Large-Scale Transit Signal Priority Implementation:

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Overview

- Background
- TSP System Components and Functionality
- Effective Planning
- Implementing a System
- Lessons Learned

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Transit Signal Priority (TSP) Defined

- TSP is a tool used to improve transit performance and reliability
- Facilitates the movement of transit vehicles through traffic signals, resulting in:
  - Reduced transit travel times
  - Improved schedule adherence
  - Improved transit efficiency
  - Increased road network efficiency

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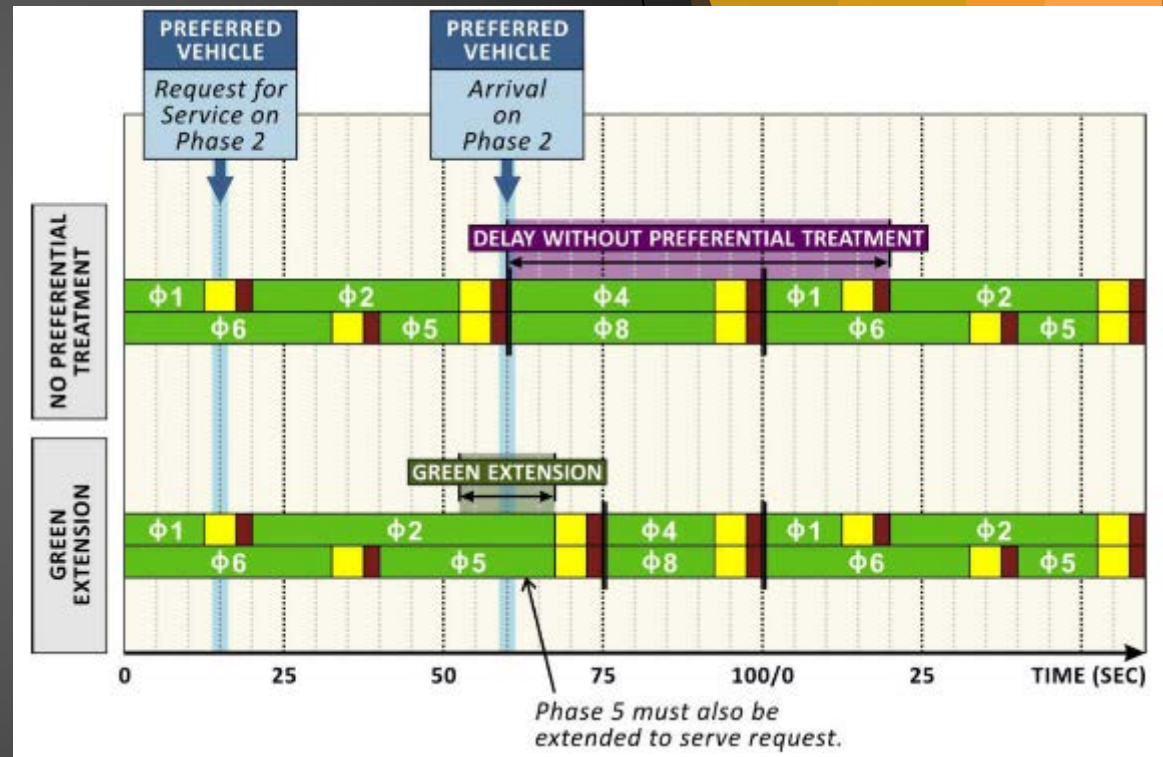
Source: Li, Y., Koonce, P., Li M., Zhou, K., Li, Y., Beaird, S., Zhang, W., Hegen, L., Hu, K., Skabardonis, A., and Z. Sun. Transit Signal Priority Research Tools. Publication FTA-CA-26-7049-2008.1. U.S. Department of Transportation, 2008.

Transit Signal Priority (TSP) Defined

- The most common TSP strategies :
  - Extend a phase to allow a transit vehicle to pass, or
  - Terminate conflicting phases to allow early service
- The result is reduced transit delay



