Civil Design Considerations for ITS Implementations

FEBRUARY 22, 2017

Case Study Format and Purpose

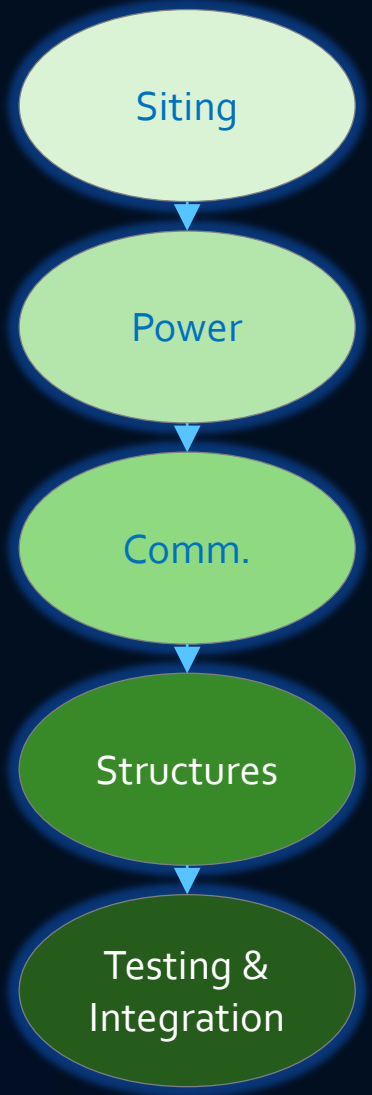
- Case Study Purpose
  - Provide overview of civil design considerations related to Intelligent Transportation Systems (ITS)
  - Explore approaches to integrating ITS components into field settings
- Components
  - 1: Presentation
  - 2: Take Home Exercise
  - 3: Debrief

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

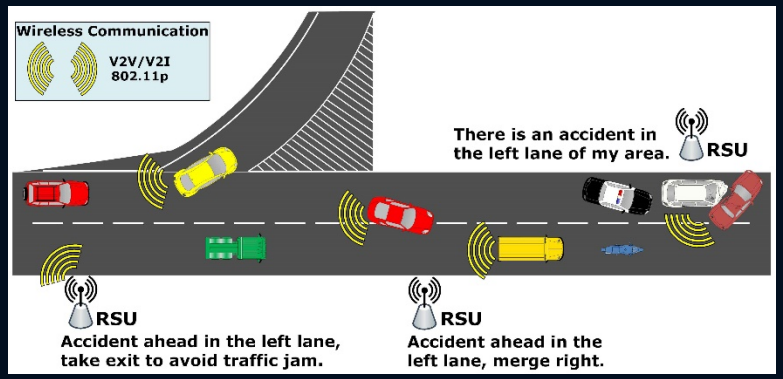
Local ITS Example Instructor to modify

- Local Example
  - Visible to students
    - Current developments
    - Recent publicity
    - Innovative technology

Graphics add interest

Embedding a video enlivens the lecture

Areas of R & D

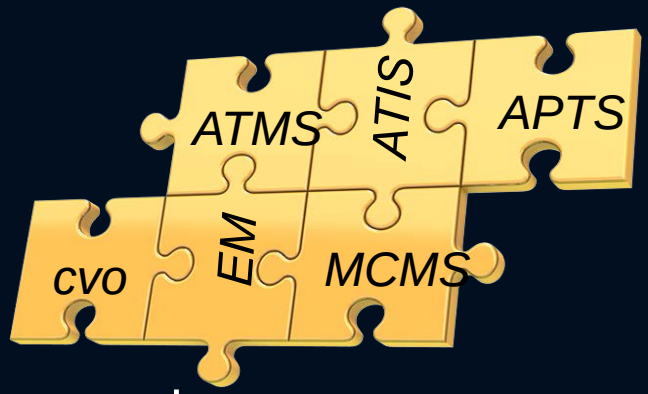


- Connected Vehicles (CV)
  - DSRC wireless
    - Vehicle-to-vehicle (V2V) in NHTSA rulemaking process
    - Vehicle-to-infrastructure uses roadside devices to reach TMCs and service providers
    - Vehicle-to-everything (V2X) offers communication path to pedestrians, cyclists, others
    - Focused on 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 Arhcitecture (CVRIA) incorporates CV concepts

