# The TAM Rule and Pavement Management

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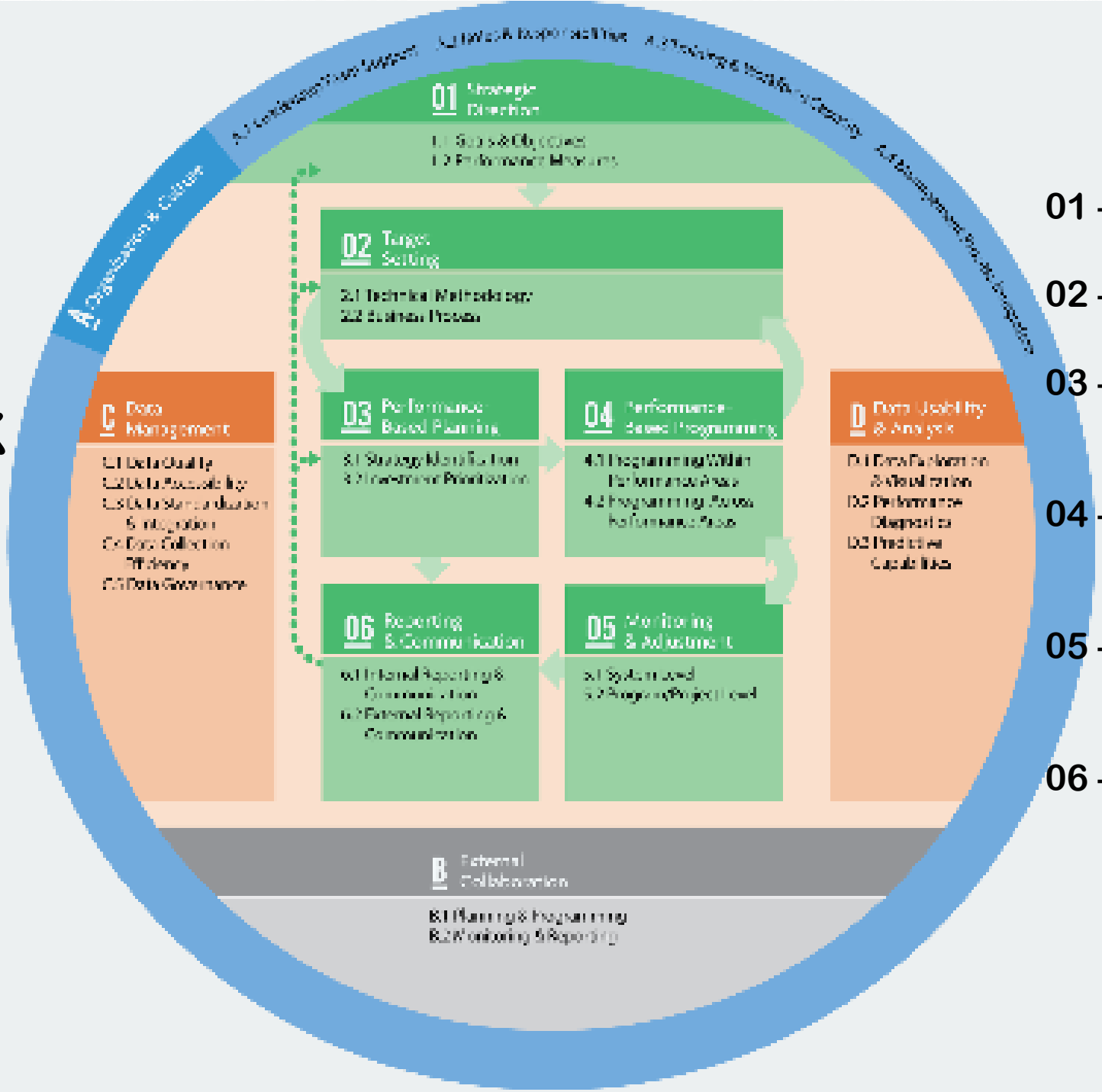
# TAMP

- The Transportation Asset Management rule in MAP-21 requires the development and implementation of a Transportation Asset Management Plan (TAMP) for highways, with two core assets required to be included:
- Bridges
- Pavements

# TAMP

- Plan has a 10-year horizon and must include performance targets for bridge and pavement national measures.

# TPM FRAMEWORK




01 – Strategic Direction

02 – Target Setting

03 – Performance-based planning

04 – Performance-based programming

05 – Monitoring and adjustment

06 – Reporting and communication

# Pavement target-setting

- Three key questions need to be answered to do this:
  - At what scale do we invest in pavements?
  - At what scale do we predict performance?
  - At what scale do we report performance?

# At what scale do we invest in pavements?

- **Set goals, conduct strategic analysis at the network and program level, but:**
- **Act on individual analysis units, or "sections," generally in the 0.5 to 5.0 mile range**
- **Not likely to change wholesale to a 0.10-mile basis**
  - User costs (delays) and project mobilization costs probably dwarf efficiency gains in conditions.

# At what scale do we predict performance?

- Option A:  At the program (network) level
- Option B:  At the section level
- Option C:  At the performance reporting interval level

# At what scale do we predict performance?

- Option A: At the program (network) level
- Option B: At the section level (CTDOT)
- Option C: At the performance reporting interval level

# At what scale do we measure and report performance?

- **HPMS basis, typically 0.10-mile segments.**
  - Will capture performance variability that is not captured in a measurement aggregated over the pavement management analysis units (sections.)

**KEY QUESTION**

How do we set performance targets that are accurately reflected in the measurements?

# Guiding principle 1

- **The Transportation Asset Management Plan (TAMP) is the basis for pavement investment**
  - Uses Pavement Management System
    - **Pavement Management System focuses on State of Good Repair**
  - Uses appropriate time horizon for pavement strategy development
  - Takes into consideration cross-asset resource allocation and constraints
  - Performance is a reflection (outcome) of the implementation of a TAMP

# Guiding principle 2

- **Pavement investments are made at the section (project) level**
  - Reflects current (and future) agency practice
  - Investing at 0.10-mile level not realistic
  - All program-scale investment needs to be translated into a candidate project list to relate to specific pavement performance
  - PMS uses project-level investments to optimize network outcomes

# Guiding principle 3

- **Investments during the performance period need to reflect reality (likelihood of those projects being completed)**
  - Performance will reflect actual projects being done within 4 years
  - Significant portion of 4-year program is probably in the delivery pipeline
    - **In particular, capital program and rehabilitation projects**
  - Need to reflect projects (pavement interventions) that do not follow PMS rules (i.e. worst-first, band-aid treatments)