Green Extension Example, Signal Timing Manual, Second Edition

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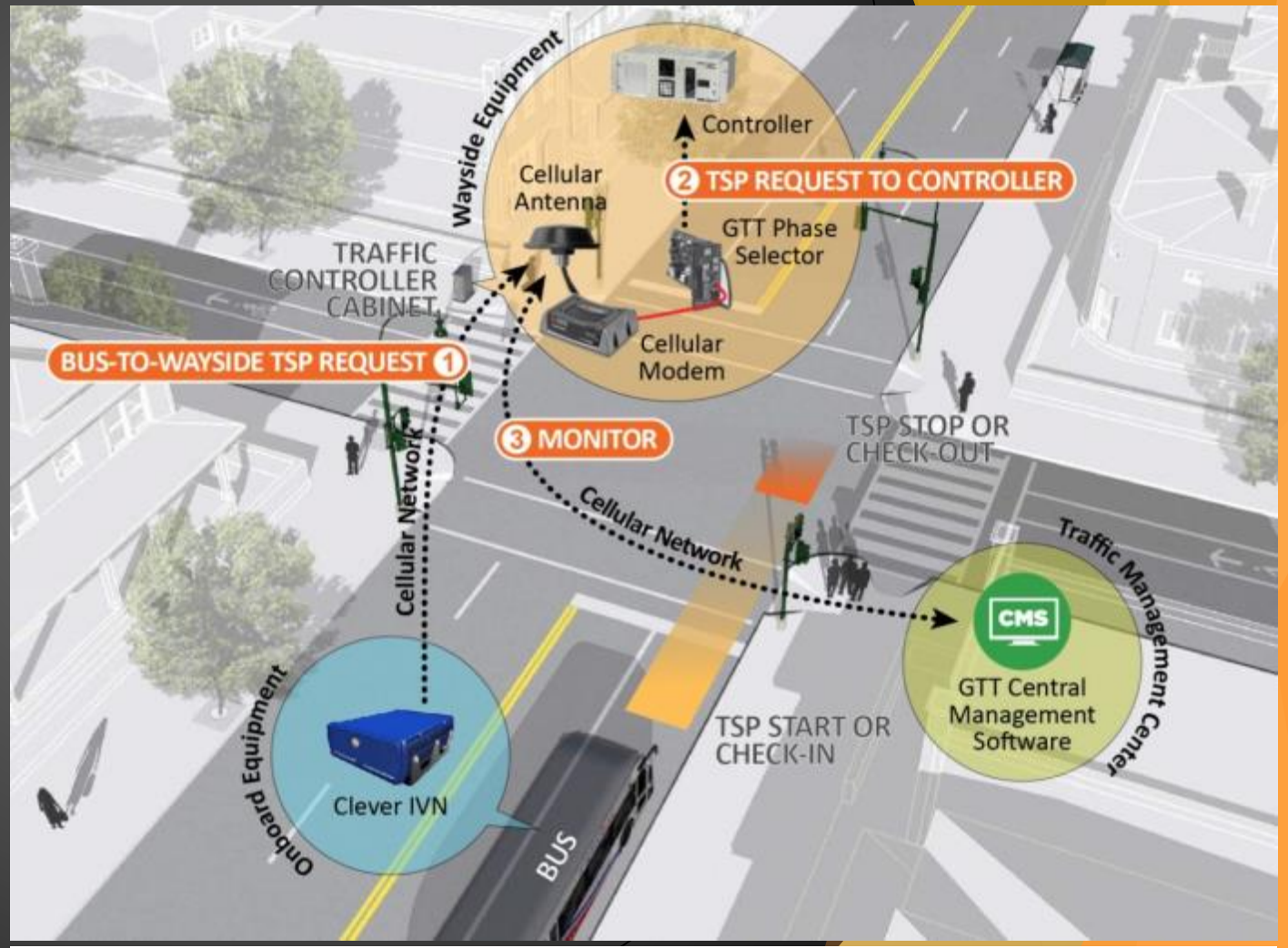
Source: Kittelson & Associates, Inc. NCHRP Report 812: Signal Timing Manual, Second Edition. Transportation Research Board, Washington, D.C., 2014.

HOW DOES TSP WORK?

- Vehicle
- Detection system
- Communication
- Signal equipment



Decentralized TSP Architecture Deployed in Washington, DC

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- **Regional Project**
  - WMATA supported, local agency driven
  - Multijurisdictional, TIGER-funded
  - DC, Virginia DOT, Alexandria, Falls Church
  - 200+ intersections