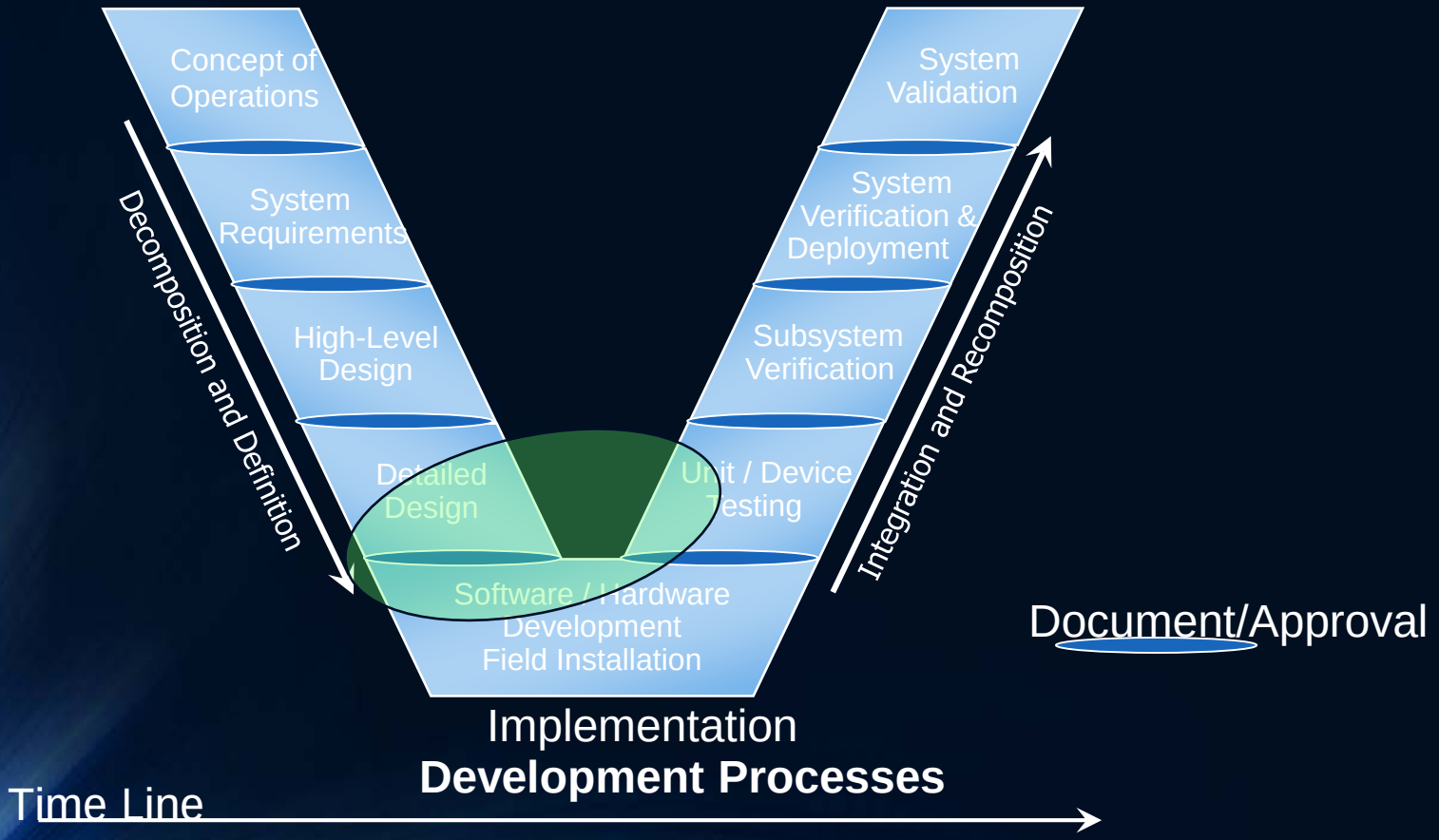
Using Standards

- 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"



