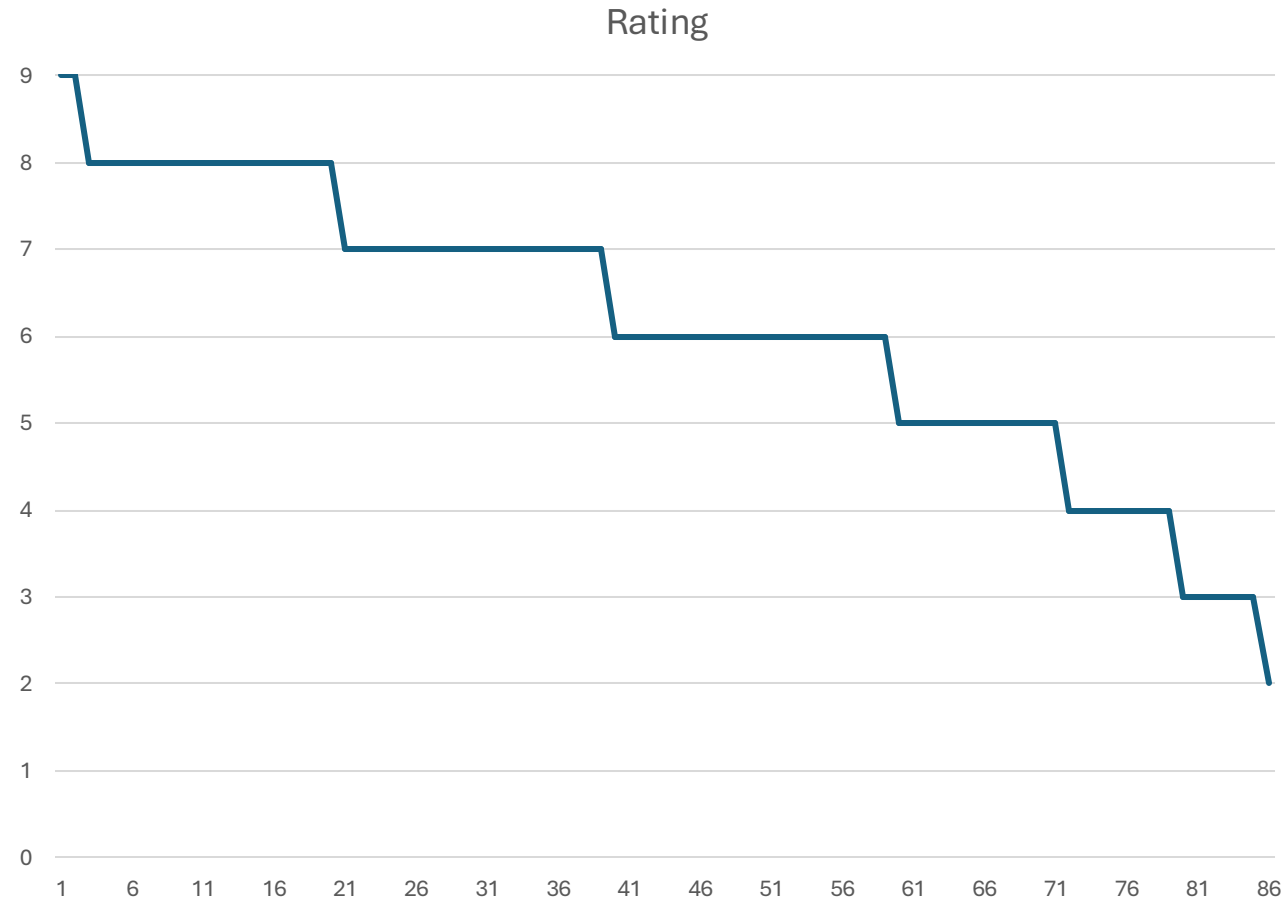
1	Years
---	-------

NBI Rating 1 *

0	Years
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Deterioration – GCR Curve

Settings » Modeling Configuration » GCR Deterioration Profiles



