Lessons Learned from ASCT and Systems Engineering

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Opening Up

• Technology Deployment Life Cycle
  – Research
  – Technology Development
  – People (Risk Tolerance)
  – Implementation

• Systematic Process

Credit: Regenold M, CTR Iowa State University
Context

- Rule 940 (ITS Architecture / Systems Engineering)
- Influence of Metropolitan Planning Organizations Growing
- Traffic Signal Programs Lack Resources
Complex Environment

- Freeway
- Arterials
- Land Use
- Peds
- Vehicles
- Bikes
- Transit
- Freight

Operations (OPS)

Maintenance

Design

Control, Detection, Communications

Funding, Procurement, Workforce, Business Processes
Project Development / Funding Process Not Well Understood

PLANNING PROCESS
- Regional Goals
- Operations Objectives
- M&O Strategies
- Metropolitan Transportation Plan
- Transportation Improvement Program
- Implementation

AGENCY PROCESS
- Tactics
- Strategies
- Monitoring and Evaluation

GIVEN:

PROJECT DEVELOPMENT PROCESS
- Regional Architecture
- Concept Exploration/Feasibility Study
- Systems Engineering Management Plan
- Operations & Maintenance
- Changes & Upgrades
- Retirement/Replacement

Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCiT) Systems
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Conceptual Framework (G.O.S.T)

- **Goal**: What we are trying to achieve
- **Objective**: What needs to be done to achieve the goal
- **Strategy**: Capabilities put in place to achieve the Objective
- **Tactic**: Specific methods to achieve the Strategy
Research Focus

- Funding, Procurement, Installation, Workforce, Business Processes
- Design
- Control, Detection, Communications
- Maintenance
- OPS

- Freeway
- Arterials
- Land Use
- Peds
- Vehicles
- Bikes
- Transit
- Freight
Research Problem

• Variability in traffic demand reduces the effectiveness of static signal timing plans.
  – More TOD Plans,
  – Delay Optimization,
  – Fine Tuning

• A process is needed to match signal timing plans to traffic patterns to improve efficiency.
  – Traffic Responsive

• Transition time between plans reduces effectiveness
  – Minimize Transition Time
Are We Working on the Right Problem?

GIVEN: Signal Timing Plans (Cycle, Split, Offset) are not keeping pace with variability in demand.

**Strategy**
- Capabilities put in place to achieve the Objective

**Tactic**
- Specific methods to achieve the Strategy
Adaptive Signal Control - Research

- ASC introduced in late 80s
  - Split, Cycle, Offset, Optimization, Technique (SCOOT)
  - Sydney Coordinated Adaptive Traffic System (SCATS)
  - Optimized Policies for Adaptive Control (OPAC)
  - Real-Time Traffic Adaptive Control System (RT-TRACS)
  - Real Time Hierarchal Optimized Distributed and Effective System (RHODES)
Field Demonstration Test

- Significant reductions in Delay, Fuel Consumption & Emissions
- Requires non-standard local control
- Algorithms are complex
- Extensive detection requirements
- Robust communications
- Expensive to Implement, Operate and Maintain
- Requires active monitoring and calibration
Shifting to Technology Deployment

Problem Statement
- Reduce Complexity
- Minimize Detection
- Low Bandwidth Communication
- Utilize Existing Control

Features
- NTCIP
- Econolite / Peek / Siemens / McCain
- Low Bandwidth Communication
- Existing Detection
- Spilt and Offset Tuning

Research

Technology

Deployment
People

Diffusion of Innovation

ADOPTERS’ CATEGORIES BASED ON INNOVATIVENESS

Percentage of Adopters

- Innovators: 2.5%
- Early Adopters: 13.5%
- Early Majority: 34%
- Late Majority: 34%
- Laggards: 16%

RISK

https://suzannehawkes.files.wordpress.com/2007/02/social-innovation.gif
Deployment 1991 - 2005

- Research
- Field Operational Test
  - Conditions match functional objectives
- No Systems Engineering
- Evaluations
- Organizational issues not considered
  - Skilled Staff
- Procurement – Sole Source
Technology 2006 - 2009

• FHWA Active Promotion of ACS-Lite
  – Econolite
  – Siemens
  – Peek
  – McCain
  – Naztec
  – NW Signal

• New Products
  – InSync / SynchroGreen / QuicTrac.....