# Guiding principle 4

- **Agency should be able to measure performance at the reporting interval and explain it in terms of its actions**
  - Should make the progress determination discussion about performance as much as possible (and as little about explaining uncertainty)

# Guiding principle 5

- **Agency needs to keep accounting of actions (projects)**
  - Things are likely to vary from expected value of future performance
  - Helps explain variation due to execution of projects that were not planned, and variation due to cancellation of projects that were planned
    - **Likely important in the progress determination step**

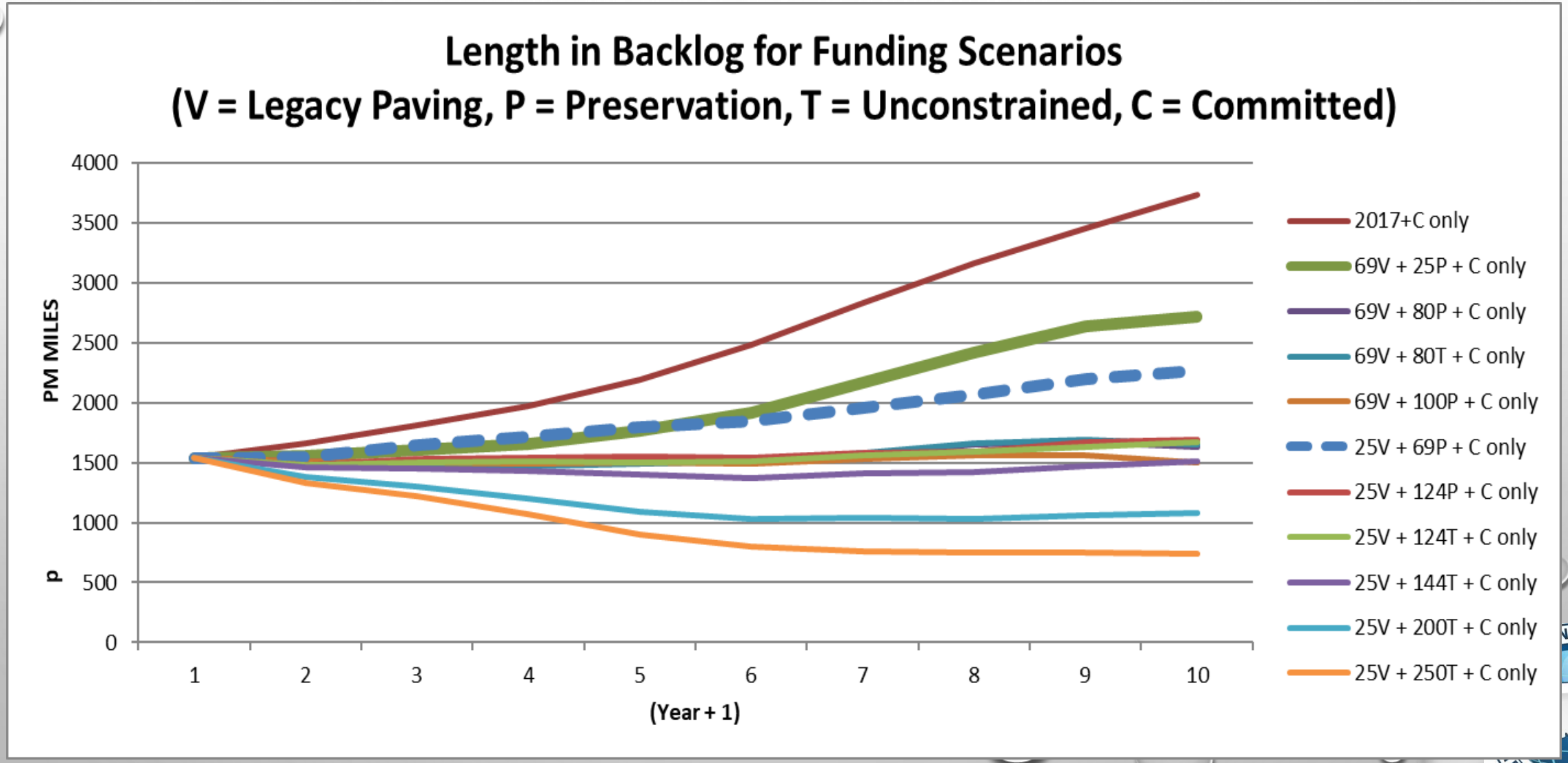
# Information needed to integrate pavement target setting with the TAMP

- Simulation of treatments that do not follow PMS rules (to reflect reality)
- List of projects in pipeline (10 years)
- Selected investment level (core TAM function)
- Pavement condition data in HPMS format

# Target-setting exercise

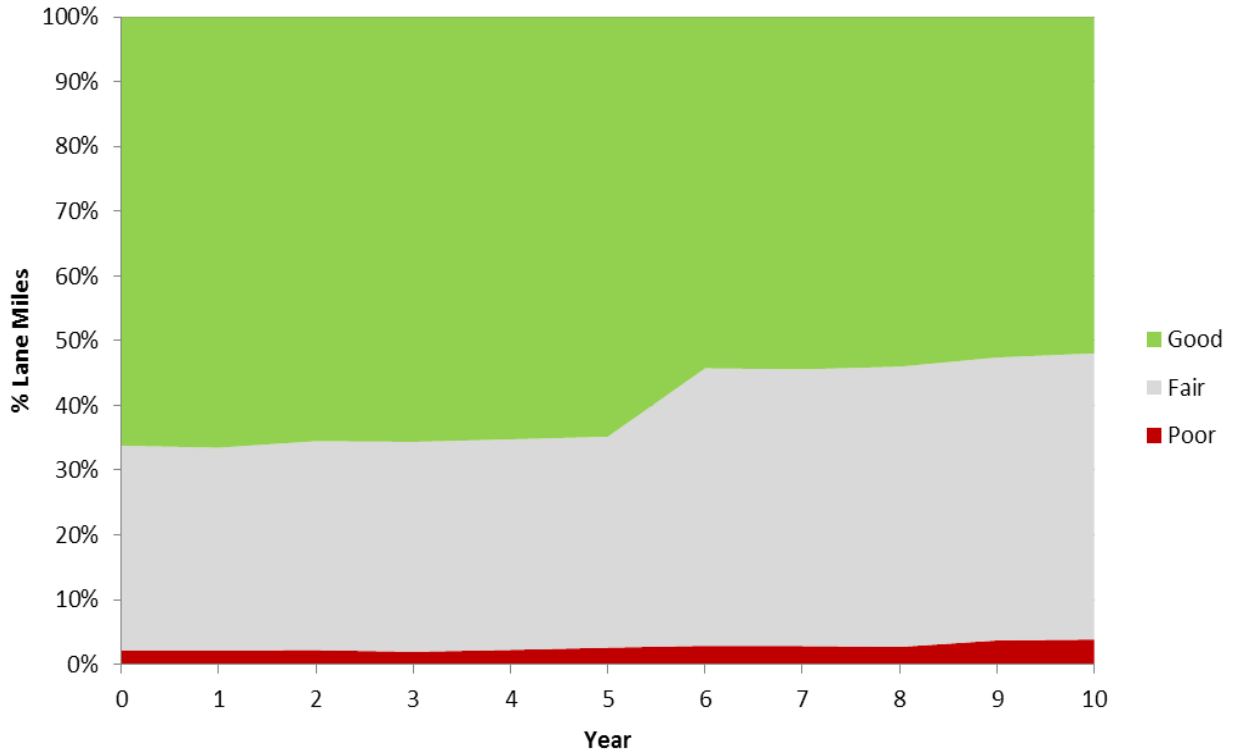
1. Strategic analysis using PMS to inform TAMP
2. Investment level decision made within the TAMP
   - This is the “real” target-setting exercise
   - Yields recommended program (including projects in the pipeline)
3. Performance predictions in terms of national measures
4. Assignment of “within-segment variability”
5. “Setting” of national performance targets

