Project Prioritization Using Multi-Objective Utility Functions

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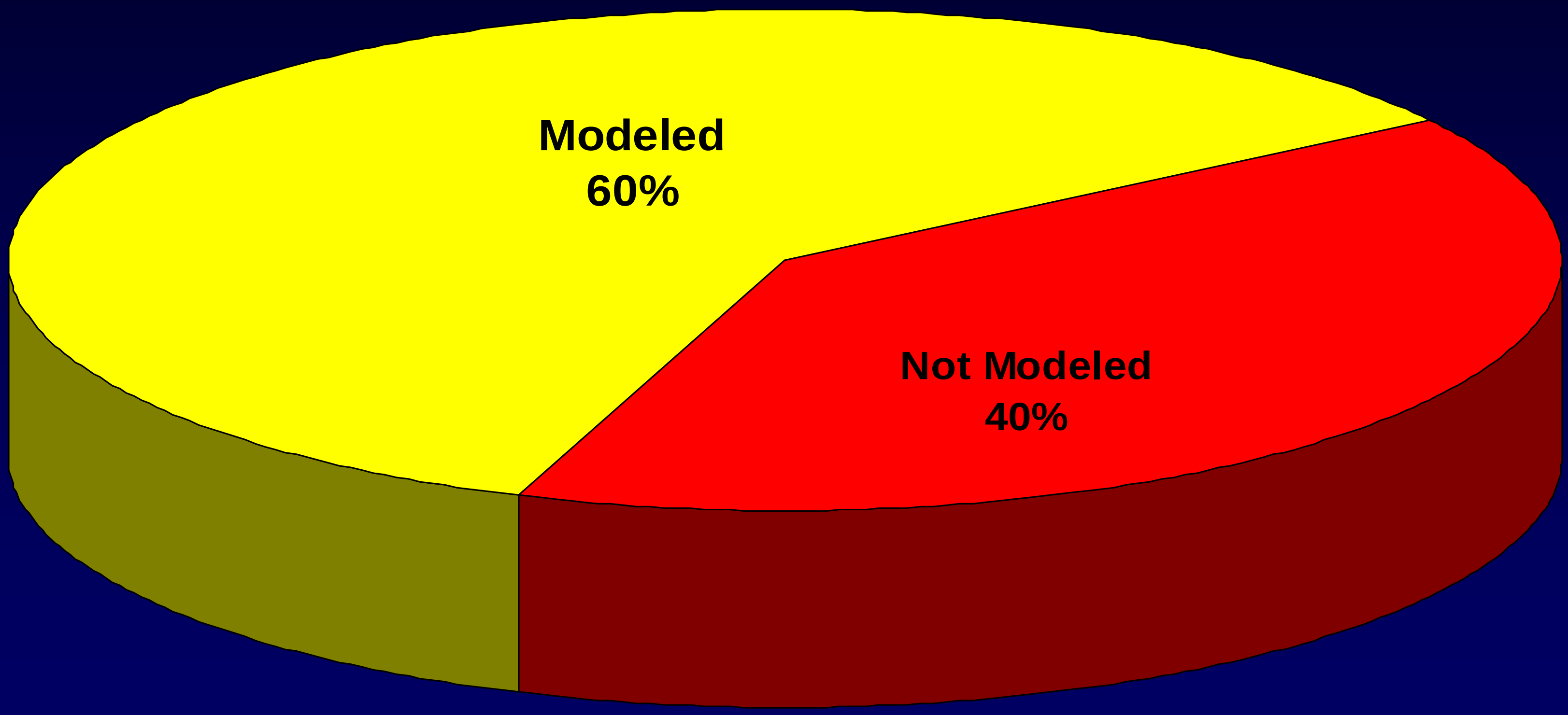
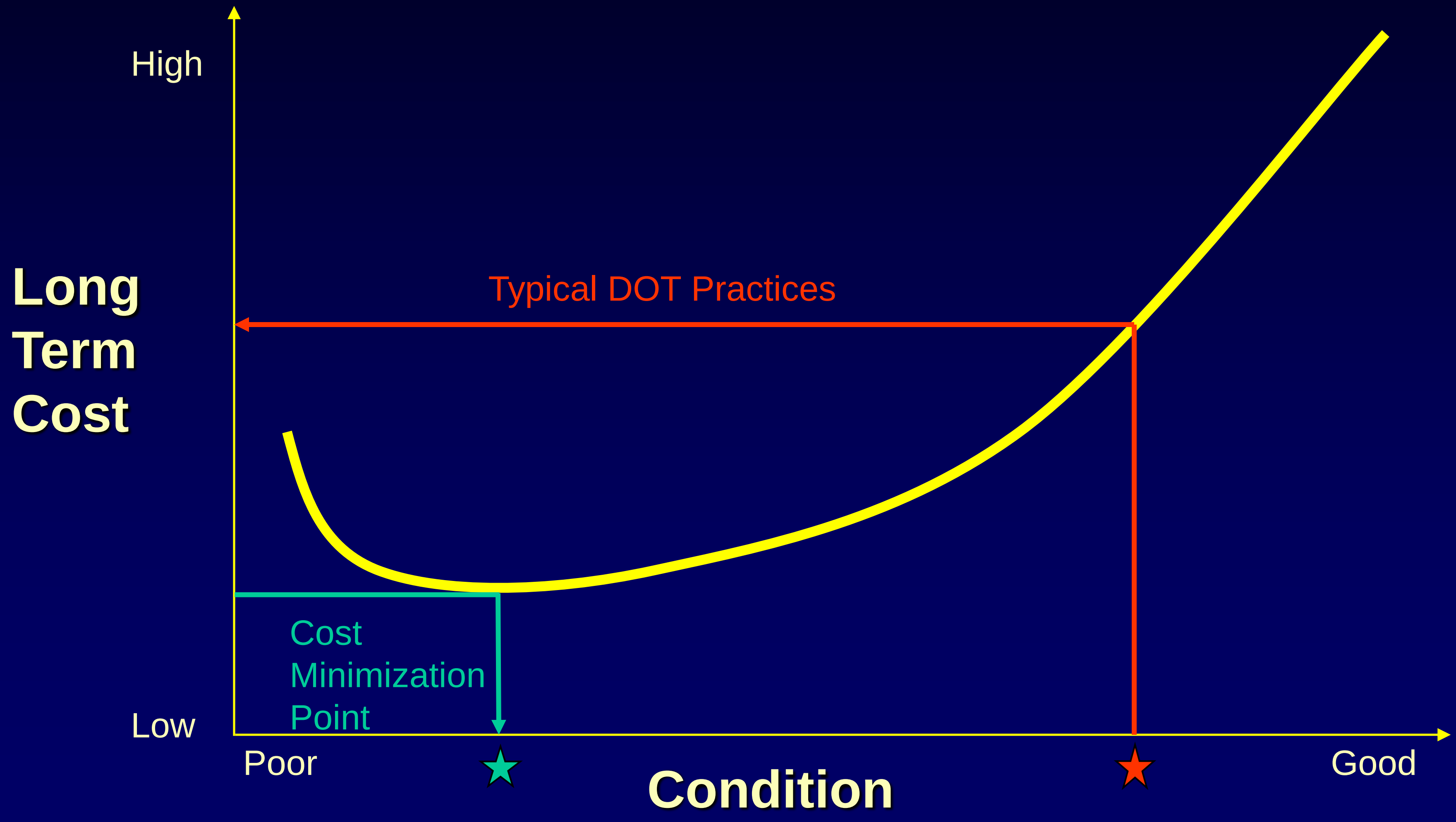