TSP IN GREATER WASHINGTON REGION

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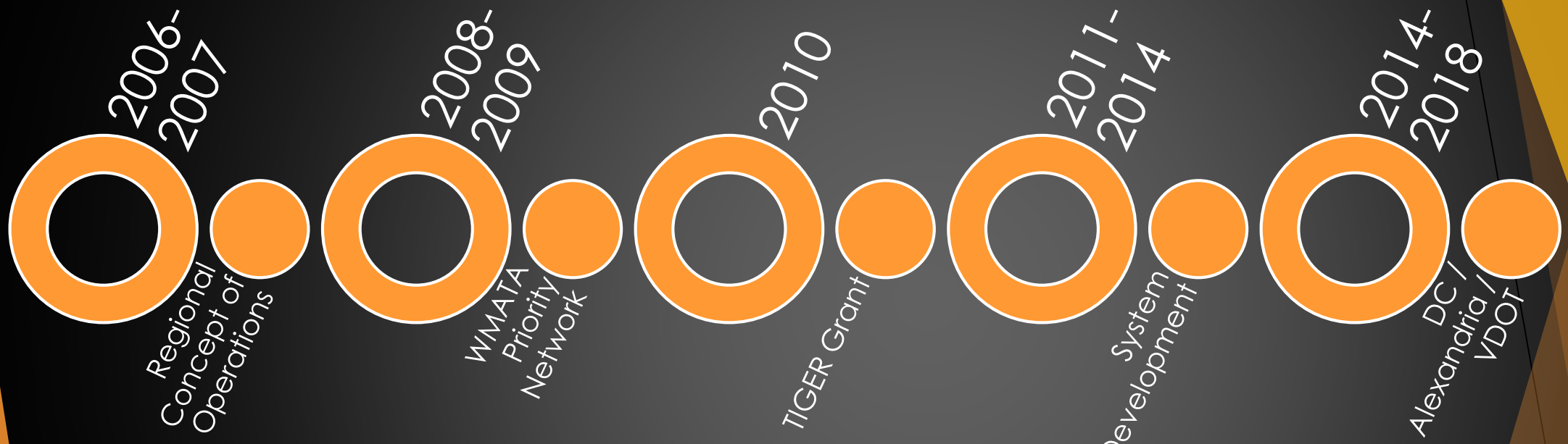

Vision to Fruition

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Effective Planning

- Traffic and Transit Systems
- Aligning goals and objectives
- Finding win-win situations

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Controller Testing

- TSP algorithms vary widely between vendors and firmware versions
- Multiple scenarios
- Test, test, and test again

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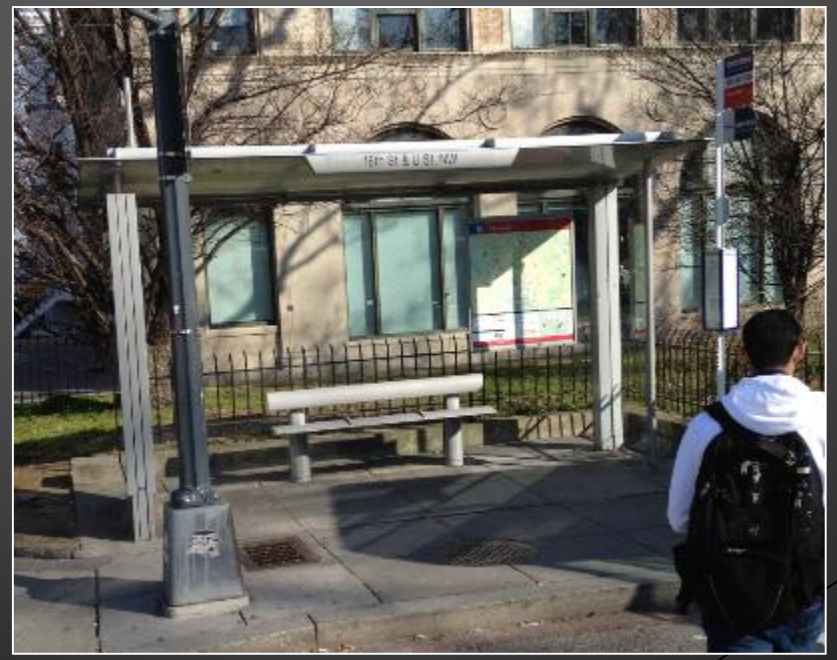
Intersection