# Investment Level Selection



## Interstate Pavements: Lane Miles in Good/Fair/Poor condition

($25M VIP + $69M Preservation)

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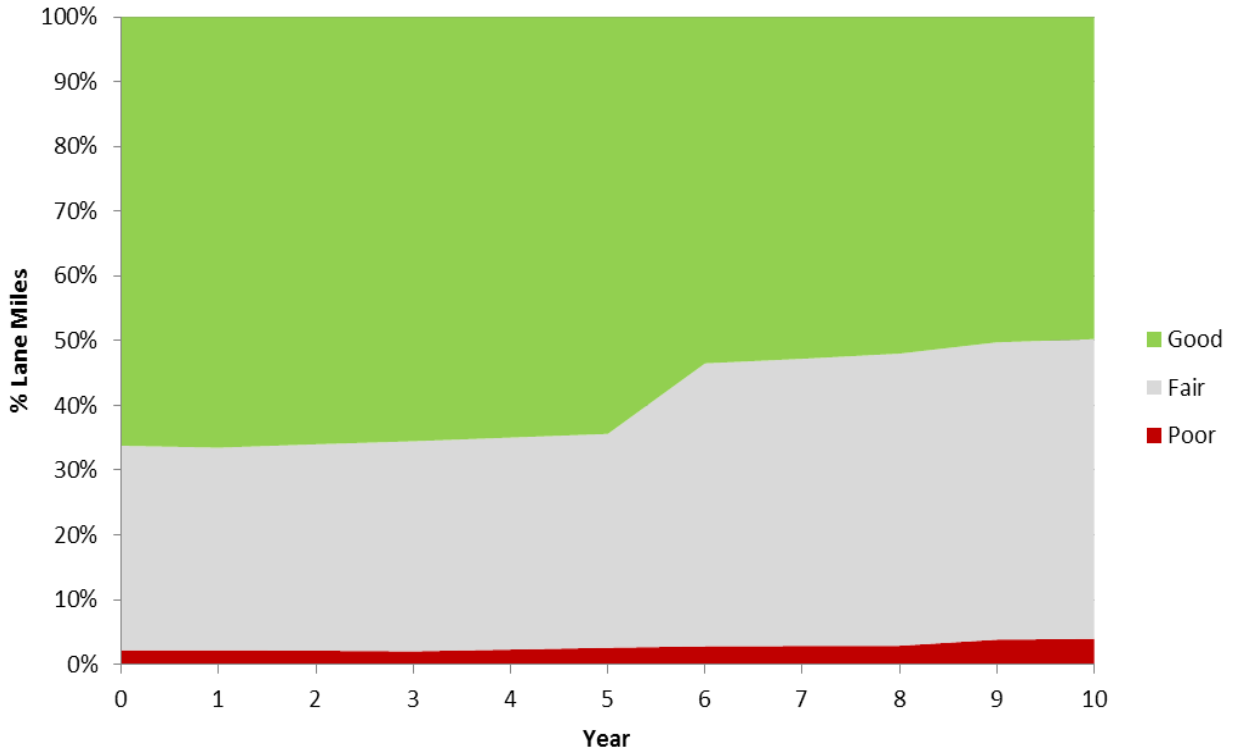