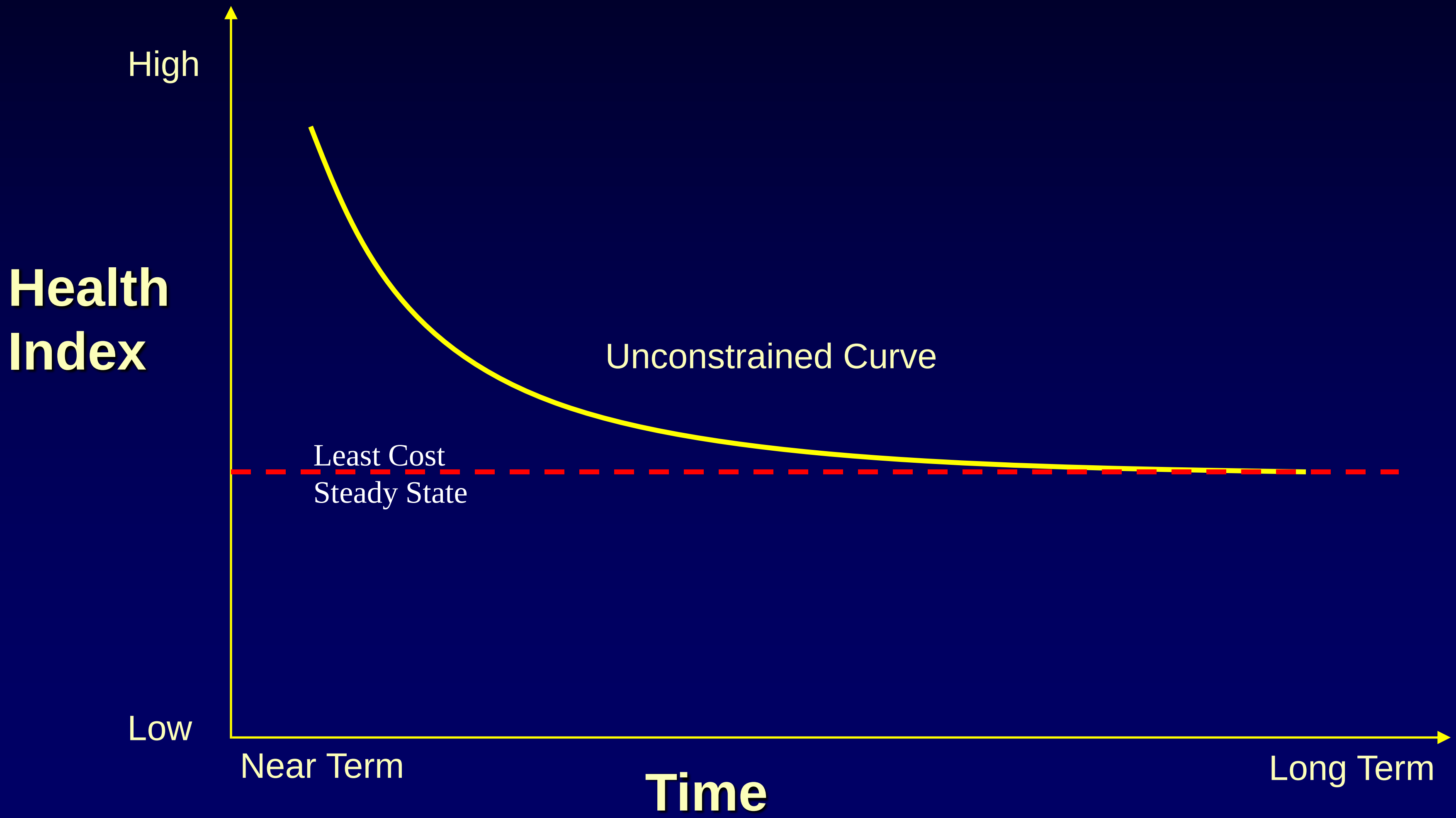
Bridge Preservation Needs



