The National Academies of
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TRANSPORTATION RESEARCH BOARD

Not Your Average Analysis: Introducing Travel Time Reliability in the HCM

Thursday, August 22, 2019
1:00-2:30 PM ET

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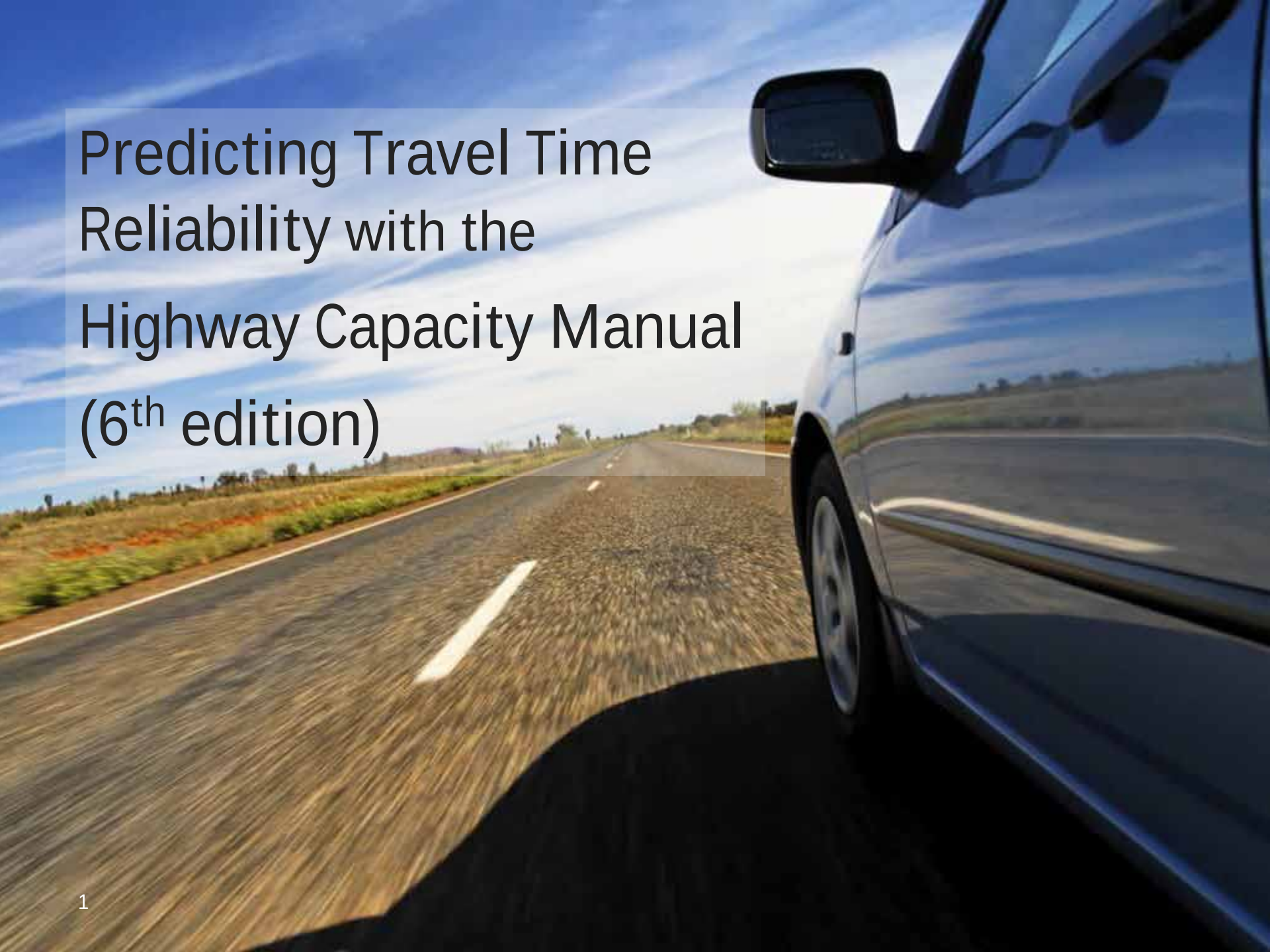
Purpose

To discuss travel time reliability estimation methods in the Highway Capacity Manual (HCM), Sixth Edition: A Guide for Multimodal Mobility Analysis.

Learning Objectives

At the end of this webinar, you will be able to:

- Apply travel time reliability methods


Predicting Travel Time Reliability with the Highway Capacity Manual (6th edition)

Learning Outcomes

- Understand the unique capabilities of the HCM methods in predicting reliability
- Learn, at a high level, about the steps in the HCM reliability method
- Learn about the ability of the HCM to predict the impacts of various non-recurring sources of congestion on performance
- Understand the ability of HCM methods to predict the benefits of traffic operations measures to improve reliability

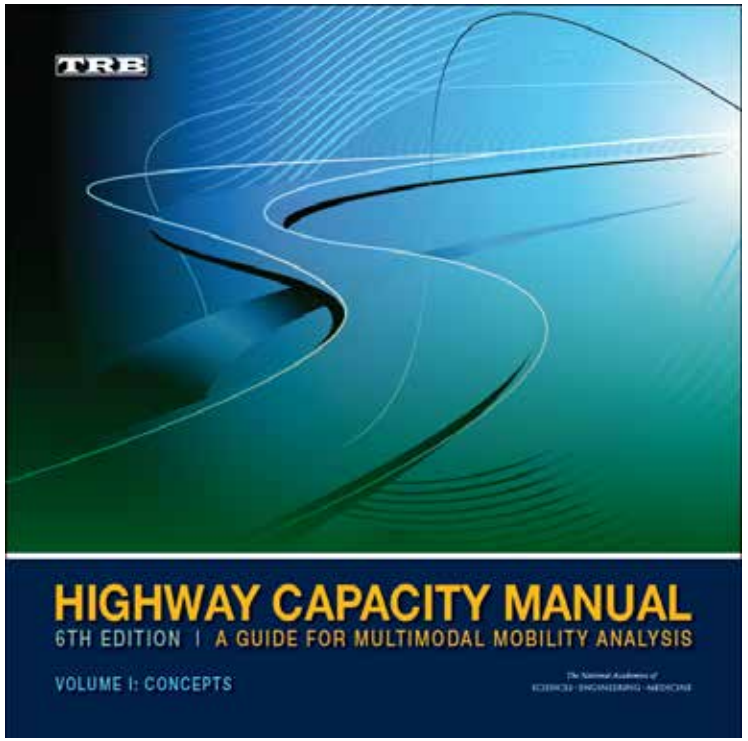
Presenters

- Richard Dowling, PE, Ph.D.
  - Senior Principal, Kittelson & Associates, Inc.
  - Past Chair, TRB Highway Capacity & QOS Committee
  - Key contributor to HCM Reliability methodology

- Tyrone Scorsone
  - Associate Planner, Kittelson & Associates, Inc.
  - Past member, TRB Highway Capacity Committee
  - Contributor to HCM reliability methodology

Presentation Overview

- Introduction to Reliability Analysis
- Overview of the HCM Reliability Method
- Applying the HCM method
- Summary




INTRODUCTION TO
RELIABILITY ANALYSIS

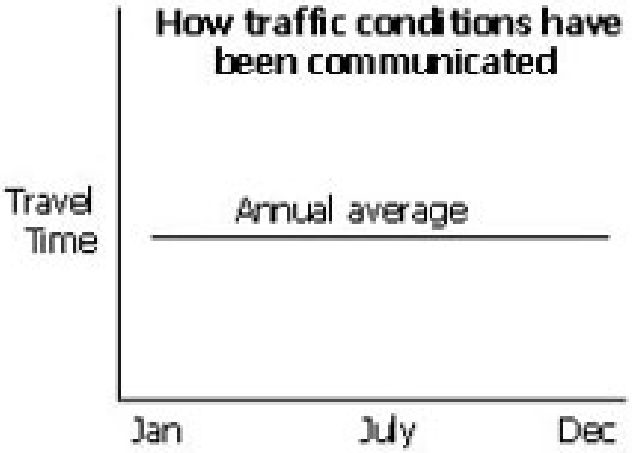
What is Travel Time Reliability

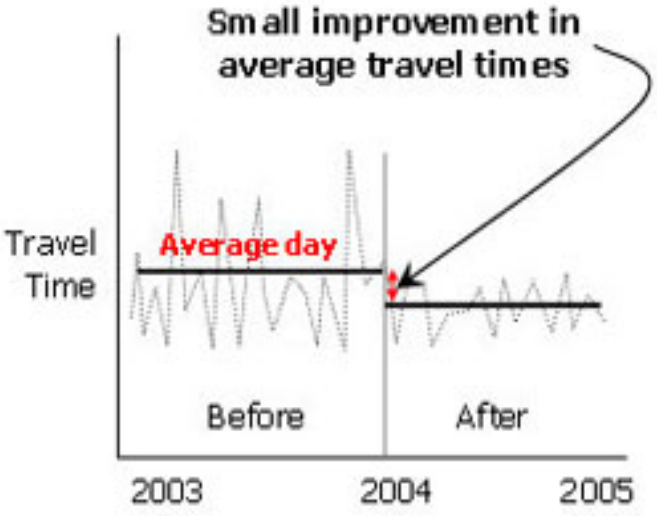
A measure of the likelihood that you will be on time, could be presented through:

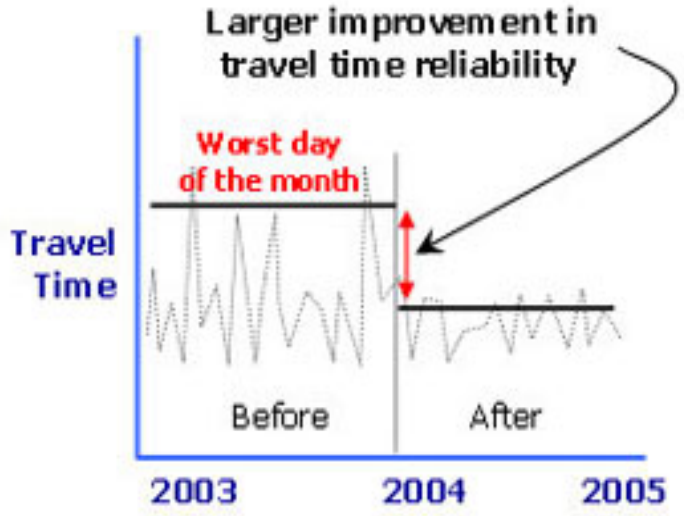
1. Percent of trips achieving an identified travel time/speed
2. Ratio of the average conditions to the worst weekly mobility conditions (80^{th} percentile)
3. Ratio of the free flow conditions to worst monthly mobility conditions (95^{th} percentile)

WHY DO WE ANALYZE THE AVERAGE DAY?

Reliability and Active Traffic Management in the HCM







Source: FHWA

Why go to the trouble of evaluating reliability?

- Reliability opens up a whole new world of options for addressing congestion problems.
  - Transportation System Management and Operation Strategies (TSM&O).
  - If you can't solve a capacity problem the traditional way with more lanes, at least with TSM&O you can:
    - Identify highly cost-effective solutions you can implement in the short term.
    - Squeeze a few more years of service life out of your facility, by increasing whole-year throughput efficiency of your facility.

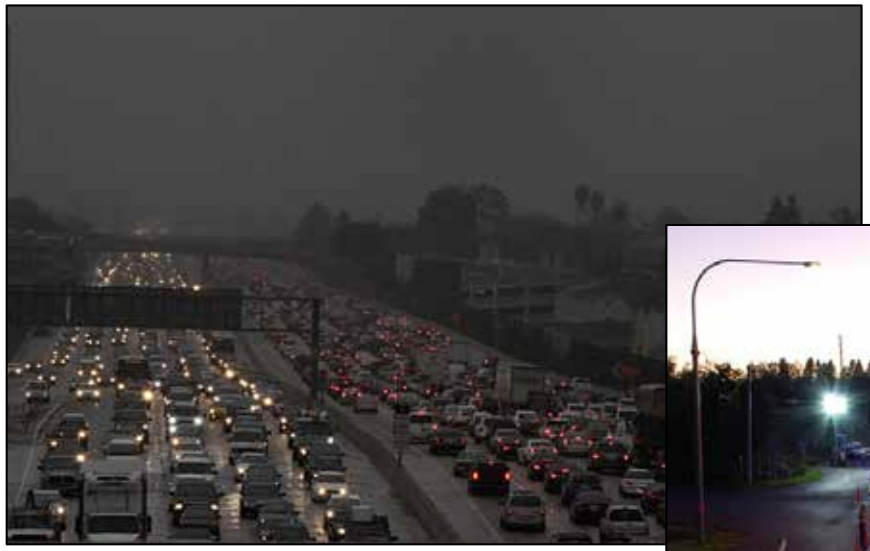
FHWA Reliability Monitoring Requirements

- 2015 FAST Act required FHWA to establish performance monitoring requirements.
- In 2017 FHWA published 23 CFR Part 490: National Performance Management Measures for NHS and Interstate highway system.
  - Includes reliability measures
  - The question: Will the agency's capital improvement program help or hinder it in achieving its performance objectives?

Two Reasons for Considering Reliability

- It's a good idea. It increases the range of solutions available to planners and engineers.
- We will have to anyway. We will have to monitor reliability to comply with the FAST Act.

