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# The US 2010 Highway Capacity Manual (HCM)

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# Presentation Outline



- **Overview of HCM**  
**Purpose**  
**History**  
**Concepts**
- **HCM 2010 Overview**  
**Organization**  
**Contents**  
**Key new Contents/Updates**
- **Looking Ahead**  
**2010 Update (In progress)**



# The Highway Capacity Manual

## Purpose of HCM

**“to provide a set of methodologies, and associated application procedures, for evaluating the multimodal performance of highway and street facilities in terms of operational measures and one or more quality of service indicators”**

**“HCM does not set policies regarding a desirable or appropriate quality of service...”**

***The Highway Capacity and Quality of Service (HCQS) Committee of the Transportation Research Board (TRB) oversees the development and maintenance of HCM***



# History of HCM

- **1950 Original Manual (150 pages, basic ideas)**
- **1965 Manual (Level of Service – LOS Concept)**
- **1985 Manual (Additional facilities, software)**
- **1985 Manual Updates (1992, 1994, 1997)**
- **2000 Manual (Corridors, Systems)**
- **2010 Manual (Multimodal)**



# Basic Concepts: Capacity

The capacity of a facility is the maximum sustainable hourly rate at which persons or vehicles reasonably can be expected to traverse a point or a uniform section of a lane or roadway during a given time period under prevailing roadway, traffic, and control conditions.

- The stated capacity for a given facility is a flow rate that can be achieved repeatedly for peak periods of sufficient demand. Stated capacity values can be achieved on facilities with similar characteristics throughout North America.
- There is influence from downstream traffic conditions, such as queues backing into the facility under evaluation
- Capacity is not the absolute maximum observed flow rate. The absolute maximum flow rate can vary from day to day and from location to location.



# Basic Concepts: Level of Service (LOS)

- **Level of service (LOS) is a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed (travel time), freedom to maneuver, traffic interruptions, and comfort & convenience.**
- **Six LOS are defined for each type of facility that has analysis procedures available**  
**LOS A represents the best operating conditions**  
**LOS F the worst**
- **Each LOS represents a range of operating conditions and the user's perception of those conditions. Safety is not included in the measures that establish LOS**



# Organization of HCM2010

- **Over 1,000 pages (35 Chapters in 4 Volumes)**

## **Volume 1 – Concepts**

- **Volume 2 – Uninterrupted Flow Facilities**
  - **Freeways, rural highways, rural roads**
- **Volume 3 – Interrupted Flow Facilities**
  - **Urban arterials, intersections, roundabouts**
  - **Signals at freeway interchanges,**
  - **Bicycle and Pedestrian paths**
- **Volume 4 – Supplemental Materials**



# Web Site

## 2010 Highway Capacity Manual

5<sup>th</sup> Edition

TRB

HCQS

Publications

Contact

Research

### Highway Capacity Volumes

1. Concepts
2. Uninterrupted Flow Facilities
3. Interrupted Flow Facilities
4. Applications Guide

### Updates

- NEW Chapter 26 (Adopted):** Interchange Ramp Terminals
- NEW Chapter X (Evaluation Copy):** Local Urban Streets
- NEW NCHRP Report XXX:** Analysis of Freeway Weaving Sections







# Vol. 1- Concepts

**Chapter 1. HCM User's Guide**

**Chapter 2. Applications**

**Chapter 3. Modal Characteristics**

**Chapter 4. Traffic Flow & Capacity Concepts**

**Chapter 5. Quality and Level of Service Concepts**

**Chapter 6. HCM & Alternative Analysis Tools**

**Chapter 7. Interpreting HCM & Alternative Tool Results**

**Chapter 8. HCM Primer (= Executive Summary)**

**Chapter 9. Glossary & Symbols**



# Vol. 2 – Uninterrupted Flow Facilities

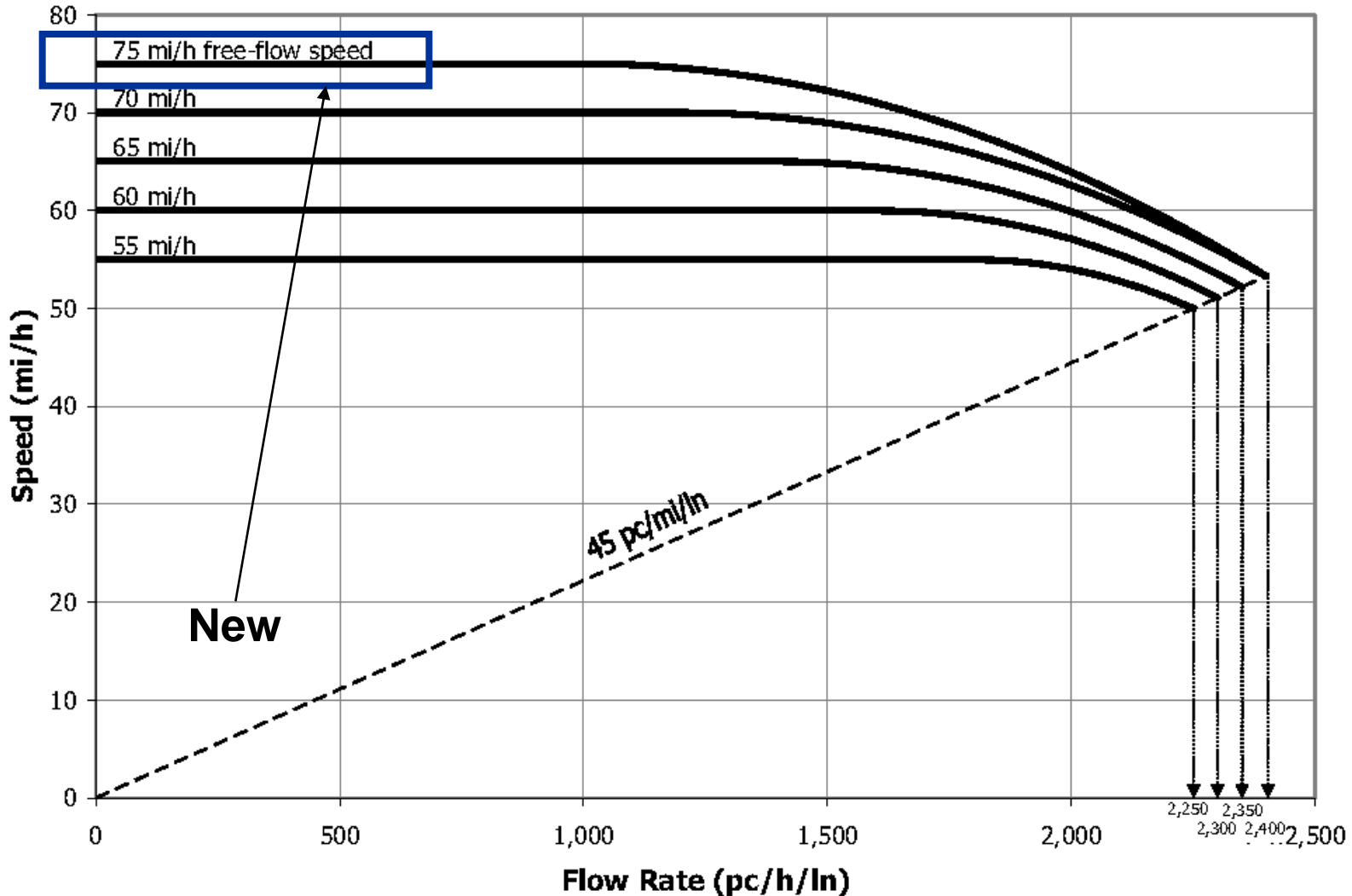
- 10. Freeway Facilities**
- 11. Basic Freeway Segments**
- 12. Freeway Weaving Segments**
- 13. Ramps and Ramp Junctions**
- 14. Multilane Highways**
- 15. Two-Lane Highways**