Least Cost Optimization



Least Cost Optimization Results

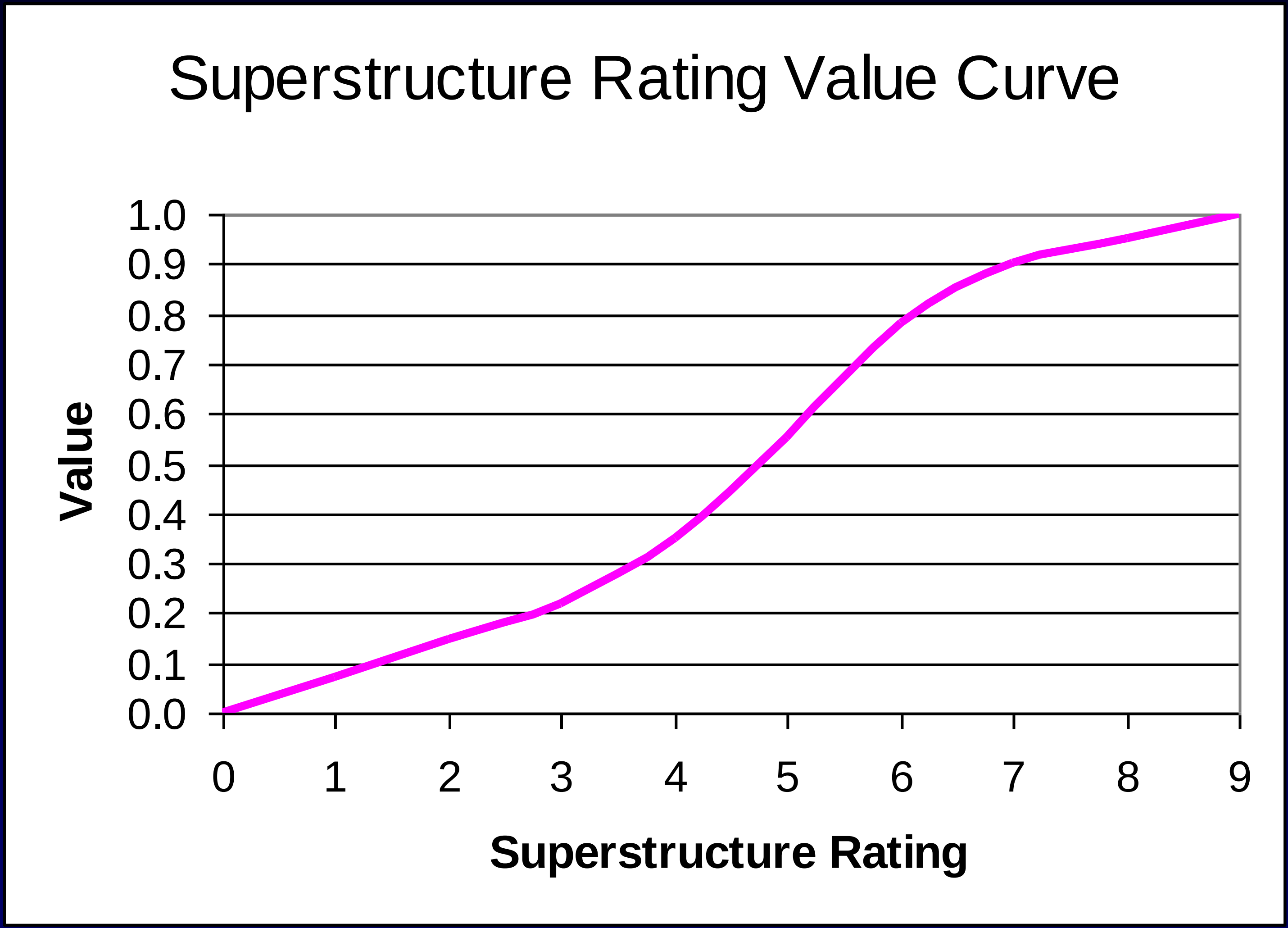


BMS Modeling Using Utility Functions

- A utility is a 0 to 1 unit less measure that can quantify action or project benefits.
- Dissimilar benefits can be combined using utility functions.
- Value Functions are user defined and can include.
  - Condition, load capacity, risks, functional needs, etc.
- The total utility of a project is equal to the weighted sum of the component utilities (value functions).

