Streamlining ITS

SOUTHWEST RESEARCH INSTITUTE®

Unifying Variable Speed Limits and
Lane Control Across State Agencies

Agenda

- Introduction
- Background
- Problems
  - Business Rules
  - Regulatory Concerns
  - Technical Challenges
- Lessons Learned
- Looking Forward

Abstract

- This presentation will explore the complicated process of developing Variable Speed Limit (VSL) and Lane Control Sign (LCS) applications for state transportation agencies. As advancements in smart transportation continue to reshape traffic management strategies of roadways, the implementation of dynamic speed limits and lane controls stand out as critical component for enhancing safety and traffic flow. The journey towards integrating these applications is not without its challenges, particularly in dealing with the diverse business logic requirements across different state agencies. This presentation will delve into the regulatory considerations, and collaborative strategies essential for successfully navigating and addressing the problems associated with deploying these technologies. Due to the shared nature of the state-owned advanced traffic management system (ATMS) solution, ActiveITS, there are also distinct challenges from a systems integration point of view. This presentation will also explore the technical intricacies and challenges of designing and implementing distinct business logic for each state agency. Lessons learned from three projects for the Tennessee Department of Transportation, Florida Department of Transportation, and Texas Department of Transportation will be discussed, along with plans for future agency integration.

Introduction

- Southwest Research Institute
  - Independent non-profit Research & Design (R&D) organization
  - Over 25 years of Intelligent Transportation Systems (ITS) experience

- AJ Skillern
  - 11 years of ITS experience
  - Work with 10 different Departments of Transportation (DOTs) for ITS software projects

What are Lane Control Signs (LCS)

- Variable message signs (VMS) that direct the usage of a travel lane
- More general term is Lane Management Sign (LMS)
- Traffic management use cases include:
  - Reversible lanes
  - Part time use lanes
  - Incident management
  - Tolling, bridge and tunnel operations
  - Diversion routing
  - General traffic flow control

What are Variable Speed Limits (VSL)

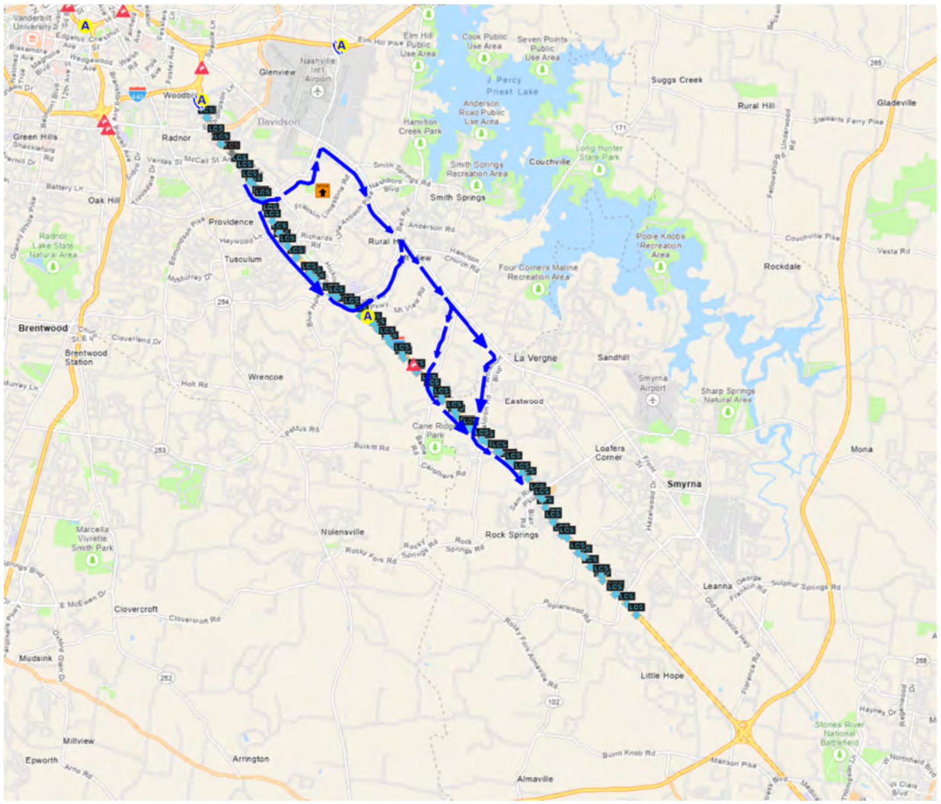
- Variable speed limit signs are used to notify drivers of changes in traffic flow speeds
- Causes can be triggered by:
  - Weather conditions
  - Traffic conditions
  - Safety concerns
- Usage may be preemptive or reactive

Picture: "Variable_speed_limit.jpg" by Novasource is in the Public Domain, CC0

What is ActiveITS?