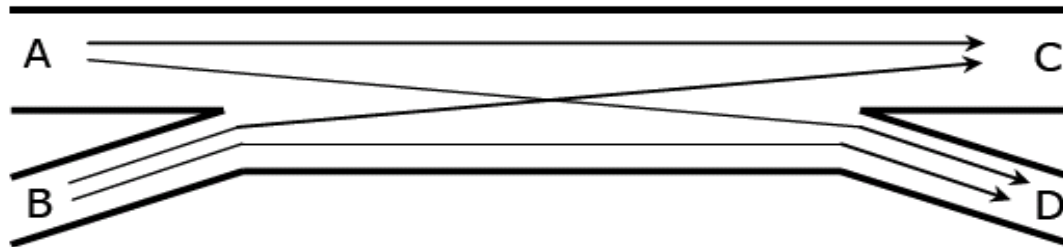
# Updated Freeway Speed-Flow Curves

Based on field data



# Freeway Weaving Segments

- **Analysis and weaving types based on the total rate of lane changing within the weave**
- **Models estimate capacity under ideal and prevailing conditions**





# Freeway Facility Analysis

- **Methodology for impacts analysis over time and space**
- **Modifications to reflect changes in other chapters**
- **Updated capacity information for:**
  - **Work Zones**
  - **Weather (rain, snow, wind, visibility)**
  - **Incidents**



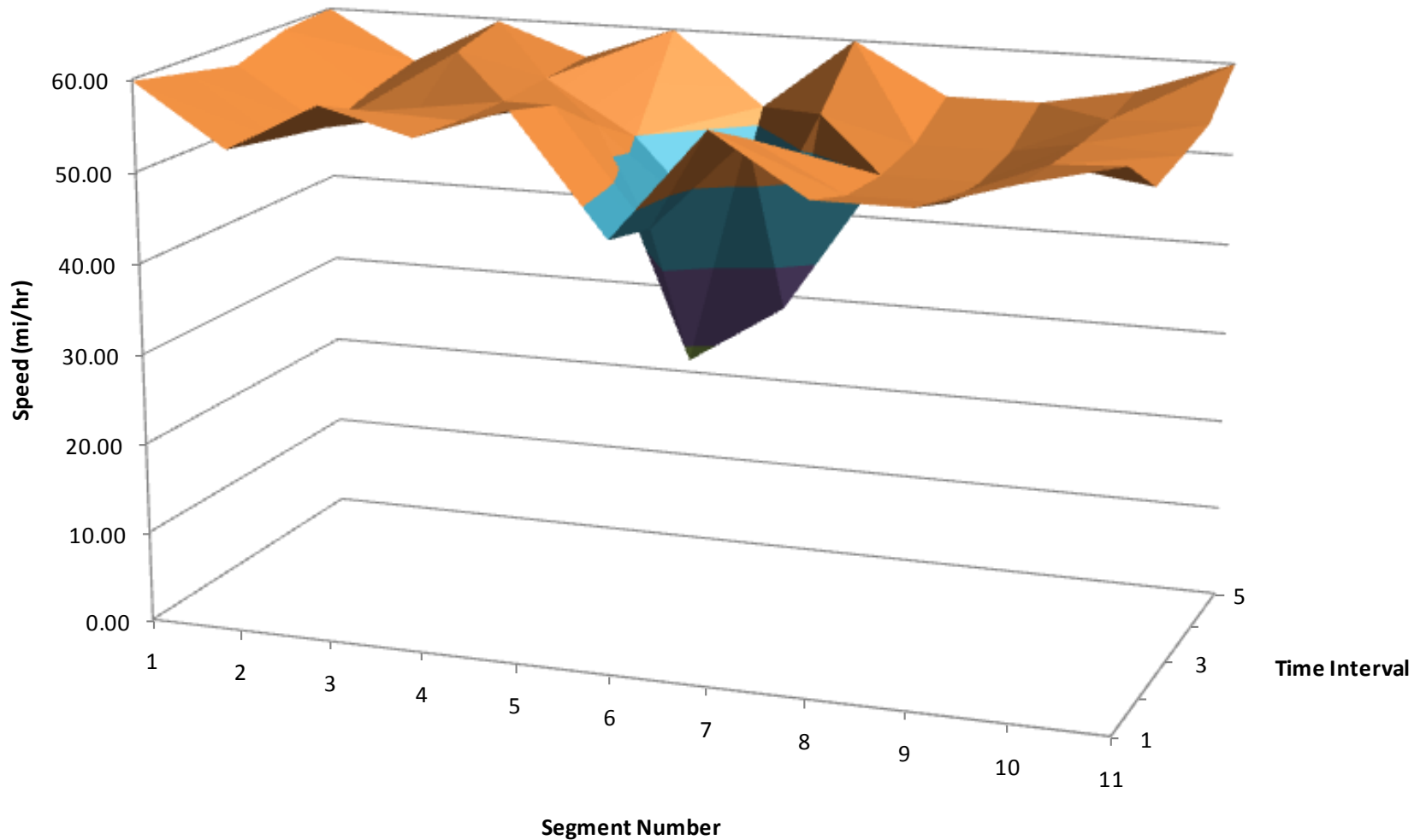
# Analysis Over Time & Space



D/C	SS 1	SS 2	SS 3	SS 4	SS 5	SS 6
16:00	0.68	0.75	0.72	0.72	0.80	0.73
16:30	0.75	0.85	0.82	0.82	0.93	0.82
17:00	0.87	0.97	0.90	0.90	1.03	0.93
17:30	0.82	0.90	0.85	0.85	0.98	0.85
18:00	0.73	0.78	0.73	0.73	0.80	0.70
18:30	0.58	0.62	0.58	0.58	0.62	0.60
MPH						
16:00	63	62	63	63	61	62
16:30	62	60	61	61	58	61
17:00	60	57	59	29	41	58
17:30	61	59	19	15	35	60
18:00	62	62	62	27	48	63
18:30	64	64	64	64	64	64