$$\text{Total Utility} = W_1(U_1) + W_2(U_2) + W_3(U_3)\ldots$$

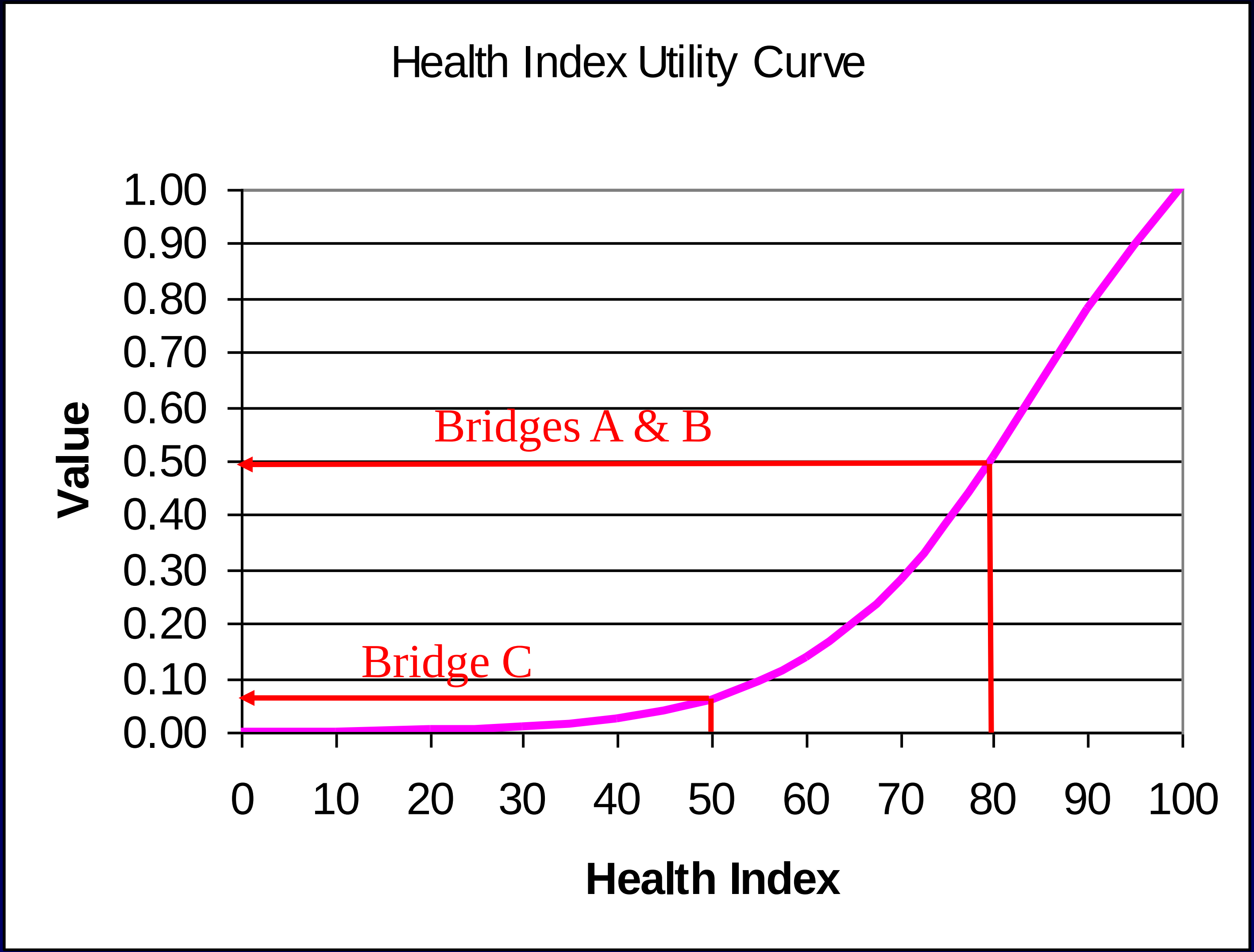
Sample Utility Function Value Curve



Example Calculation

Bridge ID	Health (BHI)	Scour 113	Load Rate	Bridge Area
Bridge A	80	7	15 tons	1000 sq m
Bridge B	80	3	40 tons	2000 sq m
Bridge C	50	5	40 tons	3000 sq m

