Transportation Asset Management Research

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Research & Development – Transportation Asset Management (TAM)

Historical Background

- 1997 Integration of Different Program Areas
- 2004 Development of Framework for Asset Management Project Selection
- 2008 Methodology for Trade-off Analysis in Asset Management

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Recently Completed Research

A Methodology for Trade-off Analysis in Asset Management, SPR 3110

December 2008

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Spheres of TAM Trade-off Analysis

Sphere 1 -- Network-level trade-offs using network-level data;

Sphere 2 -- Network-level trade-offs using project-level data;

Sphere 3 -- Project-level trade-offs using project-level data.

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Spheres of TAM Trade-off Analysis

	Project-level Trade-offs	Network-level Trade-offs
Project-level Data	**Sphere 3** Within each program area, often life-cycle based	**Sphere 2** SPR 3110 Main Focus
Network-level Data	Not Applicable	**Sphere 1** Future Research

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TAM Trade-offs at Sphere 2

(Network-level Trade-off Analysis using Project level Data)

SPR 3110 Study Objectives

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Overall Context of the TAM Problem


Pavement Asset Projects

ΔIRI


Bridge Asset Projects

ΔNBI Rating


Safety Asset Projects

ΔCrash Rate


Mobility Asset Projects

Δ v/c Ratio

Other Special Programs at INDOT

Economic development, Customer Satisfaction, etc.

- Upper- and lower-bound spending levels for (a) Overall asset program, and/or (b) each program area

- Performance thresholds for each program area

Asset Program "POOL" of Projects

Pavement Program Area | Bridge Program Area | Safety Program Area | Congestion Program Area | "Other" Program Area

Optimal decision-making based on multiple performance measures

ASSET PROGRAM OPTIMIZATION AND TRADE-OFF ANALYSIS

Ref: D. Holtz, 2008

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TAM Trade-offs at Sphere 2

(Network-level Trade-off Analysis using Project level Data)

SPR 3110 Study Objectives

1. How to determine the best mix of projects that satisfy budgetary and performance constraints?
2. How to quantify the overall impact of changes in (a) budgets (b) performance thresholds (c) political constraints?
3. How to examine trade-offs between "costs" (increased or decreased budget) and "benefits" (increased or decreased performance measures)?
4. How to examine trade-offs between two or more "benefits" (two or more performance measures)?

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Can these questions be answered, really?

- **Ideally …**
  - Same performance measure across all Program Areas, OR
  - Different performance measures but they have
    - same units, dimensions, or scale
    - same level of importance to the Asset Manager
- **But idealism is not reality**
  - Hence there is a need for
    - Weighting and scaling the different performance measures
    - Amalgamating the weighted and scaled performance measures to yield combined impact of each candidate project

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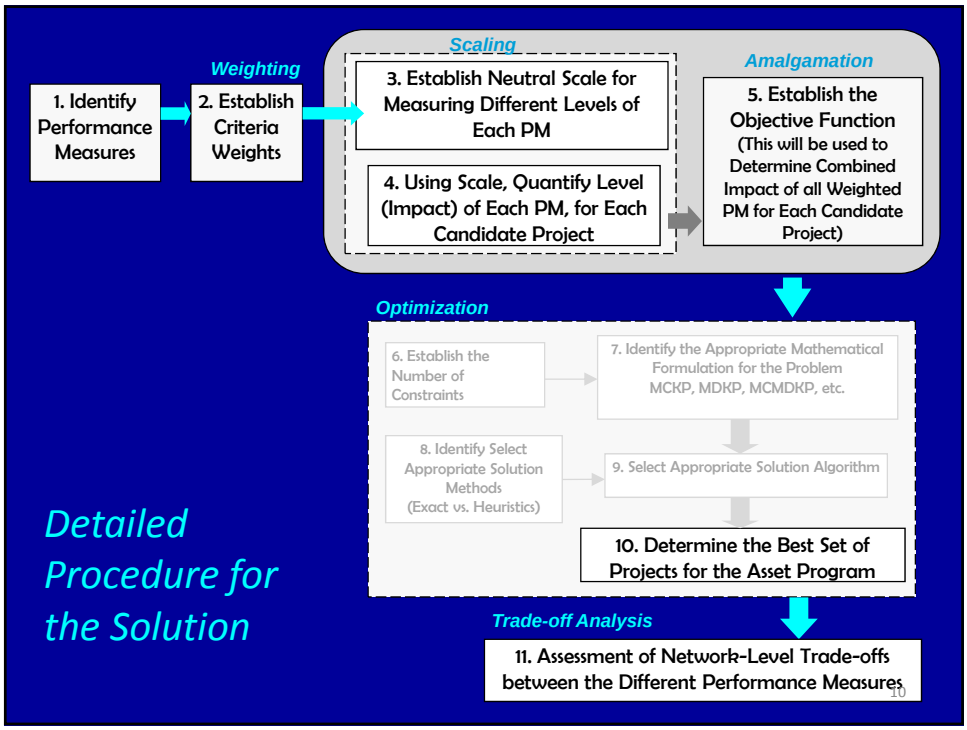

