Wyoming DOT Connected Vehicle Pilot

SYSTEM DESIGN WEBINAR

CV Pilot Deployment Overview

KATE HARTMAN, U.S. DOT

CV Pilot Deployment Overview

Wyoming CV Pilot Presentation Overview

- Site Overview – Vince Garcia
- From Planning to Deployment – Deepak Gopalakrishna
- From Planning to System Architecture – Deepak Gopalakrishna
- From Architecture to System Design – Shane Zumpf
- From Traceability to Readiness – Denny Stephens
- Lessons Learned – Tony English
- Next Steps – Vince Garcia

Site Overview

VINCE GARCIA, WYDOT

WYDOT CV Pilot Overview

Measures of Success

- Improved safety and mobility along I-80 through real-time communication with fleet drivers and managers
- Improved awareness of hazards through CV pilot applications

Implementation Elements

- 75 Roadside Units (RSUs) broadcasting and receiving messages via DSRC
- 400 equipped vehicles with on-board units (OBUs)
- V2V, V2I, I2V applications alerting drivers to various road conditions
- CV data collection for improved traffic management and traveler information

For More Information

https://wydotcvp.wyoroad.info/

From Planning to Deployment

DEEPAK GOPALAKRISHNA, ICF

WYDOT CV Pilot Phases

- The Pilot is comprised of three phases

Phase 1	• Planning (Sept. 2015 – Sept. 2016)
Phase 2	• Deployment (Oct. 2016 – April 2018)
Phase 3	• Demonstration (May 2018 – Oct. 2019)

Status After Phase 1

- ✓ Concept of Operations (ConOps)
- ✓ Security Management Operational Concept
- ✓ Safety Management Plan
- ✓ Performance Measurement and Evaluation Support Plan
- ✓ System Requirements Specification
- ✓ Application Deployment Plan
- ✓ Human Use Approval
- ✓ Participant Training and Stakeholder Education Plan
- ✓ Outreach Plan
- ✓ Comprehensive Pilot Deployment Plan

Notice to Proceed to Phase 2

Phase 2 Activities

Design

- System Architecture Document
- System Design Document

Build

- Comprehensive Acquisition Plan
- Comprehensive Installation Plan
- Application Development