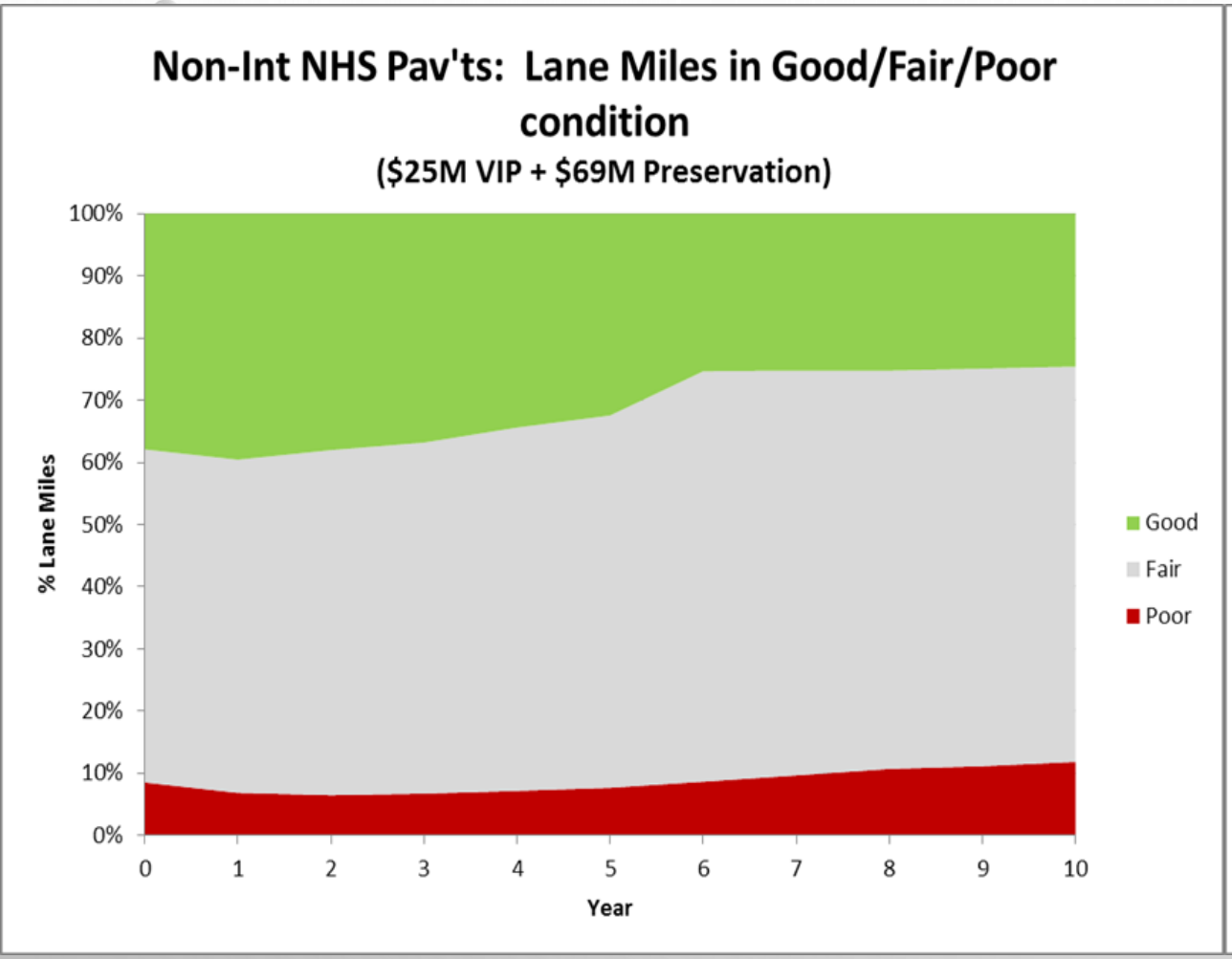
Non-Int NHS Pav'ts: Lane Miles in Good/Fair/Poor condition
($25M VIP + $69M Preservation)
% Lane Miles
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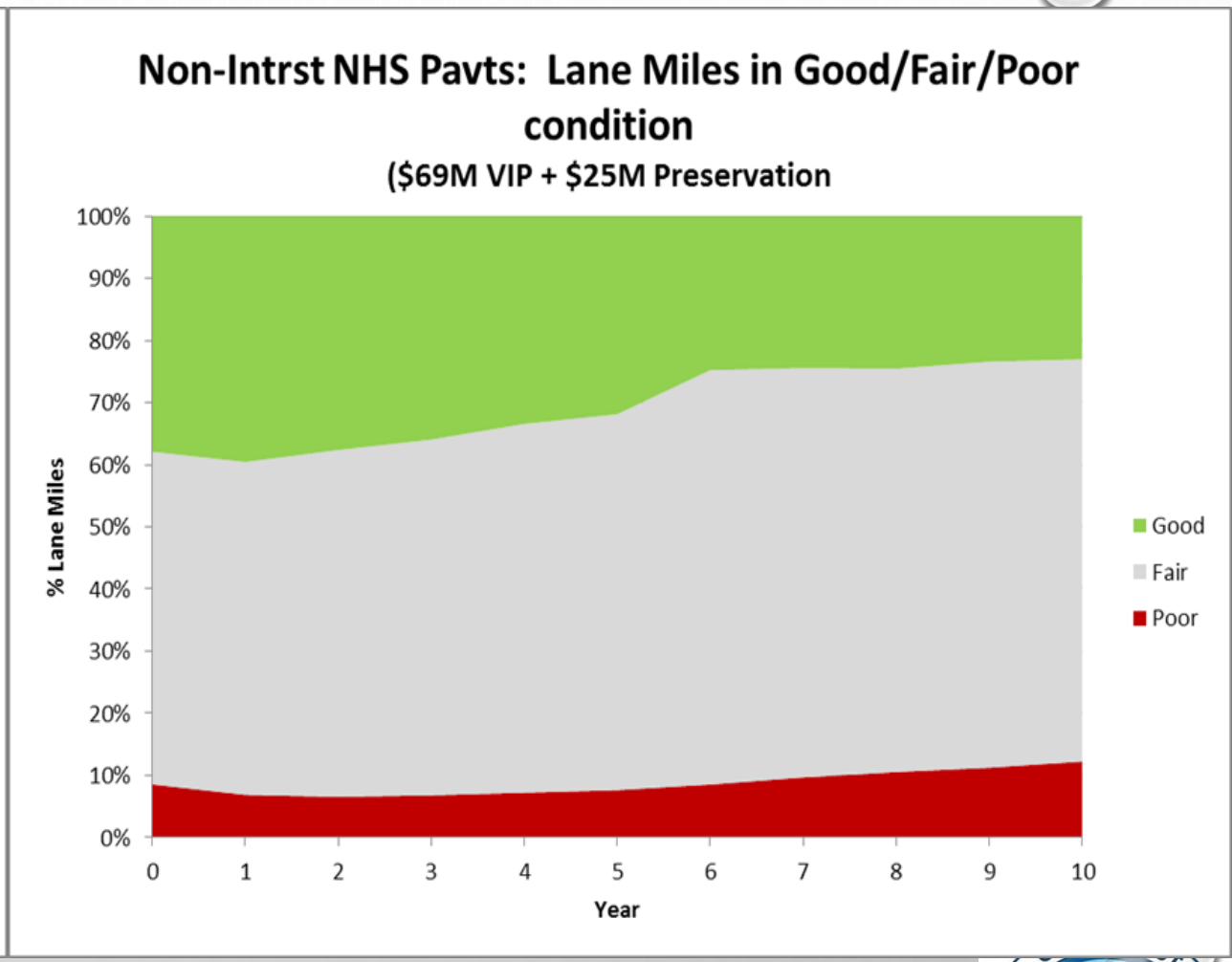
Good
Fair
Poor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# RSI as a Performance Measure

**Instead of "this is the current condition of pavement", RSI asks "what intervention is needed for this pavement".**

- Poor pavements are those that require reconstruction
- Good pavements are those that can be maintained with minimal maintenance (e.g., preservation)

| Good Condition | Fair Condition | Poor Condition |
|---|---|---|
| Do nothing or preservation as first treatment in a 10 year horizon | Light rehabilitation as first treatment in a 10 year horizon | Heavy rehabilitation or reconstruction as first treatment in a 10 year horizon |

