Incorporating Travel Time Reliability Into Planning Applications

presented to

Tennessee Model Users Group

presented by

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What I'll Cover

- Definition of travel time reliability (TTR) and why it's important
- Measuring reliability: data and methods
- Forecasting reliability
  - SHRP 2 products
  - Example applications: Tampa and Knoxville MPOs

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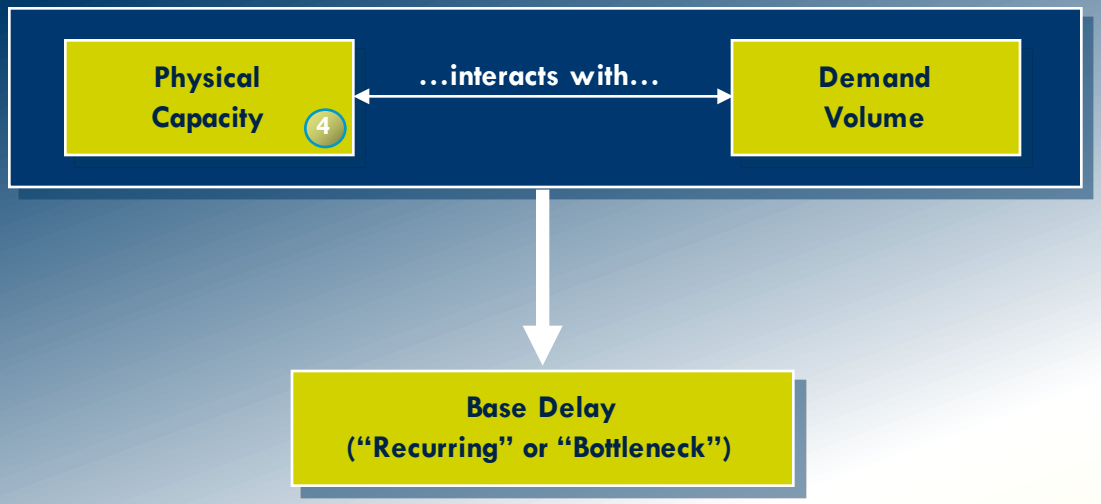
A Model of Congestion and Its Sources



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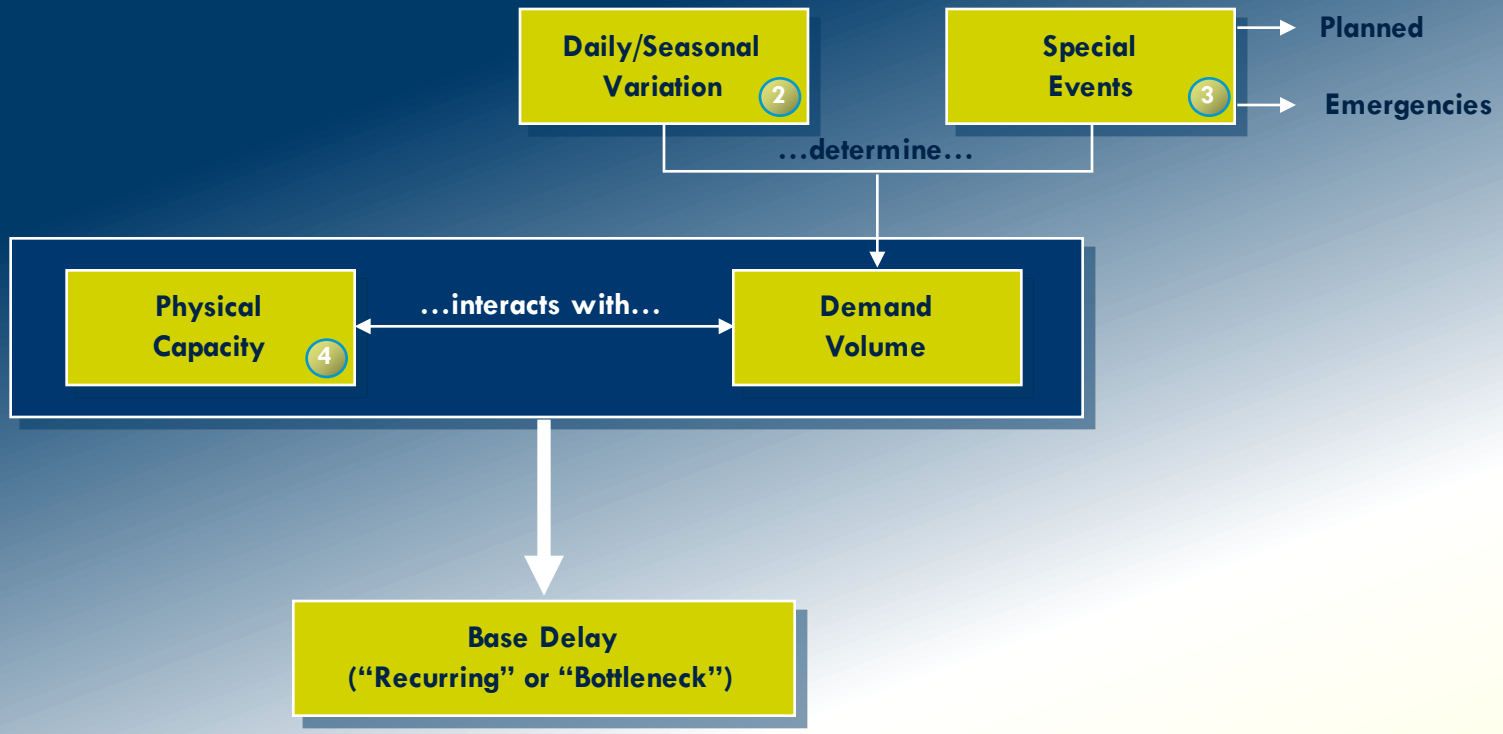