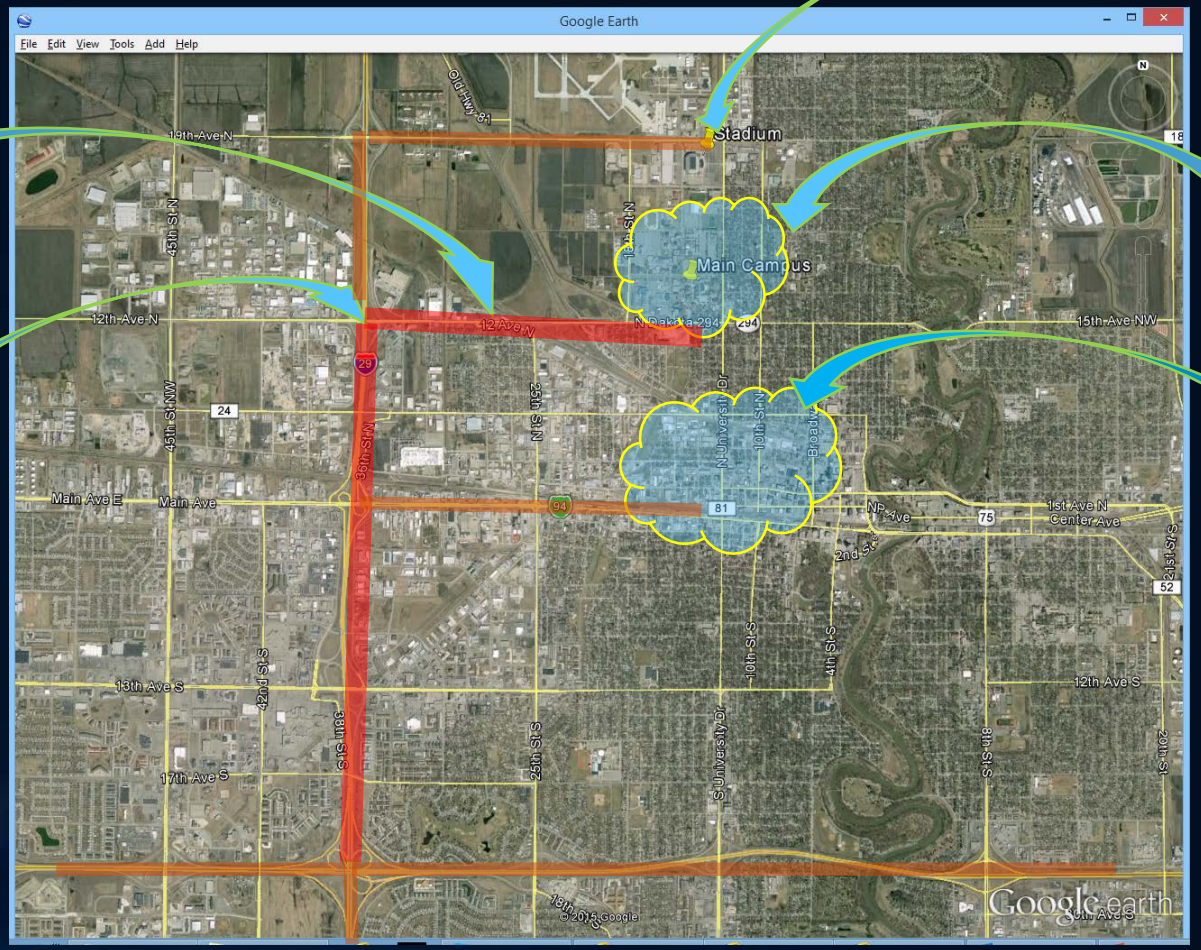
Civil Design for ITS Deployments

- 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



Stadium

Major Arterial

Campus

Freeway Interchange

Town Center

Primary Congestion

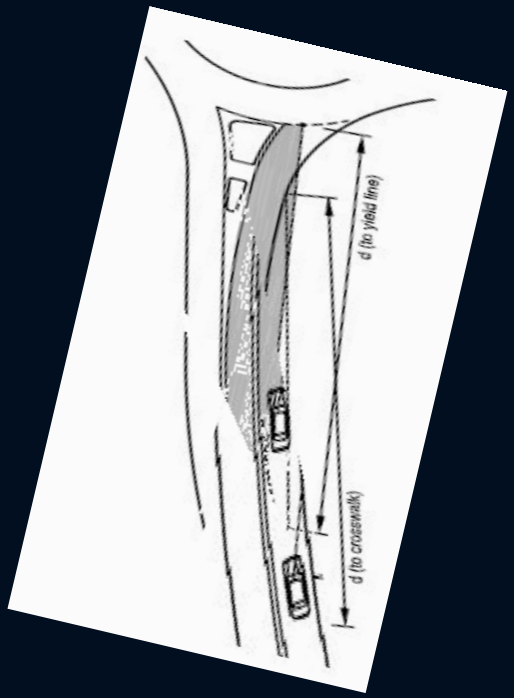
Secondary Congestion

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

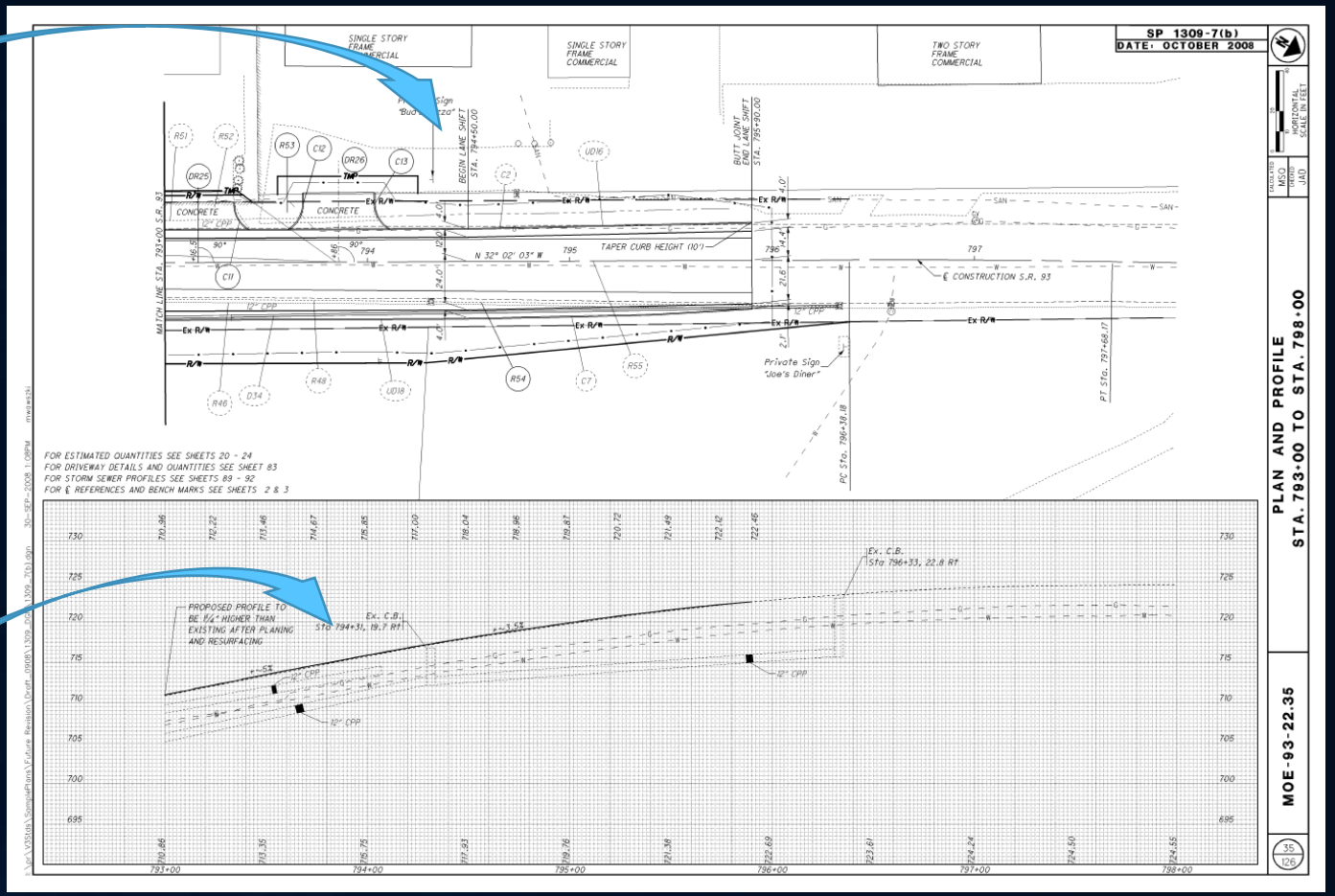