• Other Systems Under Development

• Less than 1% of all signals equipped with ASCT

• Traffic Responsive is Ubiquitous
Every Day Counts Initiative 2010 - 2012

Goal: Mainstream the use of ASCT.

Barriers:
- **Uncertainty about benefits**, 
- **Cost**, 
- **Complexity** 
- **Clear understanding of operation and maintenance requirements**
Implementation Approach

**Mission:** Provide tools to address risk, characterize ASCT as a strategy to improve operations.

**Objective 1:** ASCT/Tools will be used by 40 agencies to guide planning and implementation.

**Objective 2:** Develop Performance Measures, data needs and methodology to support evaluation of ASCT.
Systems Engineering Process

- Systems Engineering Guidebook
Systems Engineering Process

- Regional Architecture
- Needs Assessment
- Concept Selection
- Project Planning
- Systems Engineering Management Planning
- Operations and Maintenance
- Changes and Upgrades
- Retirement / Replacement

- Needs
- Req’mts
- Design and Implementation
- Testing
- System Integration
- Subsystem Integration
- Subsystem Verification
- Subsystem Testing
- Detailed Design
- Subsystem Requirements
- High-Level Design
- Concept of Operations

G O S T
WWII Analogy - Eisenhower

- How fast Germans moved armies during WWII
- America embroiled in the Red Scare
- Post war prosperity presented an opportunity
How would we use a new roadway network

• Move armies quickly
• Move people, goods & services efficiently
What slows armies down?

NEEDS

- Intersections
- Narrow roads
- Tight curves
- Incomplete network
High Level Requirements

- Limited access
- Wide lanes with shoulders
- Divided highway
- High design speed
- Comprehensive network
Detailed 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 should 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?
Did the road get built right?
Did we build the right roads?
Mitigating Risk

- Designing the roads incorrectly
- Designing the wrong roads
- Spending too much
- Taking too long to build
- Responding to challenges
Purpose of SE Model Documents

- Evaluate need for Adaptive Control
- Limitations of Existing System
- Objectives & Needs for Improved System
- Requirements to guide procurement and acceptance testing
- Basis for validation testing
Model Document *Process*

**Build Requirements**
- Answer questions
- About the situation
- About you
- Select and tailor ConOps statements
- Select and tailor requirements

**Evaluate Alternatives**
- Evaluate proposed approaches/products against requirements
- Solution feasible given constraints?

**Continue Tailoring Until Solutions...**
- Fulfill requirements
- Are feasible
US Implementation 2015
Application of Systems Engineering Before and After MSED

8% vs. 62%
Systems Engineering at all Phases

- Research
- Technology
- People
- Implementation

- Clarifies the Goals and Objectives
- Identifies Performance Measures
- Provides Context for Constraints
- Address Risks
- Conforms to Federal Regulation
- Competitive Procurement
- Manages Cost
Application to Automated Traffic Signal Performance Measures

• Systems Engineering is GIVEN
  – Goals, Objectives (NEEDS)
    • Validate research outcomes
    • Fuels Innovation
  – Requirements
    • Address risks
    • Support acceptance testing

• Leverage funding opportunities
  – Ped/Bike
  – Transit
  – Connected Vehicles, Integrated Corridor

• Collaboration and Competition help the process
• Don’t hide failures
Good Basic Service (GBS) Model

**Principles**

- Infrastructure Reliability
- Clear objectives
- Performance Measures

**Good Basic Service (GBS)**

**Dimensions**

- Design
- Operations
- Maintenance

**Support**

- Staff Development
Leg Segments and Composition

Good Basic Service (GBS)

- Design
- Operations
- Maintenance

- Local
- State
- Federal
Summary

• Organizational and Institutional Issues must be acknowledged

• A Systematic process is critical to linking Research to Implementation and can drive innovation

• Innovators and Early Adopters must be leveraged to demonstrate benefits

• The majority of the market is risks averse

• Meaningful Performance Measurement

• Top Down & Bottom Up approaches are key
Every Day Counts 4

• Request For Information (RFI)
  – Federal Register Notice
  – Innovation of Interest
    • Automated Traffic Signal Performance Measurement System

• Submit responses by email to everydaycounts@dot.gov

Deadline: January 31, 2016
Questions?

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