- Cabinet space
- Bus stop locations
- Lane configuration
- User demands



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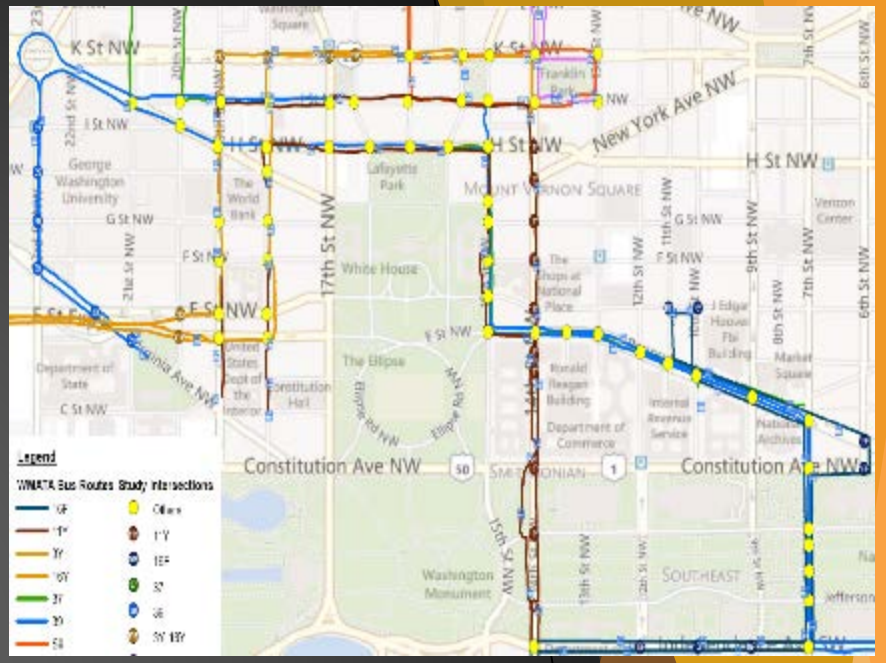
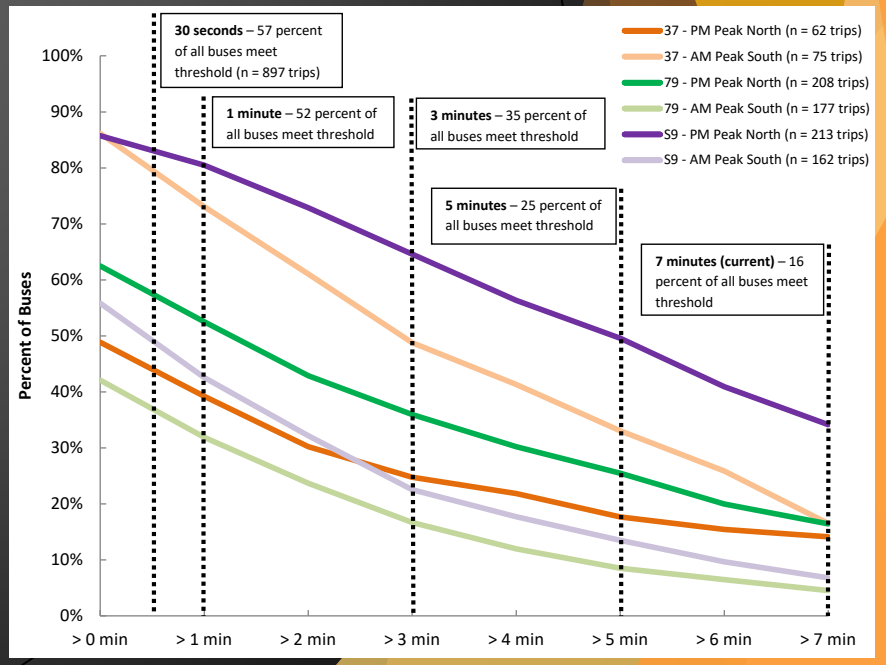
Operations: Transit

- Line route assessment
- Performance measures
  - On time performance
  - Delays
  - Headway adherence