Detailed Procedure for the Solution

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The Solution Procedure – in a Nutshell (1)

Projects

Pavement Project A
Bridge Project B
Pavement Project C
Safety Project D
Congestion Project E
Safety Project F
. . .
Project J

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The Solution Procedure – in a Nutshell (1)

Performance Measures (raw values)

Projects

	System Preservation	Safety Impacts	Mobility Impacts	. . .	PM K
Pavement Project A					
Bridge Project B					
Pavement Project C					
Safety Project D					
Congestion Project E					
Safety Project F					
. . .					
Project J					

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The Solution Procedure – in a Nutshell (2)

Performance Measures (scaled values)

Projects

	System Preservation	Safety Impacts	Mobility Impacts	. . .	PM K
Pavement Project A					
Bridge Project B					
Pavement Project C					
Safety Project D					
Congestion Project E					
Safety Project F					
. . .					
Project J					

Note: AM can carry out weighting before or after scaling

Research report provides several alternative scaling techniques

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The Solution Procedure – in a Nutshell (3)

Performance Measures (amalgamated values)

Projects

	System Preservation	Safety Impacts	Mobility Impacts	. . .	PM K	Total Impact of Project j
Pavement Project A						I_1
Bridge Project B						I_2
Pavement Project C						I_3
Safety Project D						I_4
Congestion Project E						I_5
Safety Project F						I_6
. . .						. . .
Project J						I_J

Research report provides alternative techniques for amalgamation

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The Solution Procedure – in a Nutshell (4)

Performance Measures (amalgamated values)

Projects

	System Preservation	Safety Impacts	Mobility Impacts	. . .	PM K	Total Impact of Project j
Pavement Project A						I_1
Bridge Project B						I_2
Pavement Project C						I_3
Safety Project D						I_4
Congestion Project E						I_5
Safety Project F						I_6
. . .						. . .
Project J						I_J

Optimization to identify the "best" projects

Research report provides mathematical frameworks for the optimization

The Solution Procedure – in a Nutshell (5)

Performance Measures (amalgamated values)

Projects

	System Preservation	Safety Impacts	Mobility Impacts	. . .	PM K	Total Impact of Project j
Pavement Project A						I_1
Bridge Project B						I_2
Pavement Project C						I_3
Safety Project D						I_4
Congestion Project E						I_5
Safety Project F						I_6
. . .						. . .
Project J						I_J

Trade-offs between budgets, performance levels and thresholds, risk, etc.

Research report provides mathematical framework for the trade-off analyses

Application Example of TAM Trade-offs at Sphere 2

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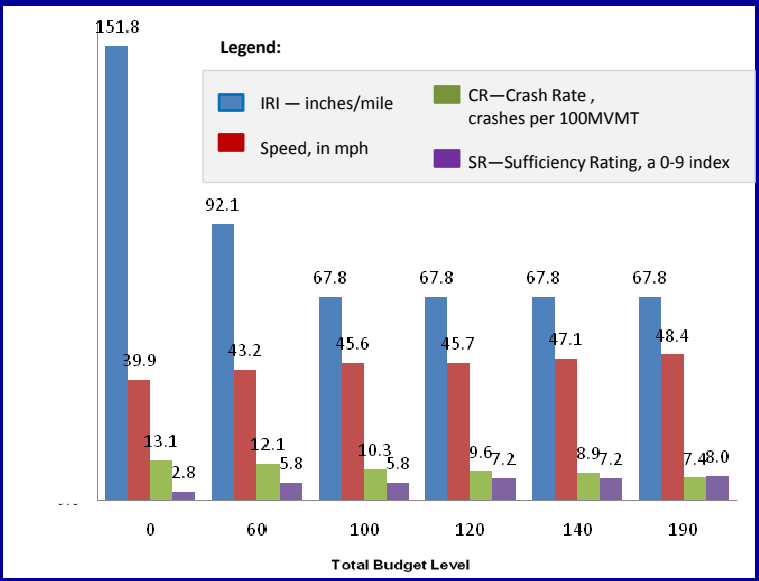
Tradeoff Analysis 1A: Change total budget levels and find out the influence on AVERAGE values of performance measures