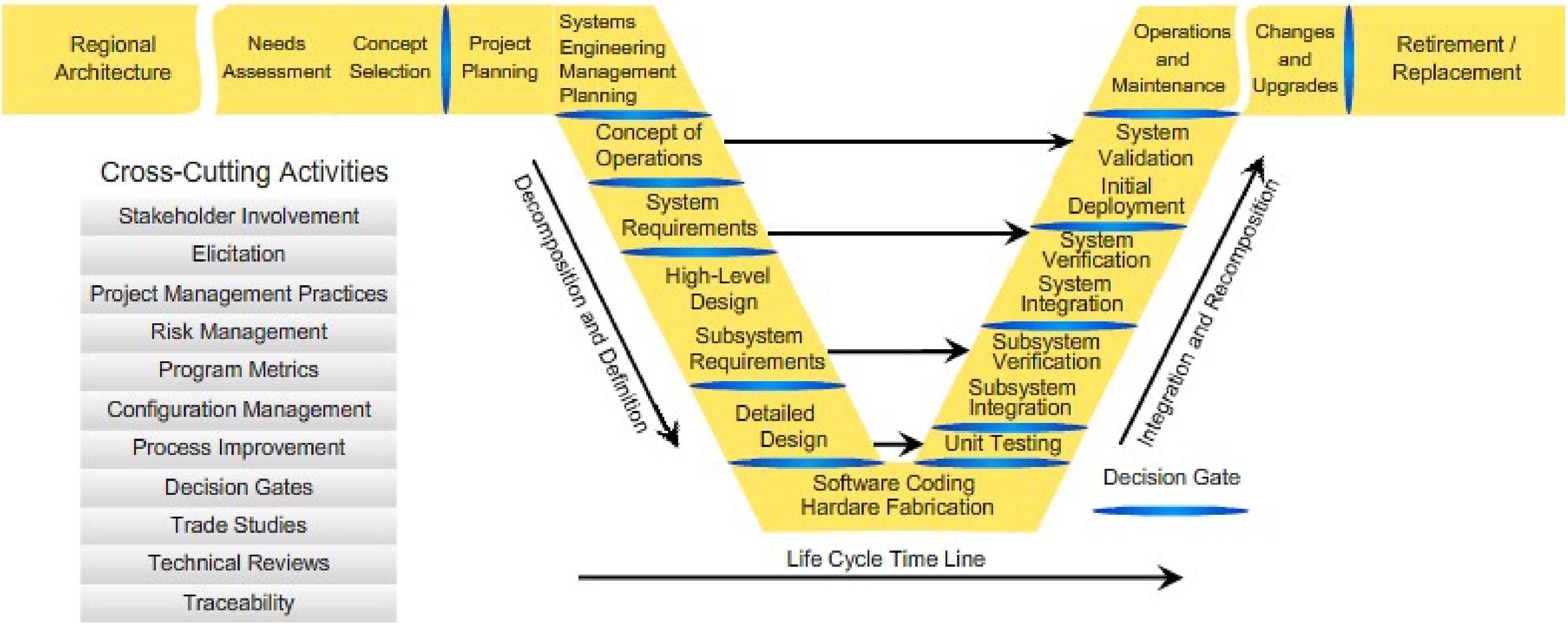
Test

- Operational Readiness Plan
- Operational Readiness Testing

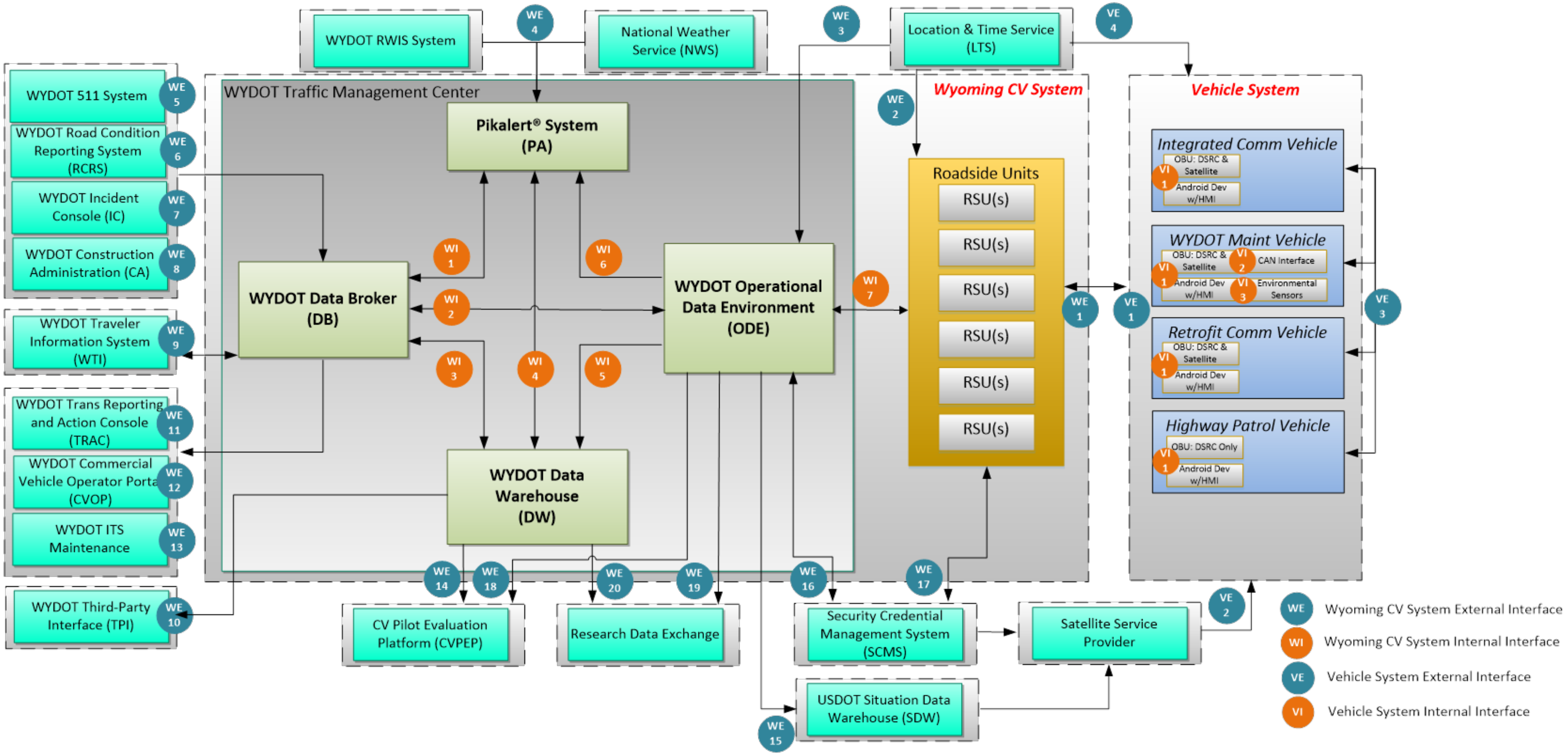
System Architecture Development

- ➢Robust systems engineering process followed

Phase -1	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Interfacing with Planning and the Regional Architecture	Concept Exploration and Benefits Analysis	Project Planning and Concept of Operations Development	System Definition and Design	System Development and Implementation	Validation, Operations and Maintenance, Changes & Upgrades	System Retirement / Replacement