Deterioration - Element

Settings > Modeling Configuration > Element Deterioration Profiles

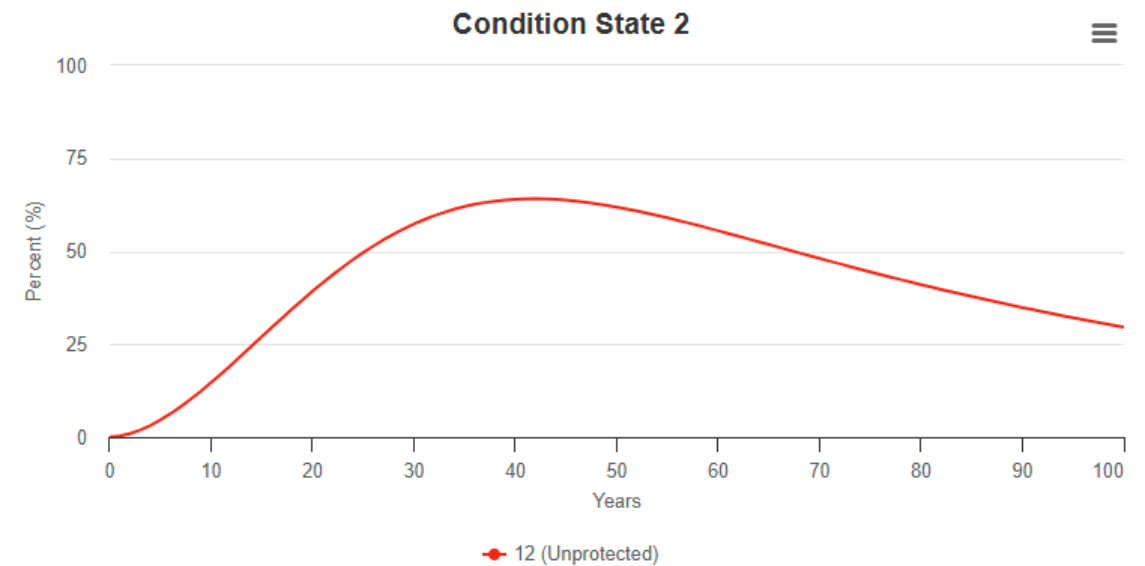
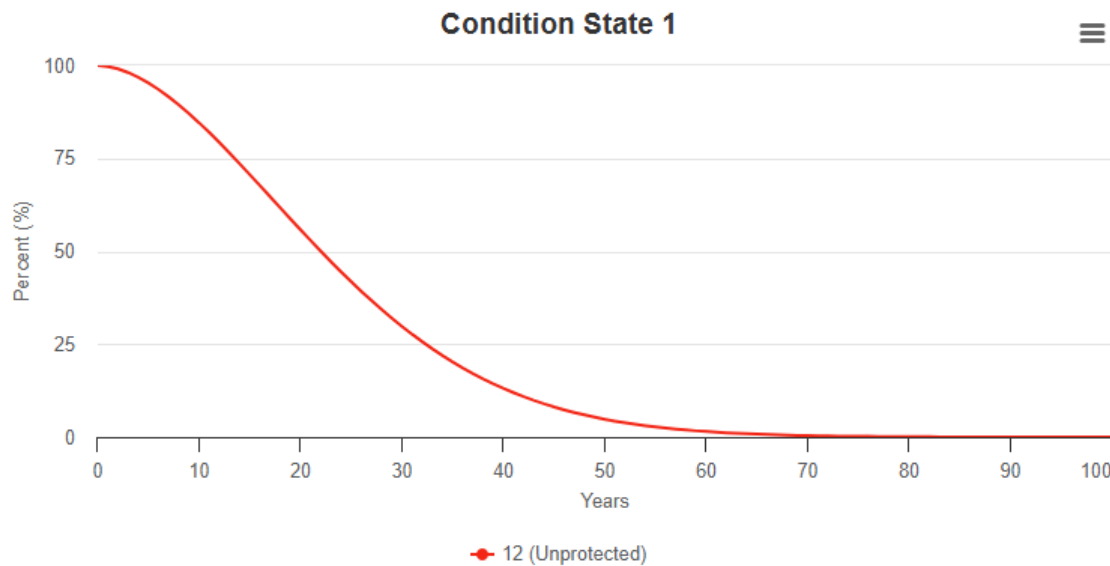
Example – 12 RC Deck Element