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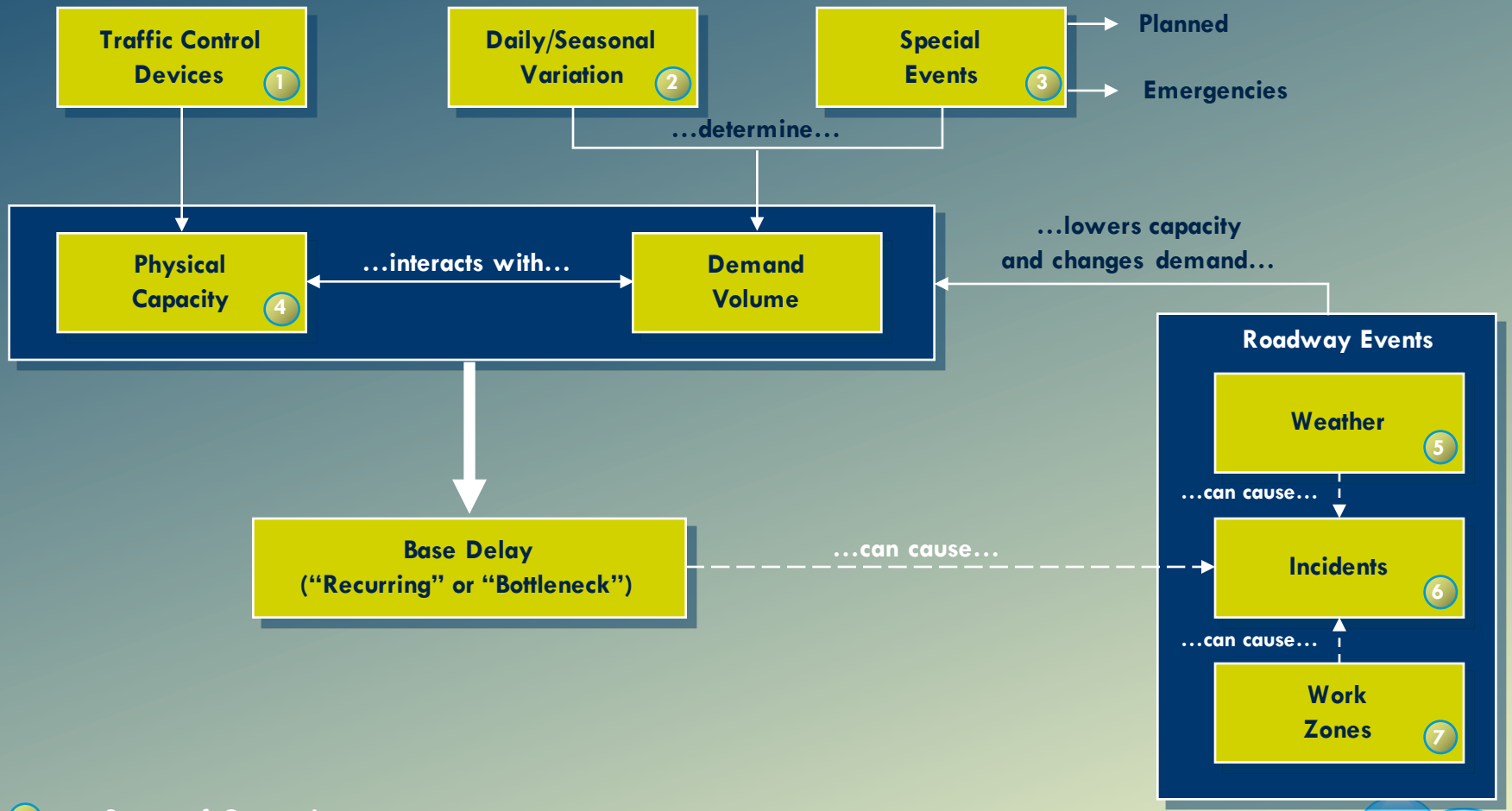

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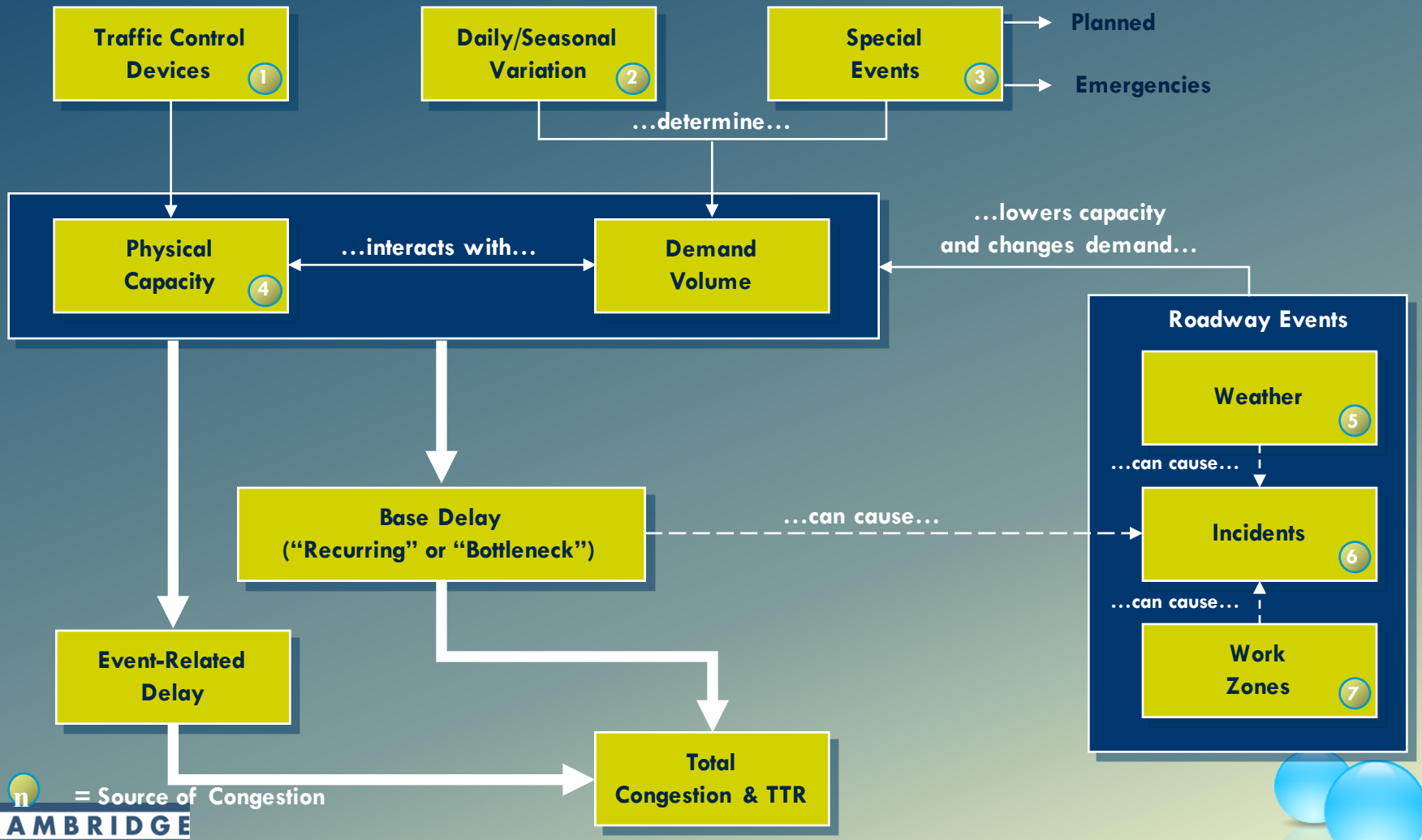

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Travel Time Reliability

- Measured by how travel time of a trip varies over time (from day-to-day) for a specific time period (e.g., peak period)
- In other words, reliability is measured as the variability of travel times
  - "How long will my trip take today compared to the same trip at the same time on any average day?"
  - … this implies …
  - Travelers should have the ability to predict travel time for a trip and to arrive at destination within an "on-time window"

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Why Is Reliability Important?

