ADAPTIVE TRAFFIC SIGNAL CONTROL

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Agenda

• The Risky ASCT Marketplace
• Federal Funding and the CFR
• What is Systems Engineering?
• Using the SE Model Docs to Efficiently Create SE Deliverables
ASCT Is Not Easy

• Many prior ASCT projects abandoned. Why?
• ASCT products vary…
  – Different objectives
  – Different configurations
  – Different business models
  – Different sustainability requirements
• New products emerging continuously
• Strong marketing environment
• Lots of visibility and scrutiny
Many Products—All Different

- ACSLite
- BALANCE
- InSync
- LA ATCS
- MOTION
- OPAC
- RHODES
- SCATS
- SCOOT
- UTOPIA

- QuicTrac
- NWS Voyage
- Multi-criteria Adaptive Control
- KLD
- Intelight
- Synchro Green
- System of the Month
Example Product Objectives

• Balance phase utilization—fair distribution of green
• Minimize arrivals on red—improve progressed flow
• Minimize queue-time density—serve the most cars waiting the longest
• Minimize combination of stops and delay—delay-offset optimization
Configurations—Operational

- Work within existing coordination parameters
- Override or ignore controller or system coordination
- Provide centralized adaptive operation
- Provide localized adaptive operation
- Optimization suited to grid networks or arterial streets?
Configurations—Architecture

- Built into central system
- Works in parallel to central system
- Built into local controller
- Separate local-cabinet processor
- Replaces field master
- Built into field master
- Uses system-to-controller interface
- Bypasses system-to-controller interface
Configurations—Infrastructure

- Separate processor may be required
- Varying interface to controllers/systems
- Varying communications requirements
- Detection
  - Existing detection
  - Special detection
- Pedestrians, emergency vehicles, transit vehicles, railroad crossings, interfaces with adjacent systems and operations, and other realities
Buying, Maintaining, and Operating

- High-capital, designed for large-scale networks
- Low-capital, designed for small-scale networks
- Agency-provided operations
  - Operations resources
  - Maintenance capability
- Supplier-provided operations
  - Accountability
  - Responsiveness
  - Term
  - Sustainability
Summary So Far... 

- Product market diverse and poorly understood
- Agency objectives, strategies, and requirements often poorly understood or articulated
- Usual product selection approaches risky
- High scrutiny by vendors, elected officials and auditors
- All ASCT projects impose high technological risk
How Will We Meet This Goal?

• By December 2012, The **EDC / ASCT tools** are used to guide the implementation or programming of 40 **ASCT** systems.

• **EDC / ASCT tools**
  – Systems Engineering Process
  – SE Workshop
  – SE Model Documents
The Role of Systems Engineering

- Understanding the problem
- Managing risk
  - Poorly articulated needs and requirements
  - Acquisitions being challenged by bidders/proposers/vendors/auditors
  - Projects not meeting agency needs
  - Schedule and budget overruns as agencies and vendors understand needs and requirements too late
- (and it is mandatory for federal-aid projects)
All ITS projects must be developed using a Systems Engineering (SE) analysis.
The analysis shall be on a scale commensurate with the project scope.
SE analysis shall address (7) requirements.
Seven Requirements of SE Analysis

1. Identify portions of the regional ITS architecture being implemented
2. Identification of participating agencies roles and responsibilities
3. Requirements definitions
4. Analysis of technology options to meet requirements
5. Procurement options
6. Identification of applicable ITS standards and testing procedures
7. Procedures and resources necessary for operations and management of the system
Procurement Regulations

- Proprietary Materials (23 CFR 635.411)
  - **Certification** of no available competitive product
    - Uniquely fulfills the *requirements* imposed on the product
    - Achieves *synchronization* with existing systems
  - **Public Interest Finding** for proprietary purchase despite *alternative* available competitive products
    - Limited *experimental* application
- Systems Engineering Analysis can provide justification
What Is Systems Engineering?
Eisenhower Wants to Build Roads

• How fast Germans moved armies during WWII
• America embroiled in the Red Scare
• Post-war prosperity presented an opportunity
How We Would Use A New Roadway Network

- Move armies quickly
- Move people, goods & services efficiently
What Slows Armies Down?

- Intersections
- Narrow roads
- Tight curves
- Incomplete network
Basic Requirements

• Limited access
• Wide lanes with shoulders
• Divided highway
• High design speed
• Comprehensive network
Functional Requirements

- The highway shall have no at-grade crossings.
- The highway shall separate the two directions of travel.
- The highway shall accommodate vehicles traveling at 70 mph.
- The highway shall have 12’ foot lanes.
- The highway shall have vertical clearance of 16.5’.
- The highway shall have maximum grade of 6%.
- The highway network shall comprise principal east-west and north-south routes.
• Did Eisenhower know anything about building roads?
• Do road builders know anything about moving armies?
• Do they need to?
Verification and Validation

- Did the road get built right?
- Did we build the right roads?
Systems Engineering

- Needs
- Requirements
- Design & Implementation
- Testing
Mitigating Risk

- Designing the roads incorrectly
- Designing the wrong roads
- Spending too much
- Taking too long to build
- Responding to challenges
SE For ASCT Projects

• Too much work to develop from scratch
• Model documents therefore make it much easier to create:
  – Concept of Operations
  – Requirements
  – High Level Design
  – Verification Plan
  – Validation Plan
Concept of Operations

• The story of **what the agency will DO**:
  – Includes viewpoints from stakeholders
  – Written from the perspective of the system operator/maintainer/user
  – Defines high-level system concept to consider alternatives
  – Provides the basis for *requirements*
  – Provides criteria for *validation*
• **Describes what the system must do:**
  – Necessary: Must be linked to a need in the ConOps
  – Clear: May get challenged!
  – Complete: Are all needs addressed?
  – Correct: Are needs addressed correctly?
  – Feasible: Is it possible?
  – Verifiable: Can you demonstrate it? *Can you prove it?*
Testing

• Verification Plan
  – Verifies that every step, if done correctly, will fulfill the requirements.

