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

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

- Freeway
- Arterials
- Land Use
- Peds
- Vehicles
- Bikes
- Transit
- Freight
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
- Stakeholder Input on Needs
- Monitoring and Evaluation

GIVEN:

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

- 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?

**Objective**

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 Hierarchical 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
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

- Needs Assessment
- Concept Selection
- Project Planning
- Systems Engineering Management Planning

- Operations and Maintenance
- Changes and Upgrades
- Retirement / Replacement

- Needs
- System Requirements
- High-Level Design
-Subsystem Requirements
-Detailed Design
-Subsystem Integration
-Software Coding
-Hardware Fabrication

- Testing
- System Verification
- System Integration
- System Testing
- System Deployment

- Implementation
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?
Systems Engineering

- Needs
- Requirements
- Design & Implementation
- Testing

The diagram illustrates the V-model approach in systems engineering, highlighting the interrelations between needs, requirements, design & implementation, and testing phases.
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

Before MSED: 8%
After MSED: 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

- Infrastructure Reliability
- Clear objectives
- Performance Measures

Principles

Good Basic Service (GBS)

- Design
- Operations
- Maintenance

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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