Model Parameters	
Copy from Element	
Median Years in CS1 *	Median Years in CS2 *
22	42
Median Years in CS3 *	Shaping Parameter *
14.86	1.8
Formula Factor	

Deterioration - Element

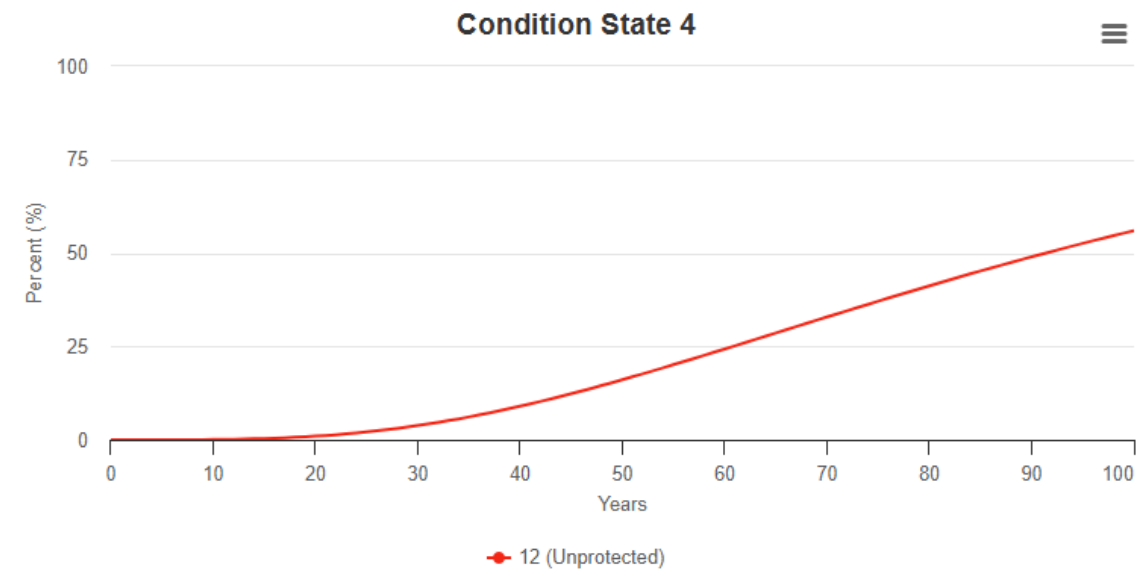
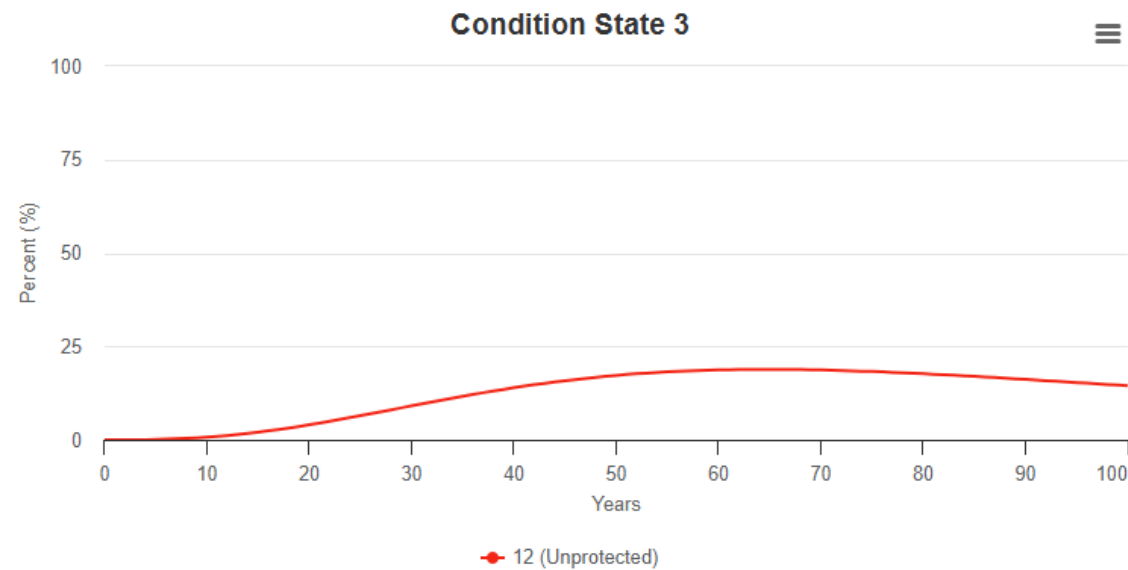
Settings > Modeling Configuration > Element Deterioration Profiles