- Less tolerance for unexpected delay
- Planning for unreliable travel has costs for users
  - » In the past we assumed only the average travel time for a trip was valued, …but..
  - » Studies have shown that variability/unpredictability has cost too
    - VOR ~ 80% of VOT
- Can be treated cost-effectively by addressing roadway "events" through operations strategies
  - » But any capacity increase or demand reduction will also improve reliability

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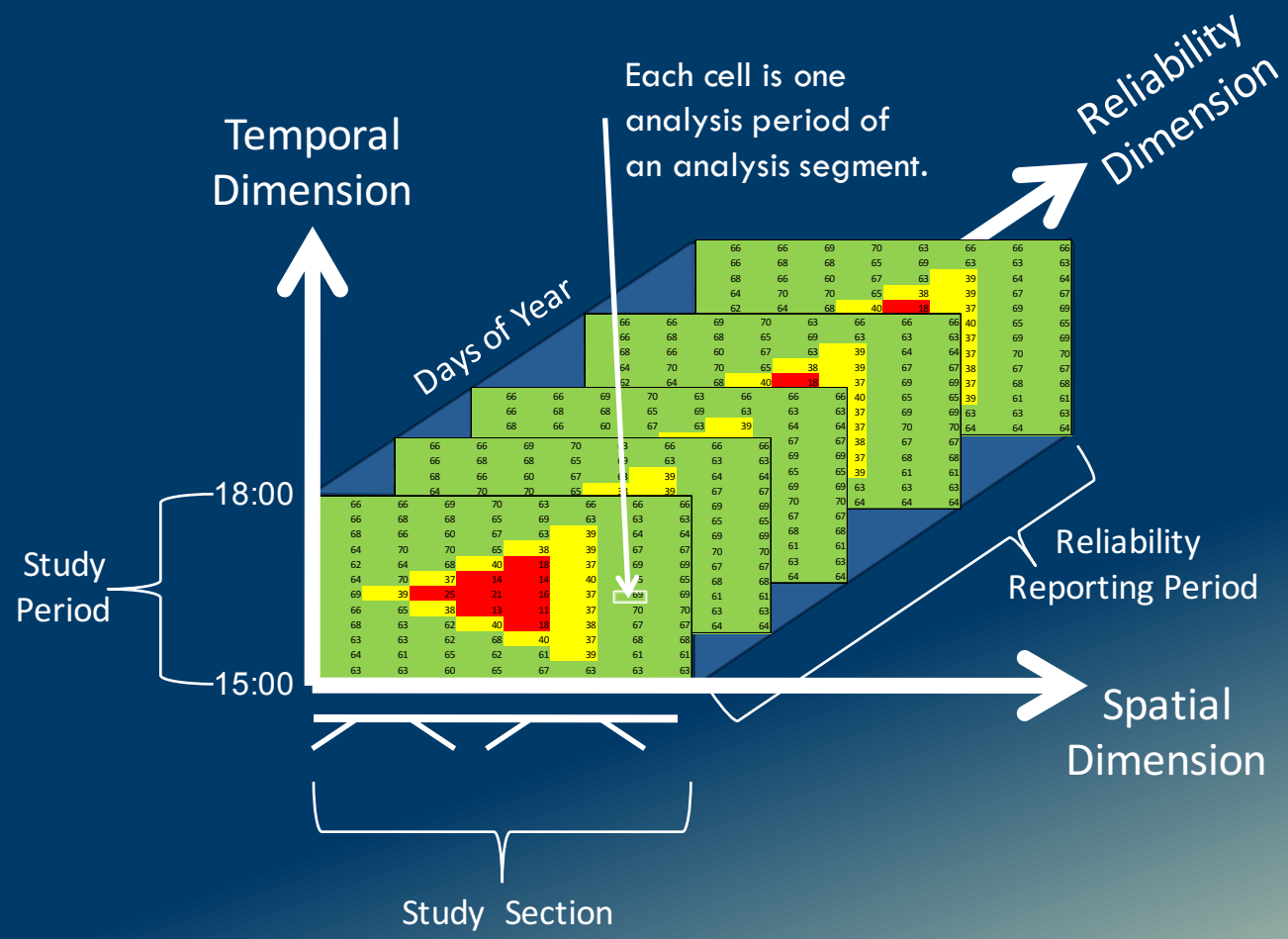
Reliability in Concept