# Example: HPMS (2012) and HERS Models

**To demonstrate performance measures:**

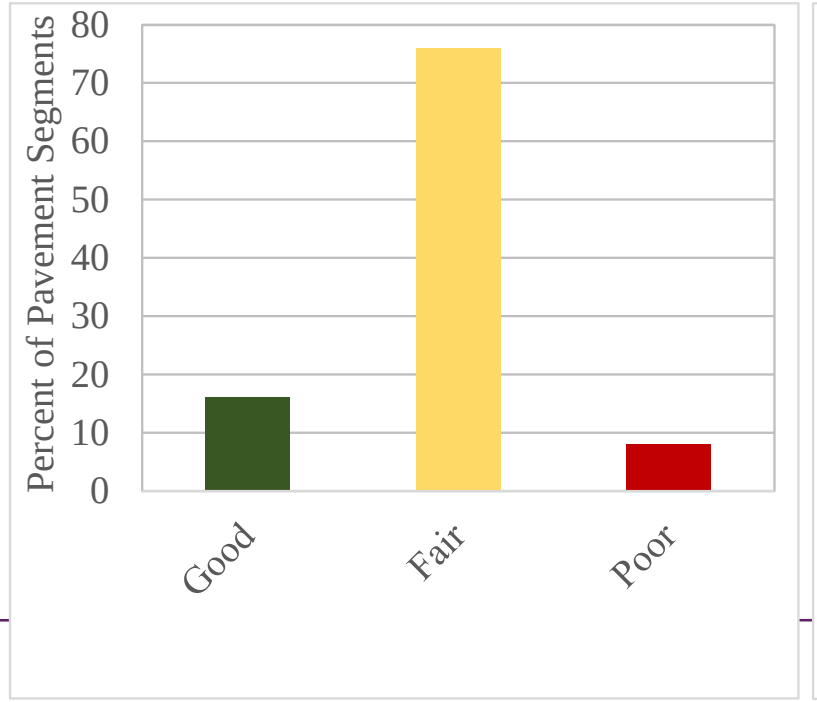
**calculated RSI and compared to NPRM Good-Fair-Poor**

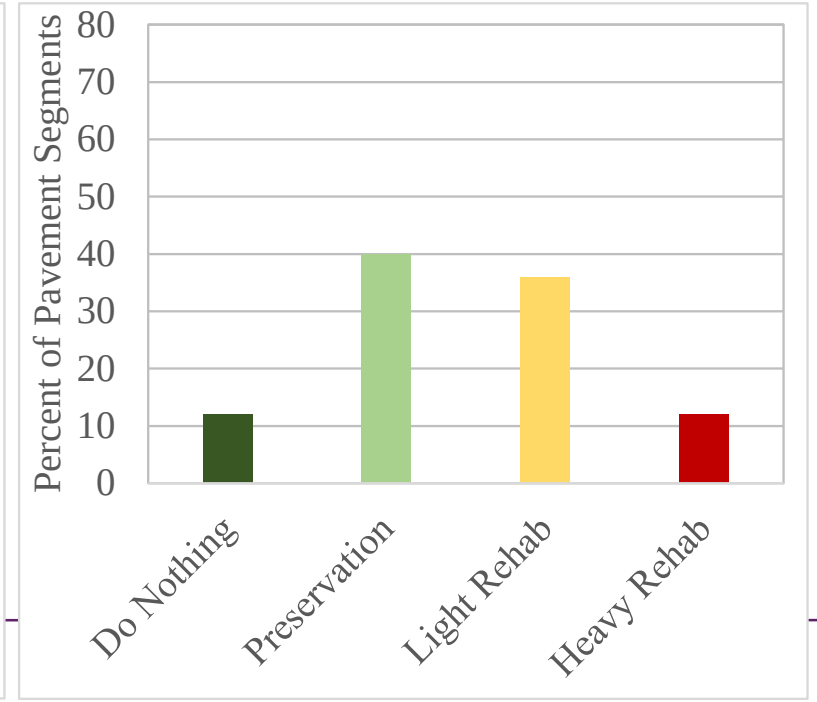
- **25 sites pseudo randomly selected**
- **HERS performance prediction models coded into Matlab™**

| | |
|---|---|
| **Do-Nothing**<br>• The IRI ≤ 170 in/mile for the 10 yrs.<br>• Rutting ≤ 0.2 inches.<br>• Fatigue cracking ≤ 10.<br>• Transverse cracking ≤ 50 per lane mile. | **Light Rehabilitation (e.g., 2.5" mill and overlay)**<br>• IRI exceeds 120 in/mile, but not 220 in/mile.<br>• Fatigue cracking exceeds 10 percent.<br>• Rutting exceeds 0.2 inches, but not 0.4 inches. |
| **Preservation (e.g., micro surfacing)**<br>• IRI less than 120 in/mile.<br>• Fatigue cracking less than 10 percent.<br>• Rutting less than 0.2 inches.<br>• Transverse cracking exceeds 50 per lane mile. | **Heavy Rehabilitation (e.g., work extends into base layer)**<br>• IRI exceeds 220 in/mile.<br>• Rutting exceeds 0.4 inches. |