Factors Influencing Reliability



Reliability Analysis in the HCM

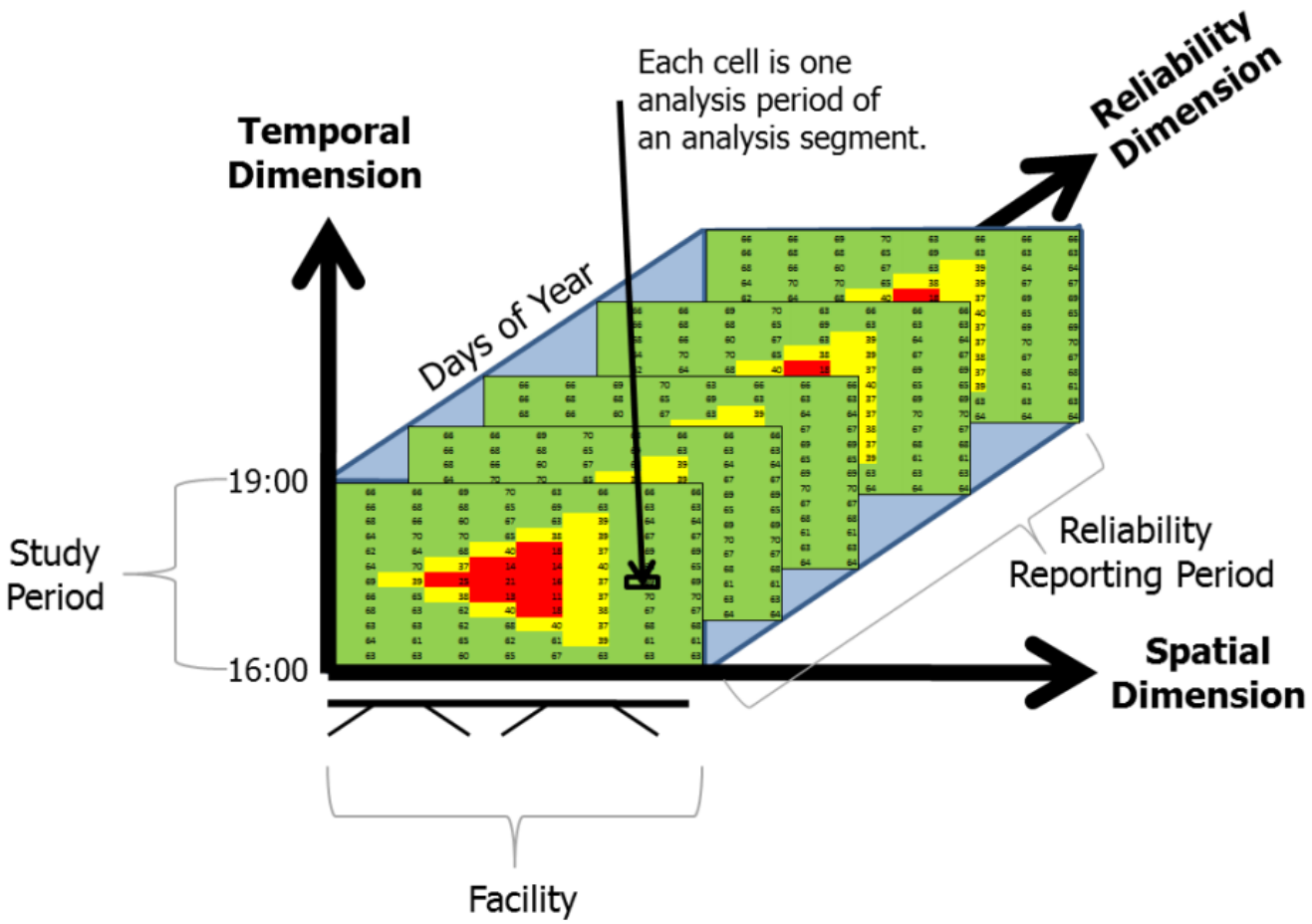
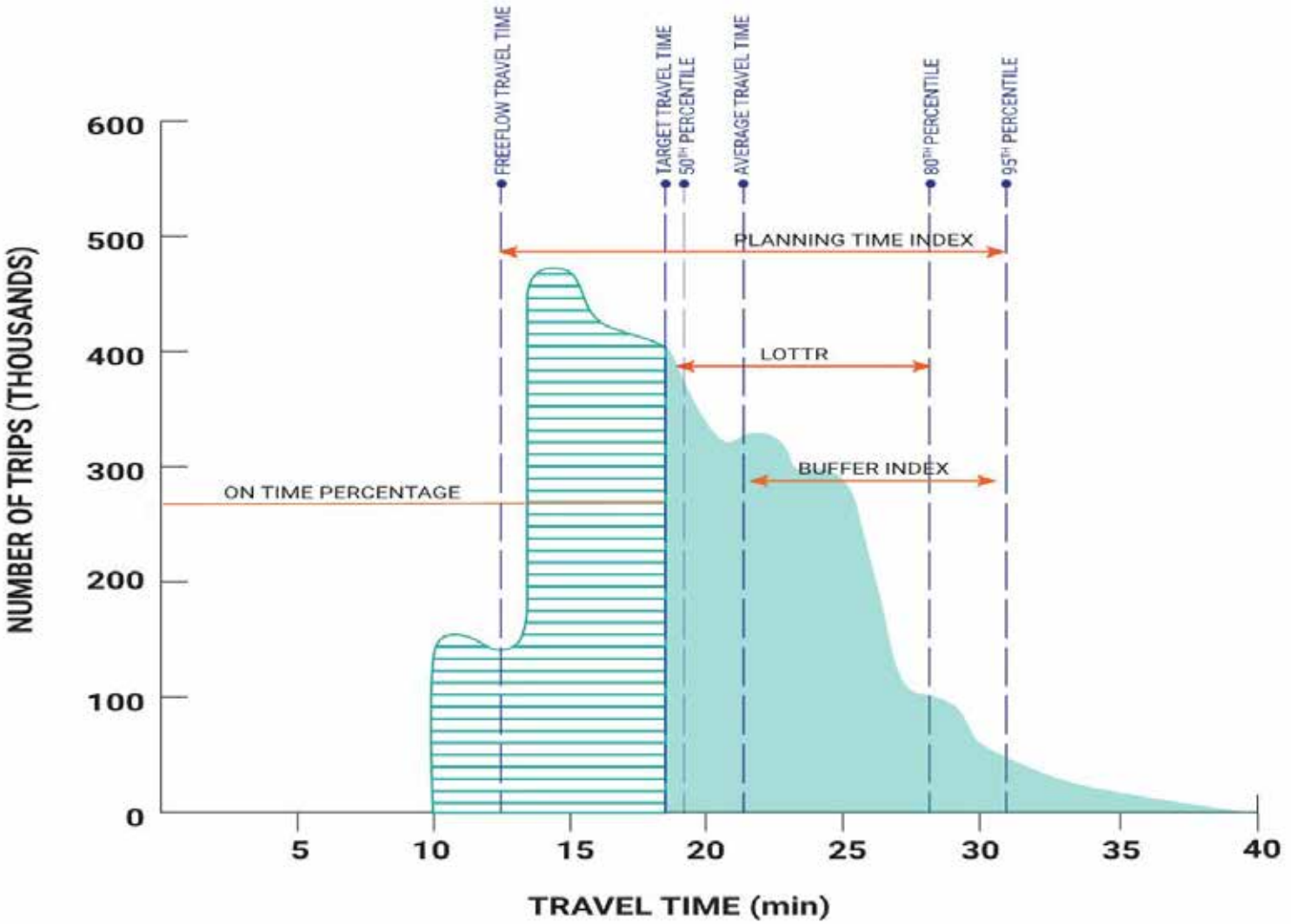
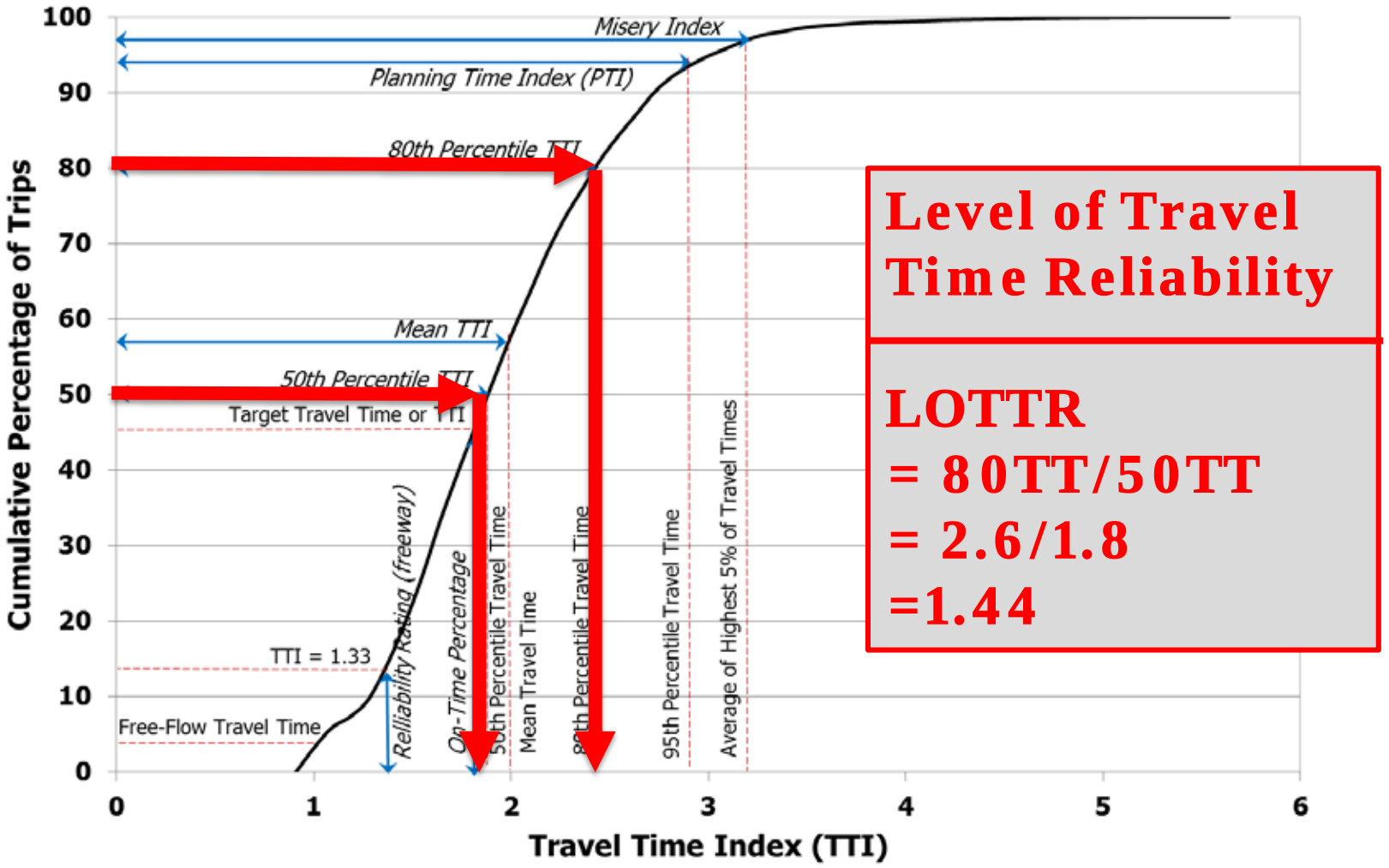


Exhibit 11-1
Schematic Representation of Freeway Reliability Analysis Time–Space Domain