System Architecture Development



Sys. Architecture – Key Outcomes/Challenges

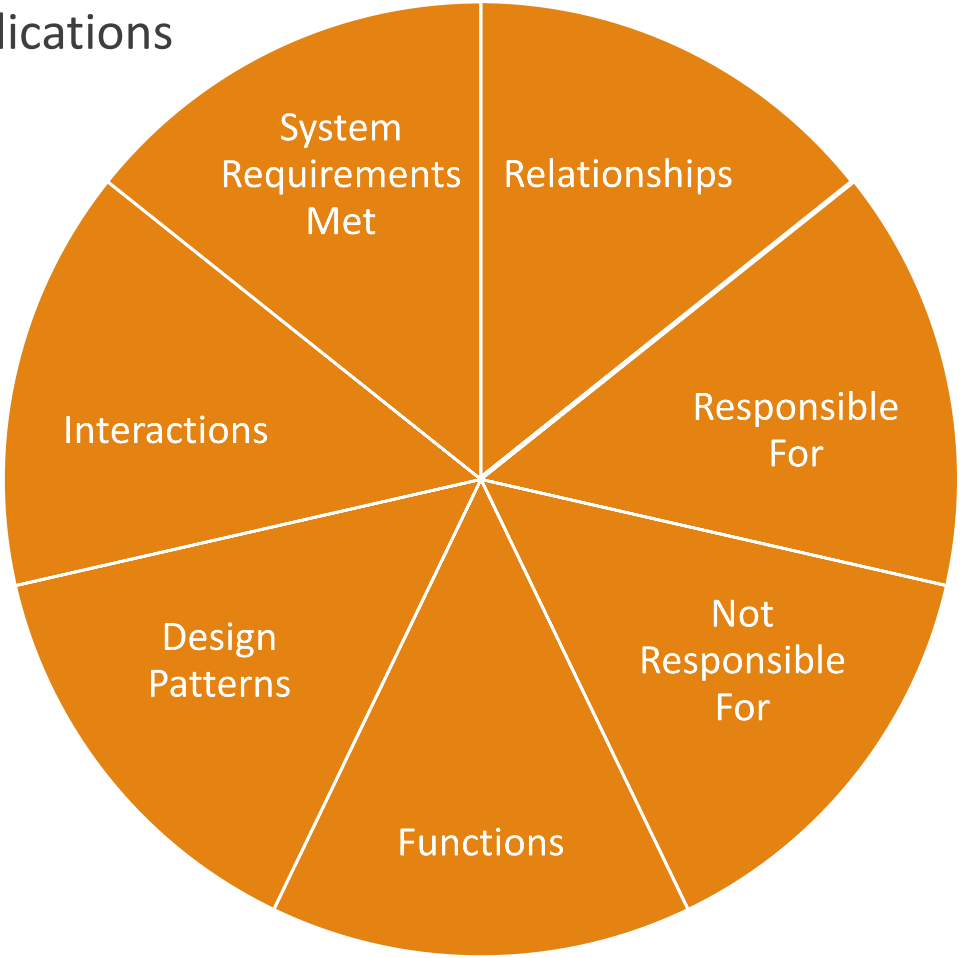
- Planning for security can be a moving target, need to develop architecture plan for research and for deployment (different goals)
- Data collection focus on operations vs. application validation
- Architect TMC network to support CV
  - Security
  - IPv6
  - Bandwidth
  - SCMS access
- Plan for mobile observations data collection and dissemination
- System architecture for weather forecasting and development of roadway alerts and advisories