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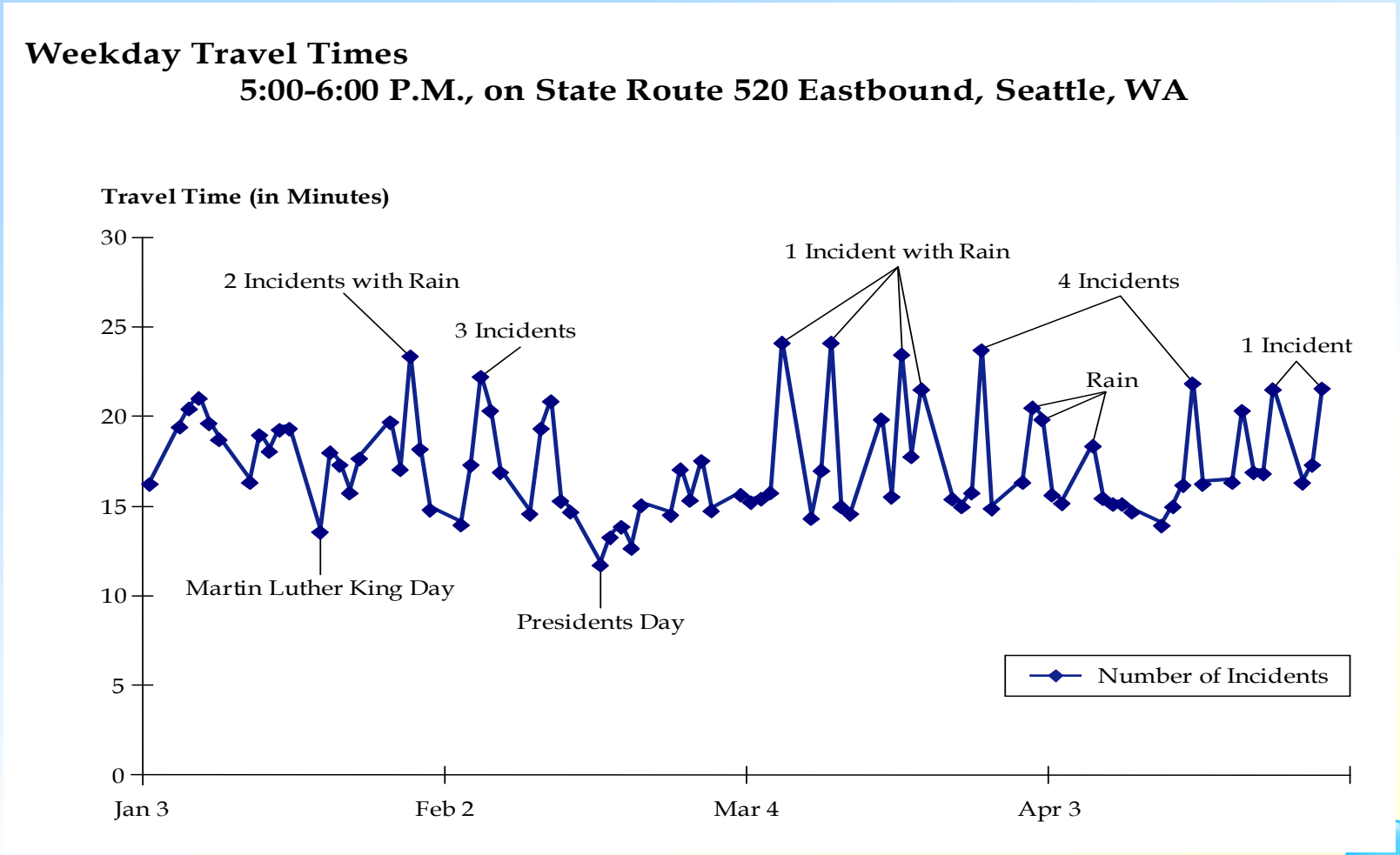
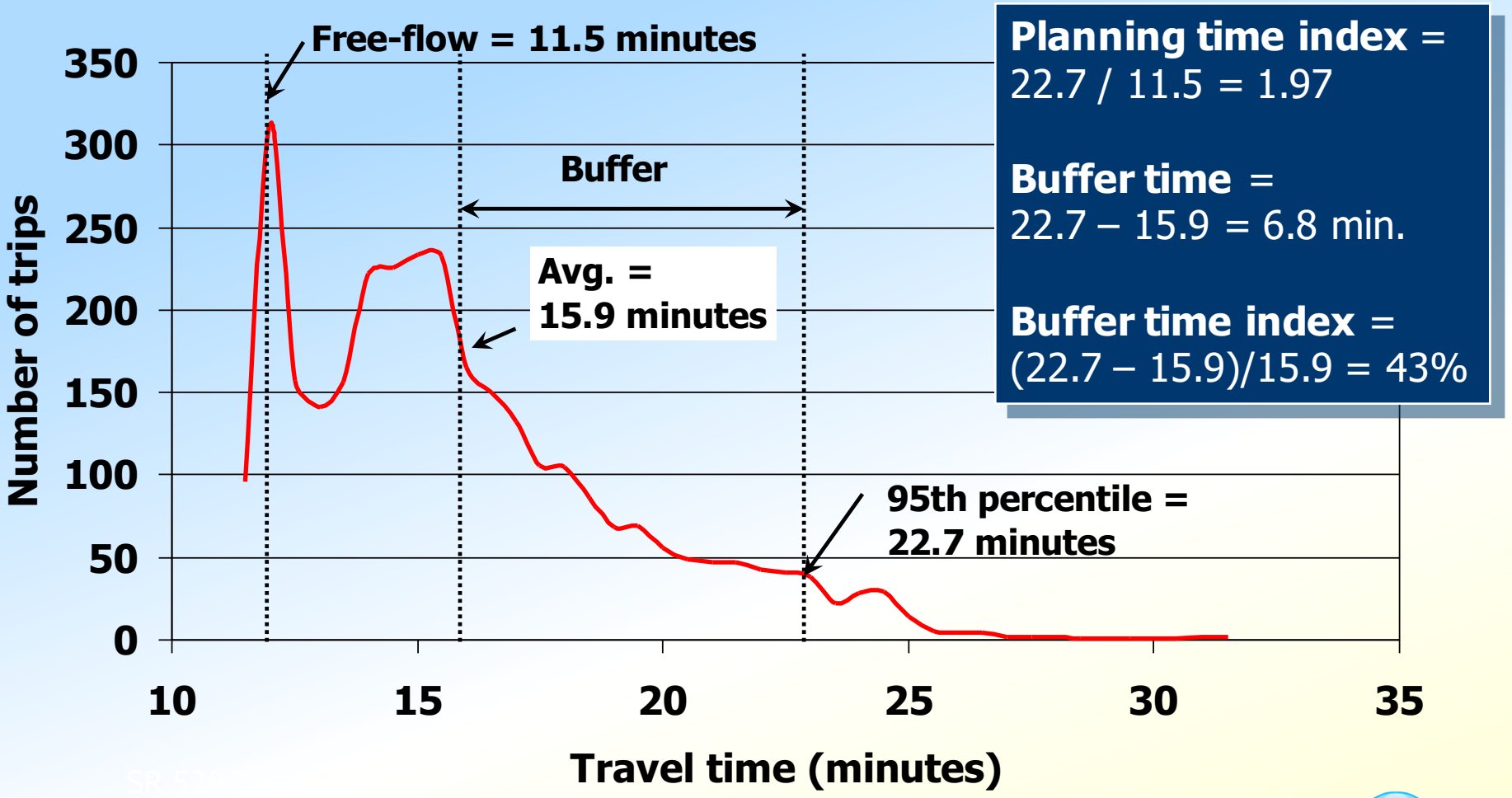
Effects of Incidents and Weather



Reliability Measures in the New HCM

Reliability	Definition
Core Measures	
Planning Time Index (PTI)	95th percentile Travel Time Index (TTI) (95th percentile travel time divided by the free flow travel time)
80th Percentile Travel Time Index	80th percentile Travel Time Index (80th percentile travel time divided by the free flow travel time)
Semi-Standard Deviation	The standard deviation of travel time pegged to free flow travel time rather than the mean travel time (variation is measured relative to free flow travel time)
Failure/On-Time Measures	Percent of trips with space mean speed less than 50 mph; 45 mph; and 30 mph Reliability Rating: Percent of trips serviced at or below a threshold travel time index (1.33 for freeways, 2.50 for urban streets)
Supplemental Measures	
Standard Deviation	Usual statistical definition
Misery Index (Modified)	The average of the highest five percent of travel times divided by the free flow travel time