- State-owned Advanced Traffic Management System (ATMS)
  - Used to manage ITS field devices, manage incidents, and disseminate information to travelers
  - Maintained by Southwest Research Institute
- Originally developed for Texas DOT (TxDOT) and Florida DOT (FDOT) in the early 2000s
- Currently used by more than 13 state DOTs, including several forum members
- As new features and modules are added to the system, these are provided to other agencies for integration

Tennessee DOT



An image showing the I-24 Integrated Corridor Management deployment of ITS devices to the southeast of Nashville from the ActiveITS user interface.

- Four regional deployments of ActiveITS
- Single deployment will use both LCS and VSL
- Devices are used as part of Integrated Corridor Management (ICM) system on I-24 outside Nashville

TDOT Lane Control Scope

- Integrated Lane Control module from TxDOT
  - Made heavy modifications to support per-lane graphical Dynamic Message Signs (DMS) instead of blank-out signs, drum, or other VMS technology
  - Customized to meet ICM project needs
- Customizations include:
  - Sign technology updates to use graphics on full-matrix DMS
  - Logic for merging overlapping response plans
  - Error handling
    - Original TxDOT module required all heads to post or fail
    - TDOT code allows for no more than one head to fail

TDOT Variable Speed Scope

- Developed a new variable speed module
  - Customized to meet ICM project needs
  - Reactive to traffic congestion and incidents
- Integrated with the LCS module
  - Typically posts normal speeds over shoulder
  - When slowing traffic, moves speed messages to signs over mainline lanes

TDOT Deployment Details

- System installed 5-foot Ledstar DMS across each lane of the overhead gantries
  - All signs are Ledstar
- Each gantry is managed as a set of signs from within ActiveITS
- All data sources are internal to ActiveITS
  - Lane closures are generated as part of incident response plans
  - Automated variable speed limits are generated and sent to the system based on current traffic conditions from traffic detectors