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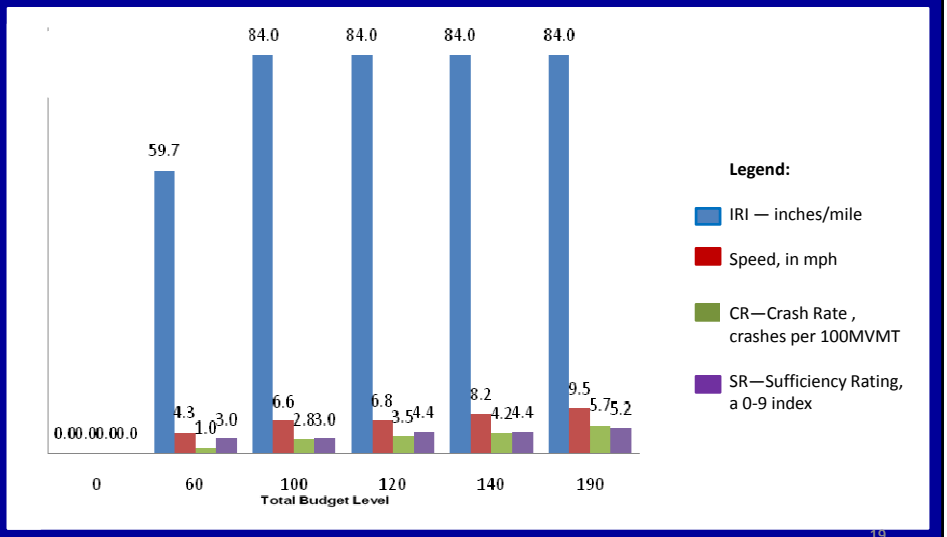
Tradeoff Analysis 1B: Change total budget levels and find out the influence on the CHANGE in values of performance measures



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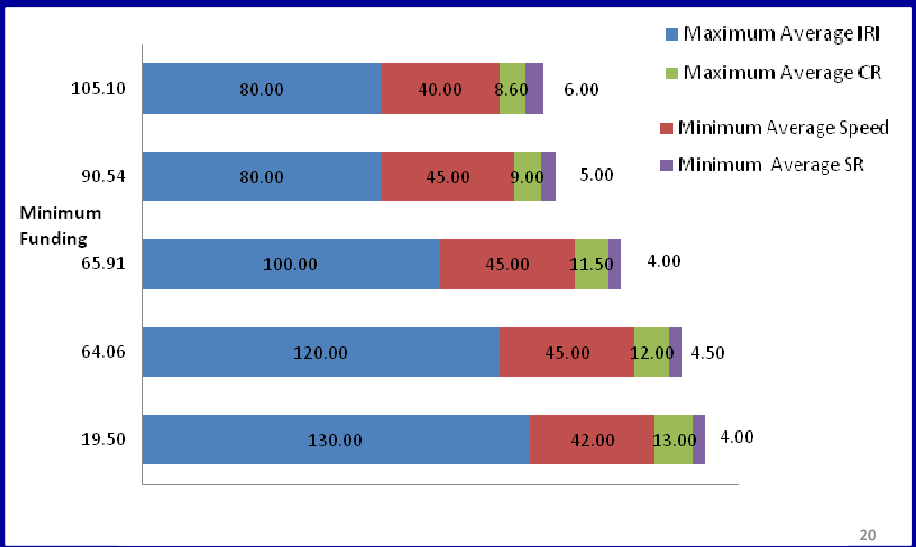
Tradeoff Analysis 2: INDOT wants to know the cost needed to meet its performance targets for pavement smoothness, safety, etc.