From Architecture to System Design

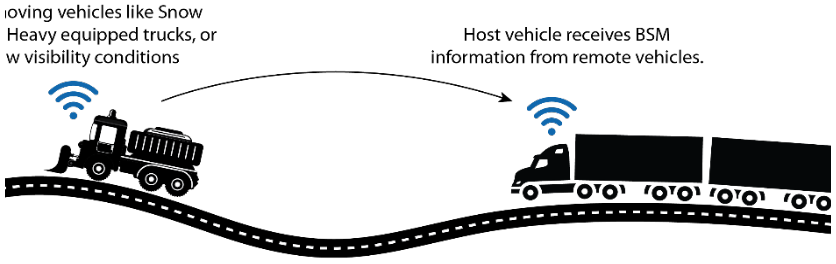
SHANE ZUMPF, TRIHYDRO

System Design

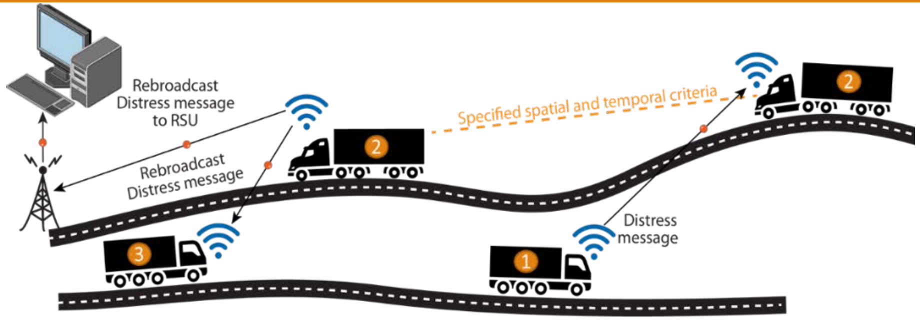
- Focus on individual applications
- Develop Interfaces
- Criteria for design



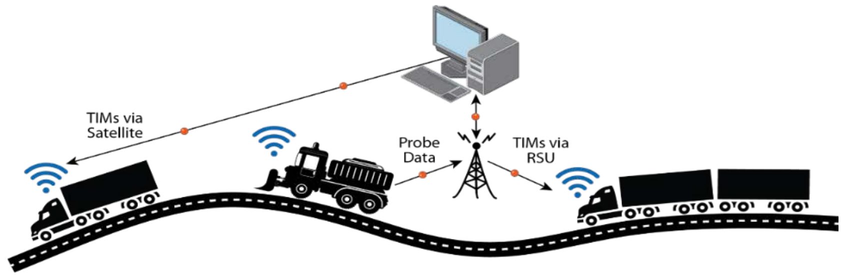
System Design – Applications



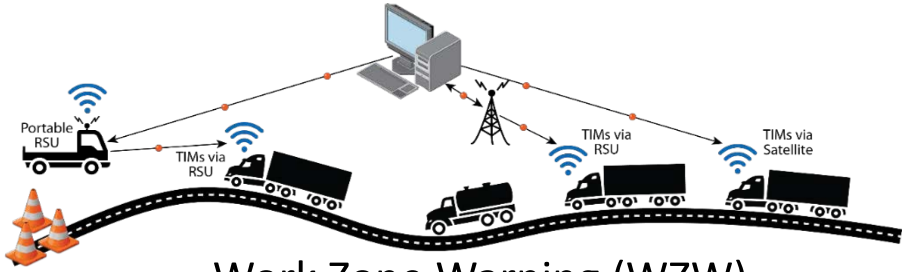
Forward Collision Warning (FCW)



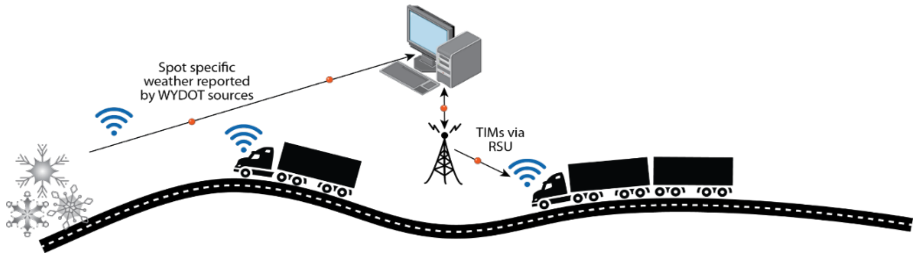
Distress Notification (DN)



I2V Situational Awareness



Work Zone Warning (WZW)



Spot Weather Impact Warning (SWIW)