Generating the Travel Time Distribution for Reliability Analysis



Reliability Performance Measure Examples



Level of Travel Time Reliability

LOTTR
= 80TT/50TT
= 2.6/1.8
=1.44

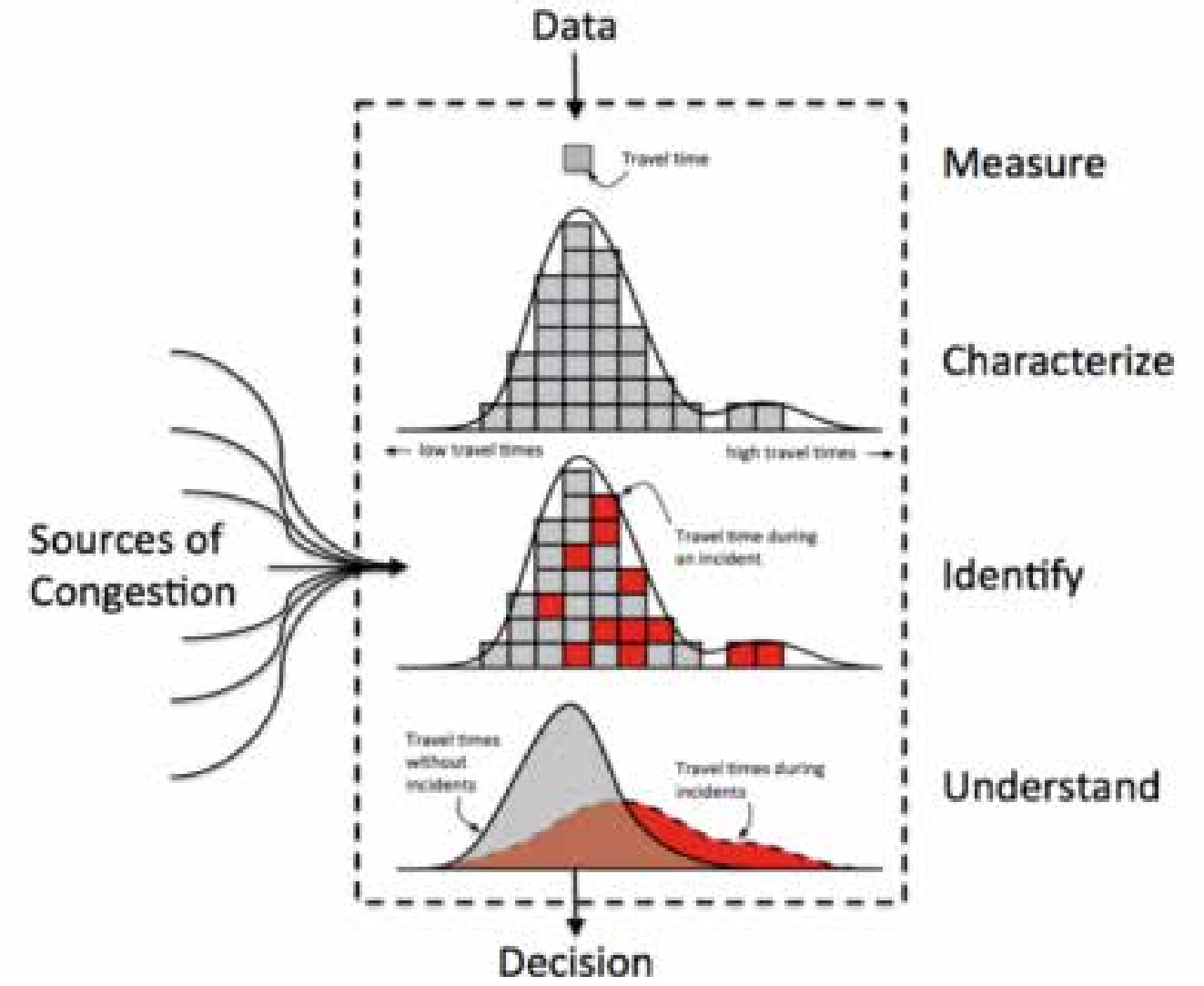
A Measure of Effectiveness

Exhibit 37-1
Freeway Ramp Metering, SR-94, Lemon Grove, California

Exhibit 37-2
Minnesota Dynamic Pricing for HOT Lanes

Exhibit 37-5
Variable Speed Limit Signs, Rotterdam, The Netherlands

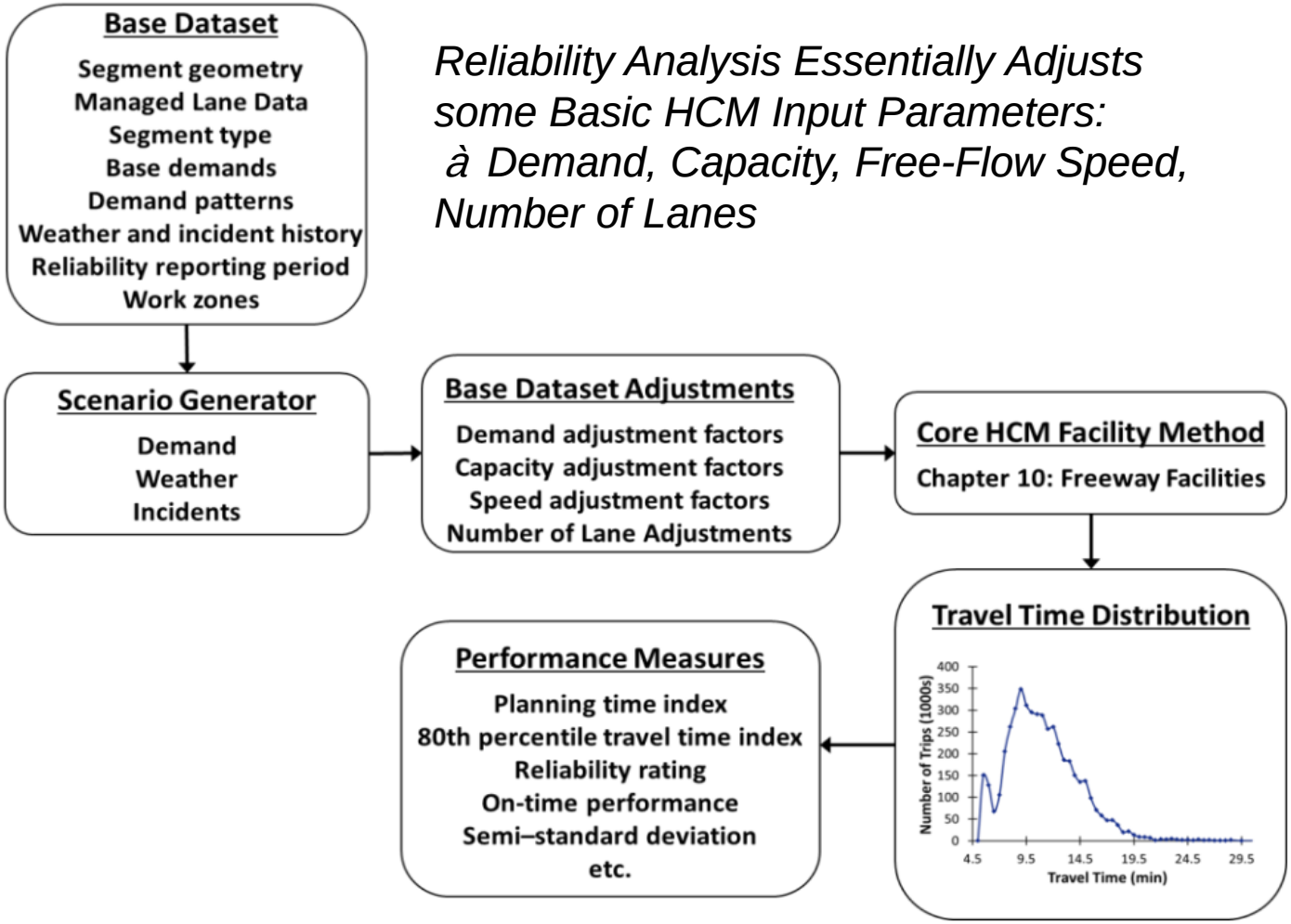
From Data to Decisions




OVERVIEW OF HCM
RELIABILITY METHOD

High Level View of Reliability Methodology in Chap. 11

Exhibit 11-7
Freeway Reliability Methodology Framework



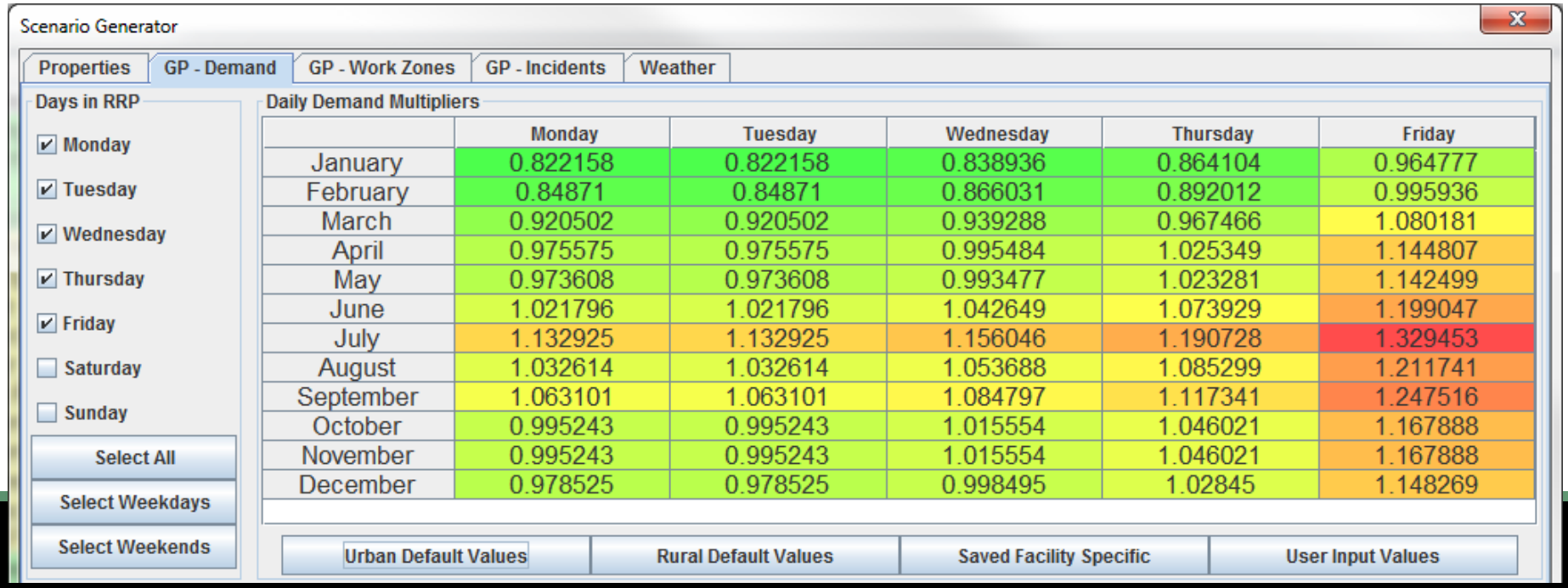
Reliability Analysis Essentially Adjusts some Basic HCM Input Parameters:
à Demand, Capacity, Free-Flow Speed, Number of Lanes

Considered Recurring and Non-Recurring Sources of Congestion in HCM Reliability Analysis

- Recurring Sources
  - Traffic Demand Variations
- Non-Recurring Sources
  - Incidents (Crashes, Stalls, etc.)
  - Severe Weather Conditions
  - Work Zones
  - Demand Surges (special events)

Traffic Demand Variation

- Variation by day of the week (Mon – Sun) and month of year.
- Default patterns embedded into *the 6th edition of HCM* should facility specific data are not available
- Use of facility-specific demand data highly recommended



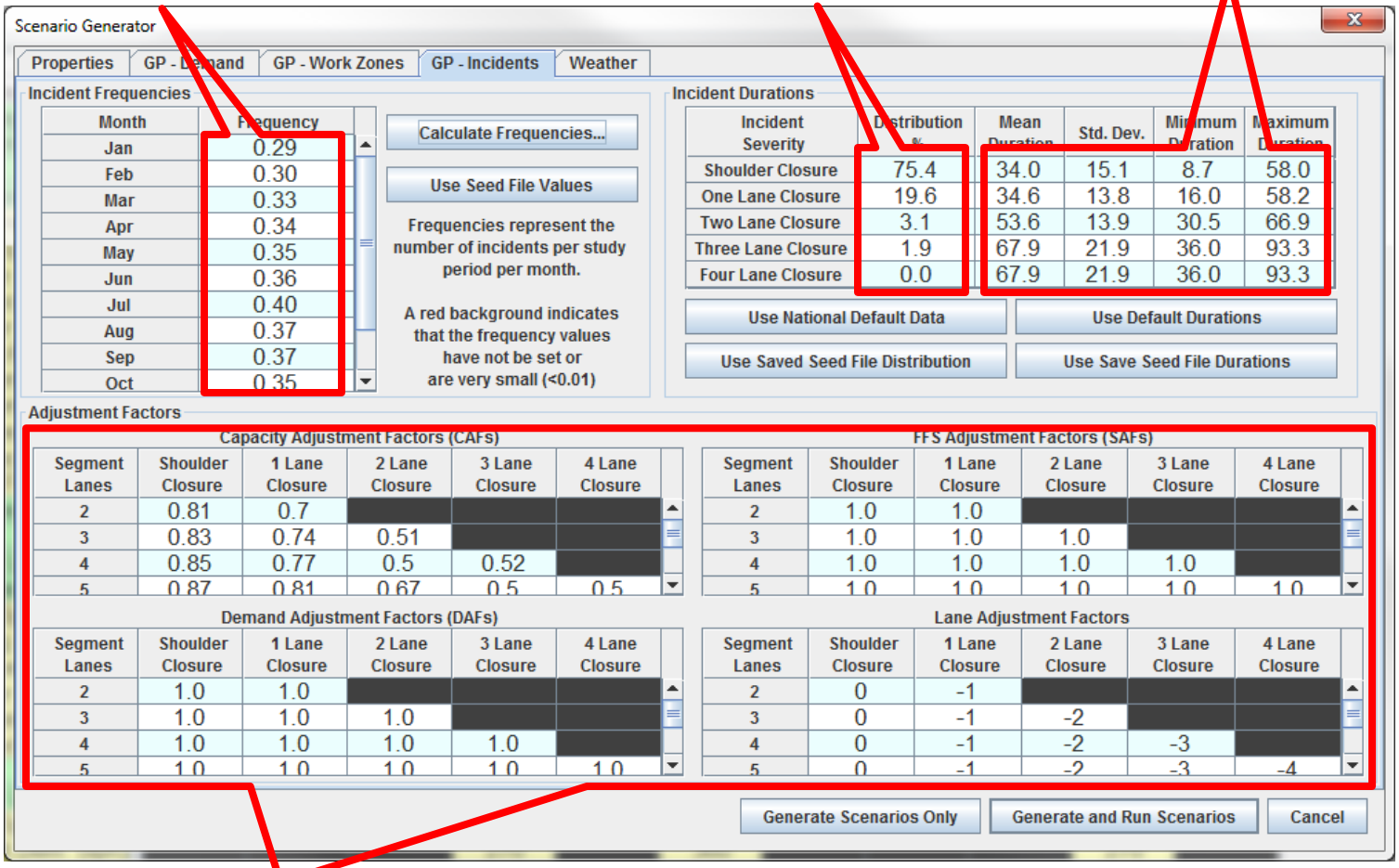
	Monday	Tuesday	Wednesday	Thursday	Friday
January	0.822158	0.822158	0.838936	0.864104	0.964777
February	0.84871	0.84871	0.866031	0.892012	0.995936
March	0.920502	0.920502	0.939288	0.967466	1.080181
April	0.975575	0.975575	0.995484	1.025349	1.144807
May	0.973608	0.973608	0.993477	1.023281	1.142499
June	1.021796	1.021796	1.042649	1.073929	1.199047
July	1.132925	1.132925	1.156046	1.190728	1.329453
August	1.032614	1.032614	1.053688	1.085299	1.211741
September	1.063101	1.063101	1.084797	1.117341	1.247516
October	0.995243	0.995243	1.015554	1.046021	1.167888
November	0.995243	0.995243	1.015554	1.046021	1.167888
December	0.978525	0.978525	0.998495	1.02845	1.148269

Reliability Incidents Parameters

Frequency of Incidents

Severity Distribution

Duration Distribution



Impact of Incidents on Capacity, Speed, and Demand

Charactarizing Inclement Weather Conditions

- Capacity and Free-Flow Speed Effects of Weather
- Defaults included in HCM6
- Weather Probabilities by Month of Year and Hour of Day
- Probabilities for the 96 largest metropolitan areas in the US are included in HCM 6th Edition computational engines

Impact of Severe Weather Conditions on HCM Parameters

Exhibit 11-20
Default CAFs by Weather Condition

Weather Type	Weather Event Definition	Capacity Adjustment Factors				
		55 mi/h	60 mi/h	65 mi/h	70 mi/h	75 mi/h
Medium rain	> 0.10-0.25 in/h	0.94	0.93	0.92	0.91	0.90
Heavy rain	> 0.25 in/h	0.89	0.88	0.86	0.84	0.82
Light snow	>0.00 – 0.05 in/h	0.97	0.96	0.96	0.95	0.95
Light–medium snow	>0.05 – 0.10 in/h	0.95	0.94	0.92	0.90	0.88
Medium–heavy snow	>0.10 – 0.50 in/h	0.93	0.91	0.90	0.88	0.87
Heavy snow	>0.50 in/h	0.80	0.78	0.76	0.74	0.72
Severe cold	<-4°F	0.93	0.92	0.92	0.91	0.90
Low visibility	0.50 – 0.99 mi	0.90	0.90	0.90	0.90	0.90
Very low visibility	0.25 – 0.49 mi	0.88	0.88	0.88	0.88	0.88
Minimal visibility	< 0.25 mi	0.90	0.90	0.90	0.90	0.90
Non–severe weather	All conditions not listed above	1.00	1.00	1.00	1.00	1.00

Source: Zegeer et al. (*1*).
Note: Speeds given in column heads are free-flow speeds.