# FREEVAL Speed Output





# Two-Lane Highways

- **Two-way analysis methodology dropped**
- **Some revisions to curves and tables**
- **New road class added for built-up areas**
  - LOS based on % free-flow speed (FDOT)
- **Bicycle LOS on two-lane highways**
- **Service volume tables**





# Vol. 3 – Interrupted Flow Facilities

- 16. Urban Street Facilities**
- 17. Urban Street Segments**
- 18. Signalized Intersections**
- 19. Two-Way Stop-Controlled Intersections**
- 20. All-Way Stop-Controlled Intersections**
- 21. Roundabouts**
- 22. Interchange Ramp Terminals**
- 23. Off-Street Pedestrian and Bicycle Facilities**

*Transit chapter removed; methodology in Transit Capacity and Quality of Service Manual (TCQS)*



# Multimodal Level of Service

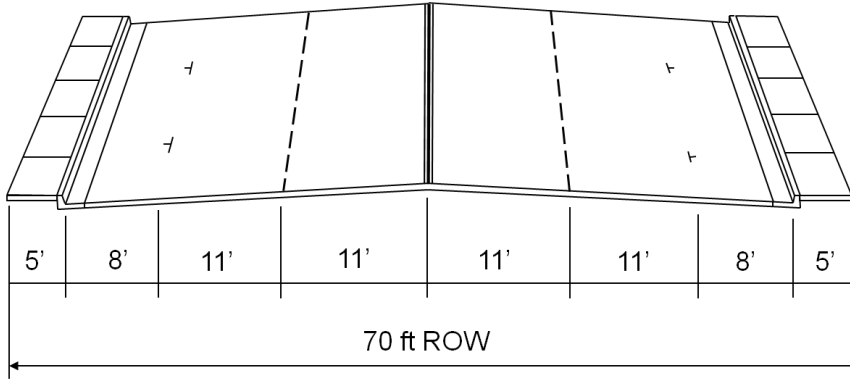
- **Simultaneous analysis of LOS for auto drivers, bus riders, bicyclists, pedestrians**
- **A method for allocating scarce street right-of-way to the various modal users of the street**





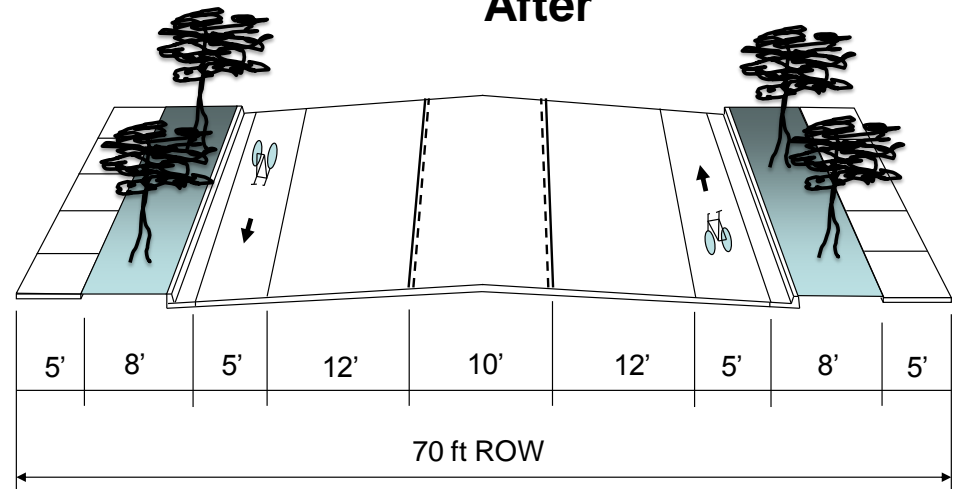
# Sharing the Street - Complete Streets

**Before**



Mode	Before	After
<b>Auto</b>	<b>C</b>	<b>D</b>
<b>Bus</b>	<b>B</b>	<b>C</b>
<b>Bicycle</b>	<b>F</b>	<b>D</b>
<b>Pedestrian</b>	<b>E</b>	<b>E</b>