TDOT VSL In Action

Image courtesy of Tennessee Department of Transportation

TDOT VSL In Action, cont'd

Image courtesy of Tennessee Department of Transportation

TDOT VSL In Action, cont'd

Image courtesy of Tennessee Department of Transportation

TDOT VSL In Action, cont'd

Image courtesy of Tennessee Department of Transportation

Florida DOT

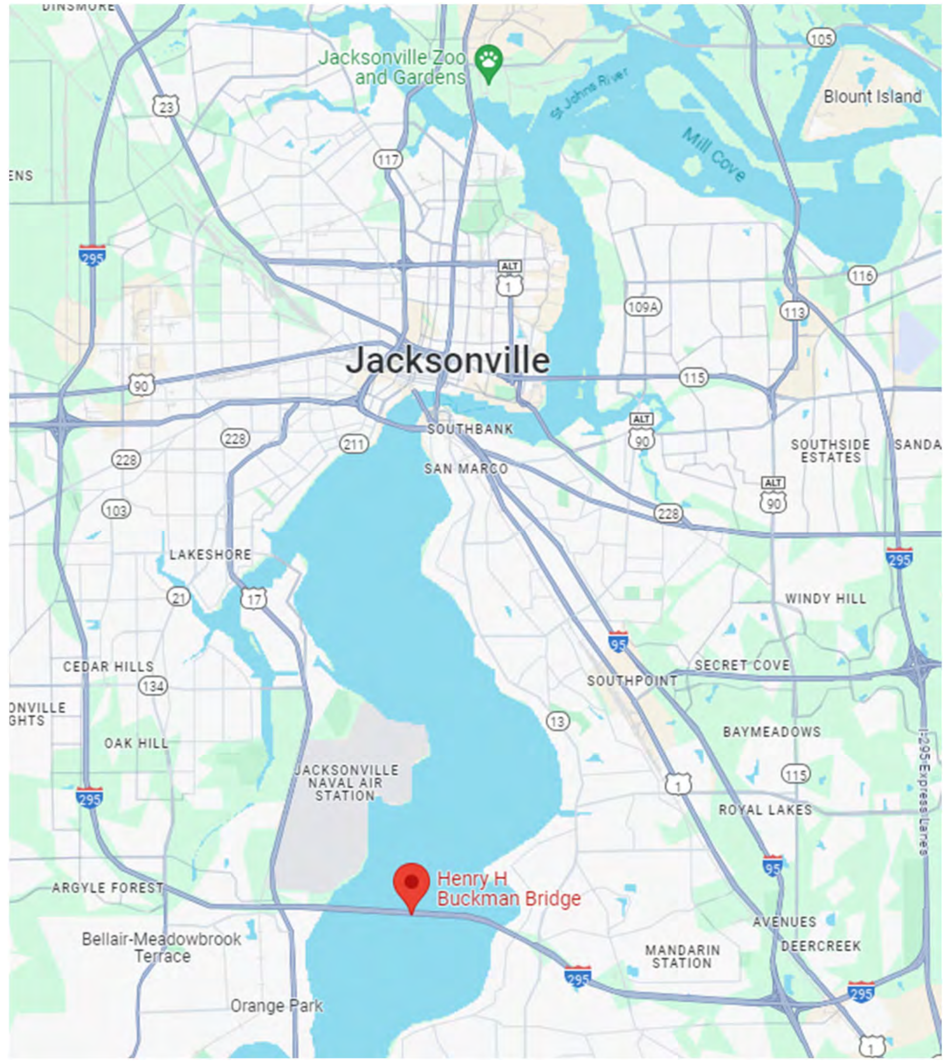
- Deployments are broken down across 7 districts, 3 tolling agencies, and a few smaller county/city deployments
- Multiple deployments will use lane control signs
  - FDOT District 2 – Jacksonville
  - Central Florida Expressway Authority (CFX)
- Single deployment using variable speeds
- Different business rules between deployments

FDOT Scope

- Integrating the Lane Control module from TDOT
- Modified the code to fit FDOT business rules
- Adding some new features for additional scenarios not present in TDOT's roadway network
- Key differences:
  - Signs are never blank, unless due to communications loss
  - Will display red X over shoulder and green arrows by default
  - Any variable speeds are manually signed
  - Handles lane splitting and merging scenarios