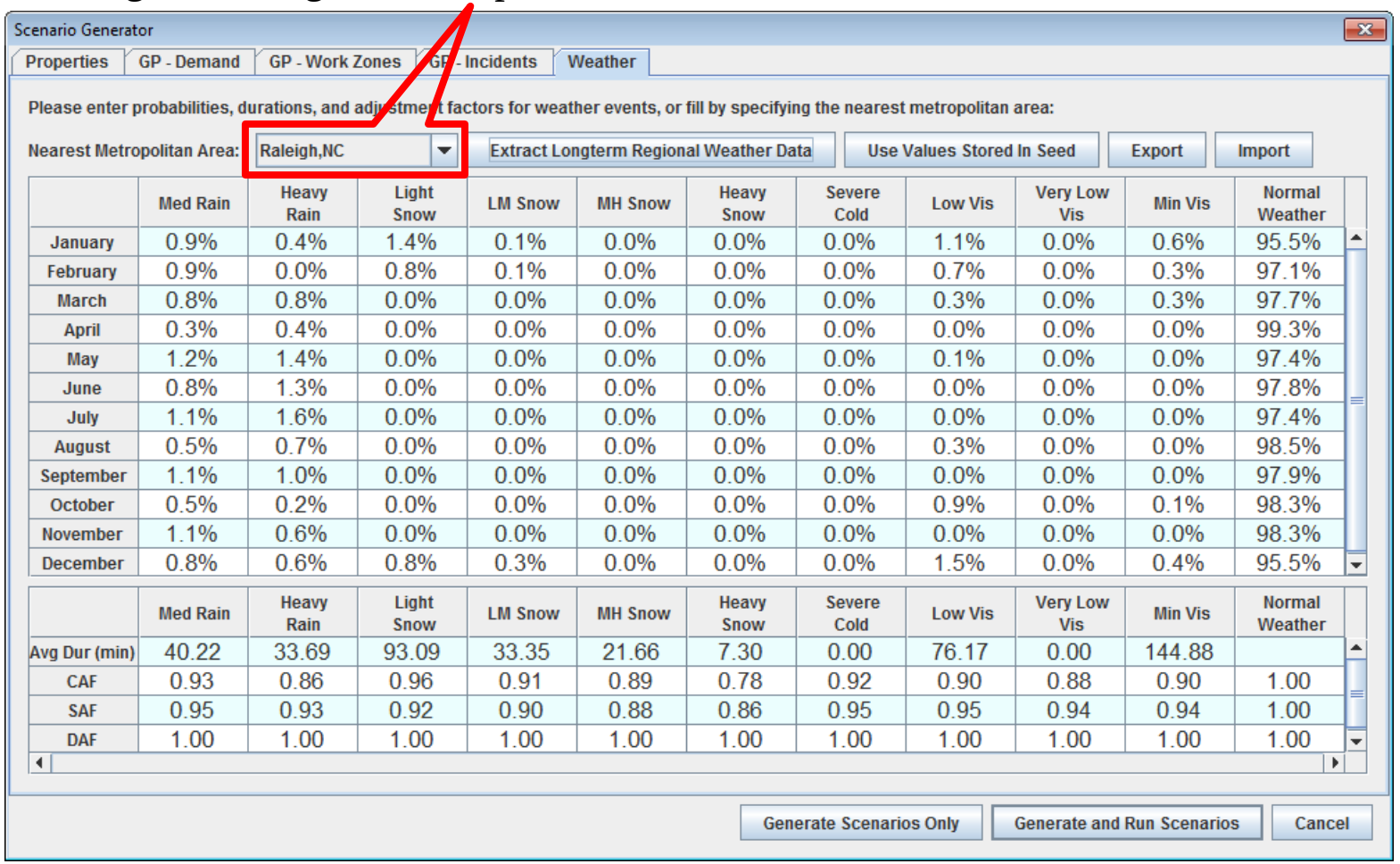
Exhibit 11-21
Default SAFs by Weather Condition

Weather Type	Weather Event Definition	Speed Adjustment Factors				
		55 mi/h	60 mi/h	65 mi/h	70 mi/h	75 mi/h
Medium rain	> 0.10-0.25 in/h	0.96	0.95	0.94	0.93	0.93
Heavy rain	> 0.25 in/h	0.94	0.93	0.93	0.92	0.91
Light snow	>0.00 – 0.05 in/h	0.94	0.92	0.89	0.87	0.84
Light–medium snow	>0.05 – 0.10 in/h	0.92	0.90	0.88	0.86	0.83
Medium–heavy snow	>0.10 – 0.50 in/h	0.90	0.88	0.86	0.84	0.82
Heavy snow	>0.50 in/h	0.88	0.86	0.85	0.83	0.81
Severe cold	<-4°F	0.95	0.95	0.94	0.93	0.92
Low visibility	0.50 – 0.99 mi	0.96	0.95	0.94	0.94	0.93
Very low visibility	0.25 – 0.49 mi	0.95	0.94	0.93	0.92	0.91
Minimal visibility	< 0.25 mi	0.95	0.94	0.93	0.92	0.91
Non–severe weather	All conditions not listed above	1.00	1.00	1.00	1.00	1.00

Source: Zegeer et al. (*1*).
Note: Speeds given in column heads are free-flow speeds.

Weather Conditions Configuration in FREEVAL

Listing of 96 largest metropolitan area in US where weather information is available



	Med Rain	Heavy Rain	Light Snow	LM Snow	MH Snow	Heavy Snow	Severe Cold	Low Vis	Very Low Vis	Min Vis	Normal Weather
January	0.9%	0.4%	1.4%	0.1%	0.0%	0.0%	0.0%	1.1%	0.0%	0.6%	95.5%
February	0.9%	0.0%	0.8%	0.1%	0.0%	0.0%	0.0%	0.7%	0.0%	0.3%	97.1%
March	0.8%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%	97.7%
April	0.3%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	99.3%
May	1.2%	1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	97.4%
June	0.8%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	97.8%
July	1.1%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	97.4%
August	0.5%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	98.5%
September	1.1%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	97.9%
October	0.5%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%	0.1%	98.3%
November	1.1%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	98.3%
December	0.8%	0.6%	0.8%	0.3%	0.0%	0.0%	0.0%	1.5%	0.0%	0.4%	95.5%

	Med Rain	Heavy Rain	Light Snow	LM Snow	MH Snow	Heavy Snow	Severe Cold	Low Vis	Very Low Vis	Min Vis	Normal Weather
Avg Dur (min)	40.22	33.69	93.09	33.35	21.66	7.30	0.00	76.17	0.00	144.88	
CAF	0.93	0.86	0.96	0.91	0.89	0.78	0.92	0.90	0.88	0.90	1.00
SAF	0.95	0.93	0.92	0.90	0.88	0.86	0.95	0.95	0.94	0.94	1.00
DAF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Likelihood of Different Weather Conditions

Impact of Weather Conditions on Capacity, Speed and Demand

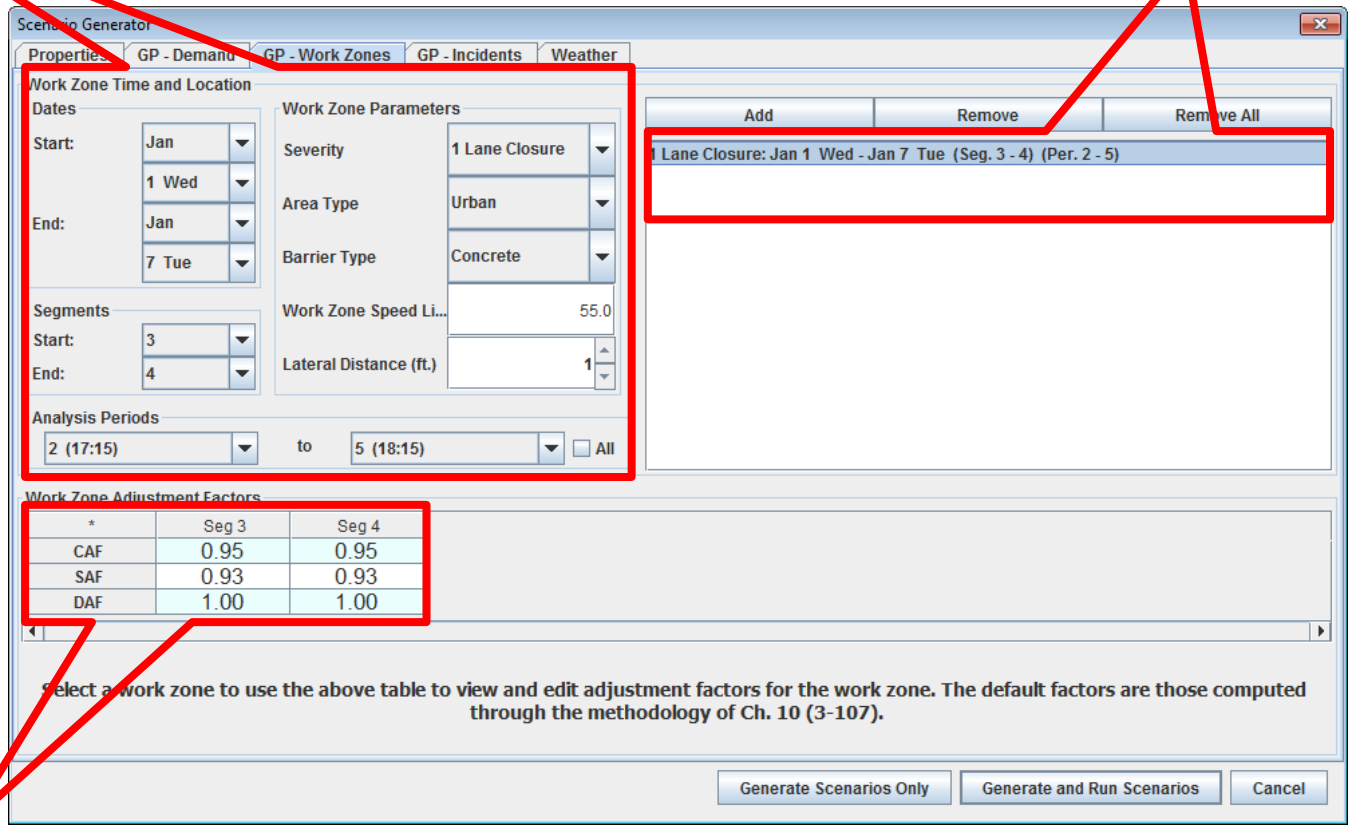
Consideration of Work Zones in Reliability Analysis

- The reliability analysis can accommodate the impact of scheduled long term work zones in the analysis.
- Short term maintenance jobs can be modeled as minor incidents
- The impact of work zone events incorporate all the capacity and free flow speed models that were developed in NCHRP 03-107.

Work Zones Configuration

Configuring Work Zone Event

List of Modeled WZ events



Impact of WZ on Capacity, Speed and Demand based on NCHRP 03-107

How Reliability Scenarios are Generated

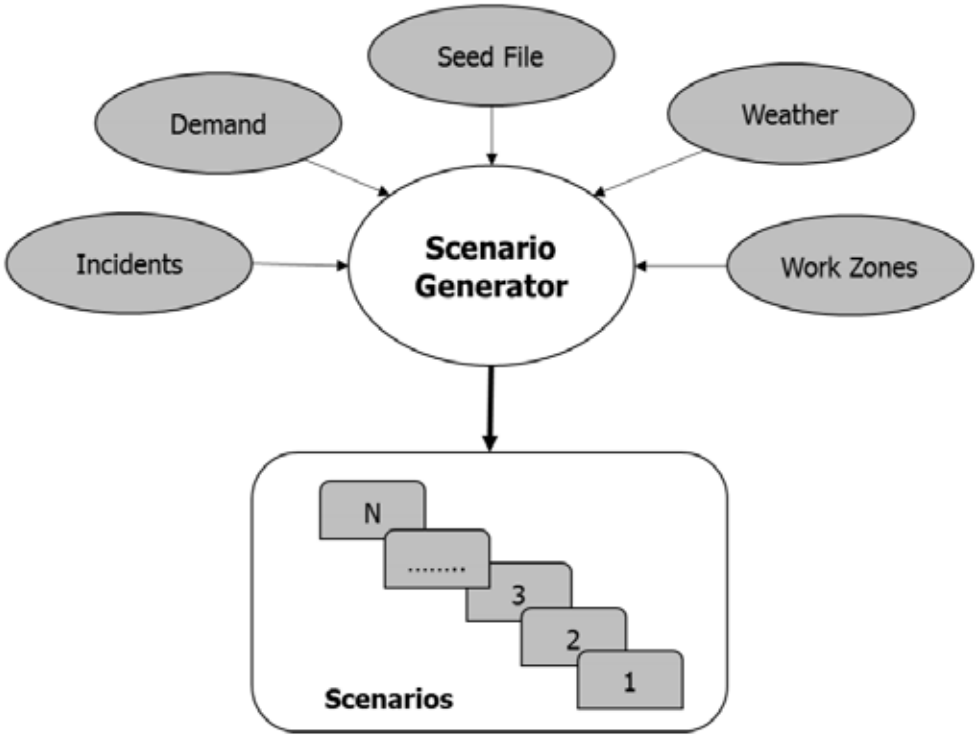
- Method uses both deterministic and stochastic modeling in an optimization scheme to generate scenarios.
  - **Traffic Demand Variations**

    (Modeled Deterministically)
  - **Incidents**

    (Modeled Stochastically)
  - **Severe Weather Conditions**

    (Modeled Stochastically)
  - **Scheduled Work Zones**

    (Modeled Deterministically)



Replication of Scenarios

- The recommended number of replications is a function of the duration of the reliability reporting period (RRP)

Exhibit 11-9
Recommended Number of Replications for Scenario Generation

RRP Duration (months)	Number of Days Considered	Recommended Number of Replications	Resulting Number of Scenarios
1	5 (all weekdays)	48	240
2	5	24	240
4	5	12	240
6	5	8	240
9	5	6	270
12*	5	4*	240*
12	2 (weekend only)	10	240
12	7 (all days)**	3	252

Notes: RRP = reliability reporting period.
*Default value.
**Not desirable; separating weekday and weekend reliability analysis is preferred.

Scenario Generation in the Facility Time-Space Domain

- Each Scenario may contain several non-recurring events
- Example shows a single scenario with the effects of a rain event (R) lasting 45 min, a two-lane closure incident (I-2) lasting one hour and a shoulder-closure incident (I-S) lasting 15 min.

Analysis Period	Segment Number									
	1	2	3	4	5	6	7	8	9	10
1										
2										
3	R	R	R	R	R	R	R	R	R	R
4	R	R	R	R	R	R	R	R	R	R
5	R	R	R	R	R	R	R	R and I-2	R	R
6								I-2		
7								I-2		
8								I-2		
9										
10										
11			I-S							
12										

Exhibit 11-5
Scenario Illustrating Weather and Incident Events

Evaluation of Scenarios and Methodology Outputs

- *Each generated scenario is evaluated by the Chapter 10 method.*
- *Each data point represents Travel Time (TT) value in an Analysis Period (15 min)*
- *Then Facility TT distribution is generated*