Plan Sheet Sample – Plan and Profile

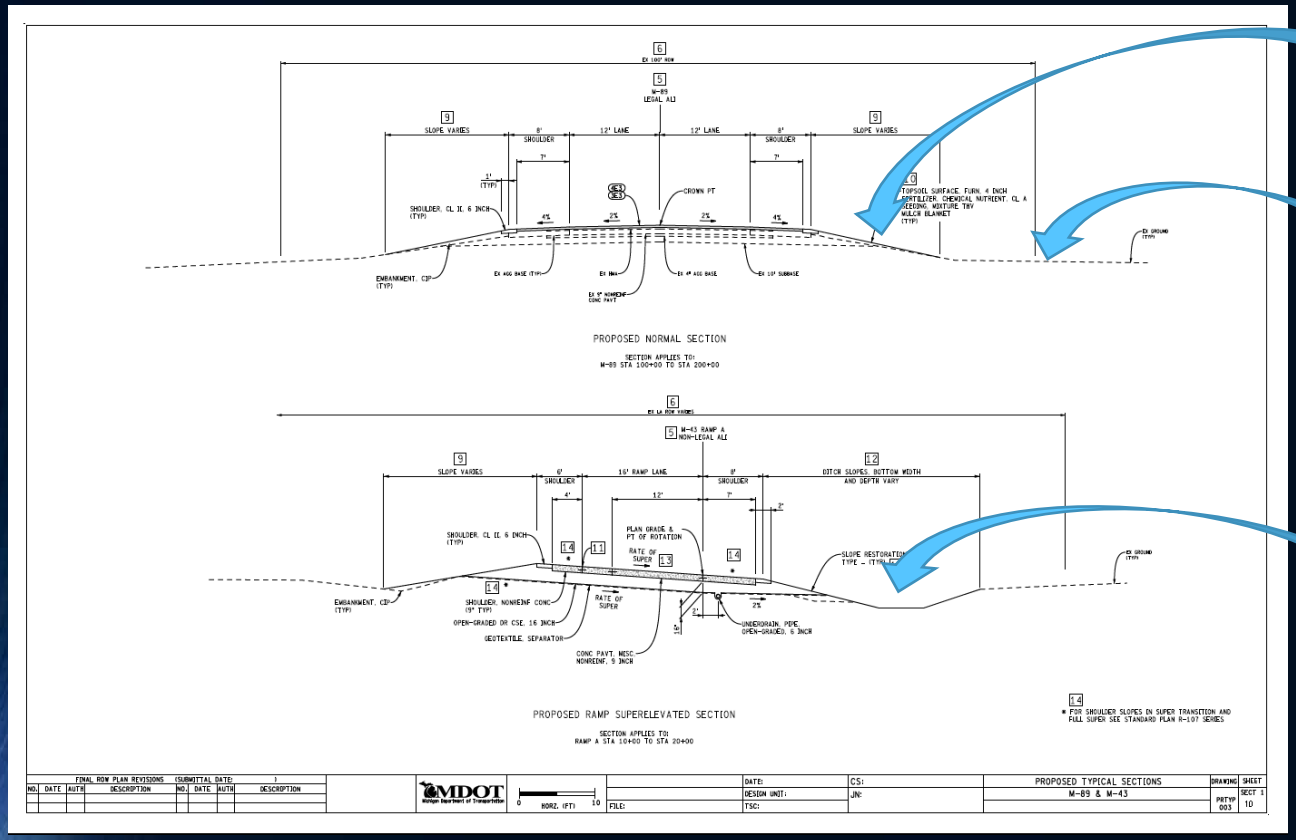
Plan

- Existing plans
  - General Information
  - Initial site line assessment

Profile



Plan Sheet Sample – Cross Section



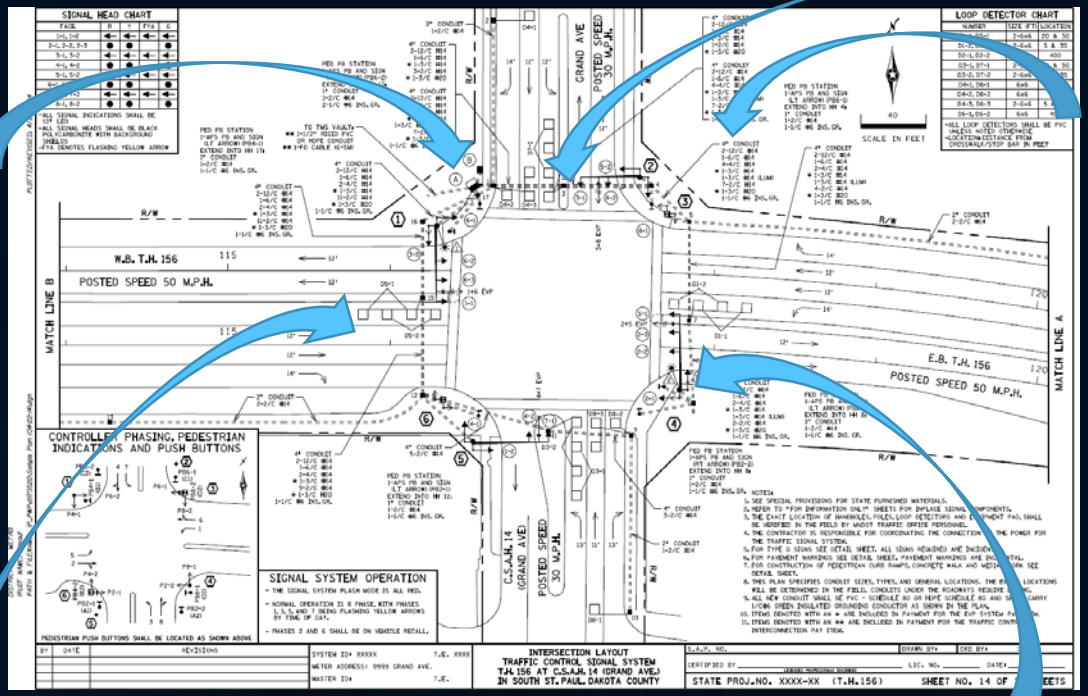
Runoff and Slope restoration

Structure height

Standing water

- Existing plans
  - Siting
  - Environmental