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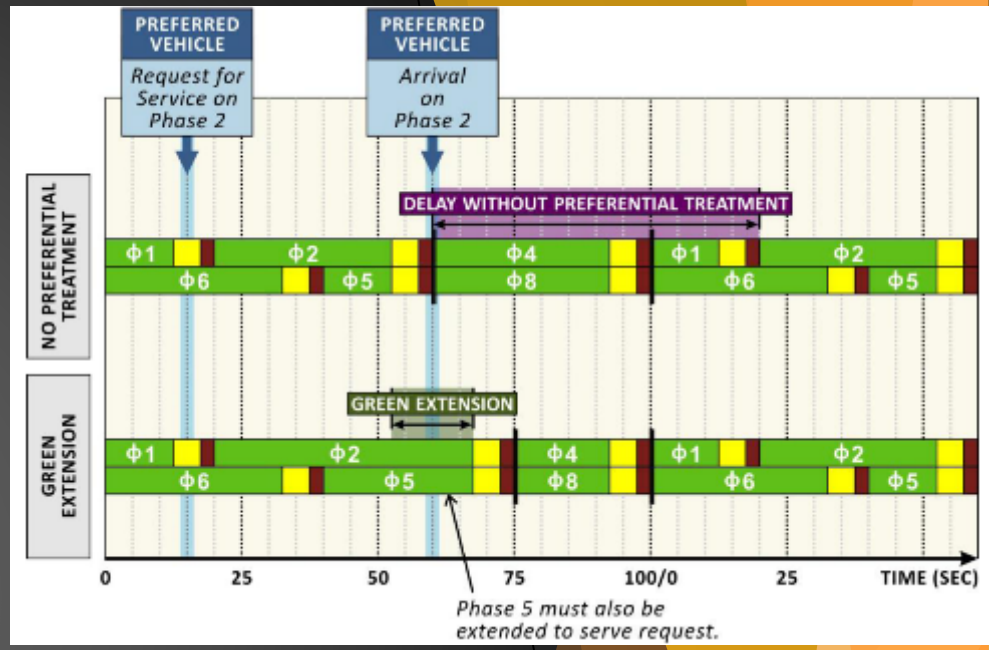
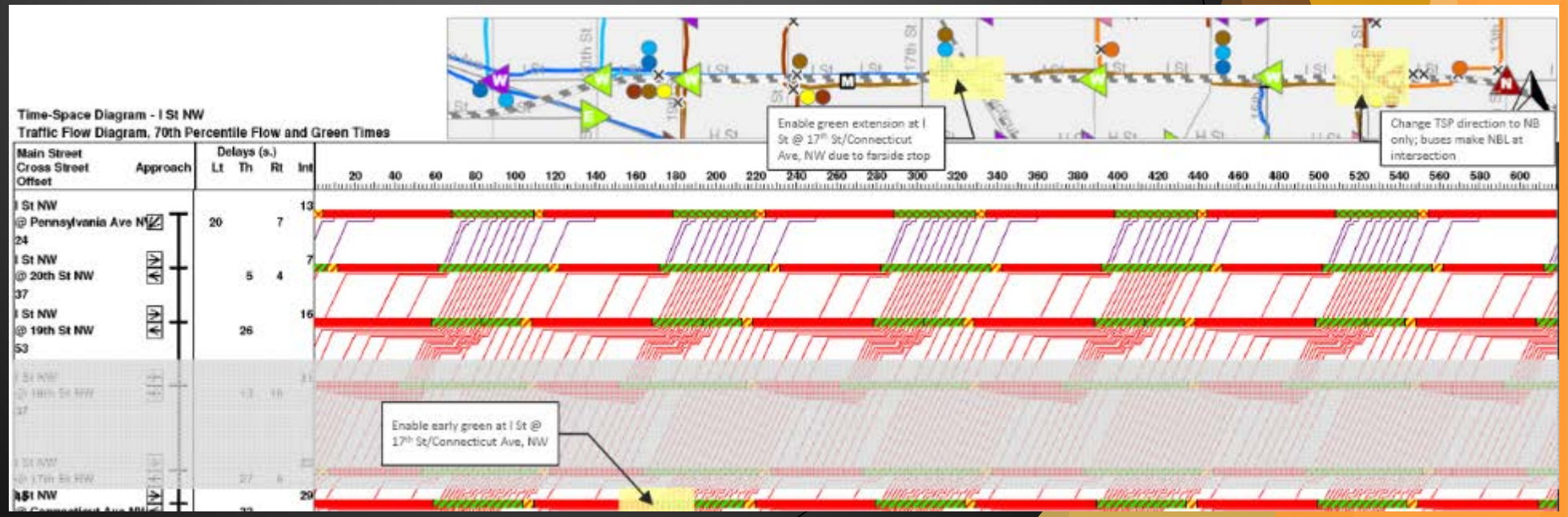
Operations: Timings