The Travel Time Distribution is the Key to Understanding Reliability

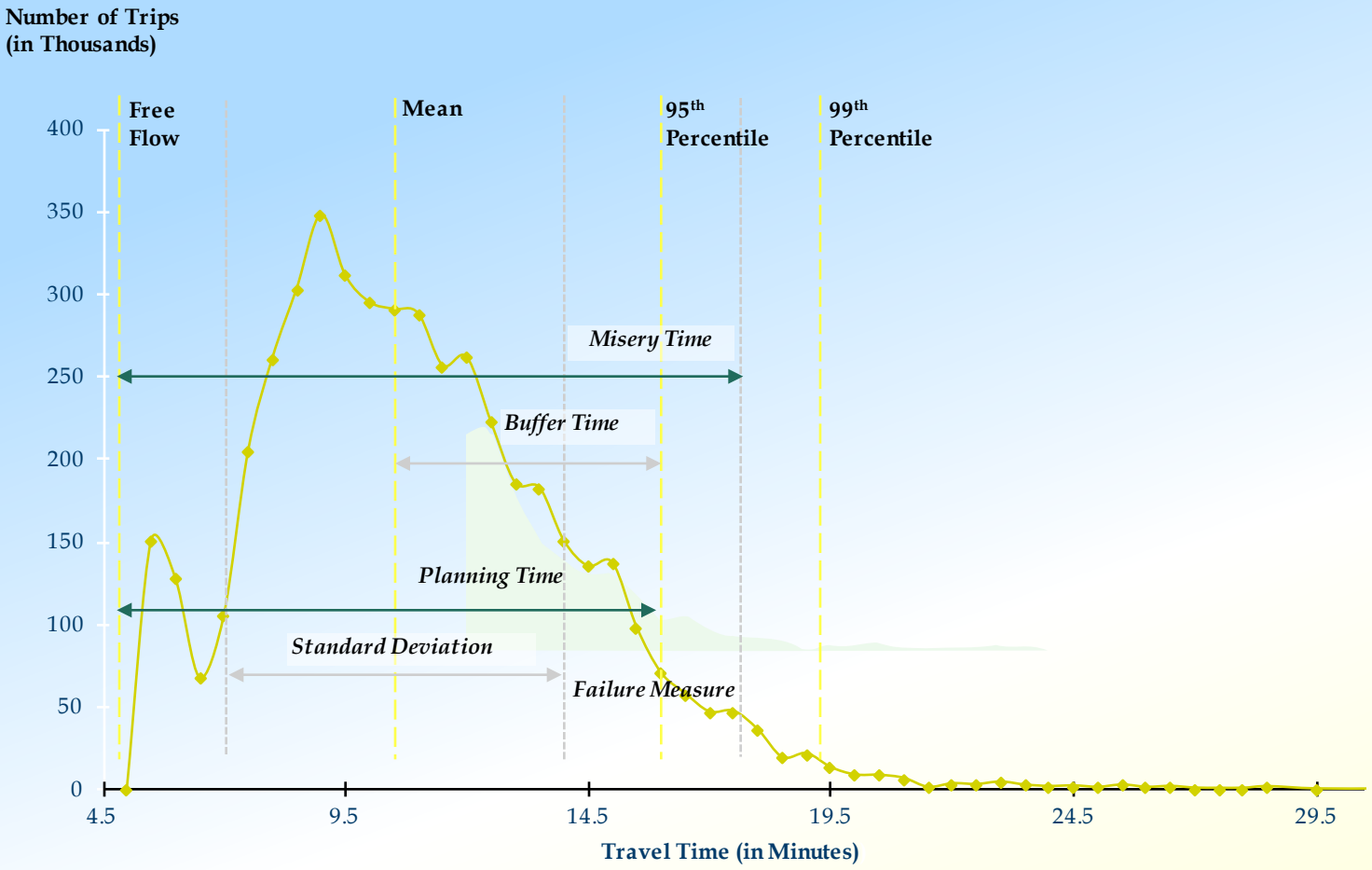


Planning time index = 22.7 / 11.5 = 1.97

Buffer time = 22.7 – 15.9 = 6.8 min.

Buffer time index = (22.7 – 15.9)/15.9 = 43%

Another Travel Time Distribution



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Reliability Prediction: SHRP 2 Tools

SHRP 2 Project	Analysis Scale (in order of increasing complexity)
C11	Sketch planning; system or project level
L07	Detailed sketch planning; mainly project level
L08	Facility analysis using HCM scale of analysis
C10	Regional planning using linked travel demand and mesoscopic simulation analysis
L04	Regional planning using linked travel demand and mesoscopic or microscopic simulation analysis

Other SHRP 2 Reliability Products

- **L02: Guidelines for creating Reliability Monitoring Programs**
  - Types of data needed
  - Data collection and processing
  - Graphics

- **L05: Incorporating Reliability into Planning and Programming**
  - Process oriented
  - Main goals:
    - Reliability used as a performance measure in project evaluations, deficiency analysis
    - Operations projects considered at all phases of project development

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Reliability Prediction for Tampa LRTP Update: SHRP 2 C11

- Part of a larger FDOT effort to get SHRP 2 analytic products into practice
  - » Reliability as a performance measure in alternative evaluations
  - » "Mainstream" consideration of operations projects
- Methodology doesn't require much data: sketch planning level
  - » AADT, capacity, incident characteristics
- Considers both recurring and incident delay
  - » BPR variant for recurring; IDAS model for incident
- Predicts several reliability metrics
  - » Planning Time Index used: 95th %ile TT/Ideal TT

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Approach

- Adapt recently developed methodologies to work with the TBRPM
  - » Create a Post-Processor for model output
    - SHRP 2 Project C11 for Reliability
    - *Highway Safety Manual* for Safety
- Develop investment scenarios for operations and safety projects
  - » Including project costs
- Conduct trade-off analysis: cost vs. outcomes

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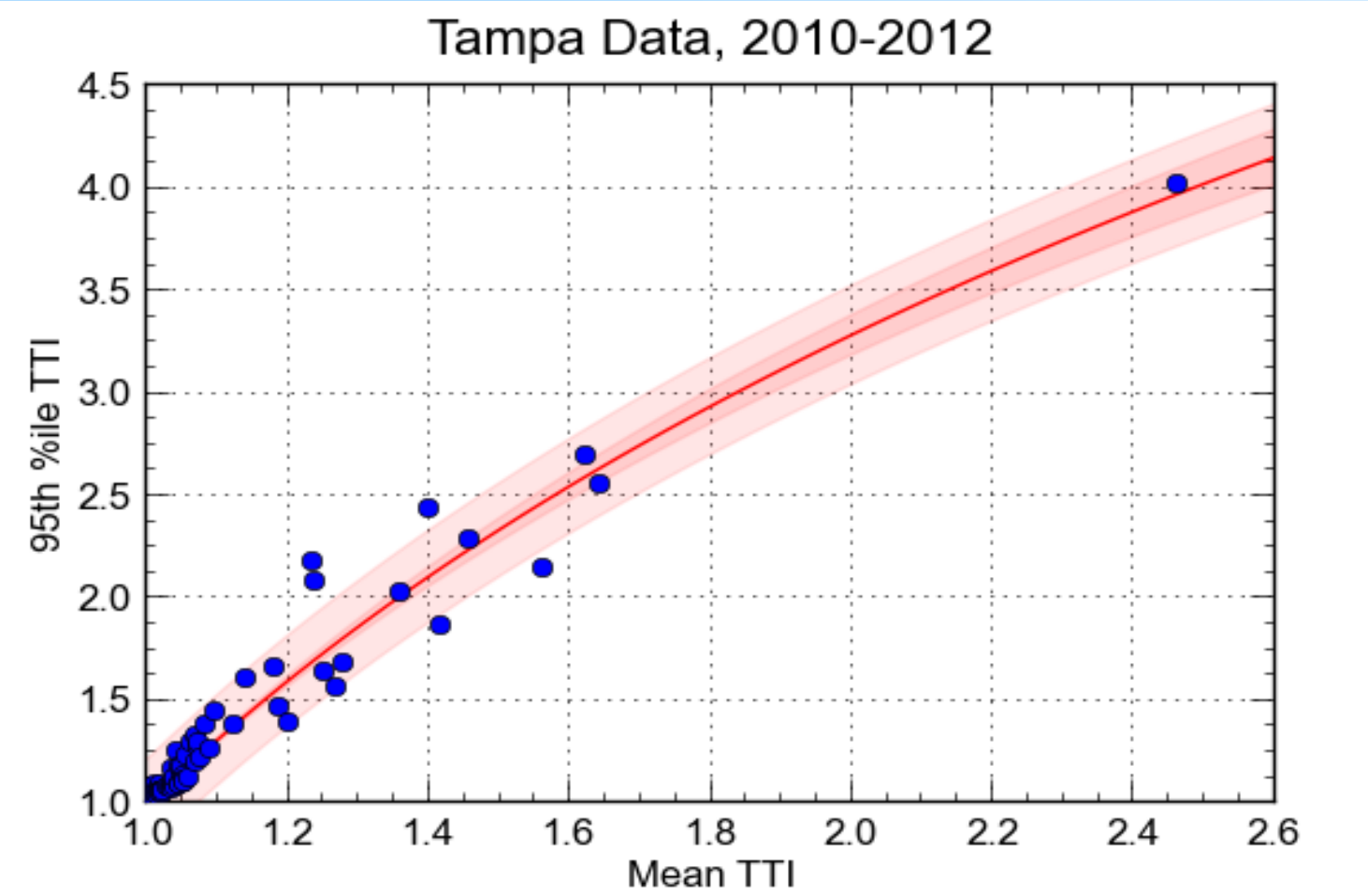
Reliability Prediction in Tampa