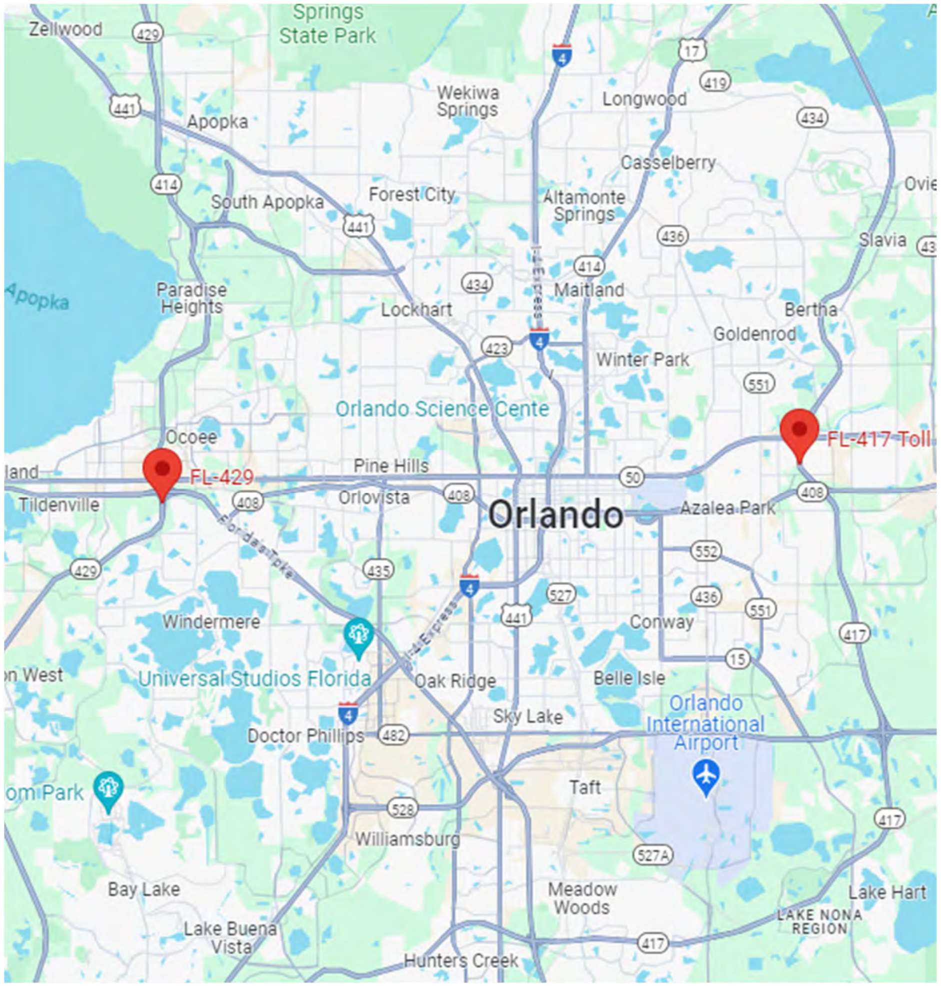
FDOT District 2 Deployment Details

- Part of a larger $10.5 million ITS construction project started in 2019 to increase safety on stretch of I-295 for Buckman Bridge
- Signing will be used to guide lane usage
- May use up to 5 or 6 upstream gantries for yellow X signing
  - Default is 2 to 3



CFX Deployment Details

- Will be deployed for part-time shoulder use project on SR-417 and SR-429 in Orlando metro area
- Deploying same signs as TDOT



CFX Deployment Testing

Texas DOT

- 10 deployments across the state, encompassing 22 districts
- One deployment will be piloting the VSL system
- One deployment will be using LCS

TxDOT Scope

- Integrating the Variable Speed Limits module from TDOT
- Added a weather-based algorithm
  - Handles weather readings for:
    - Friction
    - Visibility distance
- Customized the algorithm to meet TxDOT legislation requirements
  - Limits lowering speed limit to 15 MPH below posted speeds

Other states with VSL and LCS in ActiveITS

- Oregon DOT (ODOT)
  - Have deployments of VSL across the state
  - Controlled by ODOT developed system
  - Each deployment of VSL has unique configuration and rules
  - Future plans to integrate ActiveITS modules into existing single statewide deployment
- New Hampshire DOT (NHDOT)
  - Single statewide deployment of ActiveITS
  - VSL are installed along I-93 corridor
  - Operators manually adjust speed limits based on traffic conditions and weather
  - Messages are posted via ActiveITS

Other states without VSL and LCS in ActiveITS

- Utah DOT (UDOT)
  - Employs VSL
  - Separate from statewide ATMS
  - Not integrated with ActiveITS
- Caltrans
  - Employs LCS and VSL across state
  - Separate systems across different districts, and within districts
  - Not integrated with ActiveITS

Problems

- Problems include:
  - Diverse business rules
  - Regulatory concerns
  - Technical challenges

Diverse business rules

- Every deployment requires different business rules
- Factors that affect rules include:
  - Legislation
  - Operational policies and guidelines
  - Deployment environment
    - Urban vs. rural
    - Lane geometry
    - Tolling operations
  - Traffic management goals

Comparing LCS Business Rules

TDOT

- Used for incident management
  - Close lanes with blockage
- Signs are always active
  - Enforced by operational procedures

FDOT

- Used for incident management
  - Open part time shoulder use
  - Close lanes with blockage
- Signs are always active
  - Enforced by software

Comparing VSL Business Rules

TDOT

- Used for incident management
  - Reduce traffic speed around incident
- Signs are only active during incident
- Use traffic speed readings to calculate automated variable speed limit