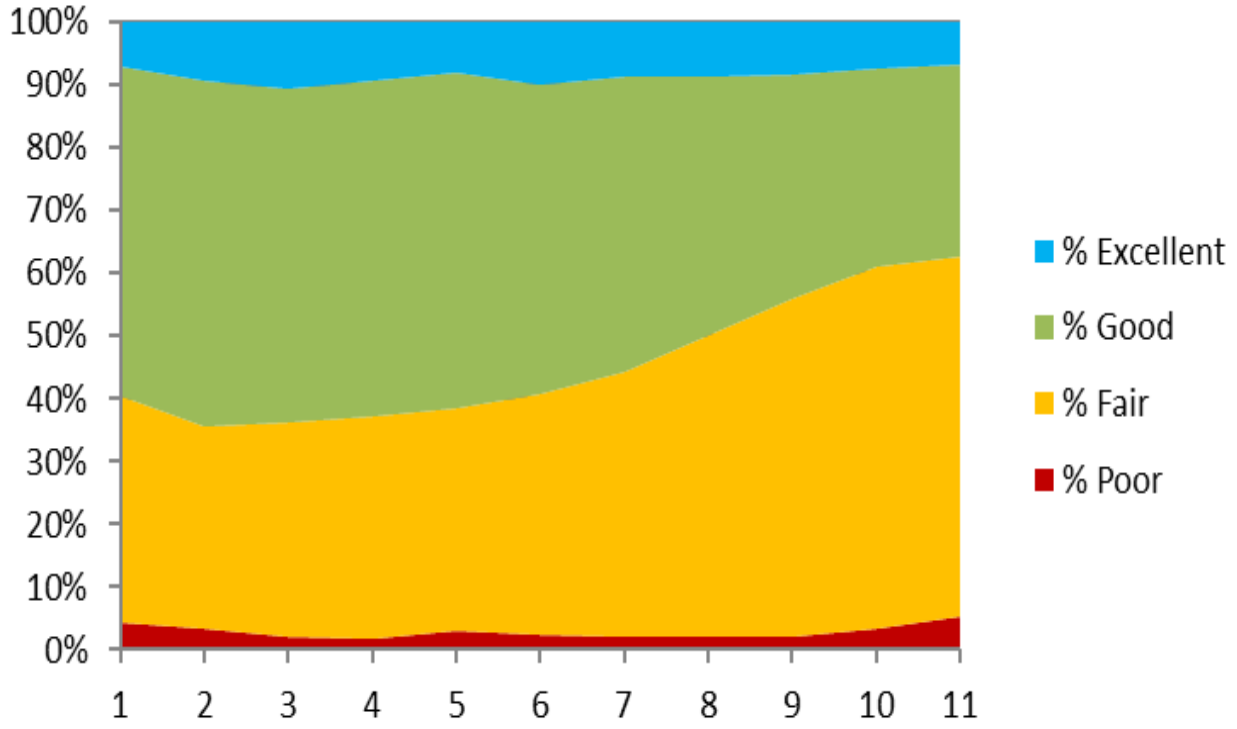
# Results

- **8% poor, corresponded to heavy rehab**
- **One fair segment needed heavy rehab**
- **‘Good’ pavements = ‘Do Nothing’ or ‘Preservation’**
  - One required light rehab, fatigue cracking increased rapidly

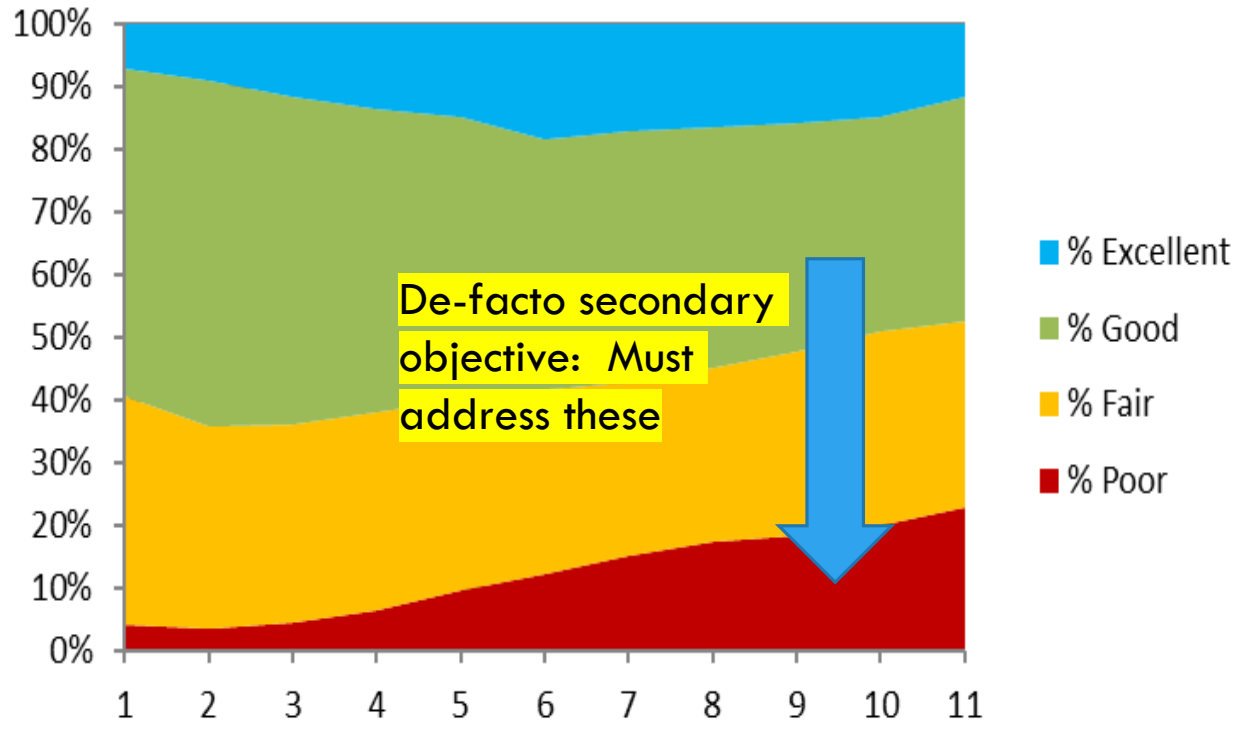


## Condition Distribution (69V,25P)




## Condition Distribution (25V, 69P)




**NOTE: THIS CONDITION DISTRIBUTION INCLUDES INCLUDES NON-NHS HIGHWAYS)**

# Convert section-level predictions to 0.10-mile predictions

- **Deal with the Aggregation Problem**

  *"In its most general form the aggregation problem can be defined as the information loss which occurs in the substitution of aggregate, or macrolevel, data for individual, or microlevel, data."*

  W. A. V. Clark and Karen L. Avery, "The Effects of Data Aggregation in Statistical Analysis," Geographical Analysis, Vol. VIII (October 1976)

- **In pavements, deal with "within-segment variability" in section-level predictions**

# What information is lost?

- **Within segment-variability**

| 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | | Segment: 1.0 miles |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Good | Good | Good | Good | Good | Good | Good | Good | Good | Good | | Good |