- Individual intersection assessments
- Corridor





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Implementing a System

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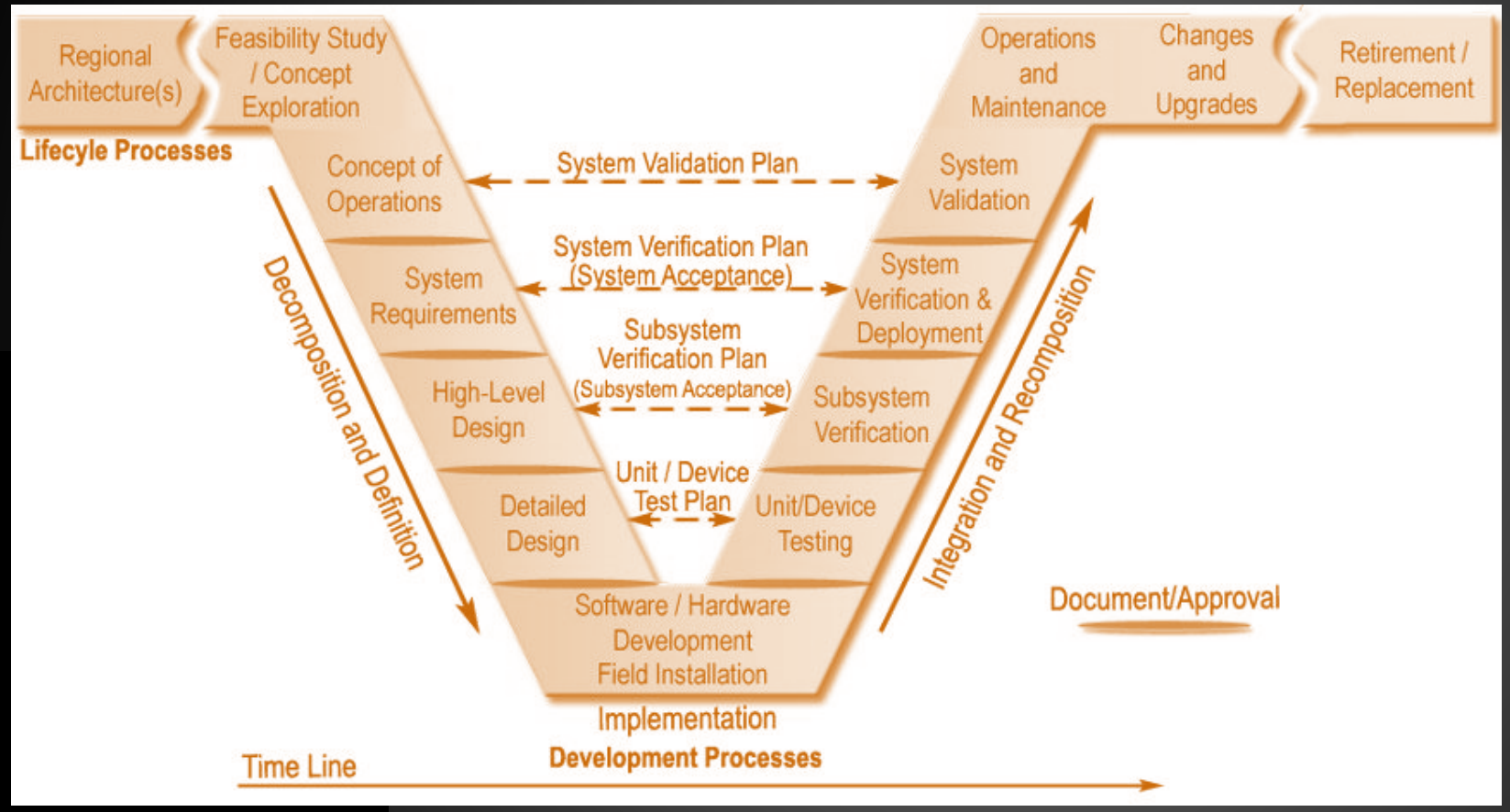
Systems Engineering