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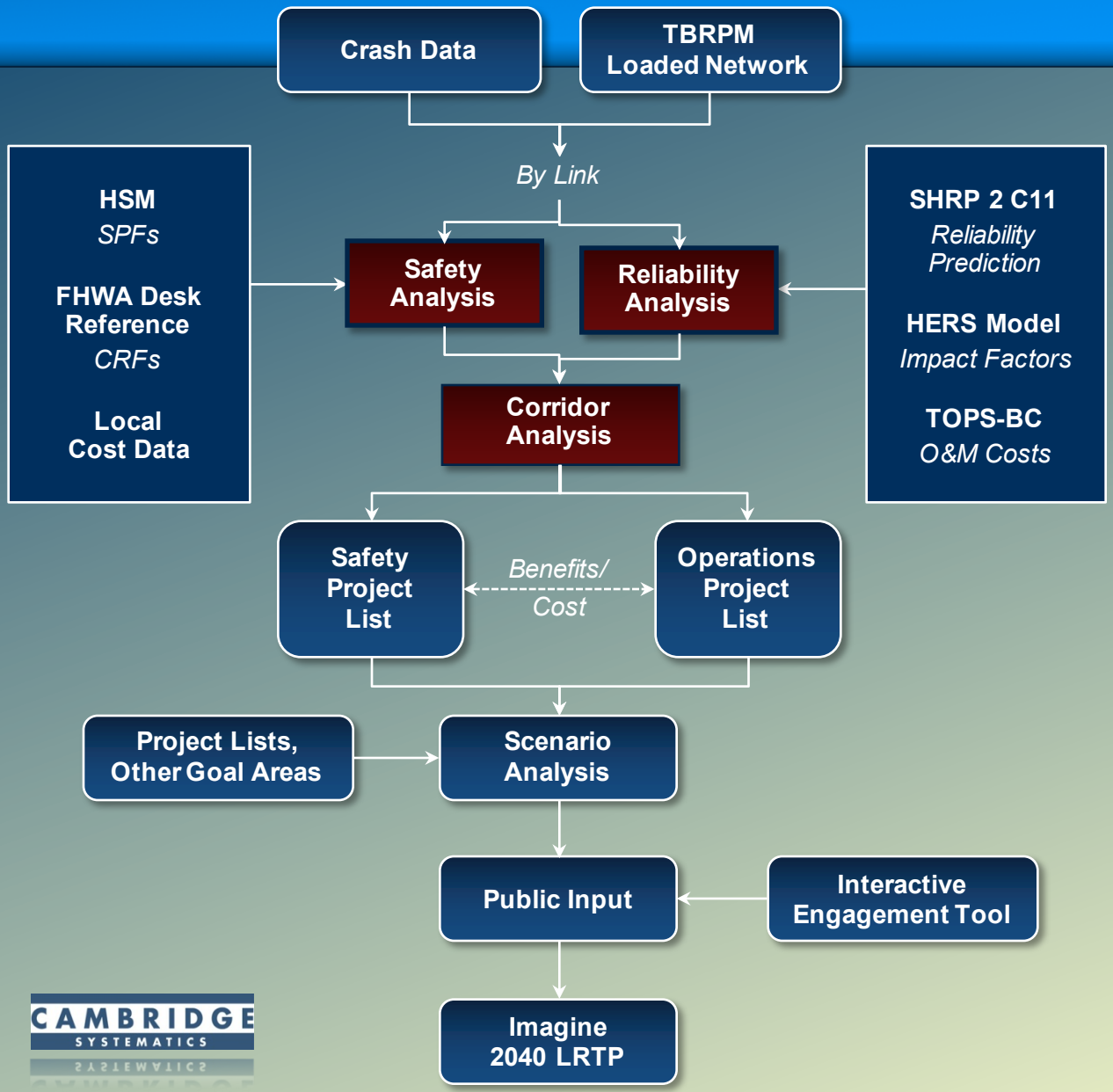
Crash Data
TBRPM Loaded Network
By Link
HSM
SPFs
FHWA Desk Reference
CRFs
Local Cost Data
Safety Analysis
Reliability Analysis
SHRP 2 C11
Reliability Prediction
HERS Model
Impact Factors
TOPS-BC
O&M Costs
Corridor Analysis
Safety Project List
Benefits/ Cost
Operations Project List
Project Lists, Other Goal Areas
Scenario Analysis
Public Input
Interactive Engagement Tool
Imagine 2040 LRTP

Scenarios Studied

- Low: traffic responsive signal control only
- Medium: "Low" + intersection geometric improvements + freeway TIM
- High: "Medium" + freeway ATM (ramp metering, VSL, lane control)

Operations Impacts

Analysis	Scenario	20-Year Cost	Impact Factor
Operations & Congestion Management	Low	$295M	Arterial capacity: +7%
	Medium	$806M	Arterial capacity: +17% Incident frequency: -5% Incident duration: -25%
	High	$957M	Arterial capacity: +17% Incident frequency: -7% Incident duration: -25% Freeway capacity: + 10%