Plan Sheet Sample - Intersection



Cabinet Location

Conduit Plant and Usage

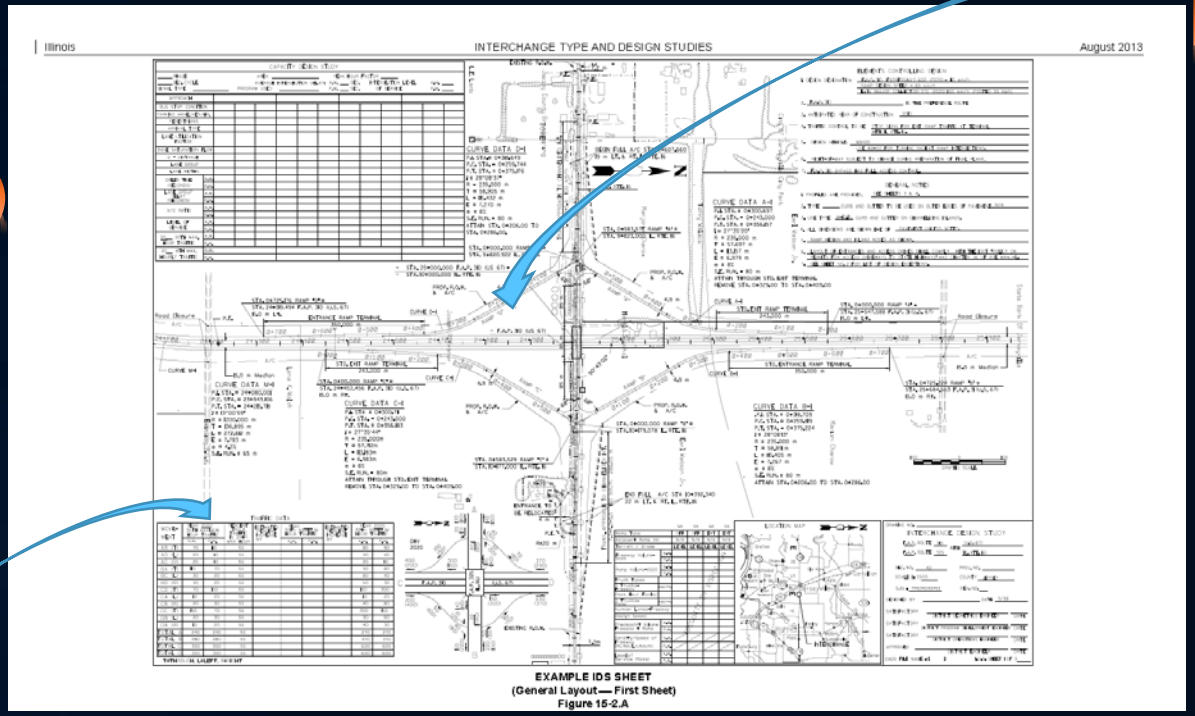
Roadway Dimensions

Potential Mounting Structures

Plan Sheet Sample - Interchange

Cabinet Location (if present)

Roadway Dimensions



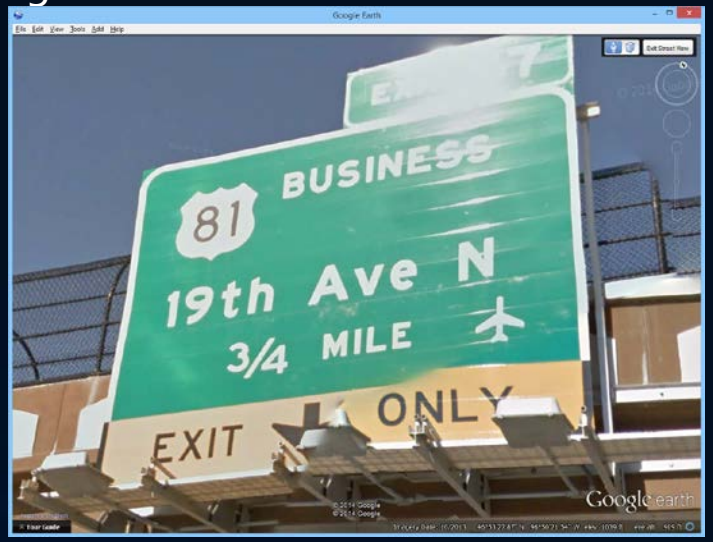
Traffic Estimates

Potential Mounting Structures (if present)

Conduit Plant and Usage (if present)