Deterioration Curves



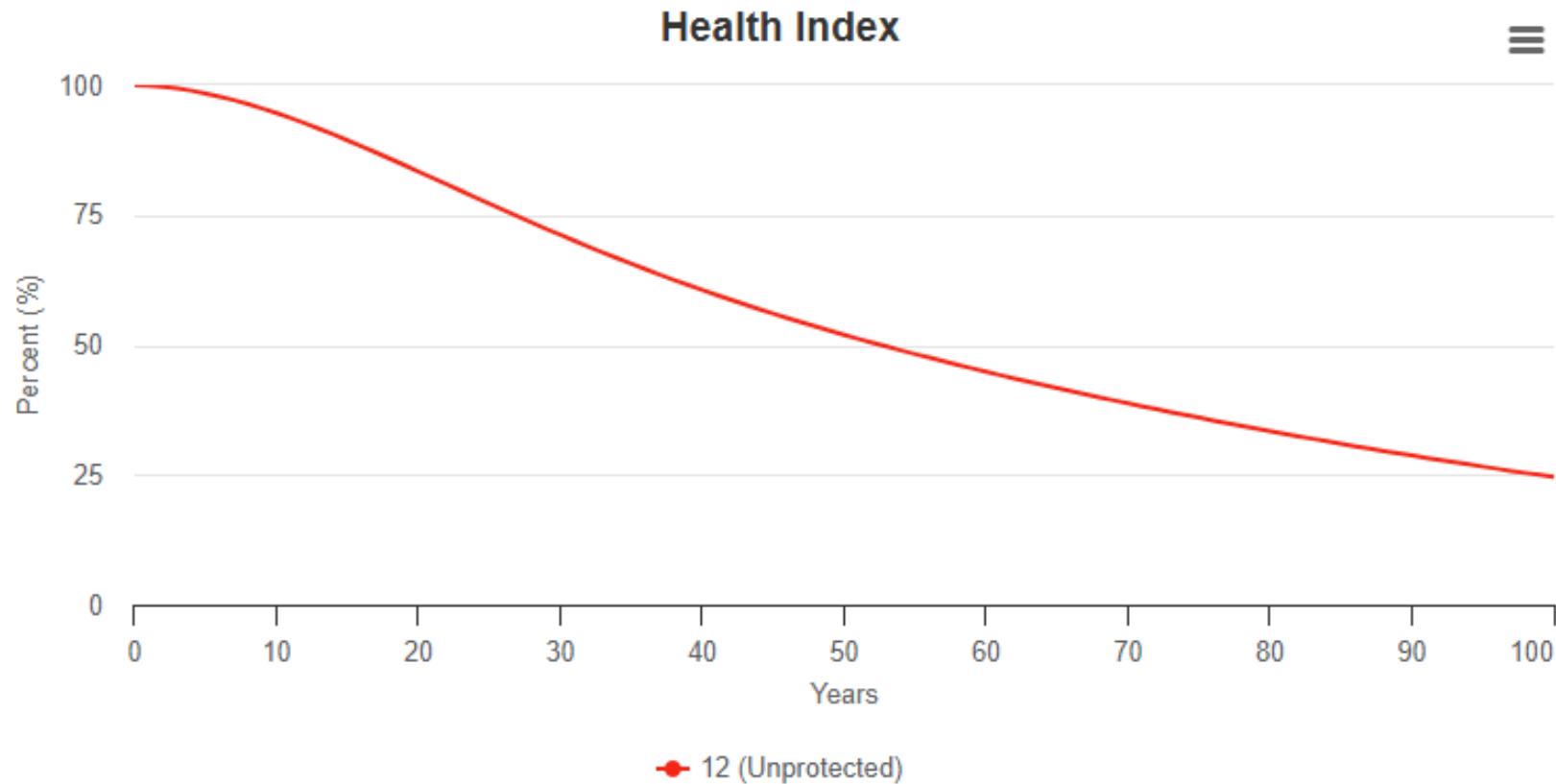
Deterioration - Element

Settings > Modeling Configuration > Element Deterioration Profiles



Deterioration - Element

Settings > Modeling Configuration > Element Deterioration Profiles



Deterioration - Element

Settings > Modeling Configuration > Element Deterioration Profiles

Year ↑	% in CS1	% in CS2	% in CS3	% in CS4	Health Index	
1	99.50	0.50	0.00	0.00	99.83	
2	98.76	1.23	0.00	0.00	99.59	
3	97.91	2.08	0.01	0.00	99.31	
4	96.98	2.99	0.03	0.00	98.99	
5	95.98	3.96	0.05	0.00	98.65	
6	94.93	4.98	0.09	0.00	98.30	
7	93.84	6.03	0.13	0.00	97.92	
8	92.72	7.10	0.17	0.01	97.53	
9	91.57	8.19	0.23	0.01	97.13	

Deterioration – NBI Conversion Profiles

Settings » Modeling Configuration » NBI Conversion Profiles

Edit NBI Conversion Profile

Details

Generic Upper Limits

Network NBI Distributions

Assigned E