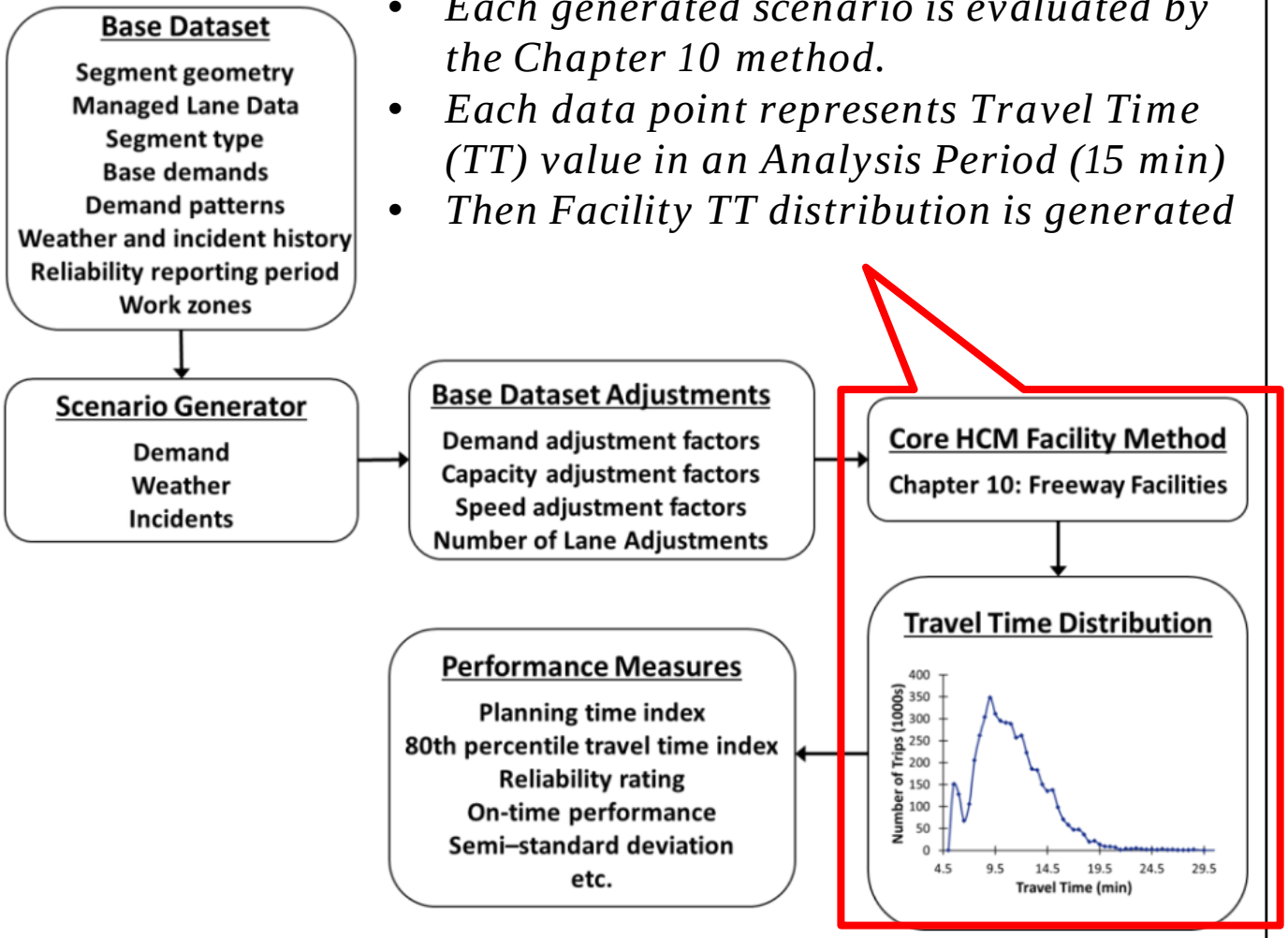
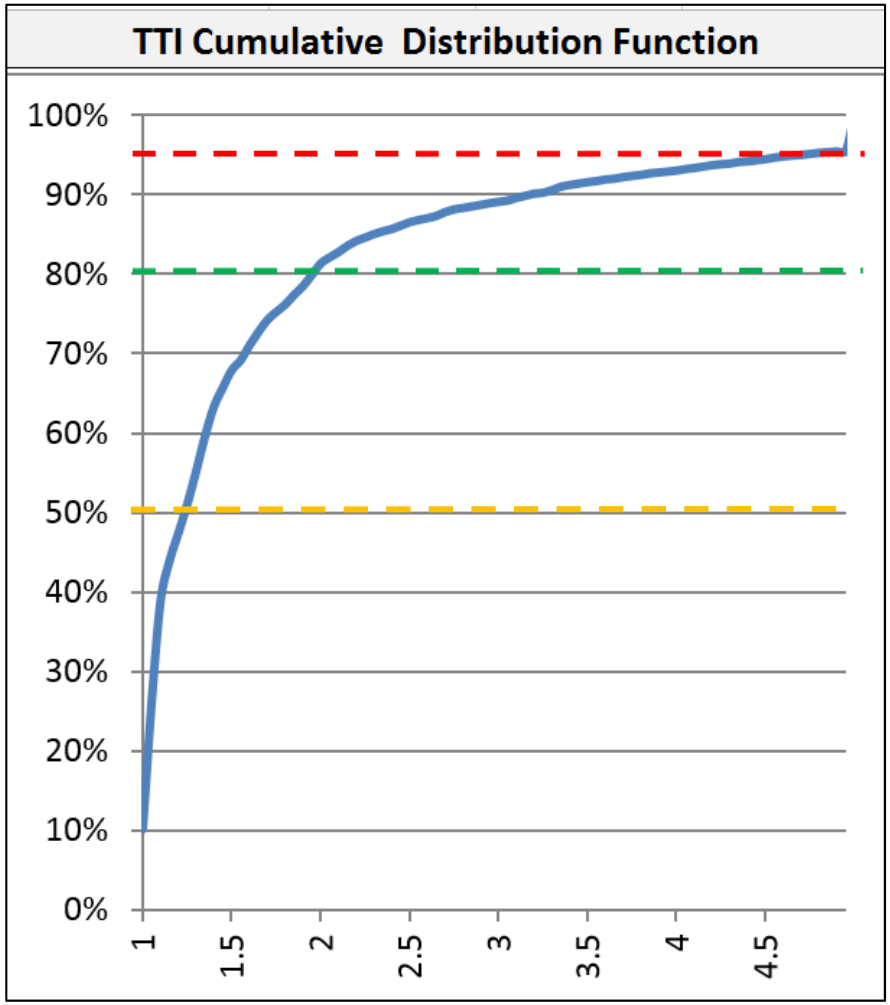


Exhibit 11-7
Freeway Reliability Methodology Framework

Reliability Performance Measures

- Reliability analysis produces "**reliability performance measures**" that include the impact of recurring and non-recurring sources of congestion.
- All performance measures are based on the estimated travel time distribution.
- To normalize and enable comparisons across facilities, travel times are divided by the free flow travel time resulting in **Travel Time Index (TTI)** distribution.



Reliability Performance Measures from the TTI Distribution

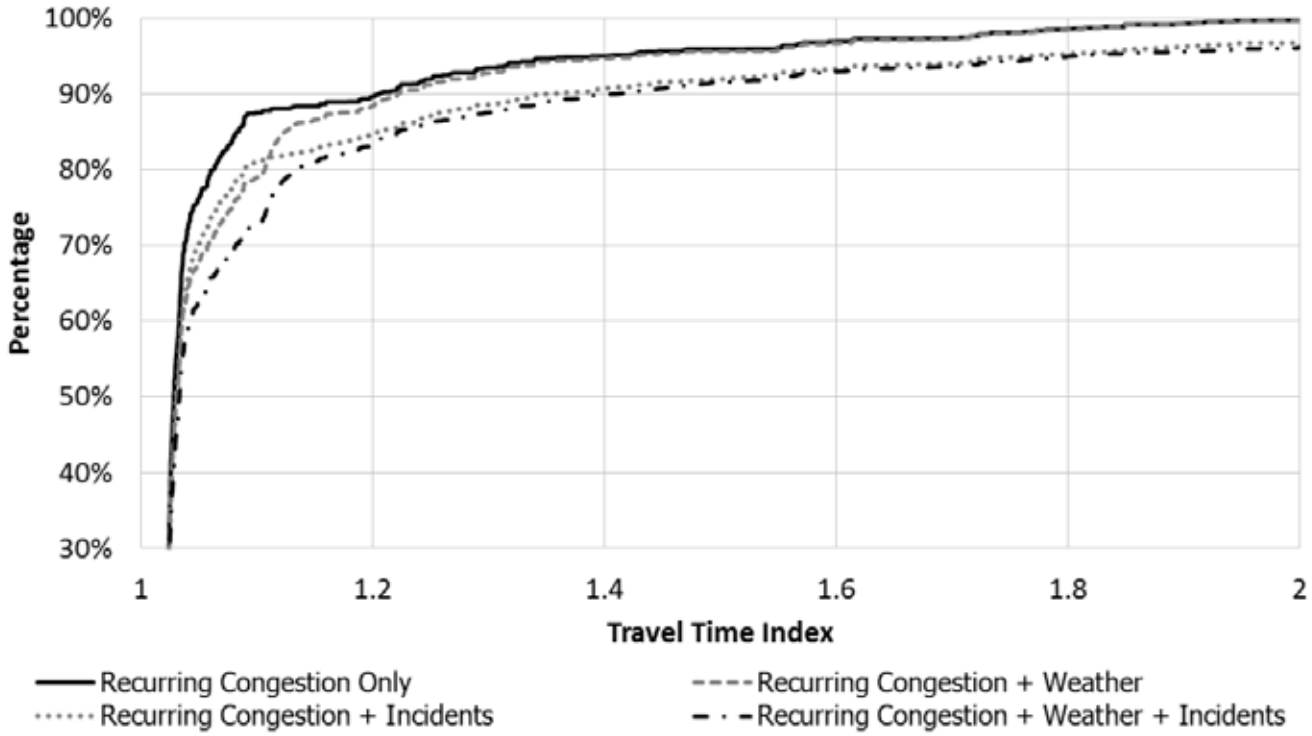
- Potential Performance Measures Derived from Distribution
  - 95th % TTI (PTI)
  - 80th % TTI
  - 50th % TTI (Median)

Used to calculate LOTTR

  - Reliability Rating – *how often the facility performs satisfactorily defined as the fraction of facility VMT operating below a TTI of 1.33*
  - Failure and on-time measures (%)
  - Misery Index - *average of the worse 5% TTI's*
  - Semi-Standard Deviation– *standard deviation from TTI=1*
  - Standard Deviation
  - %VMT at TTI>2
    - Percent vehicle-miles traveled at TTI greater than 2

Illustrating the Effect of Different Sources on Reliability

Exhibit 11-14
Illustrative Effects of Different Non-Recurring Sources of Congestion on the TTI Distribution




APPLYING THE HCM TO
RELIABILITY ANALYSIS

Applications of HCM Reliability Method

- Predicting the reliability impacts of freeway investment options.
  - Adding lanes
  - Adding HOT or HOV lanes
- Predicting the reliability benefits of transportation system management and operations strategies (TSMO).
  - Part-time shoulder use
  - Ramp metering
  - Speed harmonization

HCM Provides the Analytical Framework

- HCM provides the analytical framework for evaluating TSMO, but some linkages are missing…..
  - Insufficient US experience to predict:
    - Impacts of TSMO measures on crash experience
    - Impacts of TSMO measures on incident clearance times
    - Impacts of speed harmonization on speeds (driver compliance)
    - Impacts of CAV on crash experience, capacities, speeds.
  - Analyst must estimate these impacts off-line and input them into the HCM reliability method.
    - HCM method has the placeholders for these linkages.
- Research into some of these linkages is on the way

Example Application #1 – Performance Management

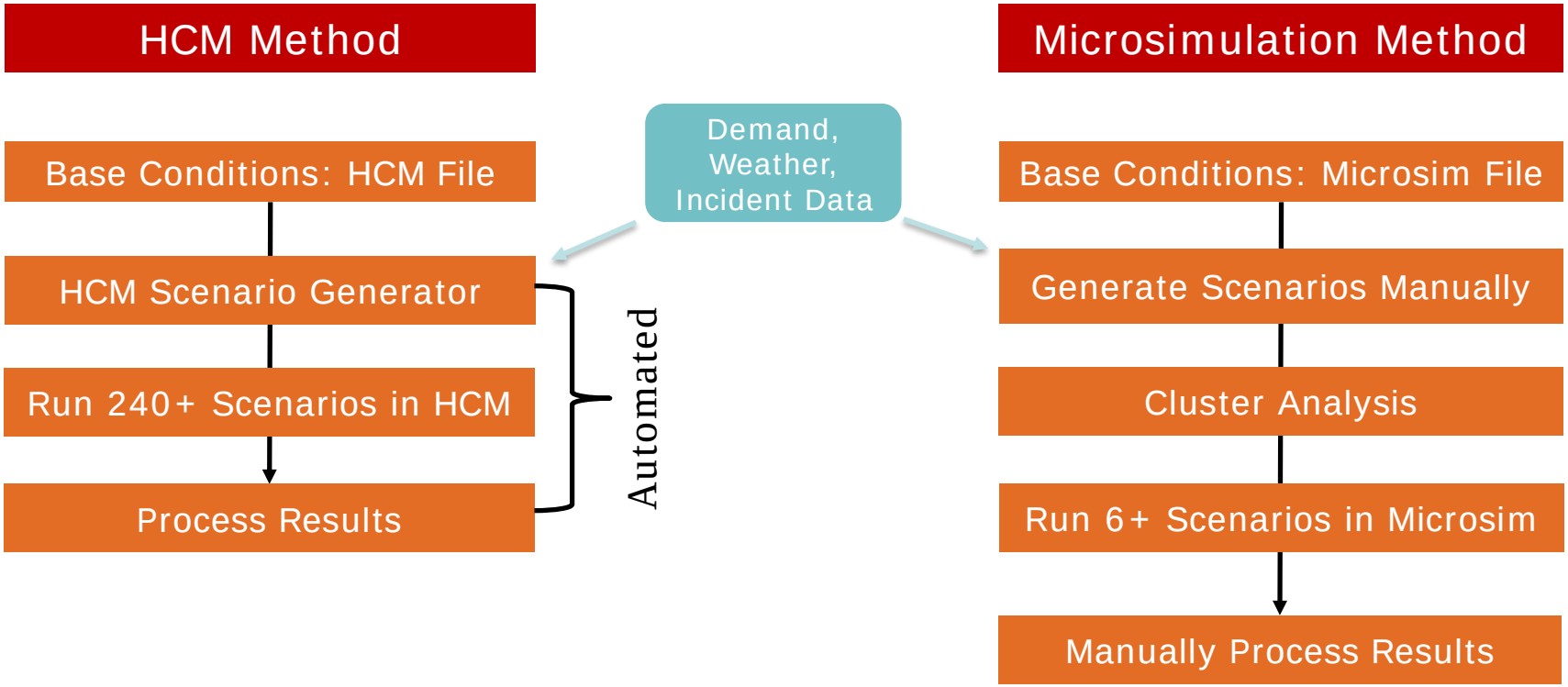
- The Problem:
  - Agency's system reliability performance has deteriorated over last few years and new FHWA rules require agency to establish a reasonable reliability objective that it can achieve with its proposed LRTP.
- The Question:
  - What can the agency's LRTP be expected to achieve (in the way of improved reliability) over the next 5 to 10 years?
    - Supplemental question: How might the CIP be tweaked with TSM&O strategies to deliver the desired reliability improvement?
    - For Regional Reliability: SHRP2-L04 Incorporating Reliability Performance Measures in Operations and Planning Modeling Tools

How can the Sixth Edition HCM help?

- Until HCM 6th Edition the only way to realistically predict reliability was to use microsimulation.
  - Code and calibrate microsimulation model for facility.
  - Develop set of incident and weather scenarios
  - Run simulation model several times
  - Pool the results.
- With the 6th Edition of the HCM, practitioners now have highly cost-efficient tool for predicting the reliability effects of infrastructure investments.

The Highway Capacity Manual vs Microsimulation

§ Predicting Reliability: the HCM vs Microsimulation



Steps to Applying the 6th Ed. HCM for Reliability

- Step 1: Define your measures of reliability.
- Step 2: Gather data for recurrent congestion HCM analysis.
- Step 3: Calibrate HCM model for recurrent congestion.
- Step 4: Run HCM reliability analysis (Future Baseline)
- Step 5: Evaluate results.
- Step 6: Select TSMO measures.
- Step 7: Re-run HCM (TSMO Alternatives).
- Step 8: Evaluate Results.