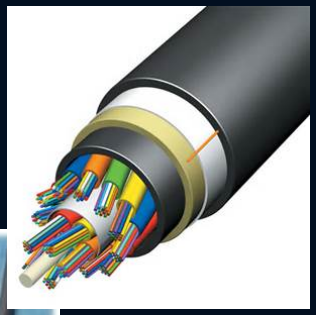
Power

- 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

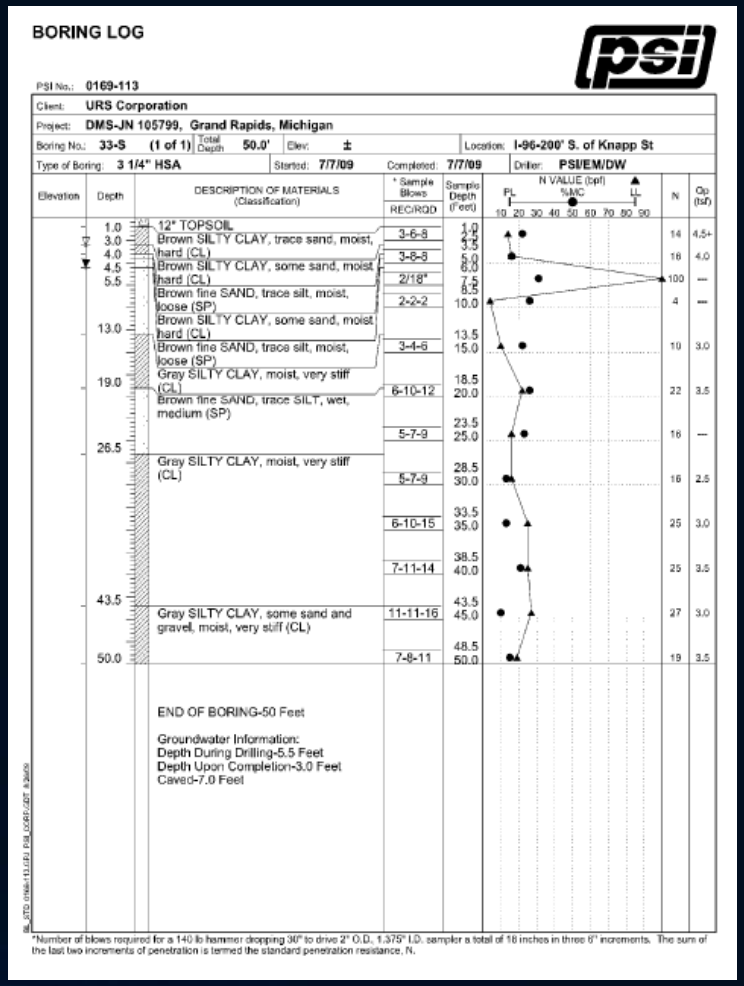
- Specific plans required to access all locations with communication need
- All choices must support user needs and requirements
  - Bandwidth
  - Reliability
  - Security
- Extensive range of options available



