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Integrated Infrastructure Asset Management
Software Solutions

Multi-Year, Multi-Constraint Strategy
to
Optimize Linear Assets Based on Life Cycle Costs

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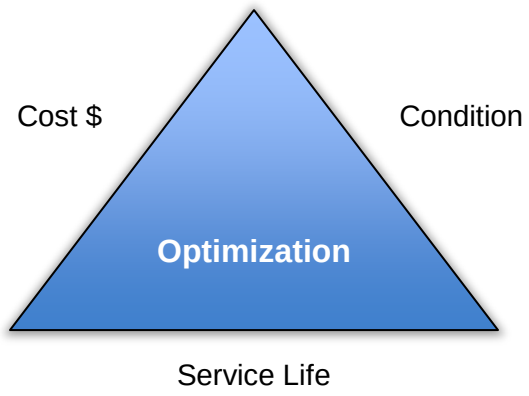
Pavement Asset Managment

- **Pavement management** is the process of planning the maintenance and rehabilitations of a network of roadways in order to **optimize** pavement condition and cost over the entire network.



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NEED for PMS

- Transportation infrastructures represent a very large amount of investment.

- Preservation of these assets implies continuous investments to achieve serviceability, safety ,life span.

- In the US, an estimated $91 billion is budgeted to maintain highway pavements, but there is still a shortfall of $89 billion annually — leading to a decline in condition and performance of pavements (*)

*. ASCE, 2013 Report Card for America's Infrastructure, American Society of Civil Engineers

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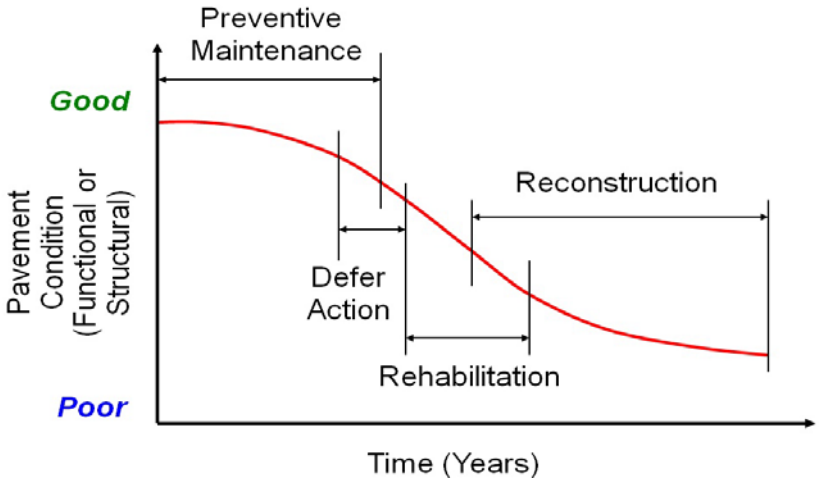
PMS Outputs : What Where When

- Desired Output is a Work Plan

- Modern PMS assist decision makers in determining “what treatment, when, and where?” by optimizing pavement network work plans under budgetary and other agency constraints and objectives.



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Common Analysis Methods

- Worst First Method
- Ranking (Benefit/Cost)
- Optimization Multi Constraint (Sequential Opt.)
- Optimization Multi Year (Holistic Opt.)

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WORST FIRST

- Overly simplistic
- Spending the budget mostly on first years
- Ignoring Preventive Maintenance
- Not Optimized

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Ranking

- Benefit Cost Analysis (BCA)
- Has been widely used by several transportation agencies
- Not too complex to implement and understand
- Cannot solve problems with multiple overlapping constraints
- It is not optimized

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Need for Multiple Overlapping Constraints

- No budget in first year, X dollar in second year, Y dollar in third year
- PCI>75 for district A and PCI>80 for district B etc.
- Constrains that targets different roadway classes (Interstate, Primary Roads, Secondary Roads)
- PCI>75 for 80% or more of the network and not more than 10% of the network to have PCI<25

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Ranking

- Available Budget is 250,000 $

Sections	Treatment	Cost	Benefit	B/C (X100)	Selected
1	T1	$40,000	1400	3.50	x
2	T2	$220,000	7500	3.41	
3	T3	$80,000	2700	3.38	x
4	T4	$150,000	4800	3.20	
5	T5	$15,000	450	3.00	x

Total Spent : 135,000 $ (55%)