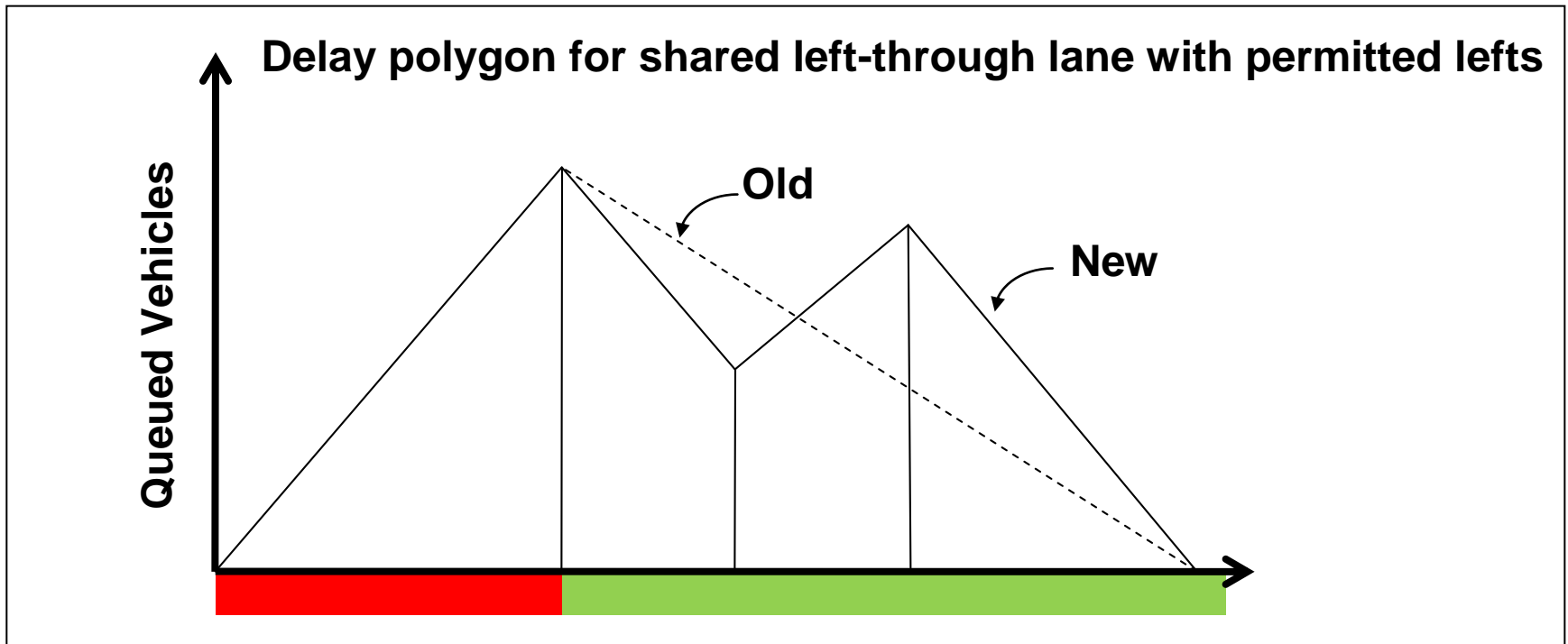
**After**





# Signalized Intersection Updates

- **Incremental queue analysis (IQA)**

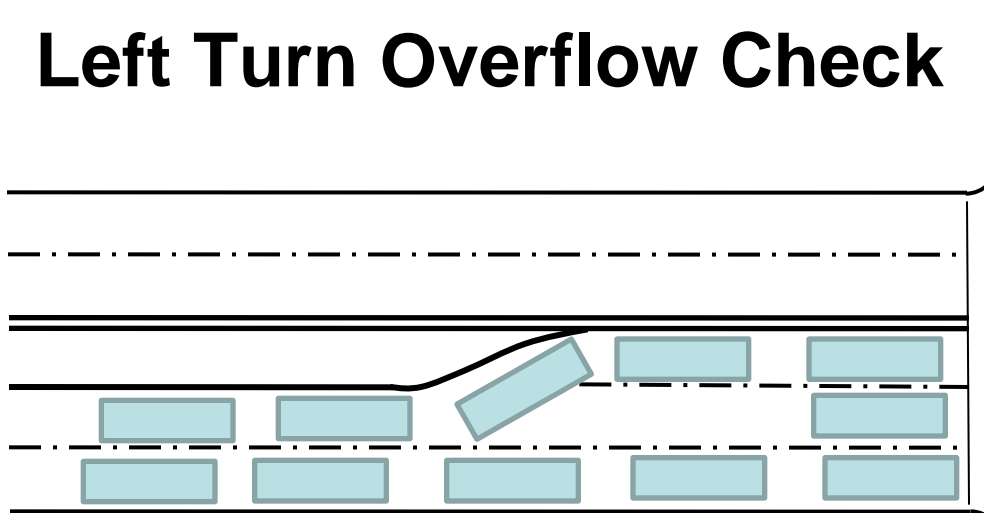


- **Traffic actuated signals**
  - Min. green, passage time, recall, dual entry, Dallas phasing, simultaneous gap out, detector length.



# Signalized Intersection Updates

## Left Turn Overflow Check



If left turn overflow occurs, review results

## Volume/capacity ratio Check

- if:  $v/c > 1.00$

Then the signalized intersection LOS is “F”



# Urban Street Analysis

- **Predicts stops (new), speed, queues**
- **Estimates LOS based on travel speed**
- **Models signal coordination**
  - force offs, yields
- **Mixed street: signal, stops, roundabout**
- **Sensitive to access management**
  - driveways, median breaks
- **Service Volume Table**



# Urban Street Service Volumes

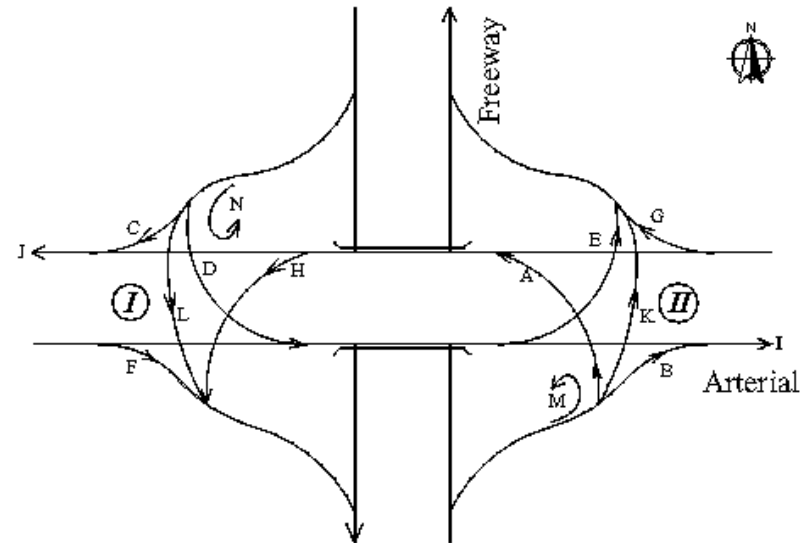
K Factor	D Factor	<u>2-Lane Streets</u>				<u>6-Lane Streets</u>				<u>8-Lane Streets</u>			
		LOS B	LOS C	LOS D	LOS E	LOS B	LOS C	LOS D	LOS E	LOS B	LOS C	LOS D	LOS E
<b>Posted Speed = 30 mi/h</b>													
0.09	0.55	NA	5.9	15.4	19.9	NA	11.3	31.4	37.9	NA	16.3	46.4	54.3
	0.60	NA	5.4	14.1	18.3	NA	10.3	28.8	34.8	NA	15.0	42.5	49.8
0.10	0.55	NA	5.3	13.8	17.9	NA	10.1	28.2	34.1	NA	14.7	41.8	48.9
	0.60	NA	4.8	12.7	16.4	NA	9.3	25.9	31.3	NA	13.5	38.3	44.8
0.11	0.55	NA	4.8	12.6	16.3	NA	9.2	25.7	31.0	NA	13.4	38.0	44.5
	0.60	NA	4.4	11.5	14.9	NA	8.4	23.5	28.4	NA	12.2	34.8	40.8
<b>Posted Speed = 45 mi/h</b>													
0.09	0.55	NA	10.3	18.6	19.9	NA	21.4	37.2	37.9	NA	31.9	54.0	54.3
	0.60	NA	9.4	17.1	18.3	NA	19.6	34.1	34.8	NA	29.2	49.5	49.8
0.10	0.55	NA	9.3	16.8	17.9	NA	19.3	33.5	34.1	NA	28.7	48.6	48.9
	0.60	NA	8.5	15.4	16.4	NA	17.7	30.7	31.3	NA	26.3	44.5	44.8
0.11	0.55	NA	8.4	15.3	16.3	NA	17.5	30.5	31.0	NA	26.1	44.2	44.4
	0.60	NA	7.7	14.0	14.9	NA	16.1	27.9	28.4	NA	23.9	40.5	40.7

Notes: NA = not applicable, LOS cannot be achieved with the stated assumptions.  
 General assumptions include: no roundabouts or all-way STOP-controlled intersections along the facility; coordinated, semi-actuated traffic signals; arrival type 4; 120-s cycle time; protected left-turn phases; 0.45 weighted average  $g/C$  ratio; exclusive left-turn lanes with adequate queue storage provided at traffic signals; no exclusive right-turn lanes provided; no restrictive median; 2-mi facility length; 10% of traffic turns left and 10% turns right at each traffic signal; PHF = 0.92; base saturation flow rate = 1,900 pc/h/ln.  
 Additional assumptions for 30-mi/h facilities: signal spacing = 1,050 ft and 20 access points/mi.  
 Additional assumptions for 45-mi/h facilities: signal spacing = 1,500 ft and 10 access points/mi.