FDOT

- Used for incident management
  - Reduce traffic speed around incident
- Signs are always active
  - Display normal speed limit without active incident
- Manually changed variable speeds

Comparing VSL Business Rules, cont'd

TDOT

- Used for incident management
  - Reduce traffic speed around incident or congestion
- Signs are only active during incident

TxDOT

- Respond to weather conditions
  - Reduce traffic speed under low visibility, low friction
- Signs are always active
  - Display normal speed limit without active incident

Deployment environment factors

- Urban vs. rural usually have different goals
  - Urban is typically looking to manage congestion
  - Rural is typically looking to increase safety or manage weather
- Lane geometry
  - Different shoulder availability on different roads
  - Lanes may split or merge to have varying number and type of lanes
- Tolling
  - Tolling operations employ these strategies
  - Primary goal is directing traffic, usually around toll booths

Regulatory concerns

- Regulatory concerns include:
  - Legislature
    - May restrict usage
    - May affect enforcement
  - Manual on Uniform Traffic Control Devices (MUTCD) conformance

Regulatory Concerns - VSL

- VSL can be regulatory or advisory
  - Typically identified by the MUTCD color scheme used:
    - Black on white or white on black is regulatory
    - Black on yellow is advisory
- Regulatory VSL can be enforced by police
  - Requires legislation to allow enforcement
  - Legislation can restrict effective use
    - Rates to change speed
    - Maximum speed changes

Regulatory Concerns - LCS

- MUTCD defines allowed signage
  - Allows green arrow, yellow X, and red X
  - Other signing needs to follow standards for size of font, allowed colors, usage of pictures or graphics
- Enforcement is not clearly defined

Regulatory Concerns - Both

- Enforcement is always a challenge
  - Drivers attempt to contest enforcement of these strategies
  - Need a reliable mechanism for recording messaging
  - Increased workload for agencies to supply this information
- If you can't enforce it, how does this impact things?
  - There is no impact!
  - People don't reliably follow advisory messaging

Technical Challenges

- Technical challenges include:
  - Diverse business rules
  - Regulations/legislation
  - Automation
  - Message conflicts
  - Message validation
  - Communications
  - Maintenance

Business rules challenges

- Diverse business rules are hard to implement within single system
- Involves a lot of configuration settings to customize usage
  - Some settings may make sense to have configurable
  - Other settings may not make sense to users

Regulatory challenges

- Legislative and other regulatory challenges complicate the technical implementation
  - Support advisory or regulatory posting
  - Support parameters for maximum speed changes
  - Support parameters for

Automation

- These are complex and controversial ITS devices
- Operationally agencies prefer to automate as much as possible
- Both VSL and LCS typically need to consider upstream *AND* downstream devices

Message conflicts

- The software should not suggest conflicting messages to operators
  - Should not allow posting either
- For LCS, consider a single lane showing a green arrow between an upstream and downstream red X
- For VSL, consider a higher speed limit between a lower speed limit displayed upstream and downstream (bounce)

Message validation

- When active, they need to always be correct
- Requires trust and verification of system operations when operating automatically
- Requires a lot of review and validation time to get to that point

Communications loss

- Devices with communication loss are an interesting challenge with "always-on" signage
  - Need to clear the message when communication is lost
  - Need to plan for known communication loss scenarios
- Need to handle updating messaging when communication is restored
  - Active management scenario that excluded previously unavailable device

Communications Reliability

- Impacts to communications can be seen from:
  - Weather
  - Remote locations
  - Connectivity in intermediate networks
  - Power supply
  - Vandalism

Maintenance

- Maintenance is a technical problem too
  - Cost to maintain hardware and software systems
- These systems require higher levels of service to preserve user trust

What does this mean?

- It's freaking hard to build one system to address these differences!