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Tampa Reliability Results

			Investment Scenario		
Highway Type	Mobility Measure	2040 Scenario	Low	Medium	High
Freeways	Average TTI	Base		1.580	
		With Improvements	1.580	1.418	1.308
	80th percentile TTI	Base		1.891	
		With Improvements	1.891	1.670	1.504
	Planning Time Index	Base		2.206	
		With Improvements	2.206	1.944	1.744
	Centerline Miles Improved		0	120	120

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SHRP 2 Now in Implementation Phase

- Goal is to move products into practice
- TDOT & Knoxville TPO have FHWA assistance funding
  - Develop L02-style monitoring system
    - MPO and state levels
  - L05: Incorporate reliability and operations into all planning documents and analyses
  - C11: Reliability forecasting for the LRTP and other planning activities
  - Replace "static" HCM analysis with L08 reliability method
  - Target setting tool based on L07 prediction model

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C11 Post-Processor Enhancements for Knoxville

- Create "user grade" post-processor
  - Make available for other TN MPOs
- Include demand variability; maybe weather?
- Replace BPR function for recurring with HCM methods
- Custom reliability relationships using local vehicle probe data
- Account for synergies between safety and capital expansion/operations projects
- Consider all congestion relief projects simultaneously: operations. Capital expansion, demand management, transit
- Can help with MAP-21 target setting

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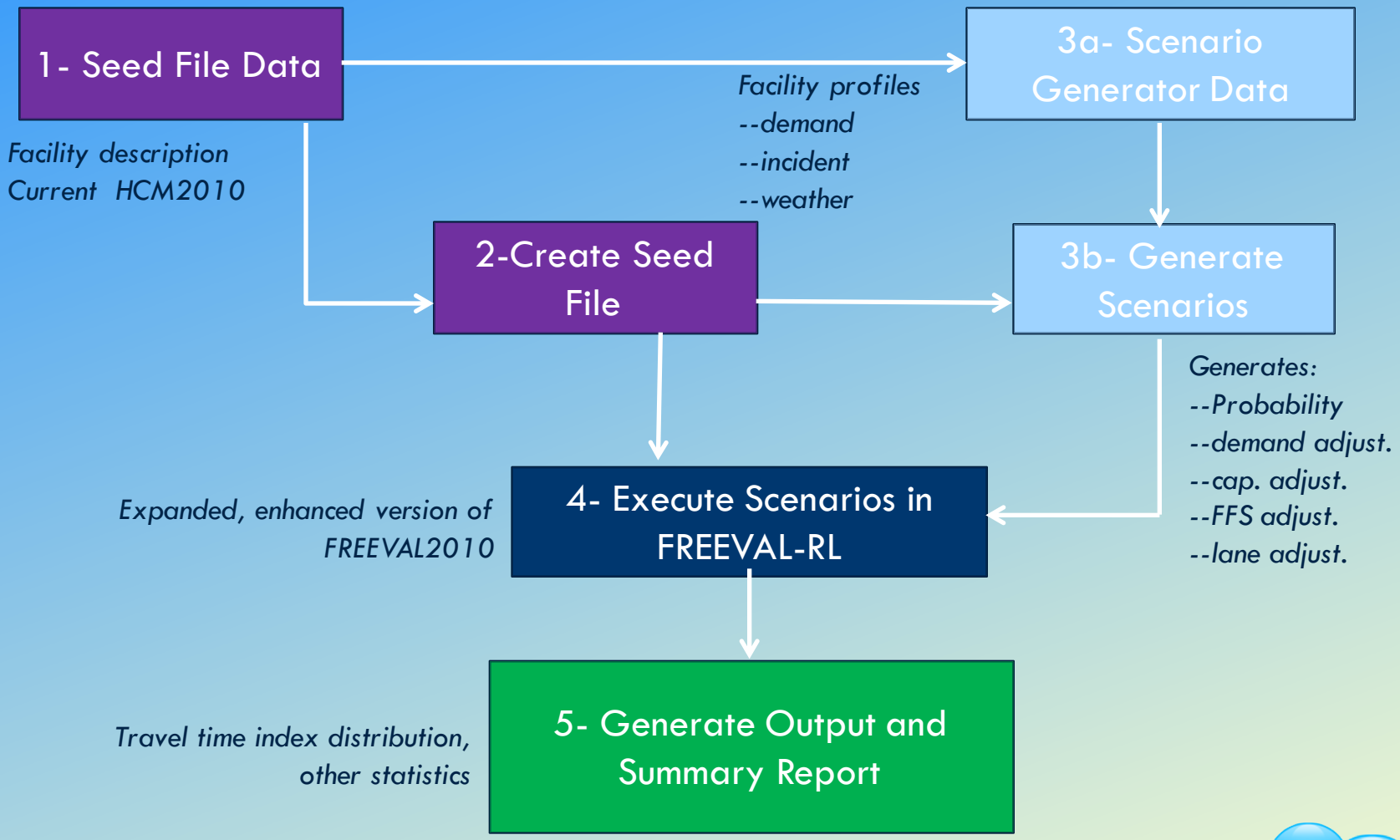
L08 Approach



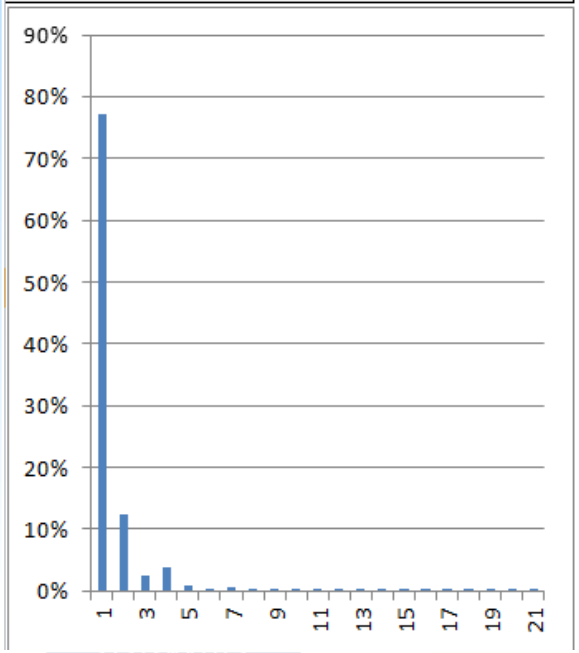
Example L08 Output

Reliability Analysis Summary Report for Base Run

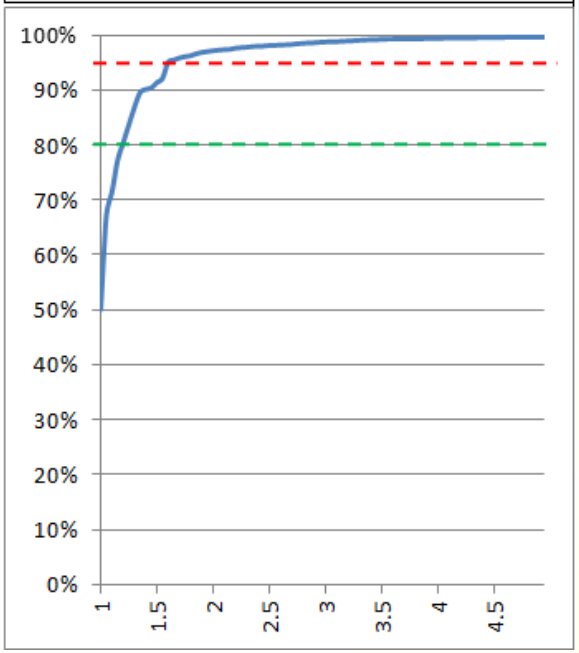
Facility Description			
Facility Length (miles)	6.0	Number of Weather Scenarios	60
Total Number of Scenarios	602	Number of Incident Scenarios	336
Duration of Scenario (hrs)	3	Numb. of Incident + Weather Scen.	198