Sum of Benefit : 4550

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3	T3	$80,000	2700	3.38	x
4	T4	$150,000	4800	3.20	x
5	T5	$15,000	450	3.00	x

Total Spent : 245,000 $ (98%)

Sum of Benefit : 7950

* Benefit is defined as the area under the condition curve for each segment (Sum of condition score over service time)

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Optimization

- Optimization checks different combo of Treatments in different years and solve for best sets of Projects
- Optimization can analyze problems that B/C ranking cannot tackle
- Optimization can handle Multiple overlapping constraints
- The solution is a real work plan with identified sections and treatments

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Multi Constraint Optimization

- Multi Constraint : Year by year analysis . Start with recommending a treatment for each section for each year (Sequential)
- Multi Constraint analyzes each single year discretely.
- Multi Constraint solution is optimal in each year.

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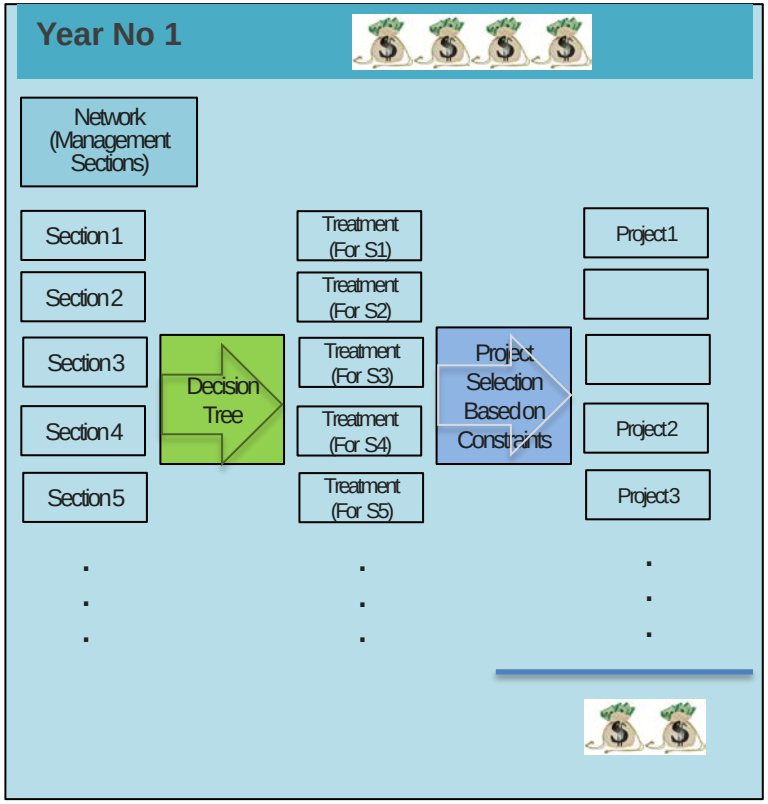
Multi - Constraint Analysis