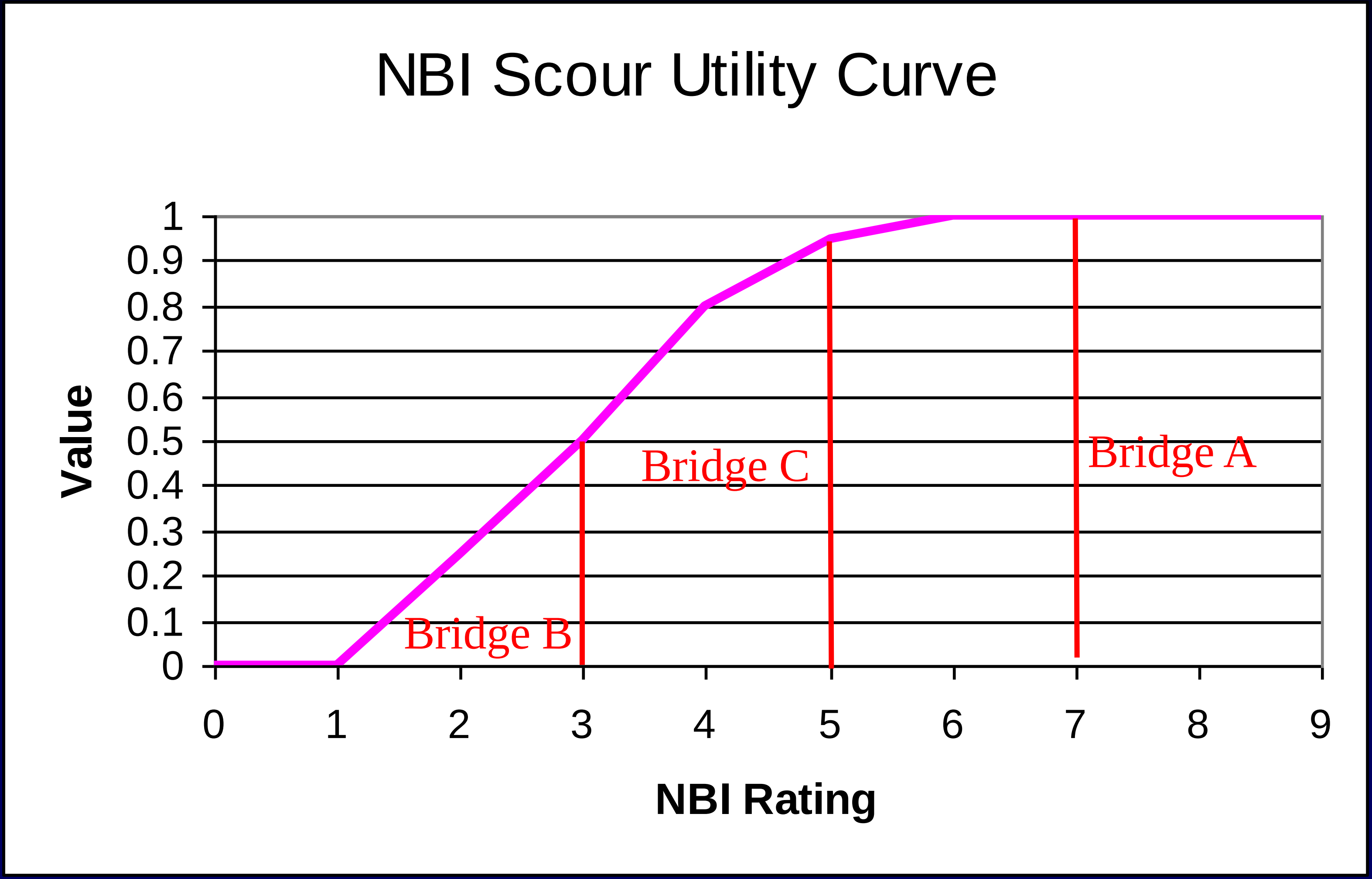
Bridge Health Index Utility Curve



Example Calculation - Condition Component

Bridge ID	Health (BHI)	U_{BHI}
Bridge A	80	0.50
Bridge B	80	0.50
Bridge C	50	0.075