Facility Reliability Performance Measures			
Mean TTI	1.21	Misery Index	3.00
50th Percentile TTI	1.05	Semi-Standard Deviation	8.00
80th percentile TTI	1.24	Percent VMT at TTI > 1.33	14.96%
95th Percentile TTI (PTI)	1.65	Percent VMT at TTI > 2	2.99%

Probability Distribution Function



Cumulative Distribution Function



At zero inclusion threshold, # of scenario runs→ 1,928

At recommended threshold of 0.01% → 602 (about 90 min)

Mean facility travel speed between 4-7 pm on weekdays ~ 49.7 mph

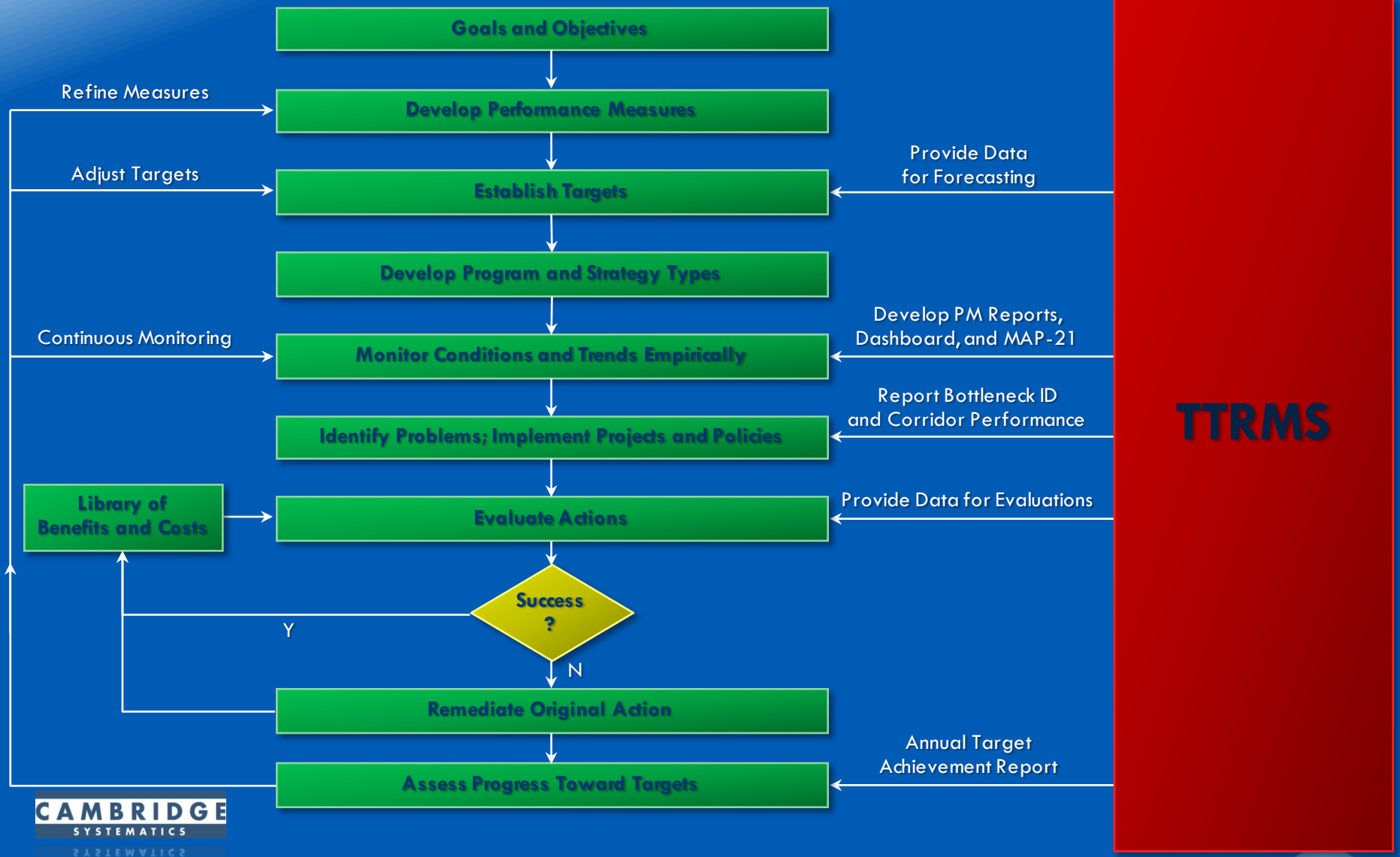
Worse 5% of time facility operates at speed < 36 mph

Unacceptable operations (TTI > 1.33) --- affect about 15% of the VMT

L02: Why do we need a Travel Time Reliability Monitoring System (TTRMS)?

- This is really just a system for measuring congestion/mobility
  - But we need to capture the "Seven Sources"
- Can have real-time applications
  - What is happening now vs. "typical" or "worst case"
- The value for planning is to support performance management

A TTRMS Supports the Performance Management Process



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WHAT THEY TELL YOU
MEASURES
USED BY
Level 1
Travel conditions are unreliable (Variable over time)
Overall Reliability
e.g., buffer index
Upper Management
Public Relations
Planners
Level 2
What's causing unreliable travel (e.g., incidents, weather, work zones)
Delay by Source
e.g., vehicle-hours
Mid-Management
Operators
Planners
Work Zones
Weather
Special Events
Incidents
Traffic Control
Demand-Variability
Base Capacity
Level 3
What aspects of operations, management, and construction need to be improved
Activities, Procedures, and Policies
Operators
Field Managers
... for incidents ...
INCIDENT TIMELINE
Incident Occurs
6:35 A.M.
Incident Recorded into CAD (Detection)
6:42 A.M.
Incident Verified
6:47 A.M.
Personnel Dispatched and Actions Initiated
6:49 A.M.
Responders Arrive to Scene
6:50-7:00 A.M.
Incident Cleared and Actions Canceled
7:15 A.M.
Return to Normal Conditions
8:26 A.M.
1
Detection Time
2
Verification Time
3
Dispatch Time
4
Response Time
5
Clearance Time
6
Time to Normal Conditions

Questions?

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