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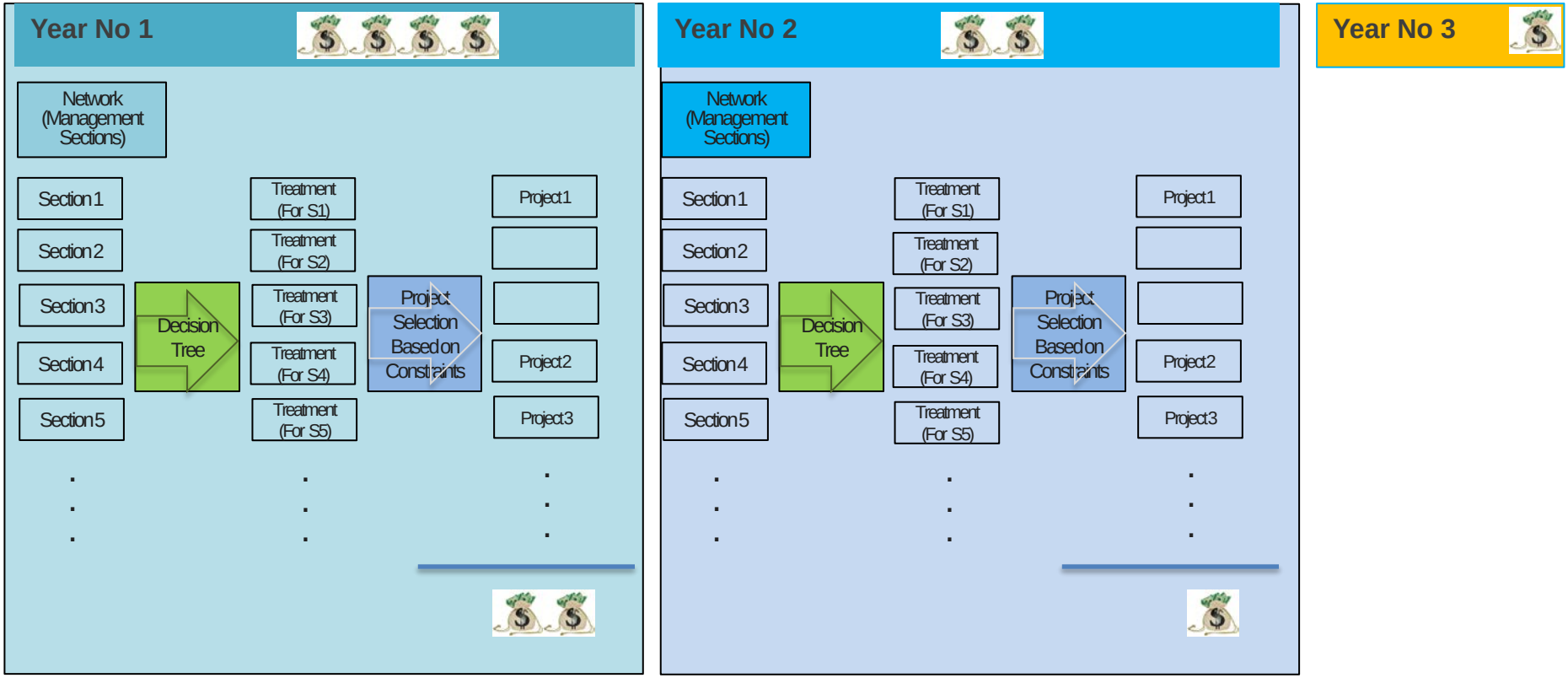
Multi - Constraint Analysis



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Multi Year Optimization

- Multi Year Multi Constraint : Checks the whole analysis Period for each section.

- More Complex, Bigger problem

- For short analysis period Multi Year results is marginally as optimal as Multi Constraint

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Multi Year

	Year 1	Year 2	Year 3	Year 4	Year 5
Strategy 1					
Strategy2					
Strategy3					
Strategy4					
Strategy5					

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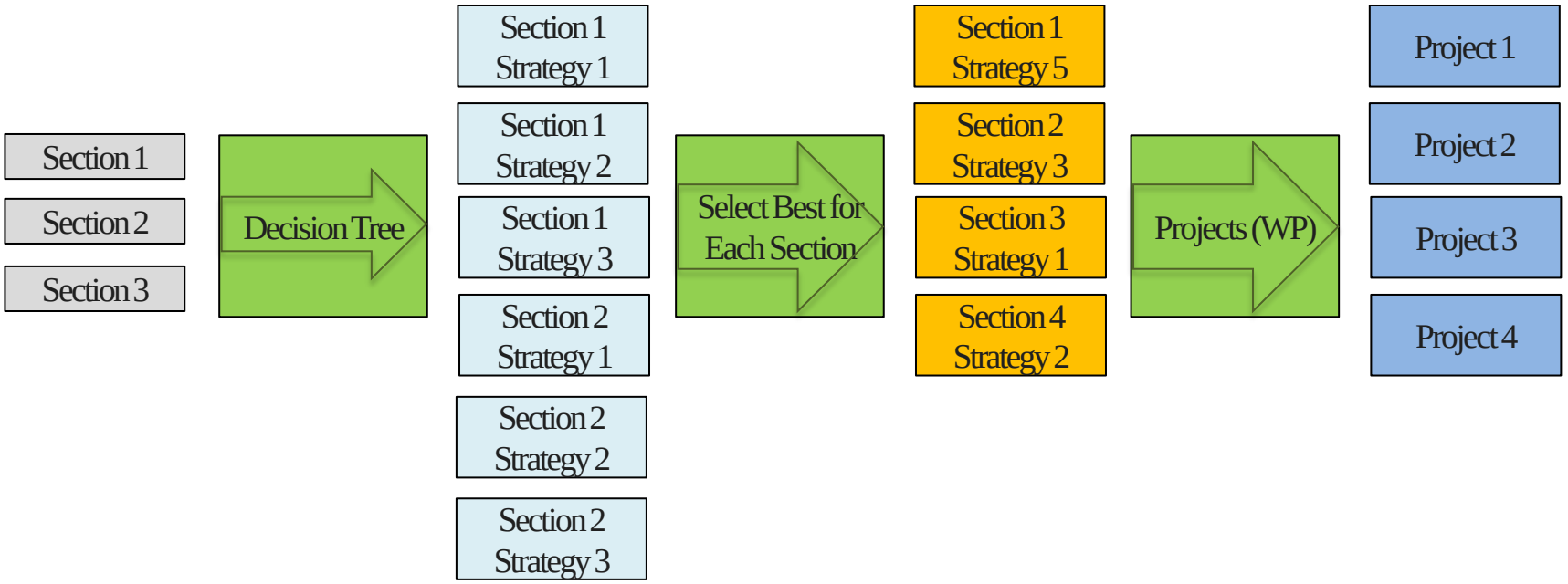
Multi Year