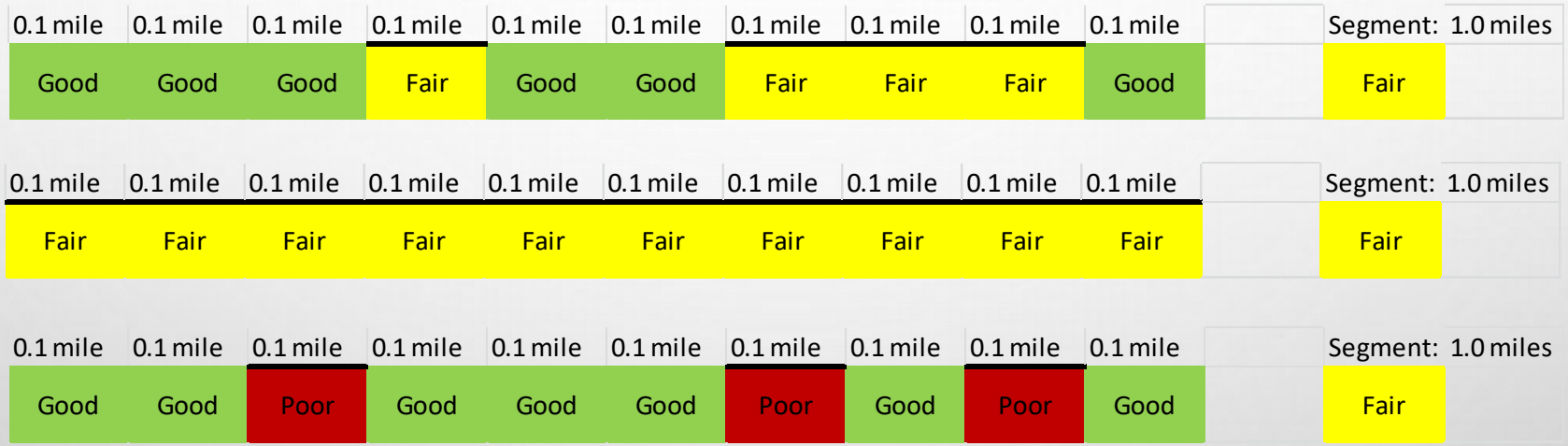
| 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | | Segment: 1.0 miles |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Good | Good | Good | Good | Good | Good | Good | Good | Fair | Good | | Good |

| 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | 0.1 mile | | Segment: 1.0 miles |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Good | Good | Good | Good | Good | Good | Fair | Fair | Fair | Good | | Good |

| Case | Length Good | Length Fair | Length Poor |
|---|---|---|---|
| A | 1.00 miles | 0.00 miles | 0.00 miles |
| B | 0.90 miles | 0.10 miles | 0.00 miles |
| C | 0.70 miles | 0.30 miles | 0.00 miles |

# What information is lost?

- **Within segment-variability**




| Case | Length "Good" | Length "Fair" | Length "Poor" |
|---|---|---|---|
| D | 0.60 miles | 0.40 miles | 0.00 miles |
| E | 0.00 miles | 1.00 miles | 0.00 miles |
| F | 0.70 miles | 0.00 miles | 0.30 miles |

# Solving the Aggregation problem (first cut)

- **Assigned Good/Fair/Poor distribution within a segment based on measurements of similar in-place pavement sections**
- **Used a lookup table from measured data**
  - Measured within-segment variability for various pavement families in existence: Surface Age, Pavement Type, Functional Class
    - **The family definition should be that which is relevant to each agency and could be replaced by single-segment performance measurements if PMS is set up that way**

# Example of assignment of performance variability

| Pavement "Family" Pavement type, Functional Class | Overall Condition (as per MAP-21) | Surface Age | % Good | % Fair | % Poor |
|---|---|---|---|---|---|
| Flexible F.C. 2 | Good | 0-3 years | 0.95 | 0.05 | 0 |
| | | 4-9 years | 0.82 | 0.15 | 0.03 |
| | | 10+ years | 0.65 | 0.27 | 0.08 |

# Example of assignment of performance variability

| Pavement "Family" Pavement type, Functional Class | Overall Condition (as per MAP-21) | Surface Age | % Good | % Fair | % Poor |
|---|---|---|---|---|---|
| Flexible F.C. 2 | Fair | 0-3 years | 0.45 | 0.50 | 0.05 |
| | | 4-9 years | 0.26 | 0.63 | 0.11 |
| | | 10+ years | 0.13 | 0.69 | 0.18 |

# Issues encountered

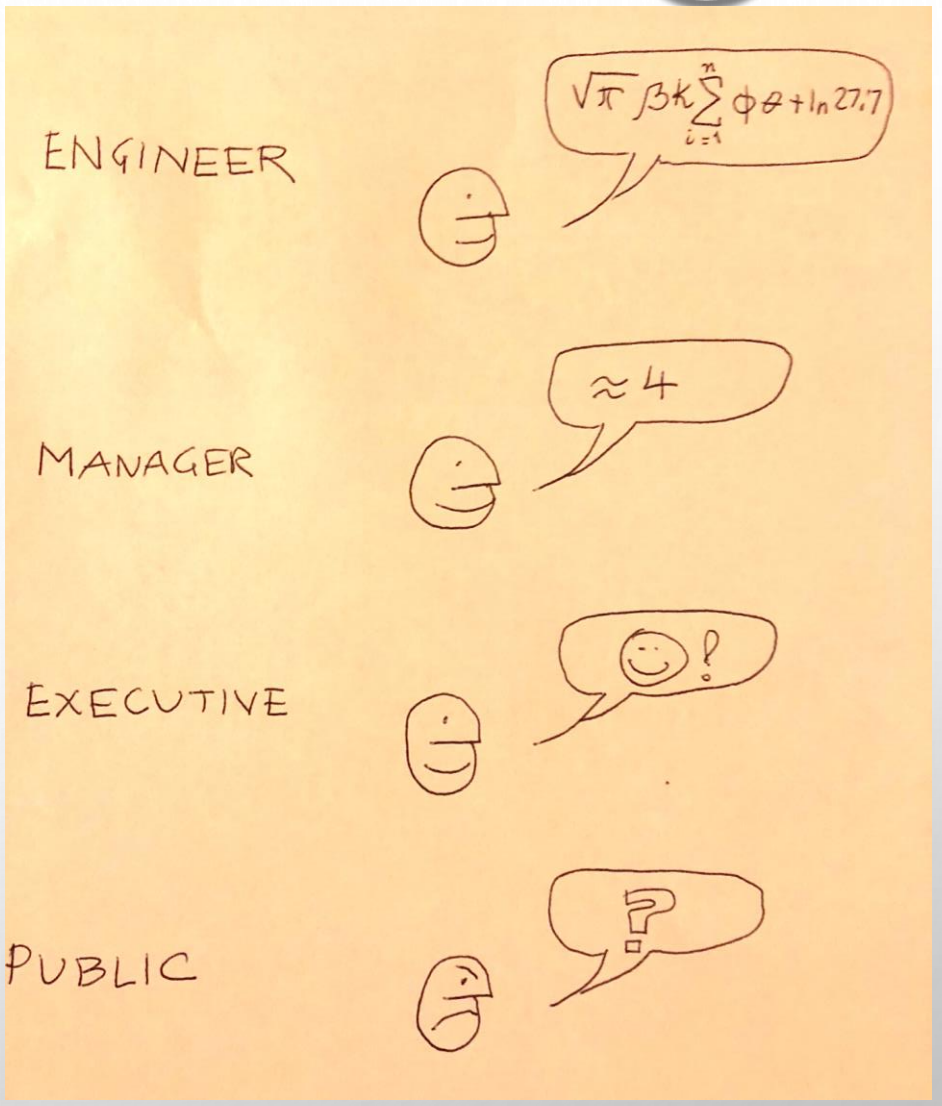
- **Having sufficient data to reliably assign "condition distribution" to 0.10-mile segments from the pavement sections**
  - Using measured data can, for example, lead to higher expected % poor for higher investments if insufficient data are available.
- **Preference for not introducing prediction error wherever possible**
  - Instead, measure (or account for) variability