# Interchange Ramp Terminals

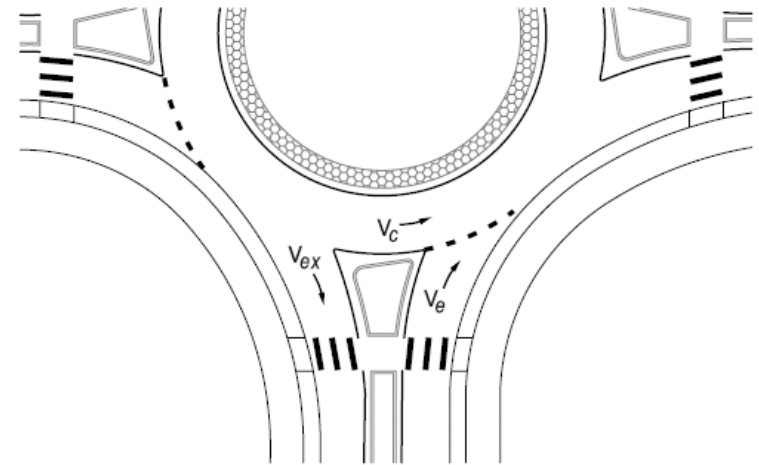
- **New Method estimates LOS for each O-D in an interchange**
- **LOS based on delay, queue storage ratio,  $v/c$**
- **Method considers**
  - Queue spillbacks
  - Uneven lane utilization
  - Demand starvation





# Roundabouts Update

- Capacity and delay by approach
- Single and multi-lane roundabouts
- US Capacities lower in the world
- Research based on US field data
- LOS based on delay





# Stop Control Intersections Updates

## Two Way

- **Extended to 6-lane arterials.**
- **U-turns**
- **Analysis of shared lanes, short lanes**
- **Pedestrian crossings analysis**

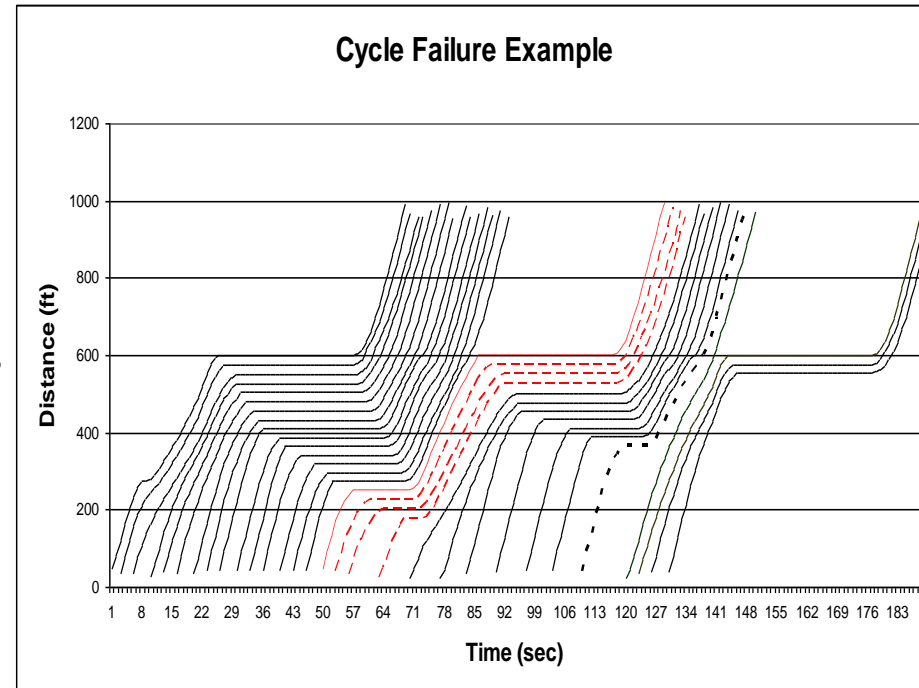
## All Way

- **Queuing model added**
- **Explicit guidance for 6-lane streets**



# Vol. 1-Chapter 6: HCM and Alternative Tools

- **Planning Methods Based on the HCM**
- **Alternative Methods (Microsimulation)**
  - Traffic modeling concepts
  - Application guide
  - Framework to apply HCM + microsimulation
  - Comparison of performance measures
  - Selection of traffic models