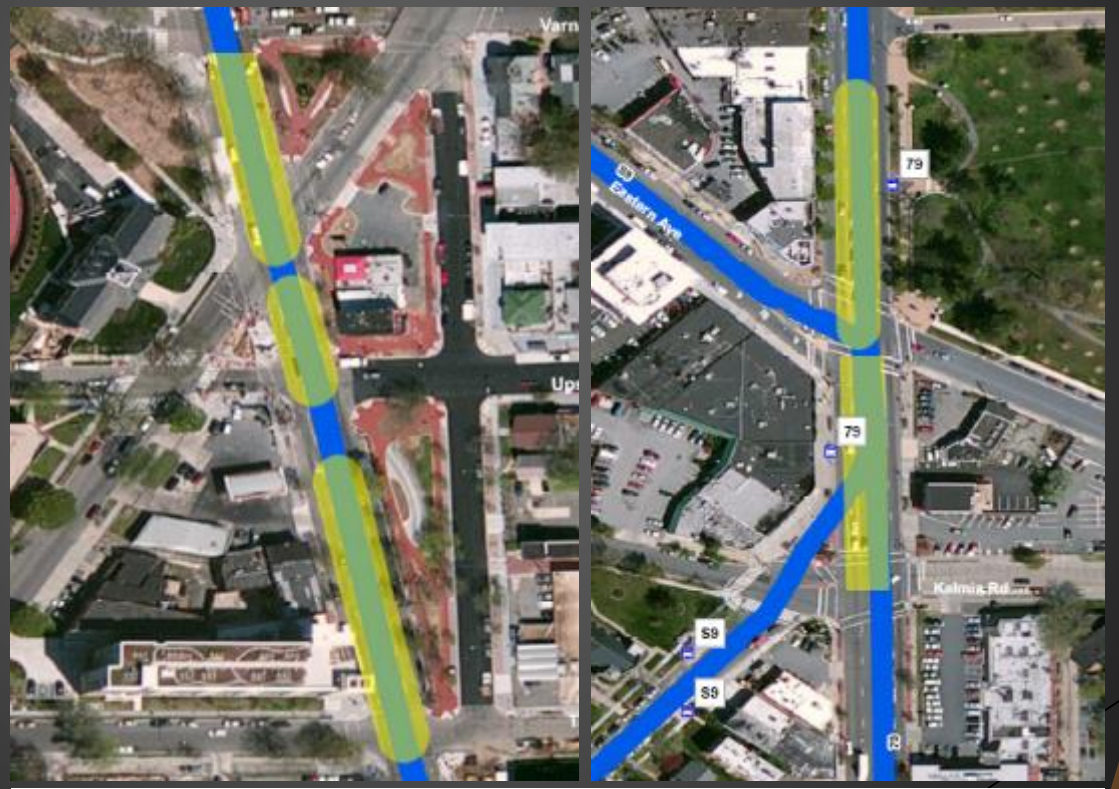
Systems Engineering "V" Diagram

Source: U.S. Department of Transportation. Systems Engineering for Intelligent Transportation Systems. Publication FHWA-HOP-07-069. FHWA and FTA, U.S. Department of Transportation. January 2007.

Systems Engineering: High-Level Design

High-Level Design

- Bus Stop Location
- Variable Green Time
- Spatial Distance
- Traffic Operations
- Intersection Screening
- On-Board Equipment Parameter Development



TSP Communication Zones at Closely Spaced Intersections
Washington, DC

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Systems Engineering: Detailed Design

Detailed Design

- In-cabinet component needs
- Component configuration
- Communications diagram
- Technical specifications

Install cellular antenna on top of cabinet

NOTE: Phase selector cards to be double-wide. Face of phase selector card covers slot #11.

Install 14-slot Input file rack for Model Series 336 Cabinet below output file rack. Install Phase selector in input file slot #12 (“I” file)

Relocate equipment approximately 8” down, adjacent to communication panel

Relocate communication panel to back of cabinet

(Proposed equipment location)

DDOT TSP Design Plan Detail

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System Testing

- Key success driver
- Objective to verify and validate end-to-end functionality
- Four-stage acceptance testing regimen

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Systems Engineering Driven Testing Process

Prototype Testing	**Purpose:** Proof of Concept **Scale:** Single intersection
Stand-Alone Testing (SAT)	**Purpose:** Verification **Scale:** Each intersection wayside equipment
Final System Acceptance Testing (FSAT)	**Purpose:** Verification **Scale:** Each intersection, end-to-end
Operational Acceptance Testing (OAT)	**Purpose:** Validation **Scale:** System-wide

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Sample Testing Scenarios: Prototype Testing

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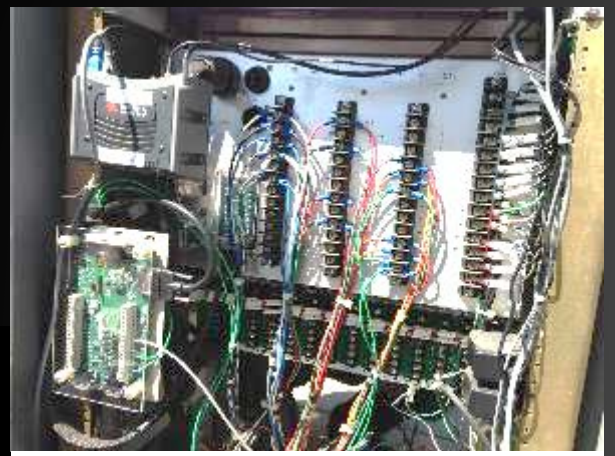
Sample Testing Scenarios: Stand-Alone Testing (SAT)