Method of CS Average *

Element Weighing

NBI Rating	Enabled	CS2 %	CS3 %	CS4 %
9	☒	1	1	1
8	☒	5	5	1
7	☒	20	5	2
6	☒		10	3
5	☒		20	5
4	☒			15
3	☒			100
2	☐			
1	☐			

Deck – BrM

Deterioration – NBI Conversion Profiles

Settings » Modeling Configuration » NBI Conversion Profiles

Deck - FHWA

Edit NBI Conversion Profile

Details

Generic Upper Limits

Network NBI Distributions

Assigned Bri

Method of CS Average *

Group by Measurement Unit Type

NBI Rating	Enabled	CS2 %	CS3 %	CS4 %
9	☐			
8	☒	0	0	0
7	☒	20	0	0
6	☒		5	0
5	☒		20	0
4	☒			20
3	☒			100
2	☐			
1	☐			

Deterioration – NBI Conversion Profiles

Settings » Modeling Configuration » NBI Conversion Profiles

BrM	FHWA				
NBI	NBI	CS 1	CS 2	CS 3	CS 4
9	8	100%	0%	0%	0%
9	7	99%	1%	0%	0%
8	7	98%	2%	0%	0%
9	6	98%	1%	1%	0%
9	4	97%	1%	1%	1%
8	4	89%	5%	5%	1%
4	4	XX	XX	21%	1%

Benefits - Actions

- What happens if I spend the money?