	Year 1	Year 2	Year 3	Year 4	Year 5
Strategy 1					
Strategy2					
Strategy3					
Strategy4					
Strategy5					



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Case Study for Analysis

- ~2000 Management Sections
- ~200000 lane miles
- 20 Treatment Alternatives
- Pavement Condition from Poor, to Good
- Average Condition Index = 70

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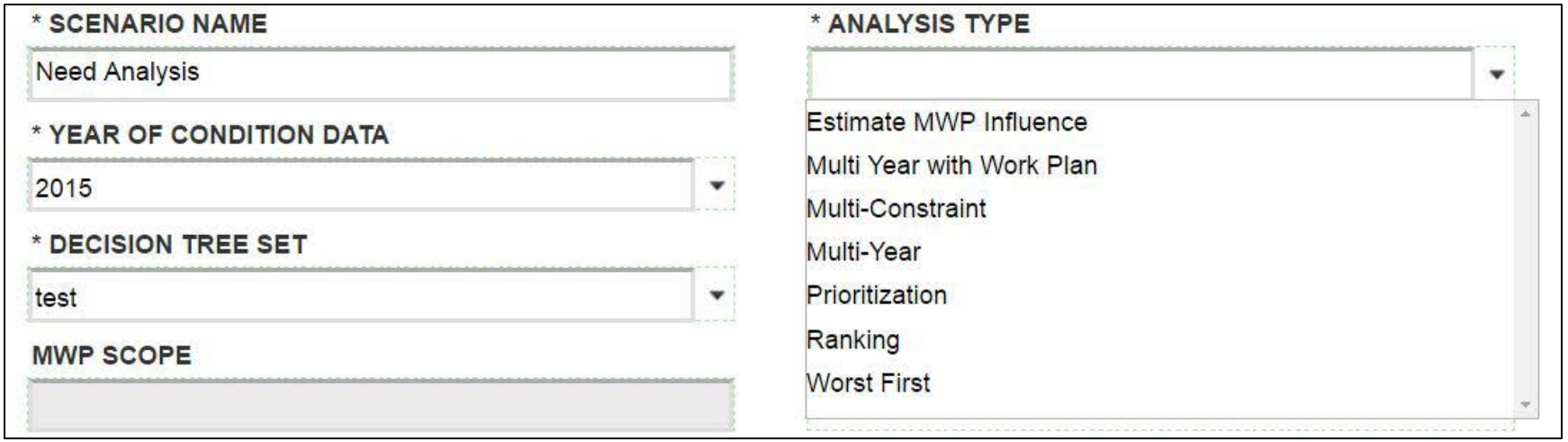
Optimization

- Optimization method presented here have been used for many large scale networks ranging from the largest highway networks in the nation (e.g., Texas, North Carolina, Virginia) to smaller county/city networks.