- 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



BORING LOG

PSI No.: 0169-113
Client: URS Corporation
Project: DMS-JN 105799, Grand Rapids, Michigan
Boring No.: 33-S (1 of 1) Total Depth 50.0' Elev: ± Location: I-96-200' S. of Knapp St
Type of Boring: 3 1/4" HSA Started: 7/7/09 Completed: 7/7/09 Driller: PSI/EM/DW

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	* Sample Blows REC/RQD	Sample Depth (Feet)	N VALUE (bpf) PL %MC LL 10 20 30 40 50 60 70 80 90	N	Qp (tsf)
	1.0	12" TOPSOIL		1.0			
	3.0	Brown SILTY CLAY, trace sand, moist, hard (CL)	3-6-8	3.5		14	4.5+
	4.0			5.0			
	4.5	Brown SILTY CLAY, some sand, moist, hard (CL)	3-6-8	6.0		16	4.0
	5.5	Brown fine SAND, trace silt, moist, loose (SP)	2/18"	7.5		100	—
		Brown SILTY CLAY, some sand, moist hard (CL)	2-2-2	8.5 10.0		4	—
	13.0	Brown fine SAND, trace silt, moist, loose (SP)	3-4-6	13.5 15.0		10	3.0
	19.0	Gray SILTY CLAY, moist, very stiff (CL)	6-10-12	18.5 20.0		22	3.5
		Brown fine SAND, trace SILT, wet, medium (SP)	5-7-9	23.5 25.0		16	—
	26.5	Gray SILTY CLAY, moist, very stiff (CL)	5-7-9	28.5 30.0		16	2.5
			6-10-15	33.5 35.0		25	3.0
			7-11-14	38.5 40.0		25	3.5
	43.5	Gray SILTY CLAY, some sand and gravel, moist, very stiff (CL)	11-11-16	43.5 45.0		27	3.0
	50.0		7-8-11	48.5 50.0		19	3.5

END OF BORING-50 Feet

Groundwater Information:
Depth During Drilling-5.5 Feet
Depth Upon Completion-3.0 Feet
Caved-7.0 Feet