System Design – Work Zone Warning

➢ Work Zone Warning – Behind the Scenes

TMC Application
- Operator Adds Planned Work Zone
- Sends Information to System

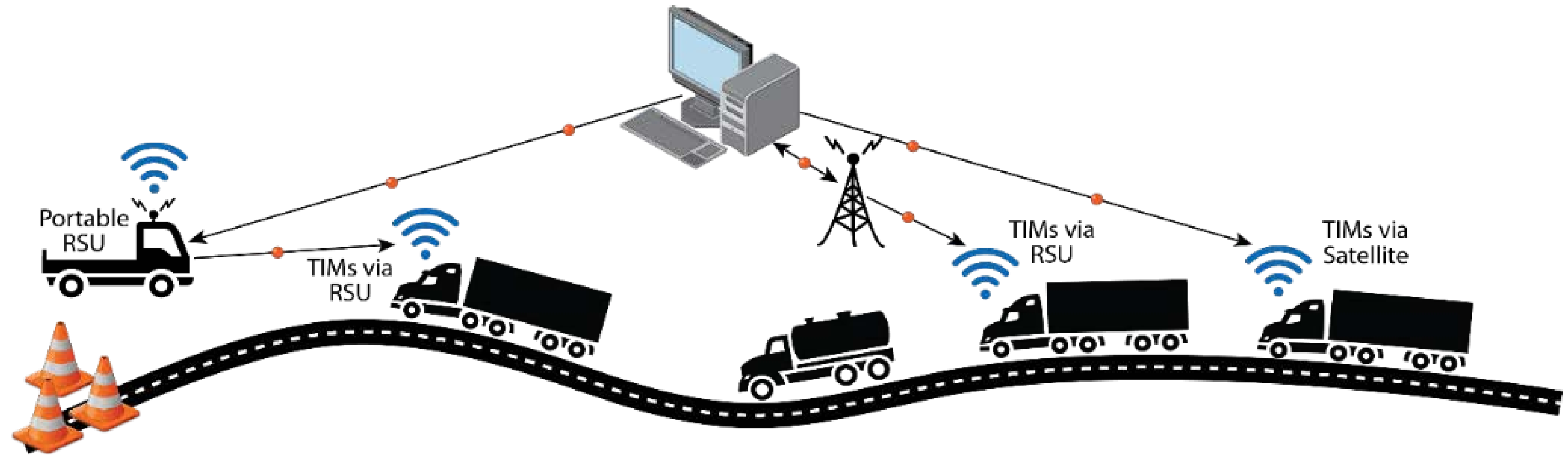
Backend Services
- Builds messages
- Determines Affected Area

RSU
- Broadcasts Alerts

Vehicles
- Receive Alerts

System Design – Work Zone Warning

- Work Zone Warning in Action



System Design – Spot Weather Warning

➢Spot Weather Warning – Behind the Scenes

Weather Data
- Remote Weather Stations
- Connected Vehicle Probe Data
- Connected Vehicle CAN Data

Pikalert
- Processes Weather Data
- Issues Weather Alerts and Forecasts

TMC Application
- Operator Receives new Alerts
- Issues Alerts to CV Environment

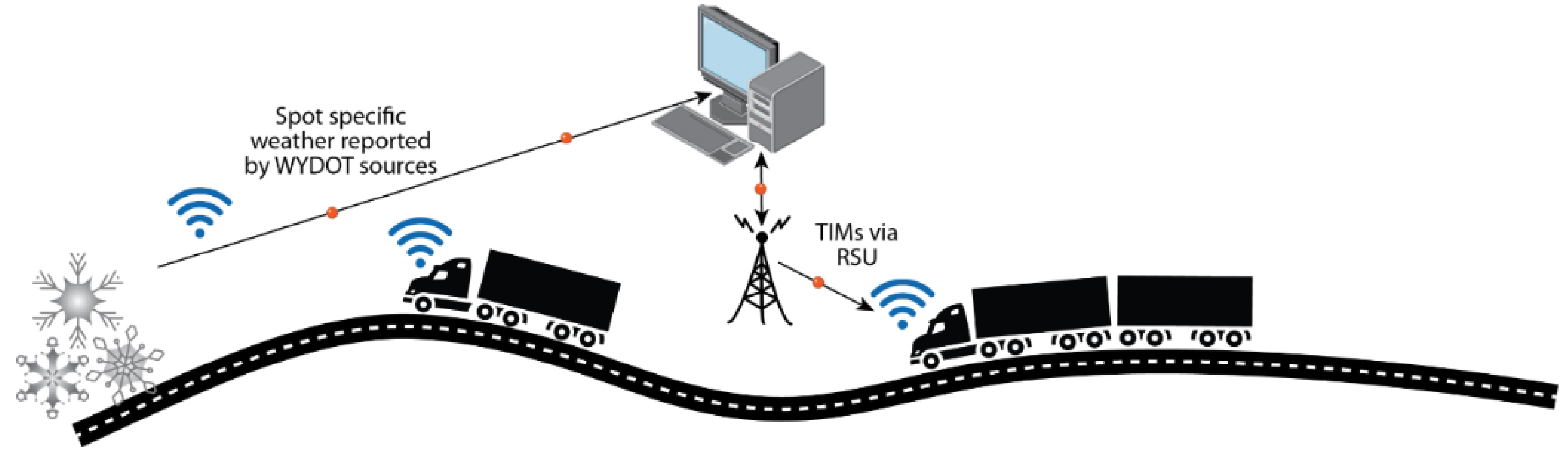
Backend Services
- Builds messages
- Determines Affected Area