- The hardest part isn't running the Optimizer it's defining what happens when you spend the money

Actions - Benefits

- Example - Place Concrete Overlay on Bridge Deck
- Benefits to create and link to Action
 - Deck Repair/Rehab
 - Place (or Replace) Concrete Overlay
 - Replace (or overlay) approach slabs
 - Replace/Upgrade bridge rail
 - Replace bridge joints, if they exist
 - All CS 3 & 4 for Deck Element – becomes CS 2
 - NBI Deck Rating = 7

Actions

Settings » Modeling Configuration » Actions

- Actions have:
 - Can have minimum cost
 - Can be network action also
 - Benefits
 - Deferments – won't do work for X years after this action
 - Can create a Work Event (B.W.03)

Benefits (Benefit Groups)

Settings › Modeling Configuration › Benefit Groups

- Benefits can have:
 - Changed Elements
 - Removed Elements
 - Replaced Elements
 - Create Protective Systems
 - Create fields (e.g. Deck = 9 with a Deck Replacement)

Actions - Benefits

- An Action is More than a Cost
 - Element Changes
 - GCR Changes
 - Protection Changes (slows future deterioration)
 - Impacts future work (deferement)
 - Impacts Condition Ratings
 - Revises risk and/or mobility
 - Impacts LCC
- Then you get your Modeled Benefit

Network Policies

Settings » Modeling Configuration » Network Policies



- Create a Network Policy Name, along with Project Category
- Actions
- Details – Action conditional Rules

Replace Bridge – Network Policy Action

Settings > Modeling Configuration > Network Policies

- If Deck Rating = 0, 1, 2, 3 or 4 – Replace
- If Super Rating = 0, 1, 2, 3 or 4 – Replace
- If Sub Rating = 0, 1, 2, 3 or 4 – Replace
- If Culvert Rating = 0, 1, 2, 3 or 4 – Replace
- You can set your own criteria – add age, element, health index, etc.
- What is your agencies definition or rules for “replacement”?

Lifecycle Policies

Settings » Modeling Configuration » LCCA Policies

Settings » Modeling Configuration » Assign LCCA Policies

- Need to create LCCA Policy Rules
- Assign a policy to your structure(s)



Lifecycle Replacement

- Using the Rule Builder (as an example)
 - Super HI ≤ 55 OR
 - Sub HI ≤ 35 ;
- Another approach
 - Bridge HI < 40 OR
 - Super HI < 50 AND Sub HI < 50
- Lots of ways to approach a structure replacement
 - Elements vs GCR

Funding Sources

Projects » Funding Sources

- Completely customizable to meet the needs
 - State vs Federal
 - Target Years and Amounts



Project Categories

Settings » Modeling Configuration » Project Categories



- Project categories allow for selection of specific actions as well as a default filter and layout.
- Project categories can be utilized on Programs » Funding Allocation to allocate funding by category.
- They are also used on the Details and Bridges & Work tab of Projects » Projects List to categorize projects and to filter work for projects.