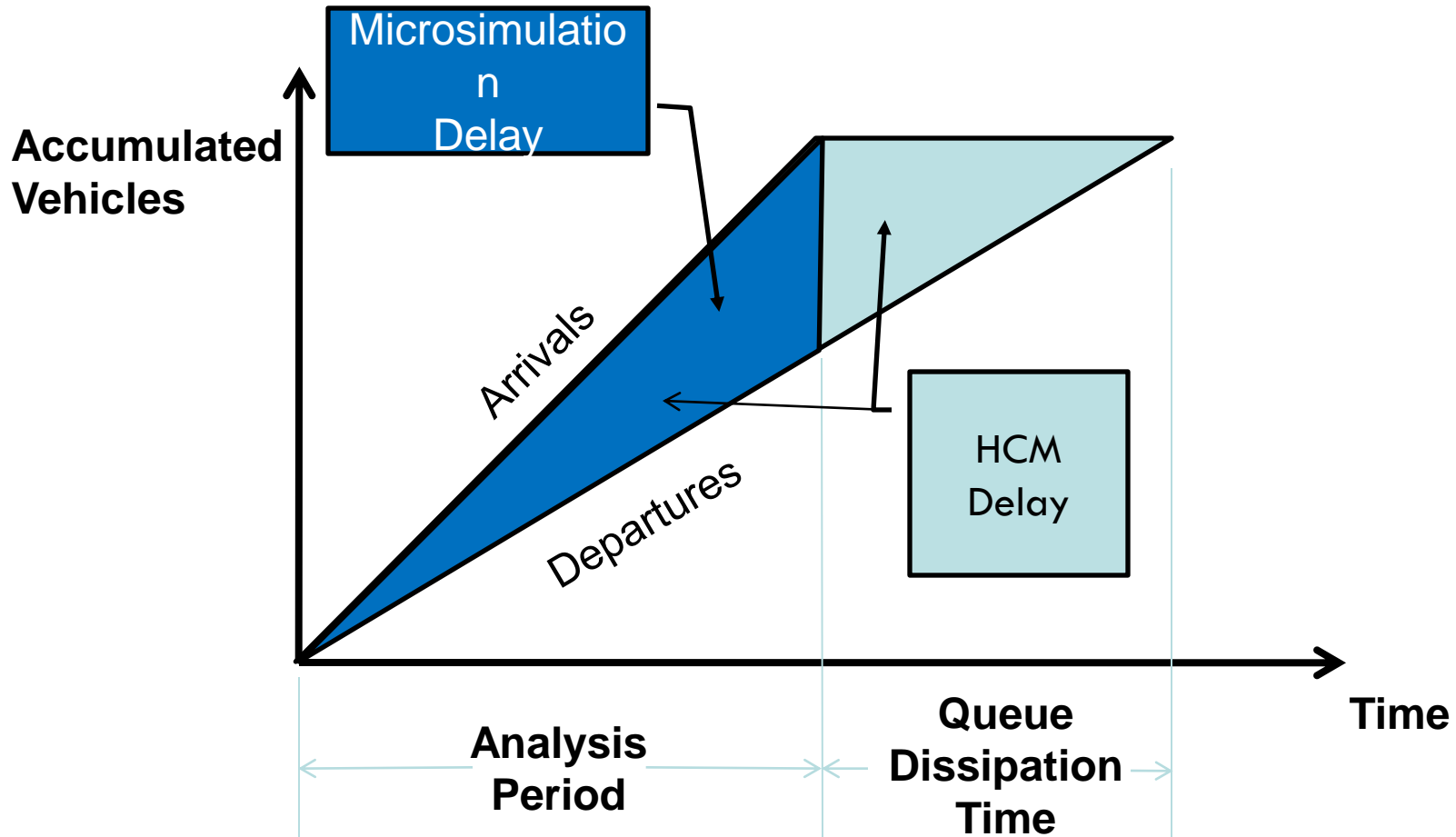


# Vol. 1- Chapter 7

## Interpreting Results

- **Uncertainty and Variability**
  - Concepts, Sources, Sensitivity Analysis
  - Uncertainty and Sensitivity of HCM results
- **Comparing HCM and Microsimulation Results**
  - Framework for comparing HCM/microsimulation results
  - Specific guidance provided in facility specific chapters
- **Presentation of HCM/Microsimulation Results**
  - Significant digits for reporting

# Microsimulation vs HCM Delay





# Vol. 4 – Supplemental Materials

- **Target Audience: Engineers and programmers**
- **12 chapters, all electronic, on the web**
  - More detailed descriptions of methods
  - Worked example problems
- **Annotated software source code**
- **Technical reference library**
- **HCM Application Guide**



# HCM2010 Software

- **Availability**
  - Source code available to all
  - Illustrates how to program the methods
  - Can be used to verify commercial software
- **Does not compete with commercial software**
  - Very limited user interface
  - Works only for simple and limited example problems



# The 2010 HCM Update (In Progress)

## Need for Update:

Several research efforts have developed material for the HCM:

- **Incorporation of Travel Time Reliability into the HCM**
- **Analysis of Managed Lanes on Freeway Facilities**
- **Traffic Signal Analysis with Varying Demands and Capacities**
- **Methodologies to Assess Advanced Transportation & Demand Management (ATDM) Strategies**
- **Guidelines on the Use of Auxiliary Through Lanes at Signalized Intersections**
- **Evaluating the Performance of Corridors with Roundabouts**
- **New Work Zone Capacity Methods**
- **Incorporating Truck Analysis into the HCM**





# User Survey Results

- **Contacted Well Over 10,000 HCM 2010 Users**
  - Received Over 1,000 Detailed Survey Responses
- **Confirmed HCM 2010 Used as Intended and Expected**
  - With Over 70% Using the HCM 2010 at Least Monthly
- **Learned Users Still Finding Their Way in HCM 2010**
  - Only 40% Multimodal Use
  - Only 60% Volume Four Use
- **Underscores HCM 2010 Update Most Appropriate**
  - Not Ready for an Entirely Redeveloped Manual



# HCM2010 Update Outline: Practitioner-focused

- **Focuses on what users need to know to apply the operations methods**
  - **More, but shorter sections; same basic flow of information as HCM 2010**
  - **Applications material moved to Other Publications (HCM Applications Guide)**
  - **Added detail on data needs, performance measures, and interpretation of results**
  - **Chapters have a consistent structure (including those with no change to the method)**
- **Designed to provide information most needed by HCM users, particularly those applying the HCM with software**