RSU
- Broadcasts Alerts

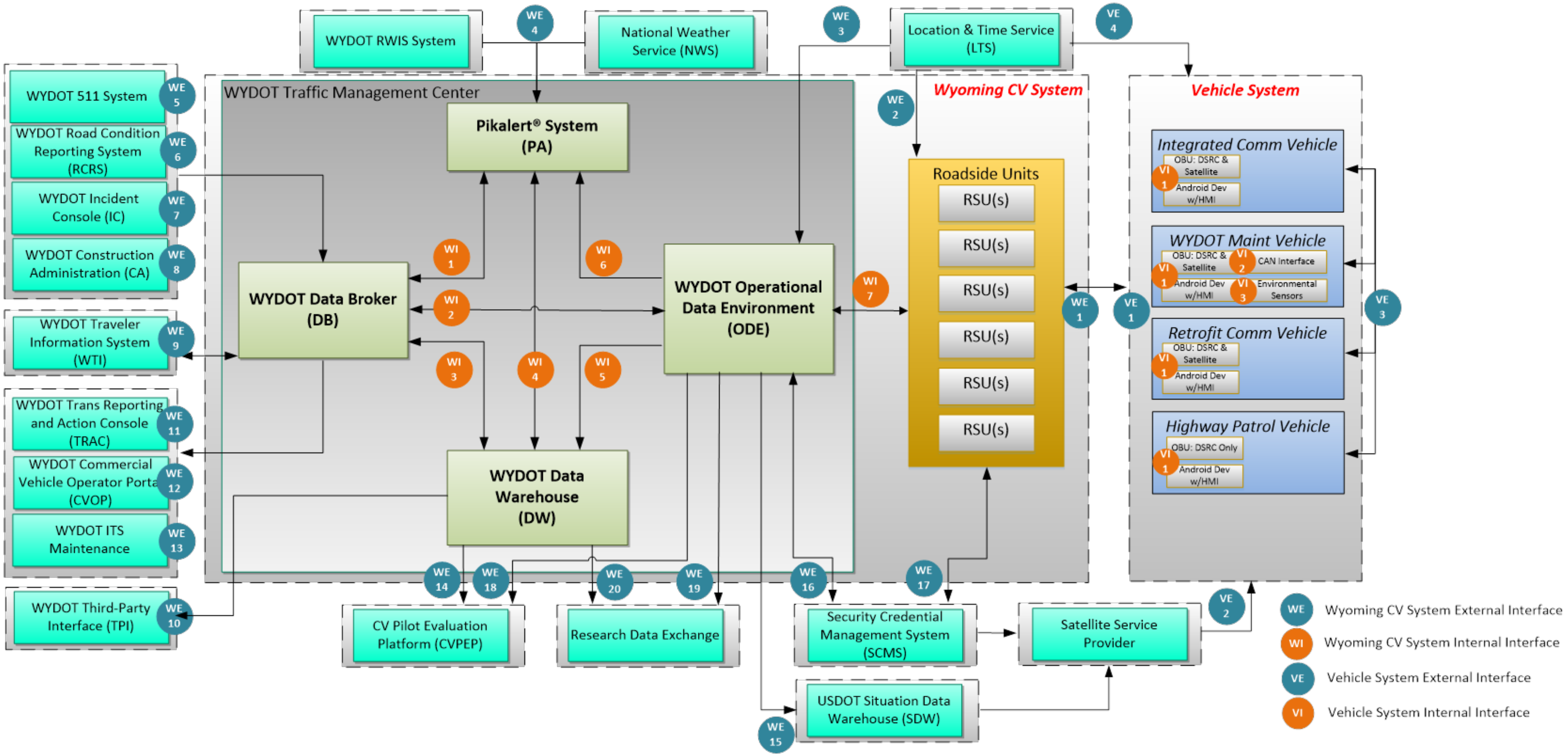
Vehicles
- Receive Alerts

System Design – Spot Weather Warning

- Spot Weather Warning in Action



System Design – Interfaces



System Design – Interfaces

- I2V DSRC Communications Interface (WE1)
- Location and Time Service (LTS) (WE2 & WE3)
- NWS and RWIS (WE4)
- WYDOT 511 Application (WE5)
- WYDOT RCRS (WE6)
- WYDOT IC (WE7)
- WYDOT Construction Administration (WE8)
- WTI (WE9)
- WYDOT TPI (WE10)
- WYDOT TRAC (WE11)
- WYDOT CVOP (WE12)
- WYDOT ITS Maintenance (WE13)
- Independent Evaluator (IE) / Research Data Exchange (RDE) (WE14, WE18, WE19 and WE20)
- USDOT SDW (WE15)
- USDOT SCMS (WE16 and WE17)