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- Case Study Number 1

  Need Analysis

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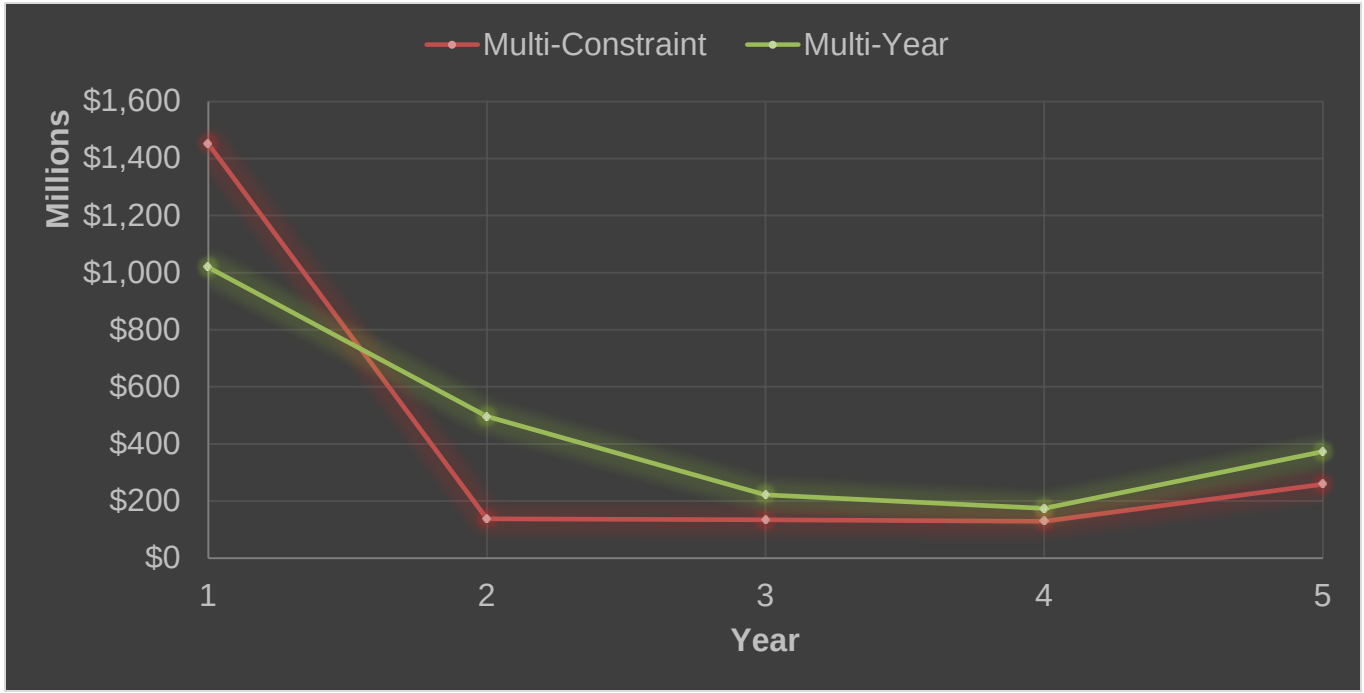
5 years- Need Analysis

Objective : Maximize Benefit
Unlimited Budget ($$$$$$)

Total spending almost was the same for both optimization methods (Need Analysis) after running analysis.

Number of Projects in the Work Plan	
Multi-Constraint	Multi-Year
1733	1687



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- Case Study Number 2
  Limited Budget Analysis