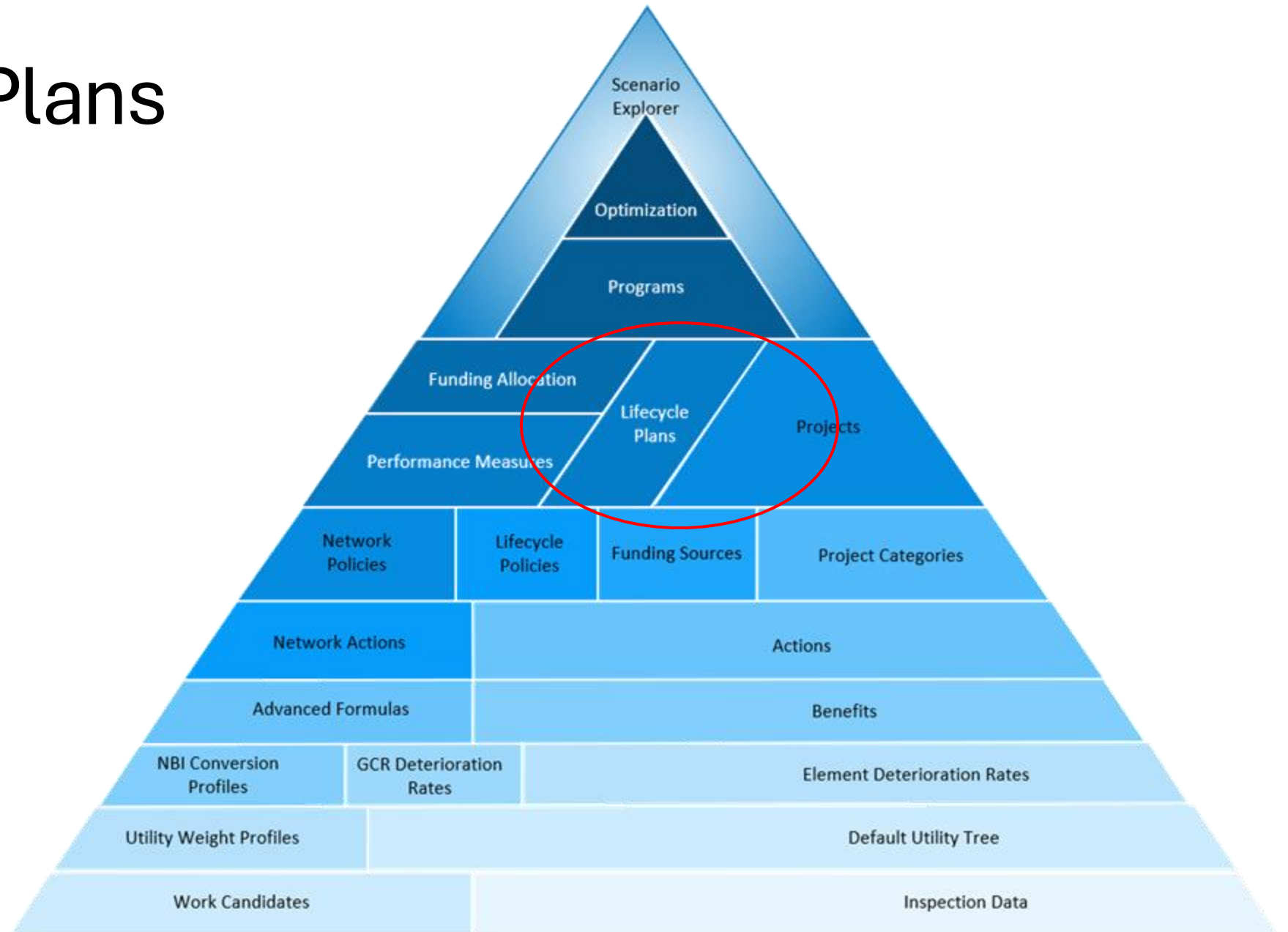
Projects

Settings » Modeling Configuration » Project Categories



- The **Projects » Project List** page allows the user to create and manage projects. A project is a collection of bridges with specific actions being performed on each bridge.

Lifecycle Plans



Analysis » LCCA Plans



- The **Analysis » LCCA Plans** page allows the user to create and manage life cycle cost analysis (LCCA) plans for specific bridges of import to the agency.
- LCCA Plans are potential future paths of care for a bridge with accompanying work and condition predictions.

LCCA Plans

Analysis » LCCA Plans



- Bridge must have a LCCA policy assigned to it and the policy must contain at least one replacement option

Programs » Performance Measures



- Performance Measures allows the user to define which criteria are used to evaluate a given program scenario.

Funding Allocation

Programs » Funding Allocation



- The funding allocation allows the user to configure the program's funding sources and amounts as well as to distribute among the programs project categories.