System Design – Interfaces of Note

- ➢CAN bus interface will be a challenge for data definition (J1939 for Heavy-Duty Trucks), also most fleets are protective of CAN interface, could be dangerous to vehicle operation and security. CAN interface is not essential to our system design
- ➢CV-PEP interface to allow data sharing, in near real time, with evaluator and internal researchers
  - Full data set, highly protected and monitored access, no ability to download data
- ➢RDE interface to allow data sharing, in near real time, with public and external to pilot researchers
  - Sanitized data set (I80 only, normal highway speeds of 5-80 mph)
  - BSM Part II is still under review for sanitization
- ➢Satellite interface to allow Traveler Information Messages (TIMs) to be sent to vehicles outside range of RSU
- ➢HSM in TMC (not yet in design), will be needed to sign TIMs (and MAP messages for other CV deployments)

System Design – Key Outcomes/Challenges

- SCMS integration should not be trivialized, it can be time consuming to get running
- Test log file offloading from OBU and RSU to TMC to validate performance of DSRC and backhaul networks
- Get comfortable with IPv6. Challenges can exist with backhaul routers, firewalls and Internet connections
- Understand how to best work with satellite services for security, numbers of messages and responsiveness expectations
- Do detailed review of in-vehicle networks, tough with snow plows and highway patrol
- Operation Data Environment useful for ASN.1, J2735 encode/decode, 1609.2 validation and signing (with HSM). Offloads much of Connected Vehicle complexities. Open source solution.
- Maturity of mobile environmental sensor collection and communication to TMC is still evolving

From Design to Readiness

DENNY STEPHENS, VITAL ASSURANCE

Operational Readiness Approach

Steps to Achieving Operational Readiness

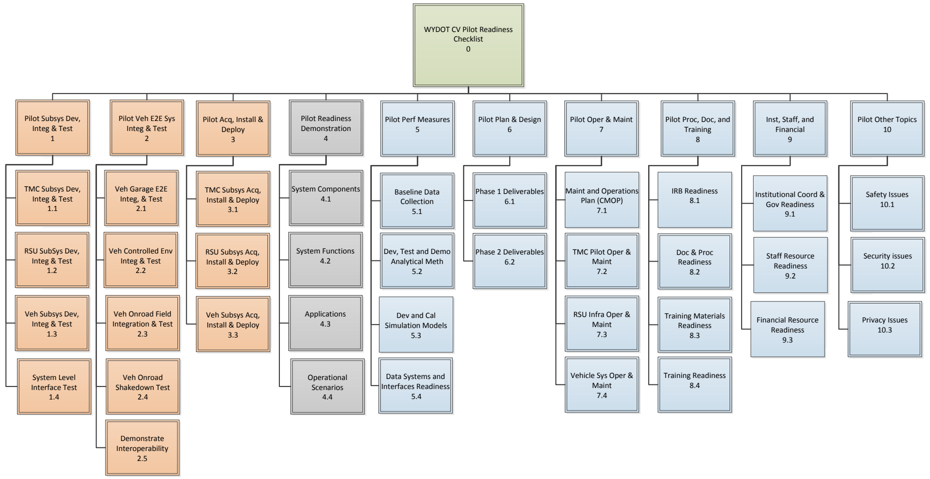
1. Requirements Verification and Acceptance Testing
2. Support Systems Readiness Checklist
3. Operational Readiness Demonstration

Nov. 2017

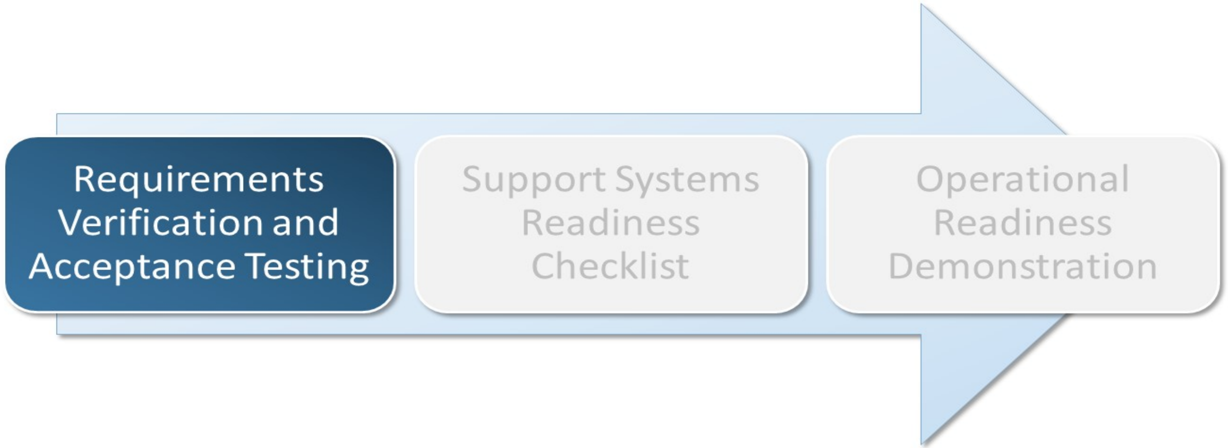
Two Day Event in Cheyenne. Begins our shakedown period with WYDOT fleets ~100 vehicles