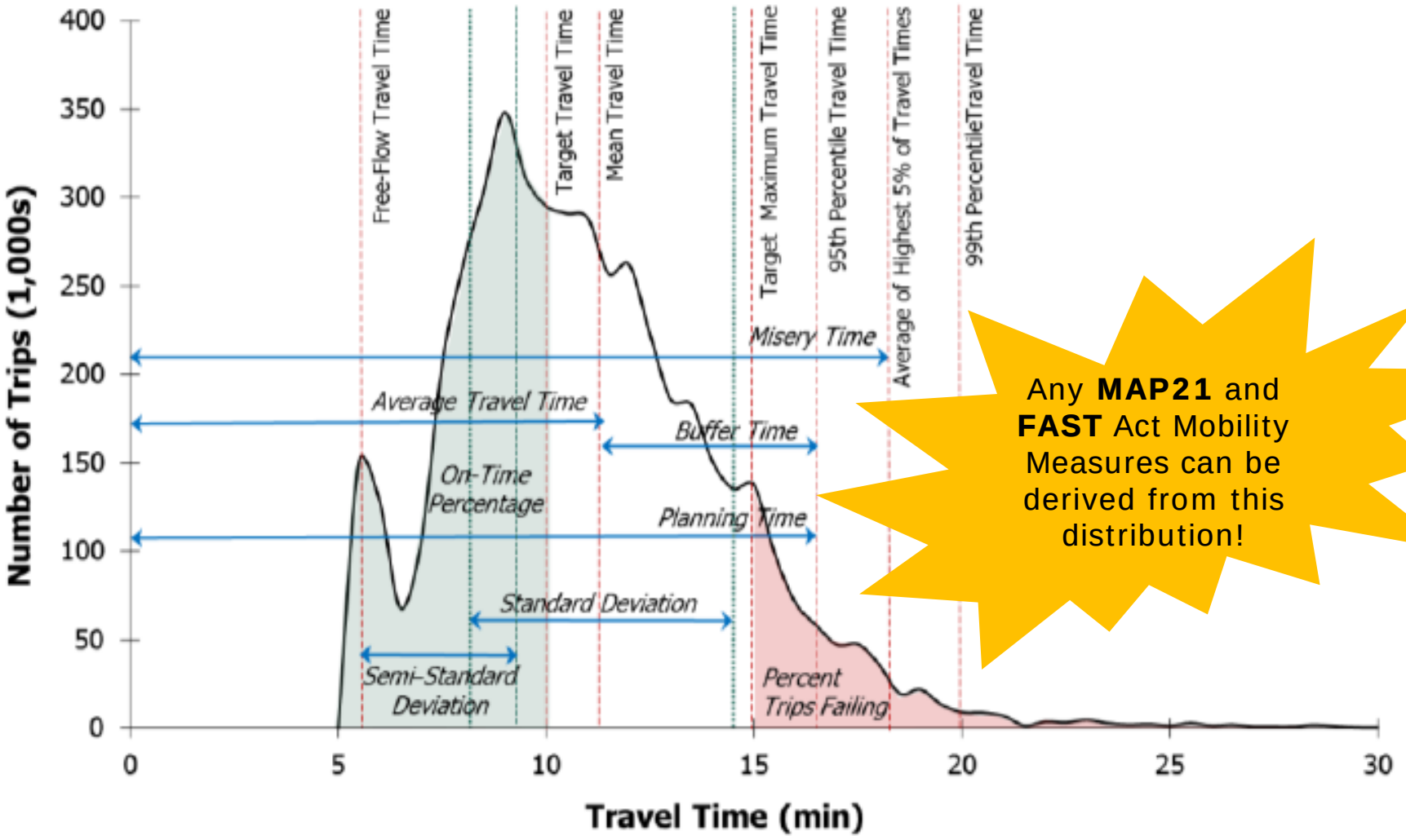
Step 1: Set Reliability Performance Measures

- HCM can't do entire system all at once (Use SHRP2-L04), but can do individual freeway or street facilities.
- Select facility(s) that LRTP investments will impact for HCM reliability analysis.
- Compute FHWA's reliability performance measures.
  - FHWA has established two reliability measures:
    - % of Interstate that has reliable travel times.
    - % of non-interstate NHS with reliable travel times.

Step 1 (cont): Set Performance Measures

- Level of Travel Time Reliability (LOTTR)
  - LOTTR = 80% Travel Time/50% Travel Time
- Compute LOTTR over one year for weekdays,
  - AM Peak (6-10AM), Midday (10-4 PM), PM Peak (4-8 PM)
  - Also for weekend days, 6AM to 8 PM.
- A segment is reliable for the specified time period if its LOTTR<1.50
- System performance is length weighted percent of segments with LOTTR<1.50

Relating HCM to FHWA Performance Measures



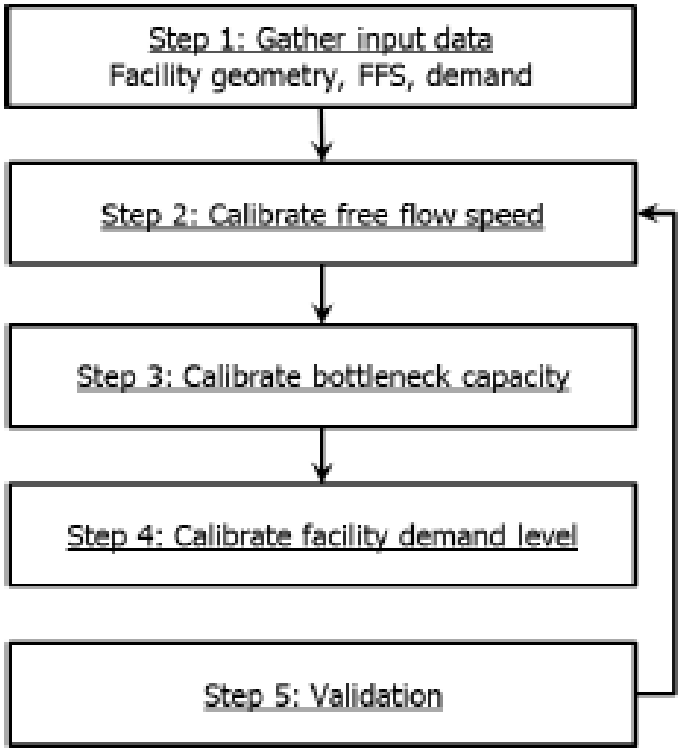
Any **MAP21** and **FAST** Act Mobility Measures can be derived from this distribution!

Step 2: Gather Data

Required Input Data (Freeway Analysis)	Conventional HCM Analysis	HCM Reliability Analysis
Lane widths and right-side lateral clearance (ft)	•	•
Ramp density (per mile)	•	•
Percentage heavy vehicles (%)	•	•
Terrain type/specific grade	•	•
Number of directional lanes	•	•
Peak hour factor (decimal)	•	•
Driver population factor (decimal)	•	•
Segment length (mi)	•	•
Directional demand (veh/h)	•	•
Variability of demand		•
Incident and crash frequencies		•
Severe weather frequencies		•
Work zone frequencies		•

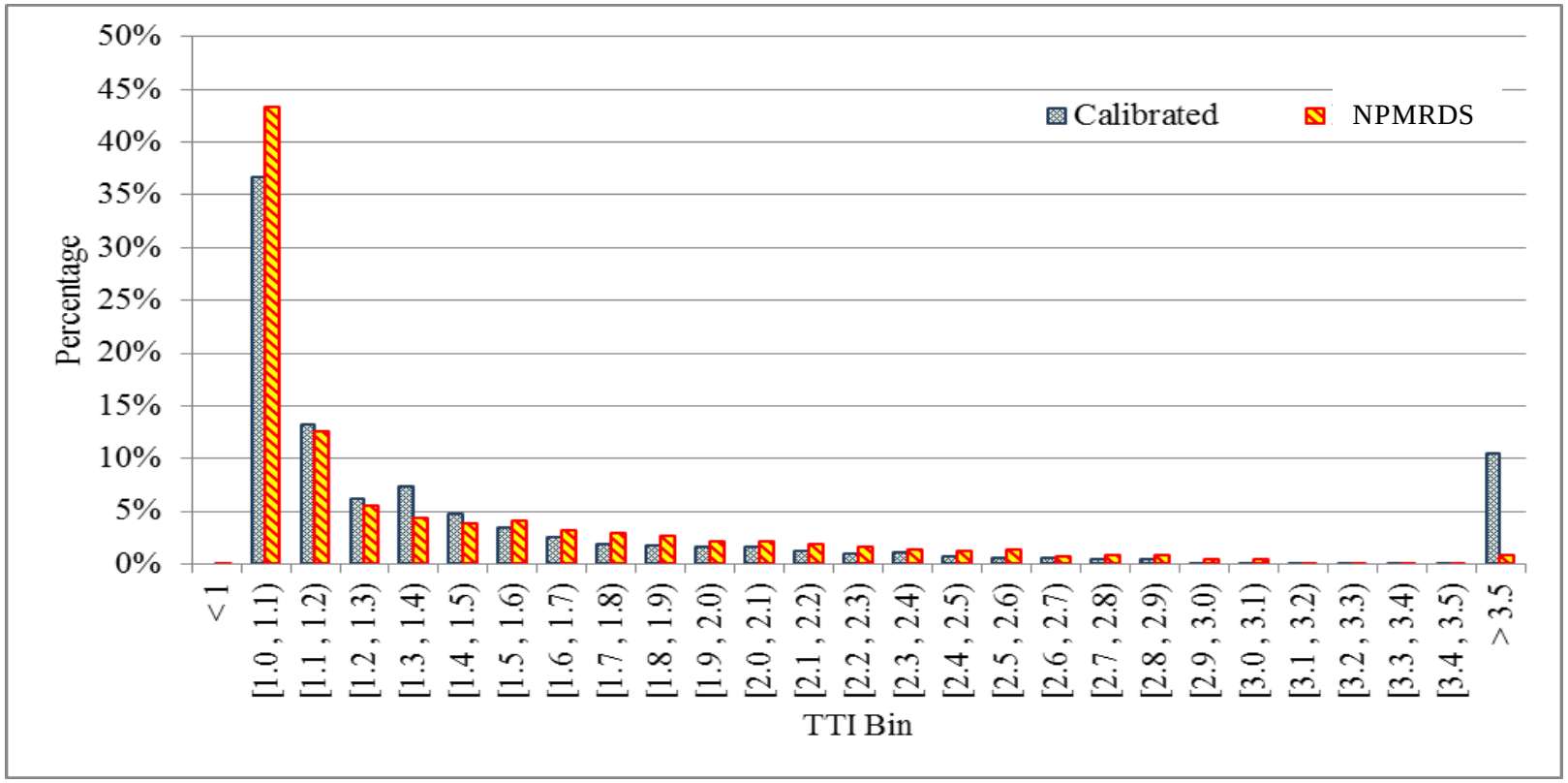
Step 3 Calibrate HCM Model – Recurring Congestion

- Calibrate HCM for recurring congestion (no incidents)
  - Calibrate HCM default speed-flow curve
    - free-flow speed
    - capacity
    - Demands
      - counts <> demand.



Step 3 Calibrate HCM – Non-Recurring Congestion

- Calibrate HCM reliability method against NPMRDS
  - Useful for error checking incident and weather data used.

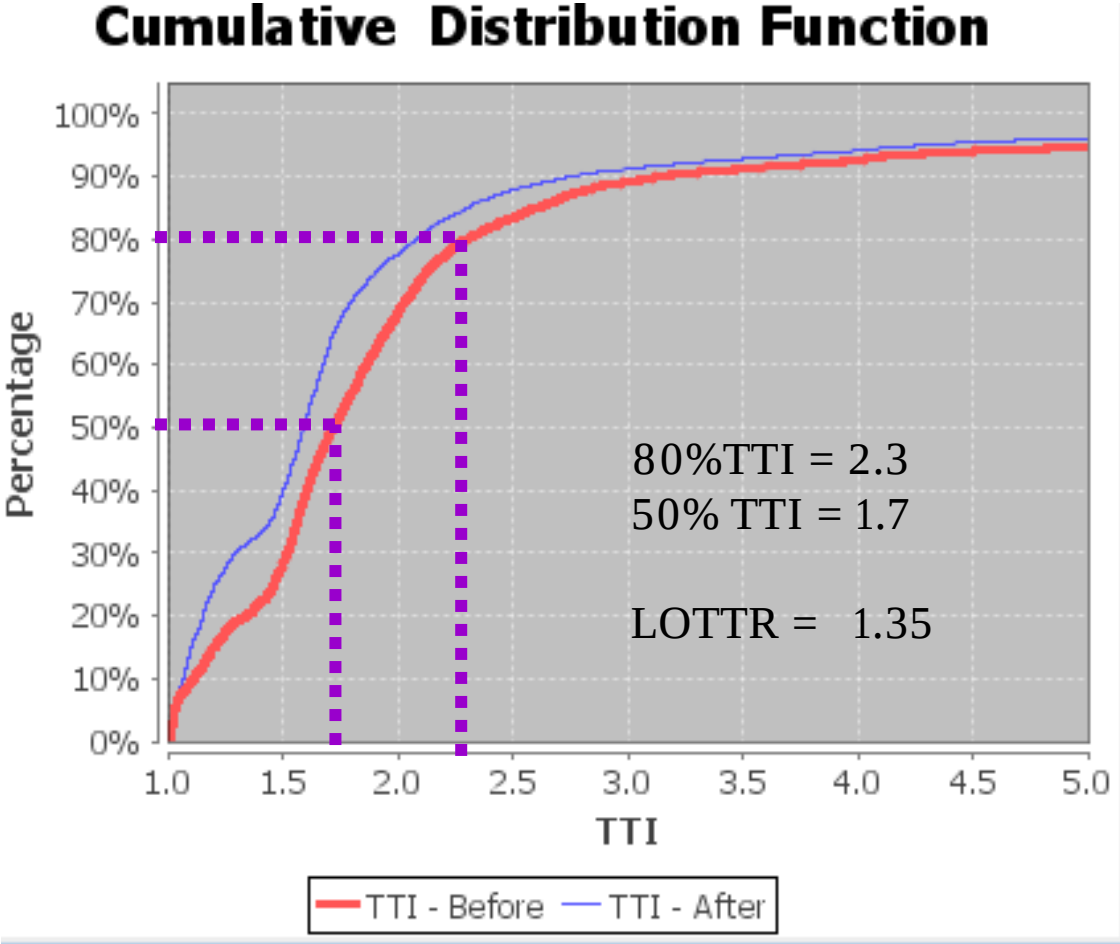


Step 4: Run HCM Reliability Analysis

- Separate HCM reliability analysis run for each FHWA reliability study period:
  - AM peak 6-10 AM
  - Midday 10 AM – 4 PM
  - PM peak 4-8 PM
  - Weekends 6 AM – 8 PM
    - HCM can do infinitely long study periods, but most software can't.
    - So pick representative 4 hour period for HCM analysis of weekend

Step 5: Evaluate Results

- Identify 50th% segment travel time and 80th% travel time for each study period.
- Note that HCM provides facility results. FHWA performance measures of length weighted segment results.