Verify Hardware Installation

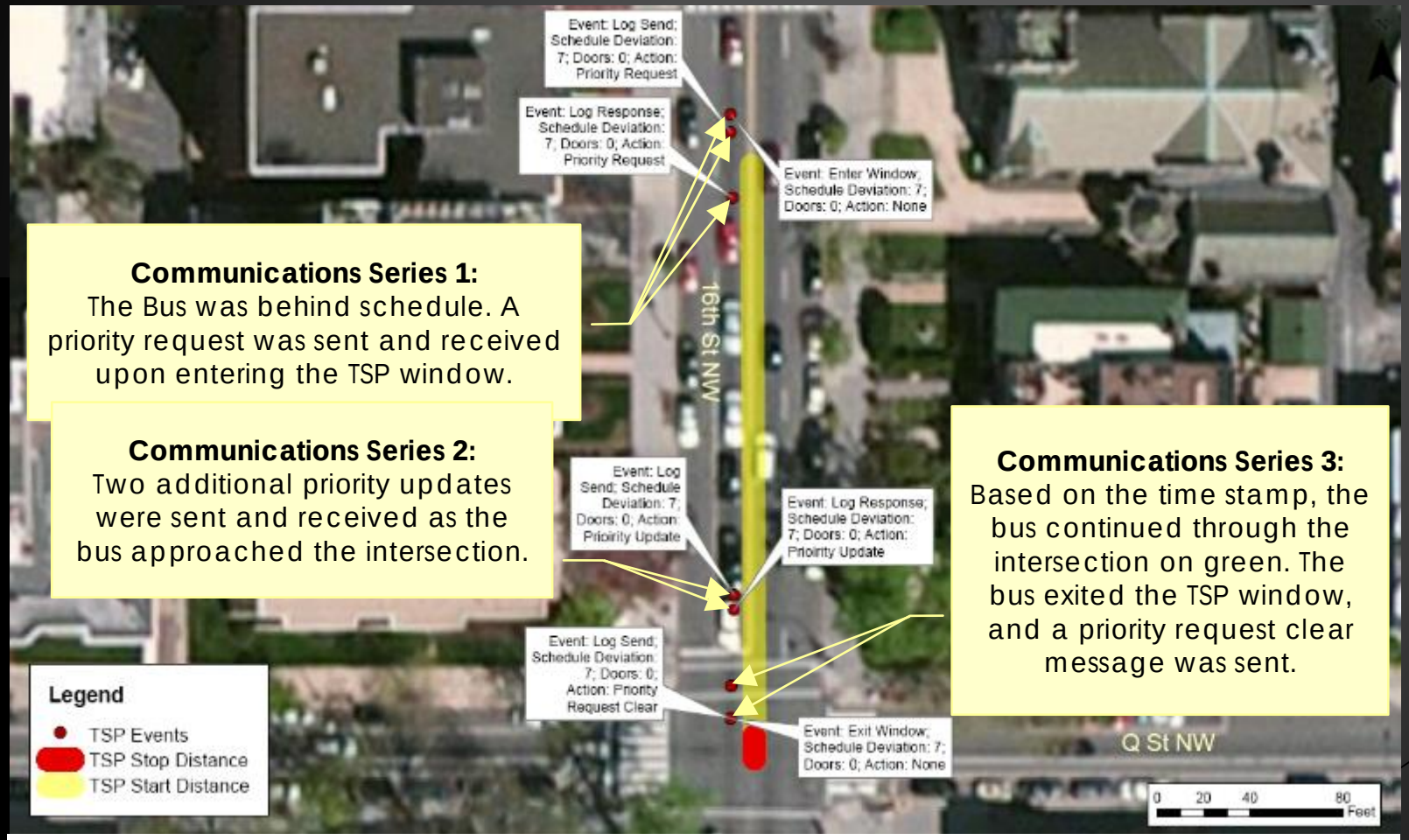
Verify Modem Functionality

Verify Cellular Modem Connection

Verify TSP Configuration in Traffic Controller

Verify Phase Selector Configuration

Sample Testing Scenarios: Final System Acceptance Testing (FSAT)



Communications Series 1:
The Bus was behind schedule. A priority request was sent and received upon entering the TSP window.

Communications Series 2:
Two additional priority updates were sent and received as the bus approached the intersection.

Communications Series 3:
Based on the time stamp, the bus continued through the intersection on green. The bus exited the TSP window, and a priority request clear message was sent.

Mapped Communication Instances for FSAT

Sample Testing Scenarios: Operational Acceptance Testing (OAT)

- Objective: full operation validation of the TSP system for a pre-determined span of time

Intersection Name	OAT Status	W/E 9/8/16 TSP Message Received by Intersection	W/E 9/15/16 TSP Message Received by Intersection	W/E 9/22/16 TSP Message Received by Intersection	W/E 9/29/16 TSP Message Received by Intersection	W/E 10/6/16 TSP Message Received by Intersection	W/E 10/13/16 TSP Message Received by Intersection
7TH ST AND MADISON DR, NW	PASS	yes	yes	yes	yes	yes	yes
7TH ST AND WASHINGTON DR, NW	PASS	yes	yes	yes	yes	yes	yes
14TH ST AND FEDERAL TRIANGLE BLDG.SOUTH	PASS	yes	yes	yes	yes	yes	yes
14TH ST AND CONSTITUTION AVE, NW	PASS	yes	yes	yes	yes	yes	yes
14TH ST AND FEDERAL TRIANGLE BLDG.NORTH	PASS	yes	yes	yes	yes	yes	yes
14TH ST AND LOWER E ST, NW	PASS	yes	yes	yes	yes	yes	yes
14TH ST AND G ST, NW	PASS	yes	yes	yes	yes	yes	yes

DDOT TSP 30-Day OAT Tracking Sample

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Lessons Learned

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Lessons Learned

- Establish formal agency roles and responsibilities prior to the commencement of the project
- Collaborative assessment: Opportunities and Constraints for Traffic and Transit
- Highlight the importance of oversight and review
- Plan for evaluation and refinement

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Thank You

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