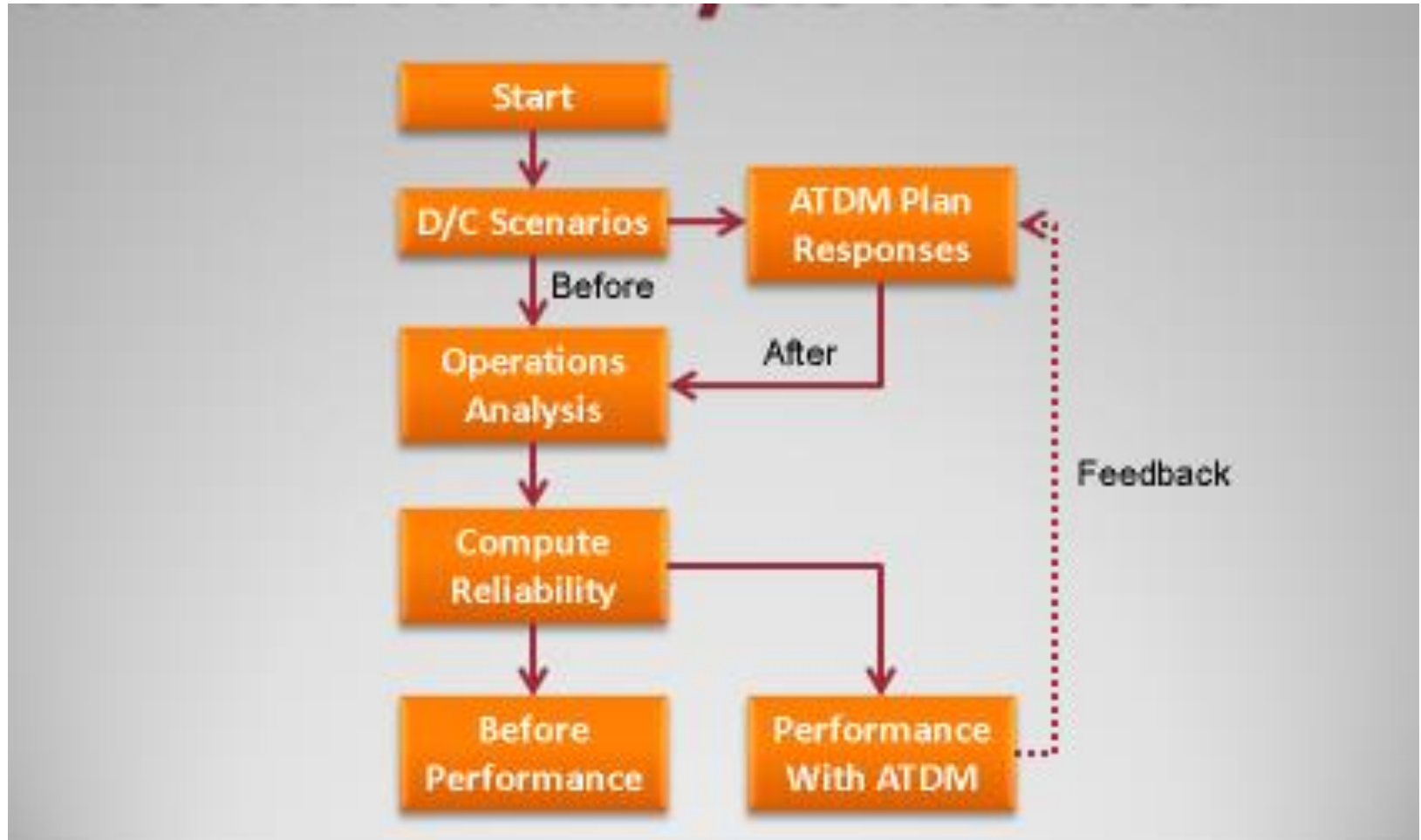
# Active Transportation and Demand Management (ATDM)

- **ATDM is a comprehensive approach to optimizing the operational performance of the roadway system through monitoring and control of systems operations and demands.**
- **Examples**
  - **Demand Metering, Congestion Pricing, Managed Lanes, Adaptive Control, Speed Harmonization, Traveler Information Systems, Incident Management, Work Zone Management**