• Validation Plan
  – Validates that every step, if done correctly, will provide a system that meets user needs.
How To Use The Systems Engineering Model Documents
Model Systems Engineering Documents for ASCT Systems

- Purpose of the document
- Document organization and how to use it
Purpose of SE Model Documents

- Evaluate need for Adaptive Control
- Usual SE process too much work for small projects...
- ...but small projects still impose big risk to small agencies
- Model documents greatly reduce effort by providing wording and documentation...
- ...but agencies still must identify their needs
Basic Organization

- Guidance—How to do systems engineering for ASCT
- Table of Concept of Operations Statements
  - ConOps statements linked to Guidance section
  - ConOps statements linked to requirements
- Table of Requirements
  - Requirements linked to ConOps statements
- Templates for Verification and Validation Plans
First Steps

- Read the guidance—straight through
- Work through the ConOps Statements
  - Choose the statements that fit
  - Scratch out the statements that don’t fit
  - Don’t change wording at this time
  - Fill in required blanks
  - Write required paragraphs
What are my next steps?

I manage a large city, with over 1000 traffic signals, I’m considering adaptive signal control for some intersections, but how do I determine the right place for adaptive?

I’m a technologist and want to use the latest and greatest. I just heard about adaptive control and it sounds great, I want one! What do I do next to get it?

I have very old traffic control system and with my recent grant I think I can afford a new system. Is it time to consider adaptive control?

I have tried time of day coordination and even traffic responsive plan selection, but I feel like there could be something better. Could adaptive control be a better solution?

Due to new air quality standards that are out, I need to improve my network. Is it time to consider adaptive control?

I been working with my consultant/vendor for many years and they have been telling me about new adaptive traffic control systems that I should consider. What locations would be the best fit for an adaptive control system?

I am getting calls on a couple of my intersections and I cannot solve the cycle/phase issues. Will adaptive control help?

I have a corridor that I run time of day coordination, but occasionally diverting traffic overwhelms the corridor, could adaptive control provide a better solution?

The planners are telling me that in the next 5-10 years there will be a 50% growth along the main corridor in the city, the current traffic control system will not handle the traffic based on the current capacity. Is it time to consider an adaptive control?
Concept of Operations

Template & Questions

• 1.0 - Purpose
• 2.0 - Scope
• 3.0 - Referenced Documents
• 4.0 – Background
  • Network Characteristics
  • Traffic Characteristics
  • Signal Grouping
  • Land Use
  • Operating Agencies
  • Existing Architecture / Infrastructure
  • Limitations and proposed changes
Alternative Non-Adaptive Strategies (ConOps Ch. 5)
(Guidance Section 4.5)

- Traffic Responsive
- Complex Coordination Features
- Variable Phase Sequence
- Coordinate alternate approaches
- Late Phase Introduction
Envisioned Adaptive Operations (ConOps Ch. 6) (Guidance Chapter 4.6)

- Objectives
  - Pipeline
  - Access Equity
  - Manage Queues
  - Variable

- Strategies / Scenarios
Adaptive Operational Scenarios

• Operational Scenarios for Traffic Events Using an Adaptive System
• (Chapter 11 of the Concept of Operation)
• Guidance Section 4.11
Specific Adaptive System and User Needs (ConOps Ch. 7) (ConOps Questions)

• Support Mobility
  – Vehicle
  – Pedestrian
  – Transit

• Provide Measurable Improvements
  – Delay
  – Travel Time
  – Safety
Envisioned Adaptive System Overview (Chap 8)

• Network Characteristics
• Type of Adaptive Operation
• Crossing Arterial Coordination
• Institutional Boundaries
• Failure Modes
• ............
Operational & Support Environment

• ConOps Chapter 9 & 10

• Guidance Chapter 4.9 & 4.10
Build Requirements

• For each selected ConOps statement:
  – Find referenced requirement
  – Select referenced requirement

• Scratch out unselected requirements
Review Requirements

• Are selected requirements not needed?
  – Does ConOps statement describe you? **Check it!**

• Are unselected requirements needed?
  – Did you miss a ConOps statement? **Check it!**

• Anything missing?
  – Write new ConOps statement and associated requirements.

• Don’t change requirement without changing ConOps statement
Design/Implementation

• Model docs now; product research later
• Use requirements in procurement process
  – Requirements are *essay questions*
  – What if no product fulfills requirements?
  – What if only one product fulfills requirements?
  – What if I’m doing more than one system?
    • With different requirements?
Proving It

• Verify design fulfills requirements
• Verify implementation conforms to design
• Validate system supports operations
Verification

• A Plan—How will the agency/vendor demonstrate that
  – The design will fulfill all requirements?
  – The selected technologies/products fulfill all requirements?
  – The installed systems fulfill all requirements?
Validation

• Another Plan—How will the agency/vendor demonstrate that
  – The design will operate as described in ConOps?
  – The selected technologies/products will support agency activities described in ConOps?
  – The complete system supports agency activities as described in ConOps?
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Questions?

http://ops.fhwa.dot.gov/arterial_mgmt/