# Dealing with the Aggregation Problem (next generation)

- **Find ways to avoid having to do this**
- **Expand PMS capability to conduct strategic analysis using actions on analysis units (sections) and have those actions be reflected in 0.10-mile segments.**
  - Take the list of projects (including multiple treatments) and apply as a fixed program to the 0.10-mile segments, including multiple treatments

# Communicating target-setting

- Target-setting methodology (maturity)
- Top risks in adopting the target
- Confidence in achieving target



# Target-Setting Maturity Model

4. **Systems approach**

Systems techniques (simulation, system dynamics) & cause-effect relationship

3. **Forecasting model**

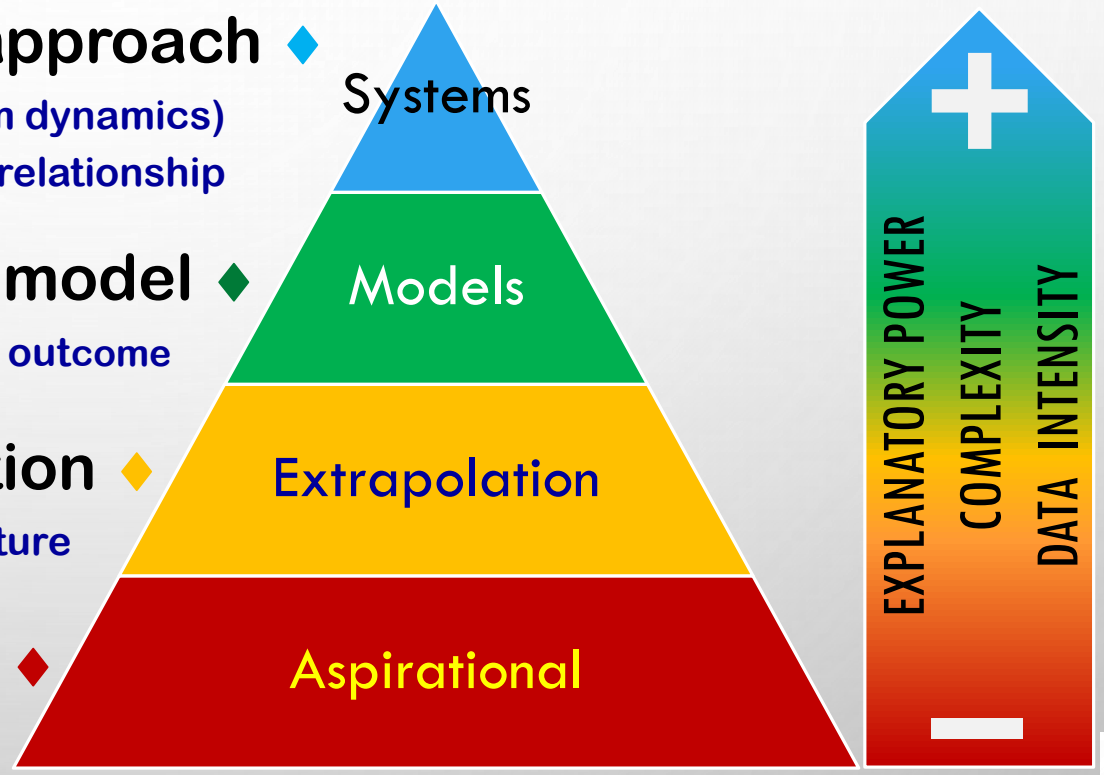
Include explanatory variables/covariates in a model, forecast outcome

2. **Extrapolation**

Use historical time series and extend into future

1. **Aspirational**

Target based on desired outcome, little data used



# Risks

- Where are our headaches going to come from?
  - Insufficient investment → declining targets
  - Abstract target definitions
  - Perception (headlines)
- We should have a strategy to address the risks
  - Develop a communications strategy (telling our story first)

# Confidence

- **Are we confident we achieve the targets?**

  Confidence is higher with:

  - **More and better data**
  - **Better understanding, more powerful models**
  - **Control over outcomes**

# Pavement Condition Measures

- % of Interstate system in "Good" and "Poor" condition
  - **MAX % Poor (Interstates): 5%**
- % of National Highway System in "Good" and "Poor" condition

| Asset (unit of measure) | Current Condition (HPMS submittal 6/2017) | | 2-year targets (2020) | | 4-year targets (2022) | |
|---|---|---|---|---|---|---|
| | Good % | Poor % | Good % | Poor % | Good % | Poor % |
| **Interstate Pavement** (lane miles) | 66.2 | 2.2 | 65.5 | 2.0 **Better** | 64.4 | 2.6 |
| **Non-Interstate NHS Pavement** (lane miles) | 37.9 | 8.6 | 36.0 | 6.8 **Better** | 31.9 | 7.6 |

| MATURITY | TOP RISK(S) | CONFIDENCE |
|---|---|---|
| Forecasting/Systems 3.5 | 1. Budgetary uncertainty<br>2. State of Good Repair definition is not captured well<br>3. Declining targets need to be communicated properly | High |

# System Reliability Measures

- % person-miles of Interstate that are "reliable"
- % person-miles of non-Interstate NHS that are "reliable"

| System (unit of measure) | Current Condition | 2-year targets (2020) | 4-year targets (2022) |
|---|---|---|---|
| | Reliable % | Reliable % | Reliable % |
| **Interstate** (person-miles) | 78.3 | 75.2 | 72.1 |
| **Non-Interstate NHS** (person-miles) | 83.6 | 80.0 | 76.4 |

*Reliability declines in all cases*

| MATURITY | TOP RISK(S) | CONFIDENCE |
|---|---|---|
| Aspirational/ Extrapolation 1.5 | 1. Reliability definition new, abstract, and may not capture individual user experience<br>2. Outcomes subject to external factors<br>3. Worsening reliability has to be communicated | Low |