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

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

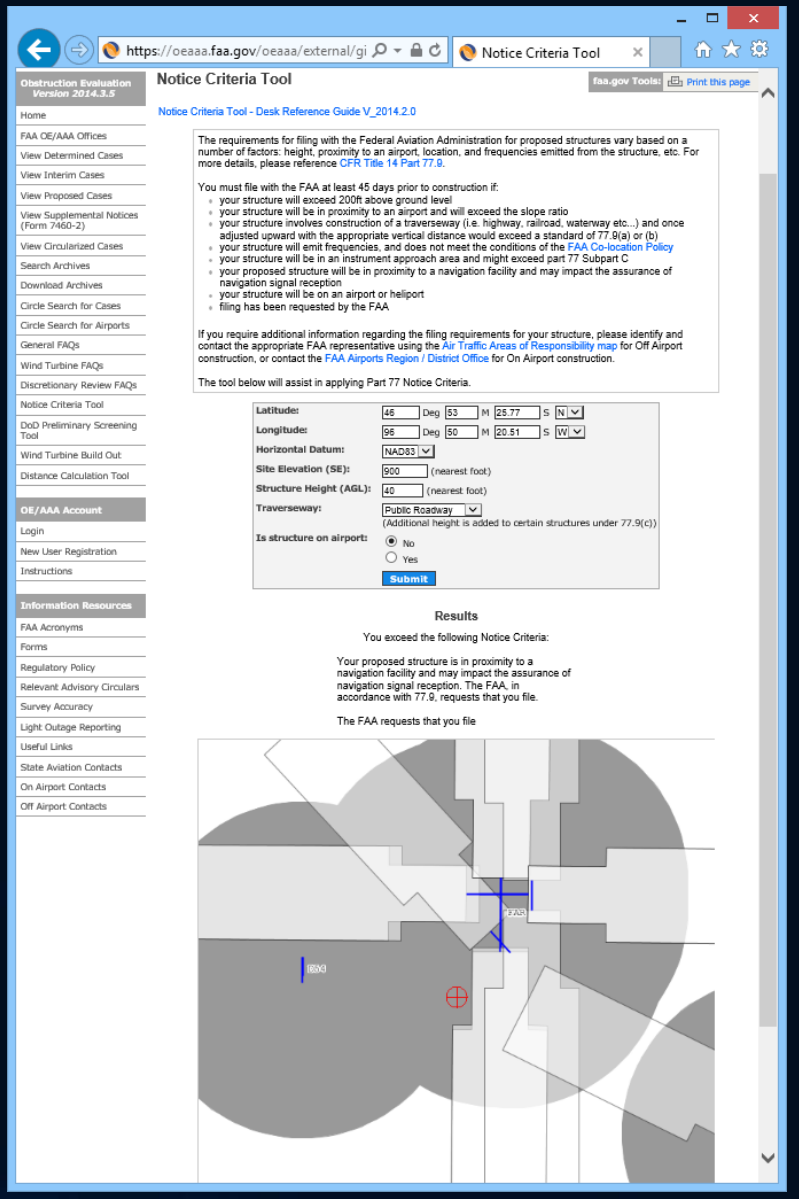
External Regulations

- Aircraft protection
- Environmental Impact
  - Waterways
  - Endangered species

- Jurisdictional requirements
  - Aesthetics
  - Departmental infrastructure ownership

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

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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

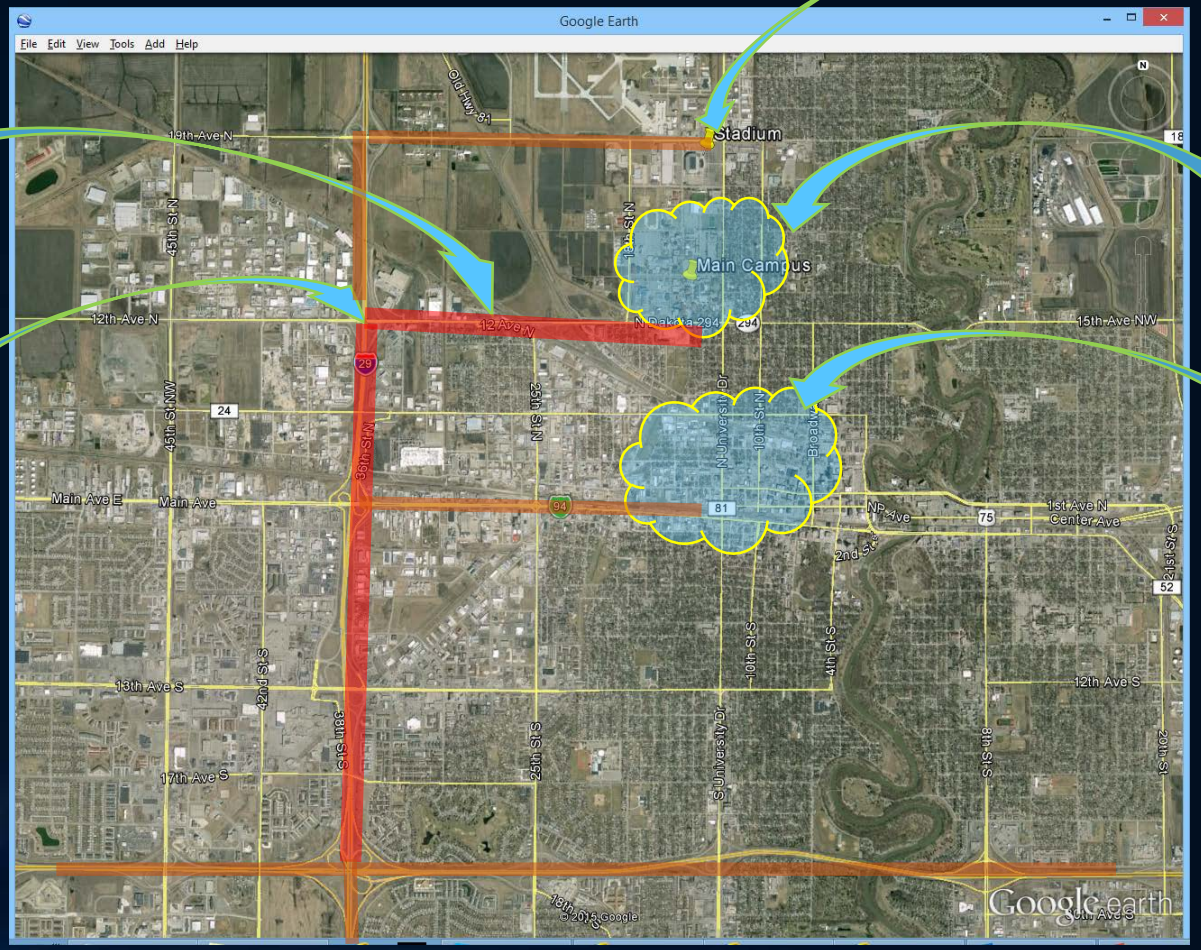
ITS Performance Measures for Evaluation

- 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



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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.