Requirements Verification and Acceptance Testing

- Systematic acceptance testing and requirements verification throughout development, integration, installation, and deployment of WYDOT CV Systems:
  - ☑ Pilot Subsystem Development, Integration, and Test Readiness
  - ☑ Pilot Vehicle End-to-end System Integration and Test Readiness
  - ☑ Pilot Acquisition, Installation, and Deployment Readiness



- Systems Readiness (at each level of development and integration) is measured by completion and internal approval of:
  - Test Cases and Procedures
  - Requirements Verification
  - Pass Acceptance Test
  - Test Results Report



Support Systems Readiness Checklist

- Operational Readiness Checklist tracks the completion and internal approval "✓" of the following Operational Readiness Measures:
  - ☑ Planning and Design Readiness
  - ☑ Pilot Performance Measures Readiness
  - ☑ Pilot Operations and Maintenance Readiness
  - ☑ Pilot Procedures, Documentation and Training Readiness
  - ☑ Pilot Institutional, Staff and Financial Readiness
  - ☑ Pilot Other Topics Readiness - Safety, Security and Privacy

Operational Readiness Demonstration

➢ System level functionality and performance test cases verify achievement of project goals and objectives through:

- Repeated Acceptance Tests to demonstrate end-to-end readiness for deployment
- Demonstrated readiness of system components, functions, apps, and scenarios
- Demonstrated safety-, security-, privacy-, and performance measure-focused readiness elements

Lessons Learned

TONY ENGLISH, TRIHYDRO

Lessons Learned

Lessons Learned	Description
Developing a robust and scalable data design for CVs is a challenge	Different requirements add significant data needs for storage and throughput which may or may not be possible technically in the real-world.
Approaches to manage for security are still in development	Evolving SCMS integration plan and outside cred management require flexibility in development of associated interfaces.
Utilize existing standards as a part of the system architecture and design process.	The use of standards helped create a solid deployment effort in Phase 2, simplified technical documentation, and assisted with interoperability.
Reserve an appropriate amount of time in the schedule to account for testing, both test planning and test execution.	Detailed test planning is dependent on many other factors including equipment availability, so the development of detailed test plans can be a lengthy process while uncertainties are nailed down.
Detailed testing is required for OBU and RSU software.	Much of the software is not yet created or not created completely.

Lessons Learned (contd.)

Lessons Learned	Description
Wireless connection between equipment can be unreliable and finding a solution can take time	Bluetooth connection can present its challenges.
Early enthusiasm may not be matched by reality	Trucking partners backed out after determining they do not have the assets or dispatch availability required to support the program.
DOT Firewalls can hinder CV integration	Firewalls can be a problem when connecting existing components to new ones—e.g., a new external modelling tool with an in-house data source.
Partnerships between different disciplines enhances system development	Combining fields of expertise can expedite the background research process—e.g., combining weather and vehicle crash expertise improves the blowover algorithm development.

Technical Issues

- Currently Being Resolved
  - DSRC Antenna Positioning on Trucks
  - Basic Safety Message for Trucks
  - Application Algorithms for Trucks
  - Bluetooth/WiFi linkage in-vehicle
  - Weather sensor quality and robustness
  - Event logging
  - Integration with security credentialing management system (SCMS)
  - IPv6
  - Traveler Information Message (TIM) formats
  - Adherence to standards
  - Back-office Transportation Management Center integration
  - Over The Air (OTA) updates
  - TBD

- Already Resolved
  - DSRC licensing
  - Roadside Units (RSU) installation
  - Third party interface

Institutional Issues

Currently Being Resolved

- Memorandums of Understanding (MoUs) with fleet partners
- Independent evaluation needs
- Operations & Maintenance procedures
- Training
- Human subjects/privacy

Already Resolved

- IRB initial approval
- Initial procurements
- Procurement & installation plans

Next Steps

VINCE GARCIA, WYDOT

Next Steps

- Operational Testing – Underway
- Operational Readiness Demonstration – November 2017
- Wyoming DOT Fleets in operations – Winter of 2017
- Phase III Begins – May 2018

Q&A