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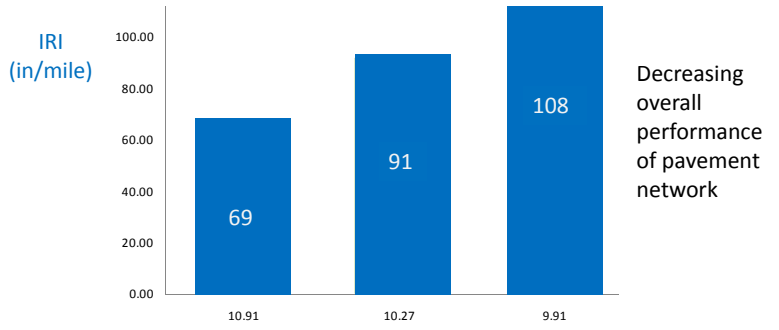
Tradeoff Analysis 3: INDOT wants to know how much of one performance measure can be sacrificed for a given amount of another (total budget is fixed)



Decreasing overall performance of pavement network

Specified Network Crash Thresholds (Avg Nr. of Crashes/100MVMT)

Increasing tightness of safety threshold

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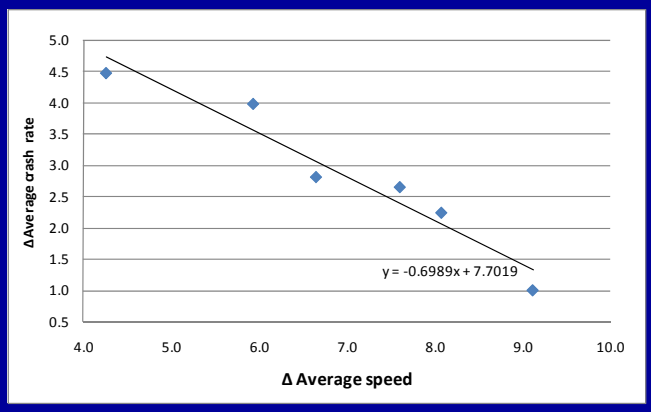
So, how much of one performance measure must INDOT "sell" in order to "buy" a certain amount of another performance measure



Gradient of line = Marginal Rate of Substitution = 0.6989 ≈ 0.7
Meaning: A decrease of 7 Crashes/100MVMT can "buy" a 10-mph speed increase

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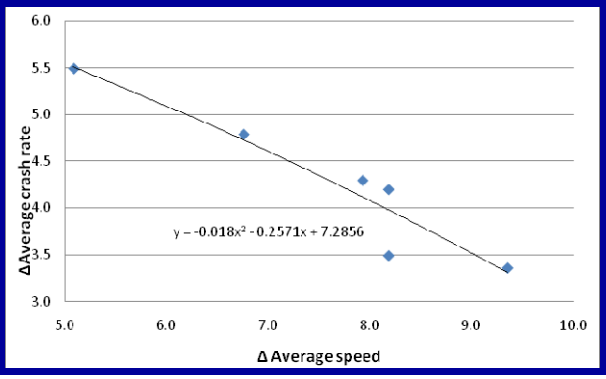
Tradeoff Analysis 4A: INDOT wants to know the PROS and CONS of shifting budget from one program are to another



Safety Budget ($M)	40	45	55	35	30	25
Congestion Budget ($M)	30	25	15	35	40	45
Δ Average speed (mile/hour)	8.1841	6.7571	5.0819	7.9299	8.1841	9.3569
ΔAverage crash rate (Crashes/100 million VMT)	4.1982	4.7862	5.4939	4.2942	3.4905	3.3603

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Implementation Suggestions

- **Decision support for Central Office or Districts:**
  - How to compare "apples and oranges" in order to select our projects fairly? Example: Do we do that safety project or that pavement project instead?
  - What will be consequences (performance impacts) for each funding level?
  - How much do we need to achieve a given network-level performance? For each district?
  - What will be the merits and demerits of shifting funds across program areas? Across districts?

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Implementation Suggestions (continued)

- Permit investigation of past trends in expenditure and performance:
  - Example: For each district, how much we spent on safety?
  - How much safety improvement was earned?
  - Is the trade-off value consistent across the districts?
  - Consistent across the years?

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Future Research in TAM

- TAM Trade-offs at Sphere 1 (Network-level trade-off analysis using network-level data)
- Extension to a multi-modal context
- Further investigation of past trends in expenditure and performance
- Enhanced mathematical formulations and solution algorithms to ensure quick analysis for large-sized problems
- Automate the AM decision-making and trade-off analysis processes

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