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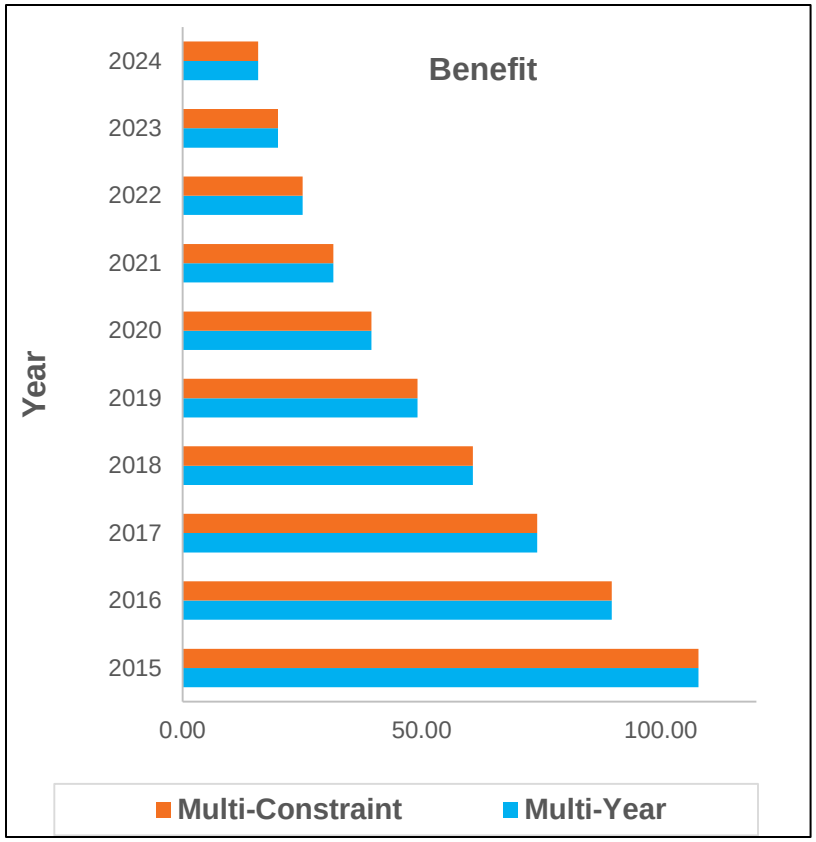
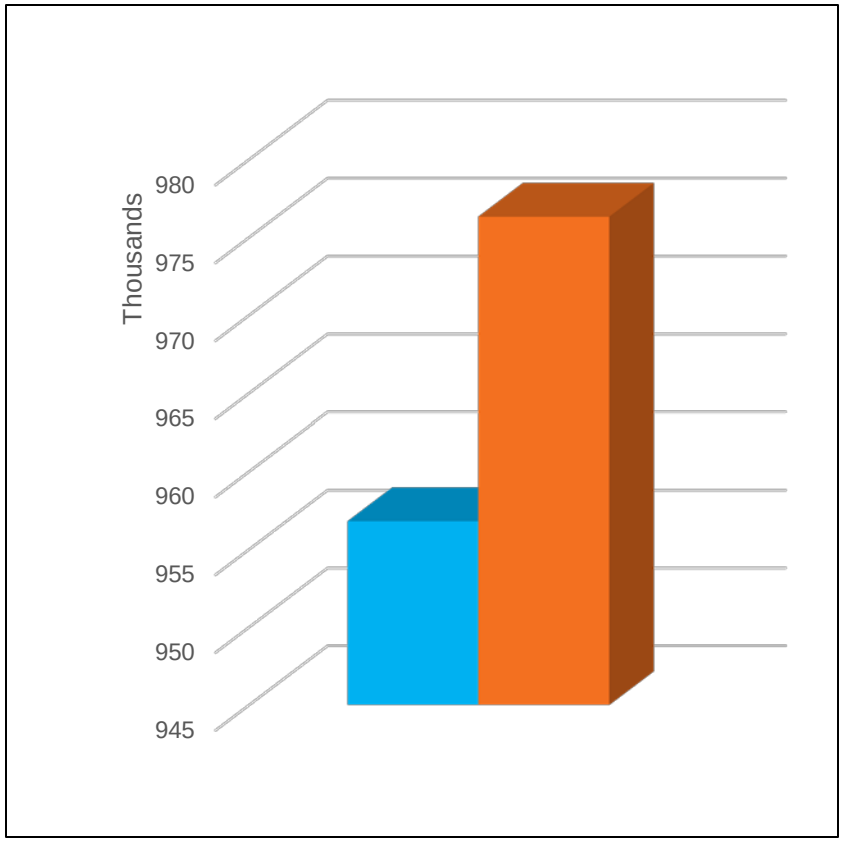
10 Year Analysis

Objective : Maximize Benefit
1000000 $ available each year





While benefits are maximized exactly the same way in both analyses, Multi Year analyses reached that benefit by spending less money which demonstrates better optimization.

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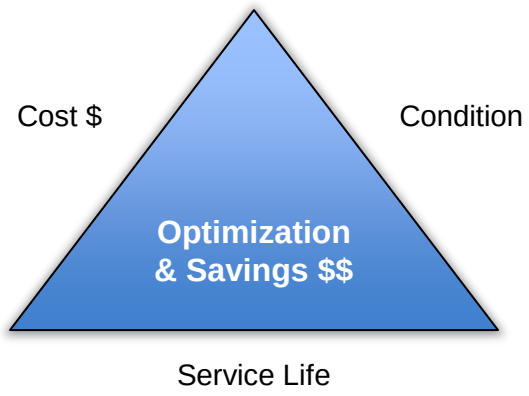
Summary

- Pavement management project selection for a large network is a complex problem specially when having several overlapping constraints.
- Solving such complex problem need appropriate approach and powerful tools



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Summary

- Ranking method is not optimized.
- Ranking method can not handle multiple constraints

- Optimization is proven to be the best solution.

- Results from analysis on different networks have shown significant budget savings when using optimization methods.

- Particularly for longer analysis periods, Multi-Year optimization analysis leads to better results and can save more money compare to Multi-Constraint analysis.

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Thank You!

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