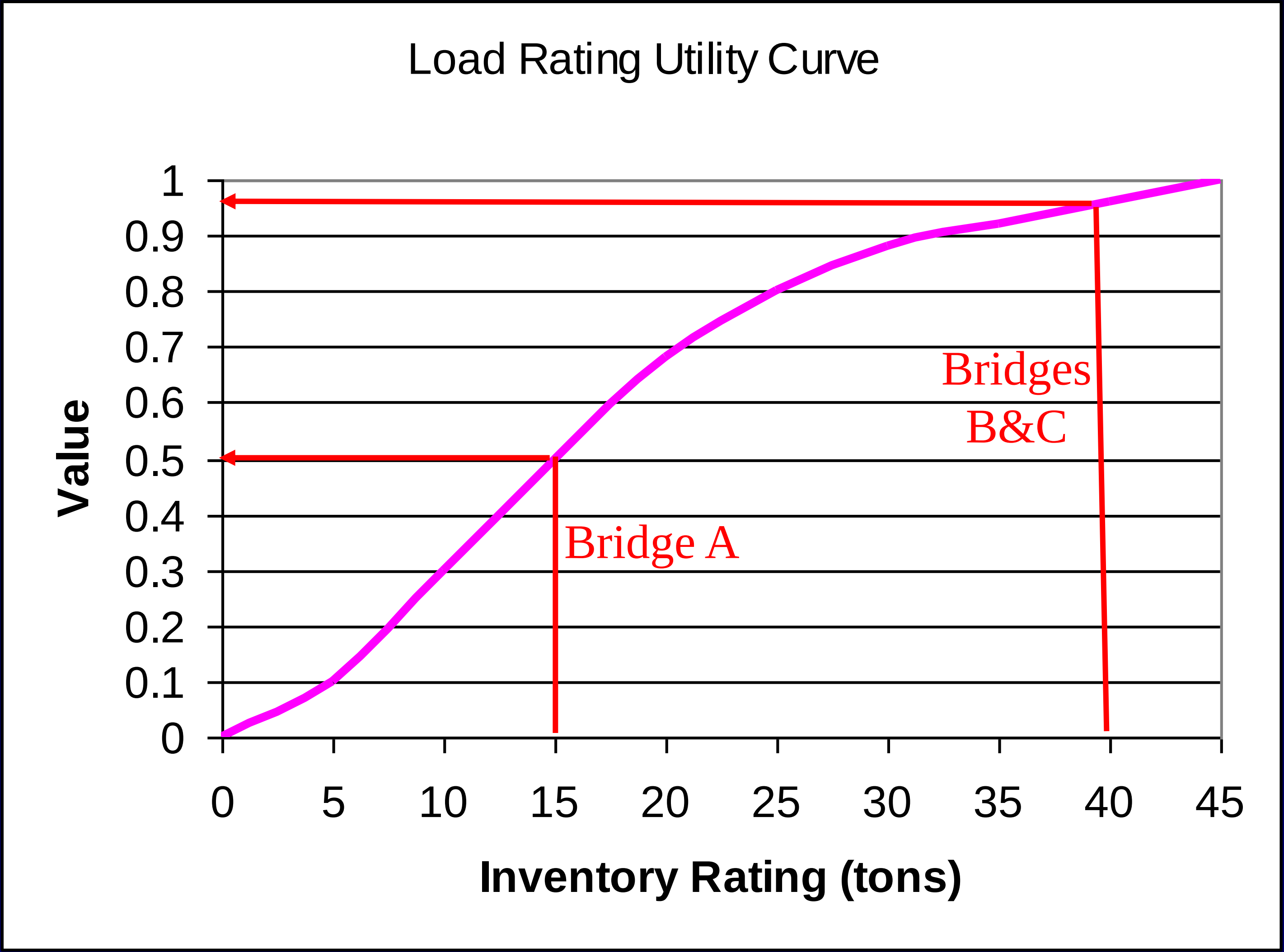
NBI Scour Utility Curve



Example Calculation – Scour Component

Bridge ID	Scour 113	U_{113}
Bridge A	7	1.0
Bridge B	3	0.5
Bridge C	5	0.95

Load Capacity Utility Curve



Example Calculation – Load Component

Bridge ID	Load Rate	U_{LR}
Bridge A	15 tons	0.5
Bridge B	40 tons	0.95
Bridge C	40 tons	0.95

Example Calculation

Bridge	BHI	U_{BHI}	Scour	U_{113}	Load	U_{LR}	W_{BHI}	W_{SC}	W_{LR}
Bridge A	80	0.50	7	1.0	15	0.50	0.50	0.30	0.20
Bridge B	80	0.50	3	0.50	40	0.95	0.50	0.30	0.20
Bridge C	50	0.075	5	0.95	40	0.95	0.50	0.30	0.20

Bridge A $U_T = (1-0.50)*0.5+(1-1)*0.3+(1-0.5)*0.2= 0.35$

Bridge B $U_T= (1-0.50)*0.5+(1-0.5)*0.3+(1-0.95)*0.2= 0.41$

Bridge C $U_T = (1-0.075)*0.5+(1-0.95)*0.3+(1-0.95)*0.2=0.95$

Project Size and Cost Introduced

Bridge ID	Total Utility	Project $	Bridge Area	$/Sq M
Bridge A	.35	1.2 mil	1000 sq m	0.0012
Bridge B	.41	2.5 mil	2000 sq m	0.0013
Bridge C	.95	9.0 mil	3000 sq m	0.003

Bridge A Project Priority = 0.35/0.0012 = 291

Bridge B Project Priority = 0.41/0.0013 = 320

Bridge C Project Priority = 0.95/.003 = 316

Summary

- Utilities can combine all project level attributes, including risks, into a single value that can be used to prioritize projects.
- Caltrans showed a strong correlation to the engineering judgment process currently used.
- The multi-objective optimization techniques are easy to understand and computations are fairly simple.
- The multi-objective utility techniques are being incorporated into Pontis and are well suited for asset management applications too.