Step 6: Select TSMO Measures

- Get Candidate TSMO Measures from FHWA Guide
  - Designing for Transportation Management and Operations: A Primer, FHWA-HOP-13-013, February 2013
- Some examples:
  - Traffic incident management.
  - Corridor, freeway, and arterial management.
  - Active transportation and demand management.
  - Work zone management.
  - Road weather management.
  - Emergency management.
  - Traveler information services.
  - Congestion pricing.
  - Parking management.
  - Freight management.

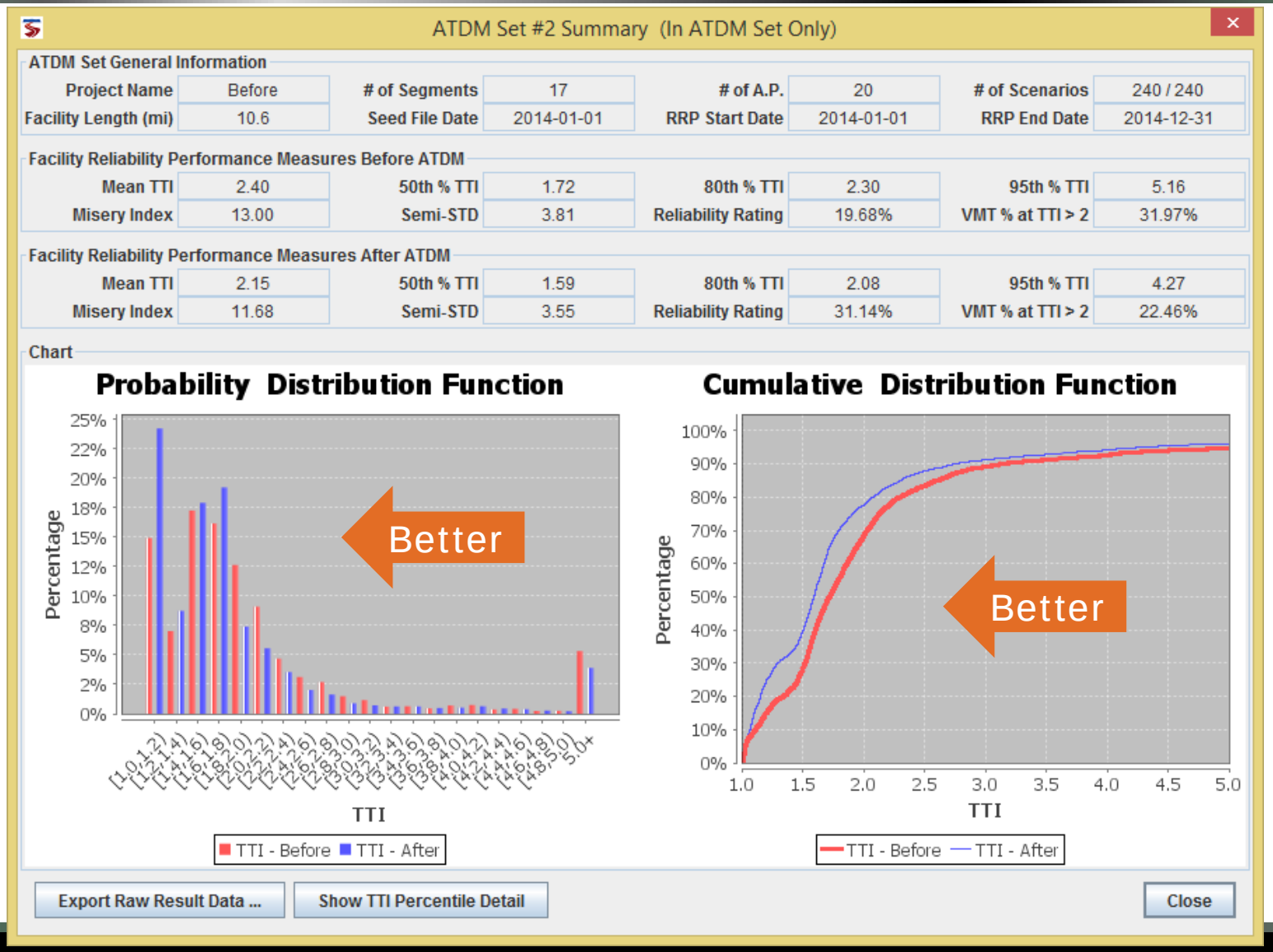
Step 6 (cont): Group TSMO Options into Alternatives

1. Baseline
2. Geometric Treatment Alternative
   - bottleneck mitigation Segments 7-11
3. Incident Management Alternative
   - improve incident response time
4. Safety Treatment Alternative
   - reduce crash rate on facility
5. Demand Management Alternative
   - promote peak spreading

Step 7: Rerun HCM, Evaluate Results

- The Challenge: To identify effects of TSMO on:
  - Demands
  - Speed-flow equations
    - Free-flow speed
    - Capacity
- HCM has set up the framework for evaluating the effects of TSMO, but does not (yet) provide the specific numbers
  - See Chapter 37, “ATDM: Supplemental”, of HCM for advice.

Step 8: Evaluate Impacts on Travel Time Distribution



Step 8. Evaluate Results – Inspecting individual days

- Before

Time

Analysis Period	Seg. 1	Seg. 2	Seg. 3	Seg. 4	Seg. 5	Seg. 6	Seg. 7	Seg. 8	Seg. 9	Seg. 10	Seg. 11	Seg. 12
#1 6:00 - 6:15	75.0	67.8	74.4	68.5	75.0	70.3	74.8	71.3	74.9	67.6	74.8	69.9
#2 6:15 - 6:30	71.9	68.7	73.2	66.1	70.1	69.0	72.3	67.7	68.9	68.3	71.5	66.7
#3 6:30 - 6:45	72.2	68.4	73.7	65.0	68.8	68.8	71.3	66.8	67.1	67.1	69.9	65.5
#4 6:45 - 7:00	69.2	68.5	71.5	63.8	65.3	65.3	68.7	64.3	64.3	64.3	68.1	63.3
#5 7:00 - 7:15	69.9	68.0	72.7	64.3	67.0	67.0	71.1	67.1	67.5	67.5	71.5	66.5
#6 7:15 - 7:30	68.9	68.2	71.6	63.8	65.5	65.5	69.6	64.9	64.9	64.9	69.7	65.1
#7 7:30 - 7:45	61.8	61.8	65.0	58.1	46.0	42.8	28.0	58.1	58.1	62.8	35.4	58.1
#8 7:45 - 8:00	62.7	66.3	30.4	36.7	33.6	32.7	26.0	58.2	51.3	40.7	27.6	58.2
#9 8:00 - 8:15	53.7	36.8	21.7	47.9	44.1	49.6	28.5	40.1	35.8	35.0	27.5	58.2
#10 8:15 - 8:30	47.4	31.0	21.5	37.3	36.6	47.9	30.8	37.3	53.0	61.8	30.0	58.2
#11 8:30 - 8:45	60.5	26.0	14.5	14.0	8.5	2.0	1.0	22.7	74.1	68.7	74.8	70.0
#12 8:45 - 9:00	1.2	1.0	1.0	1.2	1.1	1.1	1.0	35.3	74.3	68.7	74.8	69.9
#13 9:00 - 9:15	1.3	1.4	1.2	1.5	1.2	1.2	1.0	35.3	74.3	68.6	74.8	70.1
#14 9:15 - 9:30	1.0	2.3	3.2	5.0	14.1	32.3	36.1	58.3	58.3	58.3	64.3	61.6
#15 9:30 - 9:45	22.2	32.1	22.8	39.8	38.9	58.2	64.0	59.7	59.7	59.7	64.4	60.6
#16 9:45 - 10:00	31.8	30.8	23.1	40.6	39.0	58.2	63.3	58.9	58.9	58.9	63.5	60.2
#17 10:00 - 10:15	31.3	31.1	22.9	39.8	38.9	58.2	63.3	74.8	57.7	34.4	50.4	64.4
#18 10:15 - 10:30	27.9	25.7	18.0	29.0	23.8	50.5	70.1	74.9	69.5	46.4	54.5	65.9
#19 10:30 - 10:45	20.9	20.9	15.2	24.3	22.9	50.5	70.8	67.7	68.3	68.2	71.1	67.0
#20 10:45 - 11:00	26.3	20.7	17.5	48.2	40.8	58.2	64.1	60.2	60.2	60.2	65.0	62.3

Distance

- After

Time

Analysis Period	Seg. 1	Seg. 2	Seg. 3	Seg. 4	Seg. 5	Seg. 6	Seg. 7	Seg. 8	Seg. 9	Seg. 10	Seg. 11	Seg. 12
#1 6:00 - 6:15	75.0	67.8	74.4	69.1	75.0	70.8	74.8	71.5	74.9	67.6	74.8	70.0
#2 6:15 - 6:30	71.9	68.7	73.2	66.9	71.4	69.2	73.3	69.0	71.4	68.4	73.2	67.6
#3 6:30 - 6:45	72.2	68.4	73.7	67.2	72.1						73.2	67.6
#4 6:45 - 7:00	69.2	68.5	71.5	66.0	69.0						71.3	66.6
#5 7:00 - 7:15	69.9	68.0	72.7	66.6	70.6						73.5	67.7
#6 7:15 - 7:30	68.9	68.2	71.6	66.1	69.1						72.7	67.3
#7 7:30 - 7:45	61.8	55.5	30.6	38.1	58.4						63.8	62.4
#8 7:45 - 8:00	57.1	32.4	22.5	36.4	58.2						62.4	60.9
#9 8:00 - 8:15	64.6	59.6	30.5	36.4	58.2	58.2	62.8	61.3	58.4	58.4	62.7	61.3
#10 8:15 - 8:30	65.7	65.7	60.4	36.7	58.2	58.2	62.9	61.5	58.6	58.6	63.6	62.2
#11 8:30 - 8:45	68.2	59.2	30.8	23.2	6.8	3.9	1.3	35.9	74.3	68.7	74.8	70.0
#12 8:45 - 9:00	2.5	1.2	1.1	1.0	1.3	1.3	1.2	36.1	74.3	68.7	74.8	70.0
#13 9:00 - 9:15	1.5	1.5	1.4	1.7	1.4	1.4	1.2	36.1	74.3	68.6	74.8	70.0
#14 9:15 - 9:30	2.3	3.8	4.4	8.1	16.7	38.7	62.2	61.2	58.2	58.2	64.2	62.8
#15 9:30 - 9:45	28.2	32.1	23.1	37.5	38.9	58.2	64.0	62.5	59.8	59.8	64.5	63.0
#16 9:45 - 10:00	31.3	31.2	22.7	37.5	39.0	58.2	63.3	61.9	59.1	59.1	63.7	62.2
#17 10:00 - 10:15	31.0	31.8	22.7	36.9	38.9	58.2	63.3	61.9	61.5	34.7	50.4	64.3
#18 10:15 - 10:30	27.8	28.6	18.6	26.9	23.8	50.5	70.1	67.2	71.7	44.9	53.3	65.0
#19 10:30 - 10:45	32.8	34.5	23.0	23.3	22.9	50.5	70.8	67.6	68.1	68.1	71.0	66.4
#20 10:45 - 11:00	74.1	69.0	54.8	44.0	58.3	63.9	68.1	66.1	64.8	64.8	68.4	65.1

Queuing starts later,
Clears sooner

Step 8: Evaluate Selected Performance Results

Reliability Performance Measure	Base Condition	Bottleneck Treatment	Incident Management	Safety Treatment	Demand management
Facility Mean Speed (mph)	49.7	55.0	51.3	51.7	53.6
Mean VHD in a 3hr study period	263	108	213	209	150
80th% TTI)	1.65	1.16	1.61	1.61	1.29
50th% TTI	1.21	1.09	1.17	1.16	1.12
LOTTR (Level of Travel Time Reliability)	1.36	1.06	1.38	1.39	1.15
		Best		?	

Recap

- Using the HCM to evaluate how an agency can best achieve its reliability goals.
- Eight Steps
  - 1. Select reliability performance measures
  - 2. Gather data
  - 3. Calibrate HCM model
  - 4. Run the HCM reliability analysis (Baseline)
  - 5. Evaluate results
  - 6. Select TSMO measures
  - 7. Rerun HCM (Alternatives)
  - 8. Evaluate results

Don't Forget to Calibrate!

RECAP: RELIABILITY ANALYSIS WITH HCM

Recap of Reliability Analysis Using HCM

- Why Evaluate Reliability?
  - It opens up more mitigation measures besides capacity
- HCM Reliability Method
  - Scenario generator tied into the HCM analysis engine.
- Applying the HCM Reliability Method
  - Active Transportation and Demand Management
  - Transportation System Management and Operations (TSMO)

Key Benefits and Advantages of Method

- **Reliability**
  - Consistent with MAP21 and FAST Act performance requirements
  - Encompassing the effects of all sources of congestion on mobility measures --across an expanded time horizon
  - Consistency with drivers' own daily driving experiences
  - Key to selecting appropriate treatments depending on the relative contribution of congestion sources

- **Active Traffic and Demand Management**
  - Seamless tie in with reliability measures, as intended
  - Provide non-construction options for mobility enhancement
  - Enables the tailoring of strategies to scenarios

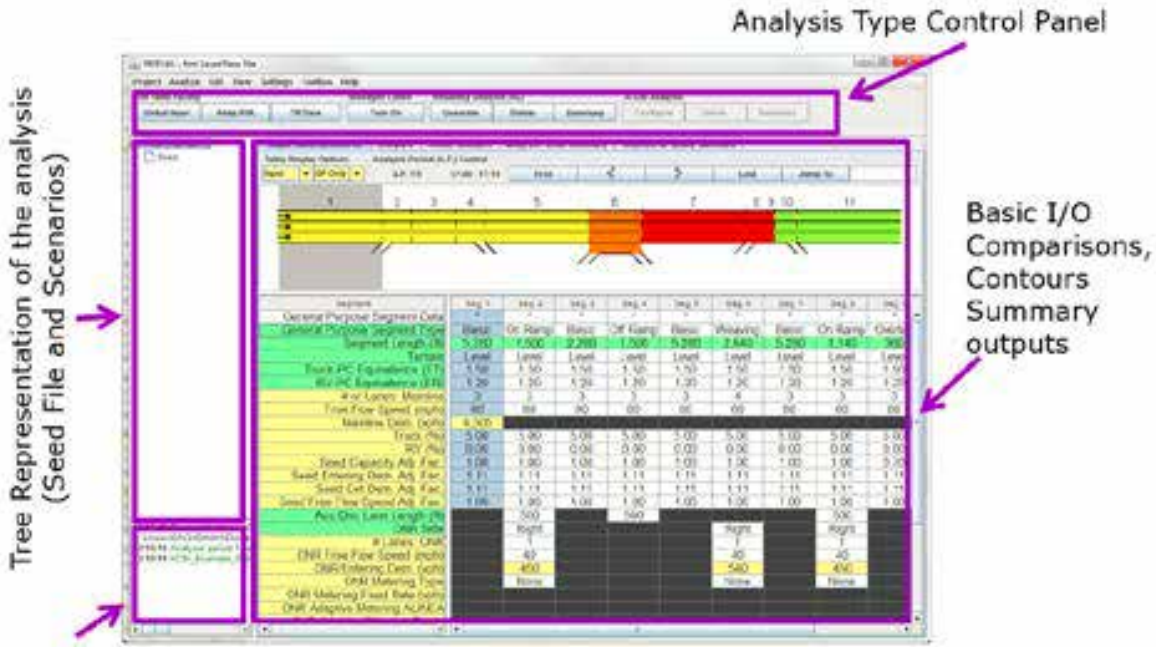
Challenges and Limitations

- **Reliability**
  - Method limited by current HCM freeway facility model limitations (interacting bottlenecks, off-ramp queuing, etc.)
  - Data needs challenges, especially on quantifying demand variation and incident details (type, severity, locations, etc.)
  - Method confined to single facility, ignores corridor effects
- **ATDM Analysis**
  - Many of the ATDM strategies adjustment factors are based on very limited data

