Civil Design Considerations for ITS Implementations

FEBRUARY 22, 2017
Case Study Format and Purpose

• Case Study Purpose
  • Provide overview of civil design considerations related to Intelligent Transportation Systems (ITS)
  • Explore approaches to integrating ITS components into field settings

• Components
  • 1: Presentation
  • 2: Take Home Exercise
  • 3: Debrief
Exercise Preview

• Topic
  • Develop Camera Location Design for Case Study

• Scenario
  • University Football Stadium traffic congestion
    • Planned events
    • Growing attendance/traffic
    • Stadium expansion
    • City transportation system cannot accommodate demand
    • Functional ITS Architecture previously developed

• Student Role
  • ITS Design Engineer

• Resources
  • Sample plan sheets
Exercise Activities

• Task 1: Siting
  • Identify locations where camera can fulfill functions
  • Consider relative merits of locations

• Task 2: Power
  • Utility coordination
  • Tie to infrastructure or not

• Task 3: Communication
  • Own versus lease
  • Utility coordination

• Task 4: Structures
  • Jurisdictional standards on structures
  • Use of existing structures

• Task 5: Integration and Testing
  • Determine how project completion will be determined
Intelligent Transportation Systems (ITS)

- Use of information and communications technologies to meet transportation needs
ITS Addresses Transportation Needs

• Delivers transportation services that address local needs
• Defines transportation systems and functions needed to deliver services
• ITS does not solve entire transportation problem
  • ITS provides tools to better manage existing transportation conditions and maximize the capacity and capabilities of current facilities
  • ITS enables travelers to be better informed, make safer and smarter use of transportation systems
Intelligent Transportation Systems (ITS) Example

- Traffic Management Center
  - Interacts with devices
    - Dynamic Message Signs (DMSs)
    - Traffic cameras
    - Highway Advisory Radios (HARs)
  - Traffic detection
  - Traffic signals
  - Personal Devices
Local ITS Example
Instructor to modify

- Local Example
  - Visible to students
    - Current developments
    - Recent publicity
    - Innovative technology
  
  Graphics add interest
  
  Embedding a video enlivens the lecture
Areas of R & D

• **Connected Vehicles (CV)**
  • DSRC wireless
    • Vehicle-to-vehicle (V2V) in NHTSA rulemaking process
    • Vehicle-to-infrastructure uses roadside devices to reach TMCs and service providers
    • Vehicle-to-everything (V2X) offers communication path to pedestrians, cyclists, others
    • Focused on safety and mobility
  • Cell phone wireless
    • Used existing cellular infrastructure to reach service providers
    • Focused on consumer-driven services
      • “Infotainment”
      • Emergency alerts
Areas of R & D

• Automated Vehicles
  • Removes human driver from control of vehicle
    • Partial automation currently available
    • Automated control with human backup in trials on public roadways
    • Fully autonomous with no manual controls (no brakes or steering wheel) in development
  • Significant safety benefit is possible
  • Based on in-vehicle sensors, actuators, and control logic
  • May be Connected Vehicles also
    • Communication introduces security issues
Putting ITS Together

- ITS has many systems, interactions, and institutions
  - How does it all fit together?
  - How do the various components interact?
  - What can be used to coordinate deployment?

- USDOT defined the National ITS Architecture Guide for ITS deployment planning

- Connected Vehicle Reference Implementation Architecture (CVRIA) incorporates CV concepts
Using Standards

- Standards are published documents that establish specifications to improve reliability and interoperability.
- For ITS, standards:
  - Define an architecture of interrelated systems that work together to deliver transportation services.
  - Are developed in conjunction with Standards Development Organizations (SDOs).
  - Cover a wide array of topics.
  - Interaction among ITS components are aided through standards.
Systems Engineering (SE)

- Systems Engineering (SE) focuses on the “system” as a whole emphasizing its total operation
  - Views the “system” from the outside as well as the inside
  - Concerned about interactions of the “system” with other systems and the environment
  - Foundation of SE is reflecting the user needs from “system” conception through operations and retirement
    - Needs and requirements are traceable through implementation, testing, and evaluation
- SE involves and manages multiple disciplines work together
- SE is an inherent part of project management since it defines a process useful for controlling system cost and schedule
- SE is all about balancing competing needs/constraints
Civil Design in the SE “V”
Civil Design for ITS Deployments

- ITS deployments utilize multiple Civil Engineering specialties
  - Transportation Engineering
    - Roadway design
    - Signage
    - Traffic control devices
  - ITS
  - Structures
  - Power
  - Communications
    - ITS Messaging Standards
    - Utility
  - Hydrology
Typical Preconditions for ITS Projects

• Existing roadway
  • Electronic plan sets frequently available
    • Some scanned plans with field markup, a.k.a. redlines

• Existing signs

• Existing traffic control devices

• Existing cabinets

• Existing conduit plant

• Willingness to reuse existing infrastructure is project dependent

• Nearby power and communications
  • Use of wireless or solar make reliable alternative
Representative Case Study
Camera Capabilities

• Purpose
  • Collect traffic condition information

• What characteristics are required to perform surveillance function?
  • Line of sight
  • Light sensitivity
  • Coverage (Resolution and Pan, Tilt & Zoom (PTZ))
  • Environmental resistance
  • Reliability
  • Power consumption
  • Maintenance access
  • Organizational standards
  • Legacy systems

• Determined prior to civil design
Camera Siting

- Coverage of roadways of interest
  - Line of sight to Interstate
    - Northbound lanes South of Interchange is primary concern
  - Line of sight to arterial
    - At Interchange and East of interchange are primary concerns

- Costs
  - Ability to leverage existing assets
    - Power
    - Communication
    - Structures
Plan Sheet Sample – Plan and Profile