# ATDM Examples

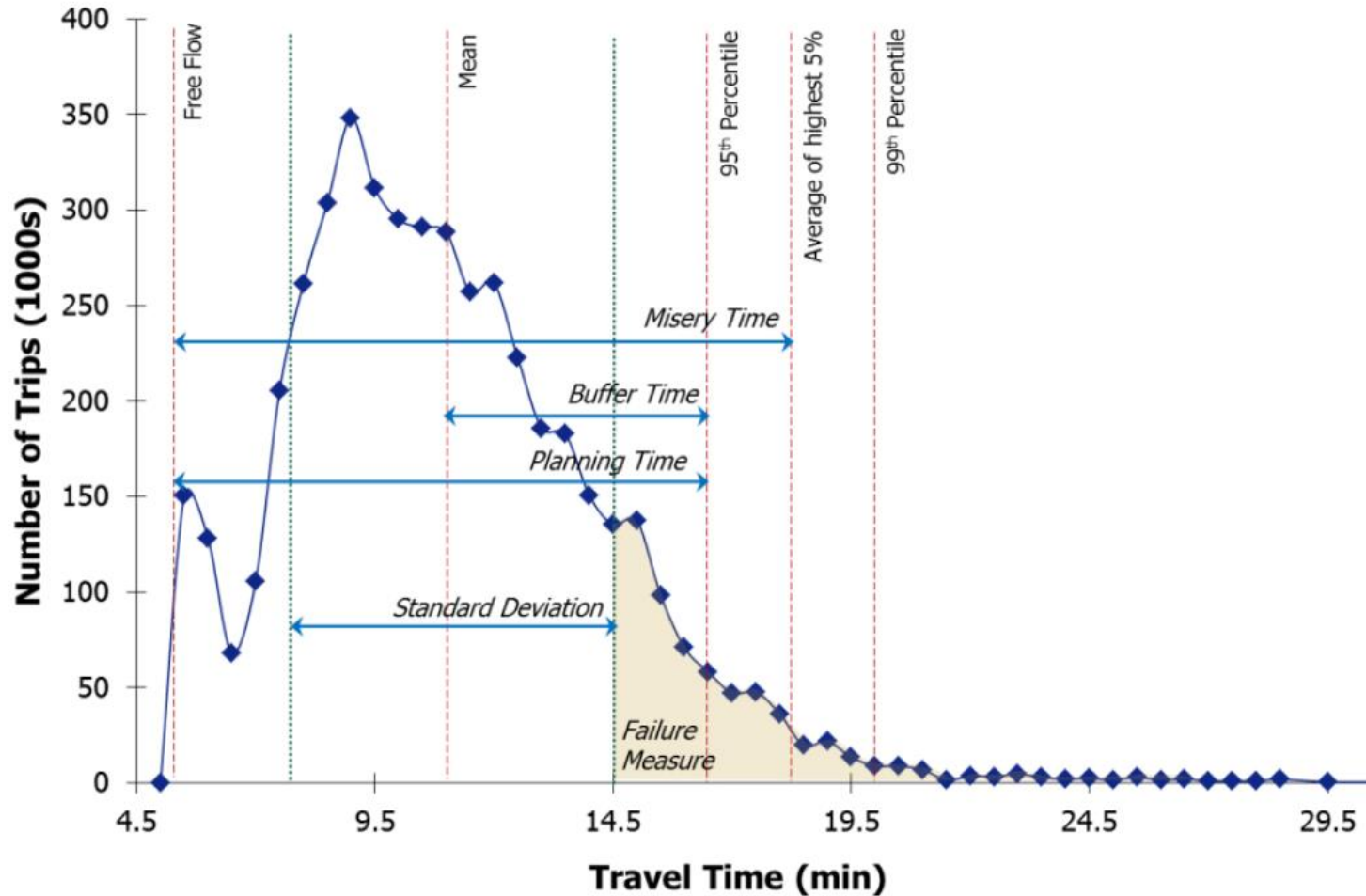


# The ATDM Analysis Method

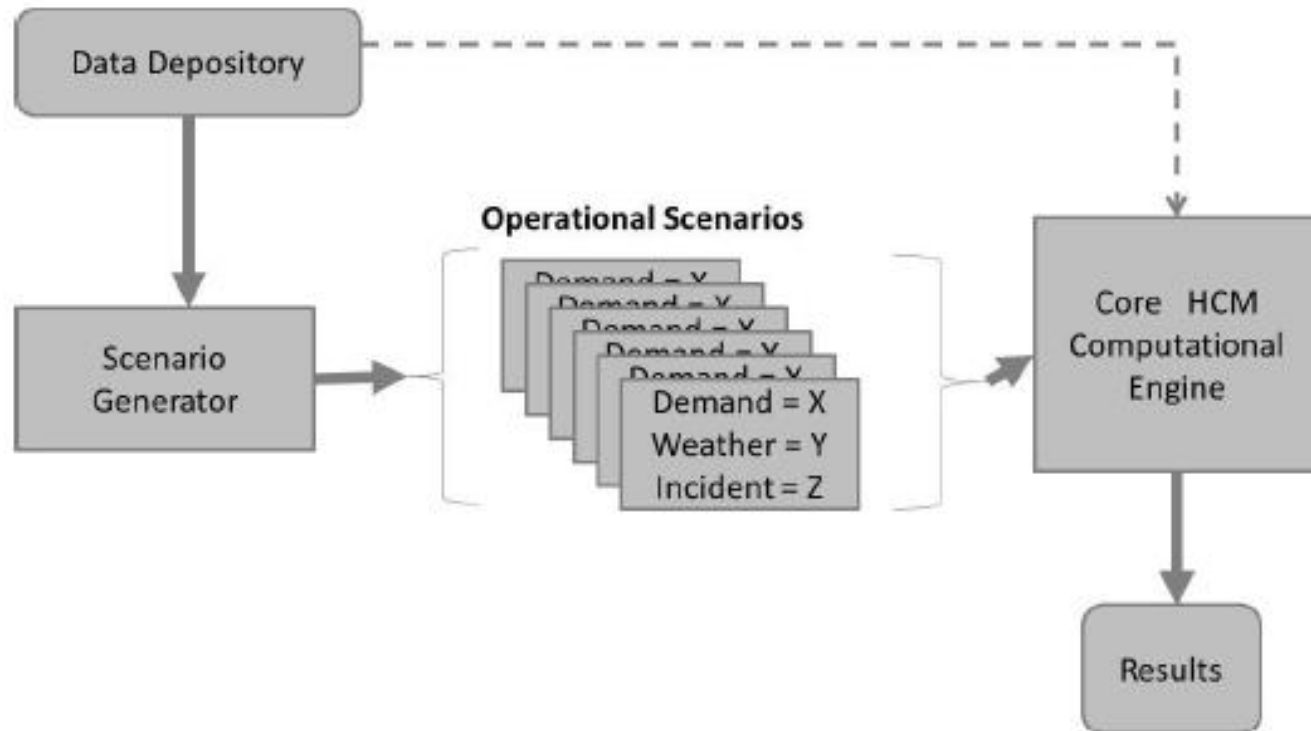




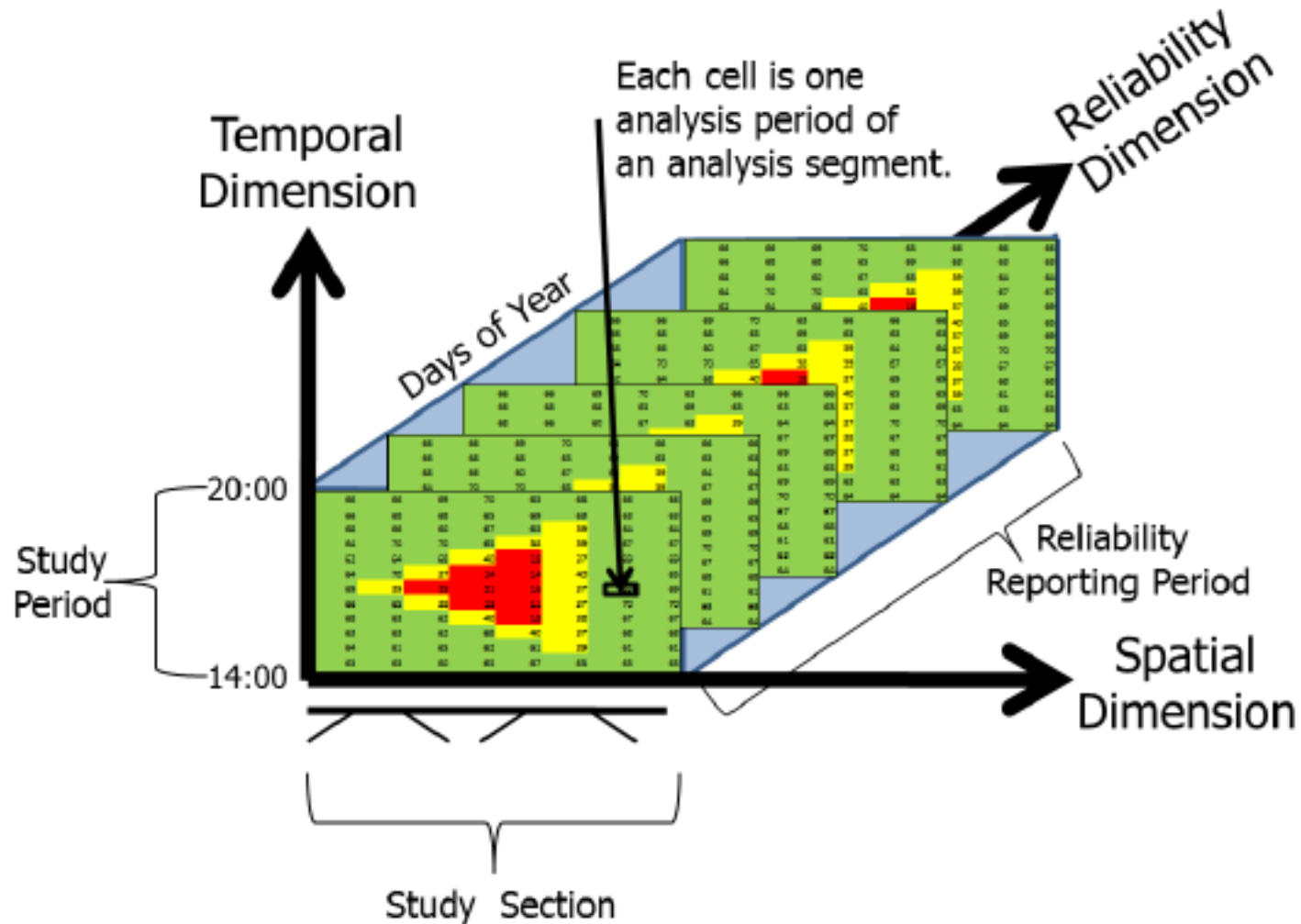
# Reliability Performance Measures



# Reliability Analysis (1)



# Reliability Analysis (2)







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