Examples of Software Implementing HCM Method

- Freeval
- Streetval
- HCS
- HCM-Calc
- Others

Reliability Applications
à Open-Source Tools Developed for HCM 6th Edition

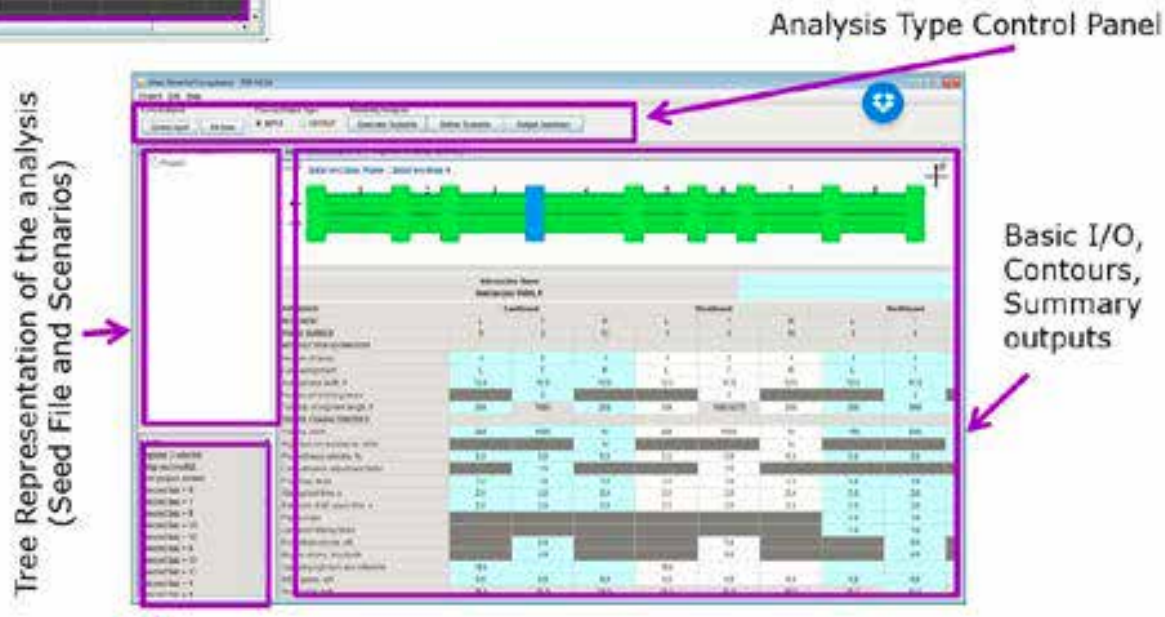


FREEVAL

à Freeway Facility and Reliability Analysis

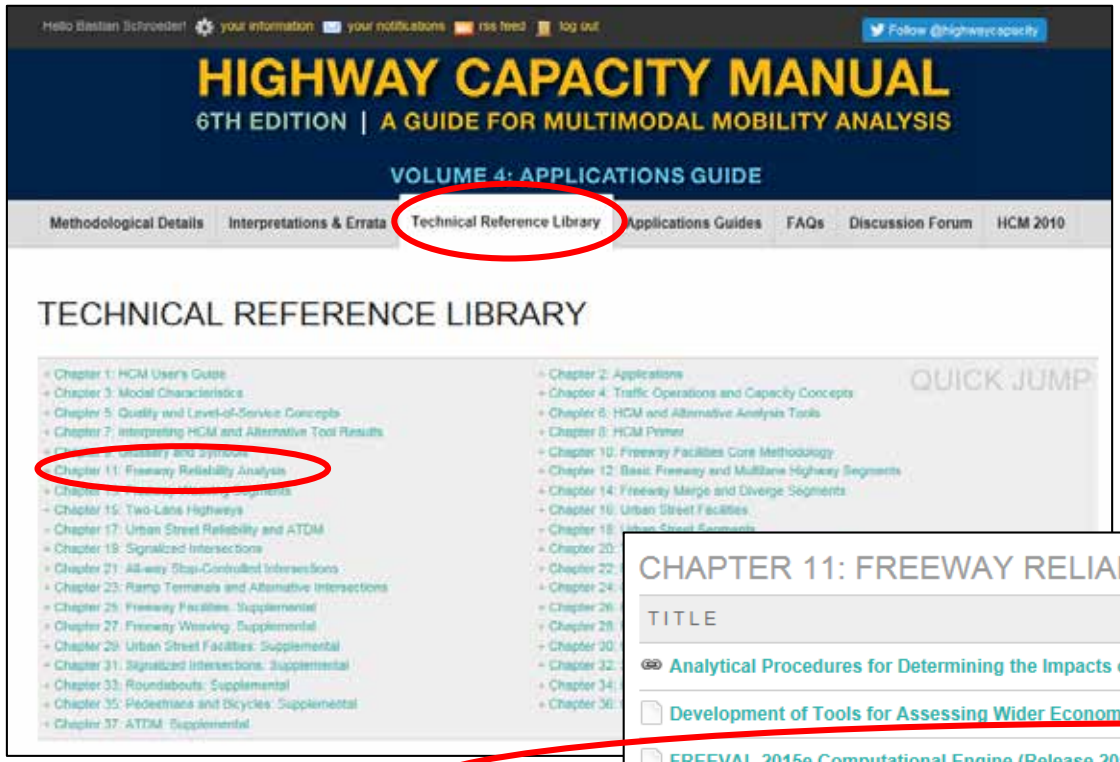
STREETVAL

à Arterial Facility and Reliability Analysis



Available in HCM Volume 4 – Technical Reference Library

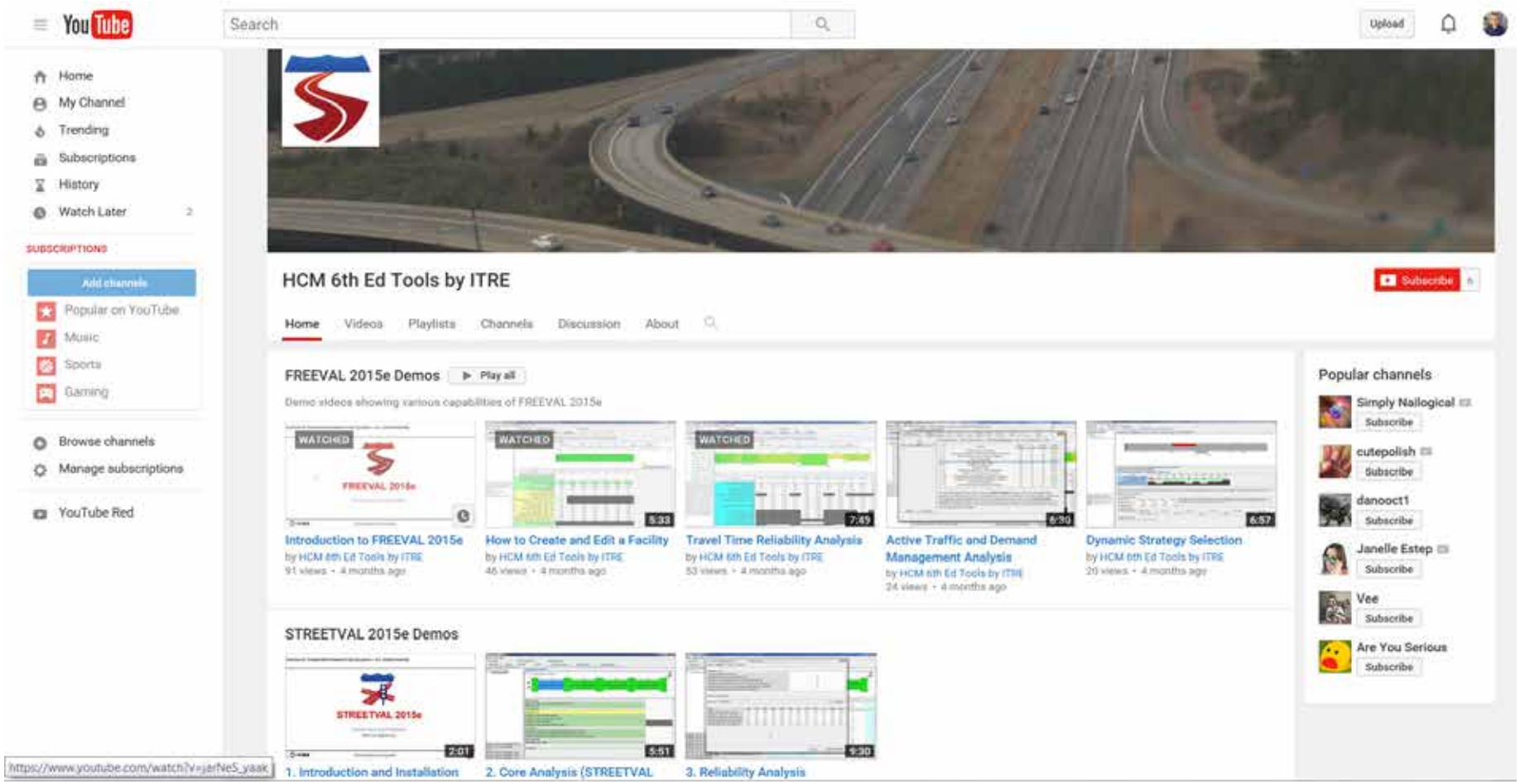
à http://hcmvolume4.org



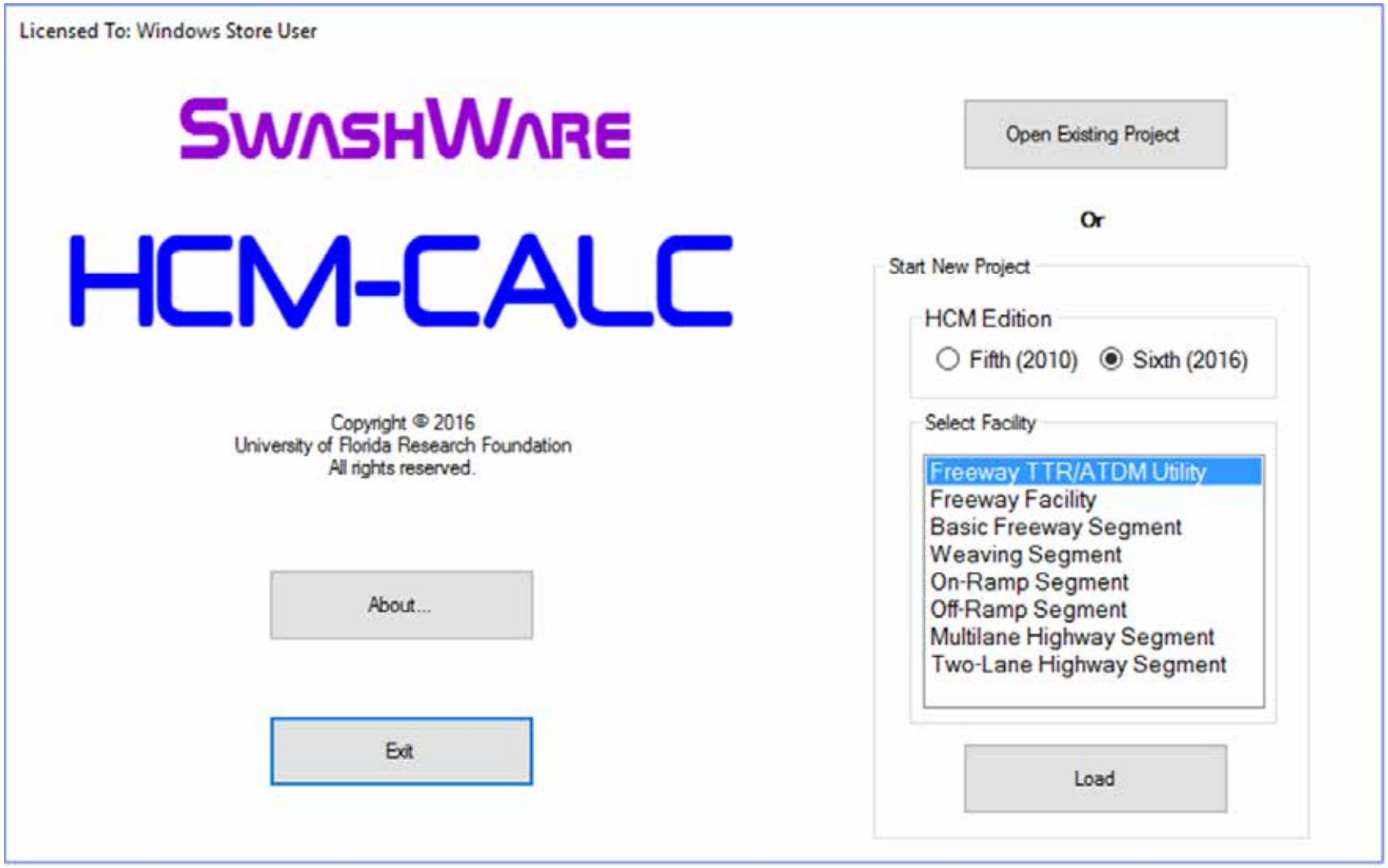
CHAPTER 11: FREEWAY RELIABILITY ANALYSIS

TITLE	SIZE
Analytical Procedures for Determining the Impacts of Reliability Mitigation Strategies	
Development of Tools for Assessing Wider Economic Benefits of Transportation	14.7 MB
FREEVAL-2015e Computational Engine (Release 20160602)	5.9 MB
FREEVAL-2015e User's Guide	3.7 MB
IDAS User's Manual - Appendix B: IDAS Default Values	211.4 KB
Incident Management Assistance Patrols: Assessment of Investment Benefits and Costs	6 MB
Incorporating Travel Time Reliability into the Highway Capacity Manual	34.4 MB
Metropolitan Weather Database for Freeway Reliability Analysis	5.9 MB
NOAA National Centers for Environmental Information (formerly the National Climatic Data Center)	
Rainfall Frequency Atlas of the U.S.: Rainfall Event Statistics	
Traffic Analysis Toolbox Volume XI: Weather and Traffic Analysis, Modeling and Simulation	2.1 MB
Weather History	

Demo Videos: http://go.ncsu.edu/FREEVAL



Reliability Analytical Tools



Reliability Analytical Tools cont.

Questions?

- Questions?