Plan

- Existing plans
- General Information
- Initial site line assessment

Profile
Plan Sheet Sample – Cross Section

- Existing plans
  - Siting
  - Environmental

Runoff and Slope restoration
Structure height
Standing water
Plan Sheet Sample - Intersection

Cabinet Location

Conduit Plant and Usage

Roadway Dimensions

Potential Mounting Structures
Plan Sheet Sample - Interchange

Cabinet Location (if present)

Roadway Dimensions

Traffic Estimates

Potential Mounting Structures (if present)

Conduit Plant and Usage (if present)
Power

• Required to operate electronic devices and communication equipment
  • Need stable, clean power supply

• Plans require coordination with Electrical Engineer

• Most commonly gained from regional power company
  • Distance from existing infrastructure drives costs
  • Possible to use existing power drop from existing cabinet

• Microgrid alternative in some cases
  • Low power application (e.g. unheated camera)
  • Location remote from power infrastructure
  • Adequate insolation or reliable wind

• Some applications require backup power
Communication

• Specific plans required to access all locations with communication need

• All choices must support user needs and requirements
  • Bandwidth
  • Reliability
  • Security

• Extensive range of options available

• Distance from existing infrastructure drives costs for wireline
  • “Last mile” may be different than trunk

• Reuse of existing infrastructure most cost effective
Mounting Structures

- **Existing structure**
  - Major advantage is cost

- **New structure**
  - **Location**
    - Soil condition
    - Protection from traffic
  - **Height**
  - **Strength**
  - **Load of device**
  - **Load of cabinet**
  - **Cabinet mounting**

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**BORING LOG**

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**END OF BORING**

Groundwater Information:
Depth During Drilling: 6' 5" Below
Depth Upon Completion = 8' 2" Below
Channel= 7' 9" Feet
ITS Device Integration and Testing

• Devices must operate to meet requirements

• Testing needs to show device characteristics to integrate with system
  • System compatibility
  • Standards

• Test plans need to be linked back to requirements
  • Testing should be incremental and progressive
  • Frequently test plans for each device and an integrated system test plan need to be developed to test all requirements
Other Issues

• Each agency will have a set of topics that must be addressed
  • Departmental checklists provide most topics

• Representative issues considered include
  • Infrastructure protection
  • External regulations
  • Coordination with other contractors
Infrastructure Protection

• Surge suppression and grounding
  • ITS infrastructure is frequently the tallest object in an area
    • Lightning suppression frequently required
  • Surge suppression is required for all copper leads exiting a cabinet

• Protection from weather
  • Heat
  • Cold
  • Moisture/sunlight

• Infestation

• Physical security

• Electronic security
External Regulations

- Aircraft protection
- Environmental Impact
  - Waterways
  - Endangered species
- Jurisdictional requirements
  - Aesthetics
  - Departmental infrastructure ownership

Architectural Pole

ITS Camera
FAA Notification Results

• Further FAA coordination is required
Coordination with Other Contractors

• DOTs frequently have several concurrent projects impacting a single section of roadway
  • Typical in location with a short construction season
  • Scheduled projects can be included in plans and budgets
  • Emergency work can result in contract changes for impacted projects
• Coordination of access for field work is the most common impact
  • Coordination can be achieved with regular meetings or teleconferences
  • In high-traffic areas, coordination of lane and shoulder closures is required
• Occasionally, projects directly conflict with each other
Local ITS Example
Instructor to modify

• Regional issues
  • Weather
    • Snow
    • Heat/Cold
    • Fog
    • Flooding
  • Business
    • Ports/Commercial vehicle
    • Agriculture
    • Tourism
  • Culture
    • Festivals
    • Religious observance

Graphics add interest
Embedding a video enlivens the lecture
Review and Approval

- Internal review in line with Quality Assurance
- Sign and seal by qualified PE(s)
- Submittal to agency for acceptance
  - Review comment disposition
- Use of a checklist is beneficial
Design Revisions

• Most projects are implemented differently than designed

• Typical revisions during civil construction
  • Existing plan sheets obsolete/inaccurate
  • Unexpected field conditions encountered
  • Design not constructable
  • Design inconsistent with policy

• Impacts range from minor notes to project cancellation
Integration and Testing

• Civil work takes place at bottom of SE “V”

• Test plans and procedures are developed during the design phases

• Testing takes place against project requirements
  • Compliance with each requirement must be demonstrated to complete a project
  • Infrastructure supports functional requirements
  • Infrastructure must meet some maintenance and reliability requirements

• Operation of an unaccepted system is a common, risky practice
Evaluation

• “Reasoned consideration of how well project goals and objectives are being achieved”

• Evaluation initiated early in ITS program
  • Currently written based on SAFETEA-LU in 2005
  • Updated frequently
  • USDOT Evaluation Guidelines online at http://www.its.dot.gov/evaluation/eguide_resource.htm

• Best performed by independent analysts
  • Self-evaluations acceptable in some cases

• Evaluation planning occurs during project planning
ITS Performance Measures for Evaluation

• Identified based upon goals and objectives
• Can be qualitative or quantitative
• Should be easily obtained
  • If MOE not available, less direct surrogates can be collected
• A single project can address multiple goals
  • MOEs should be selected to assess each goal
Moving Forward with ITS

• ITS is a tool for the transportation professional to address transportation problems without physical capacity expansion

• Challenges
  • Institutional diversity and varied needs
  • Technological complexity integrating differing systems and employing advanced capabilities in legacy systems

• Need a common language and tools to advance ITS planning and institutional buy-in
Representative Case Study
Case Study Purpose

• Examine civil design processes related to ITS
• Explore approaches to integrating ITS components into field settings
Take Home Exercise

• Using the information presented in this session and knowledge of structures, design a camera pole for installation near the Interstate interchange with 12th Street North.