TDOT - Lessons Learned Pros

- Project team had a clear vision of the desired system functionality
- Agile methodology made it easy to adjust to changes in plans
- Size and location of the deployment made system functionality simpler

TDOT – Lessons Learned Cons

- Agile methodology added changes to system functionality
- Algorithms require accurate data
  - Analysis from Vanderbilt showed that many traffic detectors were improperly configured

FDOT - Lessons Learned Pros

- Ability to reuse the existing code base was a huge time and cost saving factor
  - Over 80% cost savings compared to initial development costs
  - Schedule was able to be accelerated

FDOT - Lessons Learned Cons

- Business logic rules were significant enough that there was a large non-trivial effort to address them
  - Merging and splitting lanes
  - Non-blank default messaging
  - Flashing beacon usage
  - Lane signing rules were more complex than TDOT

TxDOT - Lessons Learned Pros

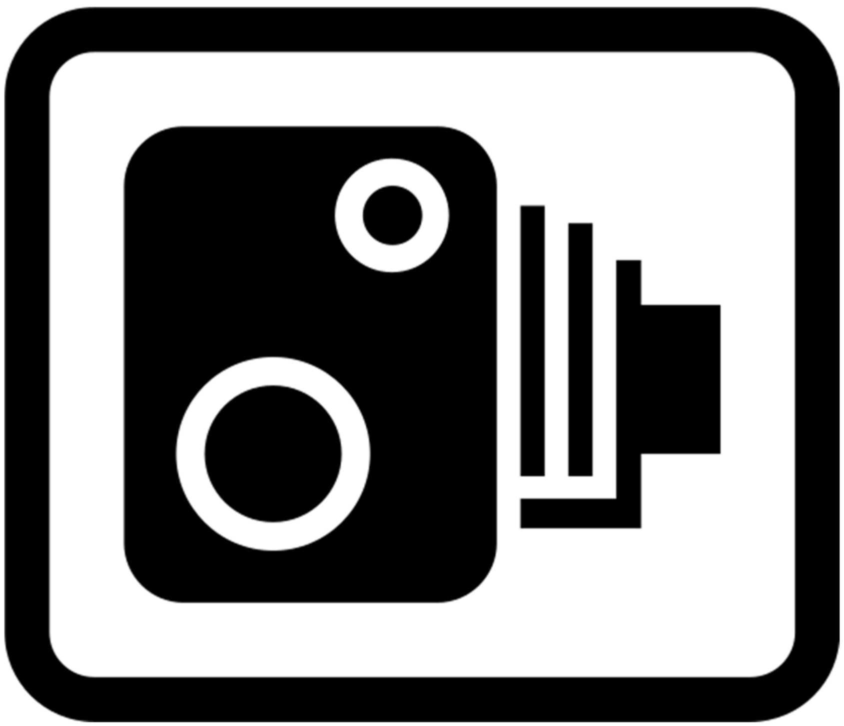
- Ability to reuse the existing code base was a huge time and cost saving factor
- Algorithmic differences between weather and traffic were similar enough that it was not an issue

TxDOT - Lessons Learned Cons

- Agile methodology can be good and bad
  - Agile software development is good for changes in plans
  - Software development is fluid, and the final product should meet user needs, but may be different than what was originally requested
  - Can lead to confusion when identifying supported functionality
  - TDOT development used agile methodology

Other External Lessons

- European systems
  - Speed camera/automated enforcement is standard
    - Highly controversial in the US
    - Very effective traffic management strategy
    - Ramp metering has similar issues



Picture: "UK traffic sign 879.svg" by United Kingdom - Department for Transport is licensed under OGL v1.0

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Applying Lessons Learned - ODOT

- Things to consider:
  - Making things more configurable or flexible never hurts
  - Need to understand differences between existing system and new system
  - Any way to re-use an existing system is always more cost or time efficient than building from scratch

Questions

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Acronyms

- ATMS – Advanced Traffic Management System
- CFX – Central Florida Expressway Authority
- DMS – Dynamic Message Sign
- DOT – Department of Transportation
- FDOT – Florida Department of Transportation
- ICM – Integrated Corridor Management
- ITS – Intelligent Transportation Systems
- LCS – Lane Control Signs
- LMS – Lane Management Signs
- MUTCD – Manual on Uniform Traffic Control Devices
- NHDOT – New Hampshire Department of Transportation
- ODOT – Oregon Department of Transportation
- R&D – Research and Development
- TDOT – Tennessee Department of Transportation
- TxDOT – Texas Department of Transportation
- UDOT – Utah Department of Transportation
- VMS – Variable Message Sign
- VSL – Variable Speed Limit