Programs

Programs » Program List



- Programs page allows the user to create and manage programs.
- Program is a collection of projects with specific constraints (budget or performance) over a set amount of time.
- Programs in a way – define the Optimization Problem

Optimization

Programs » Program Optimization



- Program Optimization allows the user to run an optimization on a selected program scenario.
- The optimization is a benefit cost analysis on a pool of project alternatives that selects the projects that best meet the programs goals under its specified constraints.
- Optimization doesn't eliminate engineering judgment, but it makes the consequences of that judgment visible.

Scenario Explorer

Programs » Scenario Explorer



- There is no single “best” program – only the best program for a defined set of objectives and constraints
 - Scenario A – Maximize Condition
 - Scenario B – Minimize Risk
 - Scenario C – Minimize LCC
 - Scenario D – Maximize Mobility
 - Scenario E – Some balance of those objectives
- With the same network and same bridges – can give different priorities and a different investment program
- Scenario Explorer lets you see the consequences of this

Scenario Explorer

Programs » Scenario Explorer



- The scenario explorer page allows the user to visually compare the performance of a program's optimized scenarios.
- Program scenarios are created and managed on the **Scenarios** tab of [Programs » Program List](#). Scenarios within a program can differ based on:
 - funding, as set on [Programs » Funding Allocation](#)
 - performance measures, as set on [Programs » Performance Measures](#)
 - element deterioration profiles, as set on the **Scenarios** tab of [Programs » Program List](#)
 - frozen projects, as set on the **Management** tab of [Projects » Projects List](#) or on [Programs » Assign Project](#)

Don't try to build the Whole Model at Once

- Start Small – e.g. decks
 - Actions & Benefits
 - Deterioration
 - Policies
 - Programs
- The Optimization

The Optimization Roadmap

- **1 — Trust the data**
- **2 — Define the goals**
- **3 — Predict deterioration**
- **4 — Define the consequences of action**
- **5 — Apply agency policies**
- **6 — Define available resources**
- **7 — Build feasible projects**
- **8 — Apply constraints**
- **9 — Optimize**
- **10 — Compare scenarios**
- **11 — Learn and refine**

Optimization

- Don't optimize the answer. Optimize the decision.
- Trust the data.
- Define what matters.
- Predict what happens if we do nothing.
- Define what happens if we spend money.
- Apply agency rules and constraints.
- Then—and only then—optimize.

And for some fun

- I asked Chat GPT the following two prompts:
 - Does FHWA require states to have a BMS?
 - Map each of the six requirements against what AASHTOWare BrM 7.2 actually does and place in a table

Fun results

§515.17 requirement	What FHWA requires	What BrM 7.2 provides	My assessment
(a) Inventory & condition data	Collect, process, store & update NHS bridge inventory and condition data	NBI/SNBI inventory, inspection/element data, condition states, maintenance/project data, database, reporting/API	Strongly satisfies
(b) Forecast deterioration	Forecast deterioration of NHS bridges	Element-level deterioration models, transition probabilities/rates, future condition forecasting, treatment impacts	Strongly satisfies
(c) Life-cycle benefit/cost	Evaluate alternative actions, including no action , over asset life cycle	Actions, costs, benefits, utility, lifecycle plans/policies, LCCA, treatment sequences and future deterioration	Strongly satisfies

Looks good

§515.17 requirement	What FHWA requires	What BrM 7.2 provides	My assessment
(d) Short/long-term budget needs	Identify funding needs for bridge condition	Unconstrained needs, funding scenarios, forecast conditions, minimum-cost/performance scenarios, gap analysis	Strongly satisfies
(e) Maximize program benefits under constraints	Select strategies/projects maximizing benefits within financial constraints	BrM 7 Optimizer: utility maximization, budgets, policies, performance measures, criticality, frozen projects, programs/scenarios	Strongly satisfies
(f) Recommend programs & schedules	Recommend programs and implementation schedules within policy/budget constraints	Optimizer produces project lists, years, programs/scenarios and future network outcomes	Strongly satisfies



Questions

Jira -

<https://aashtowarebridge.atlassian.net/servicedesk/customer/portal/112>

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