Next Generation Work Zone Integration and Dissemination

Work Zone Data Exchange (WZDx) Development from Planning to Operations

17TH ANNUAL WESTERN STATES RURAL TRANSPORTATION TECHNOLOGY IMPLEMENTERS FORUM

JUNE 15, 2022

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Introduction – Who we are

Justin Belk – WZDx Project Lead

- Mr. Justin Belk is the Region Traffic Operations Engineer for Washington State DOT's Olympic Region where he oversees traffic engineering and operations initiatives in an area spanning from the boundary of Mount Rainier National Park through the urban South Puget Sound Area to the tip of the rugged Olympic Peninsula. Previously, he served WSDOT Headquarters as the Statewide Integrated Corridor Operations Engineer developing and implementing policies and standards for TMCs, arterial operations, ITS deployments, and connected vehicle/CAT initiatives. Prior to that, he worked at various cities and consultant firms across multiple states, specializing in transportation engineering/planning and ITS technology. He received his BS in Civil Engineering from Missouri University of Science & Technology and is a registered engineer in Oregon and Washington. He spends a large amount of his free time thinking about transportation, whether he is hiking, biking, or serving as a Citizen Representative on Intercity Transit's Authority Board.

Introduction – Who we are

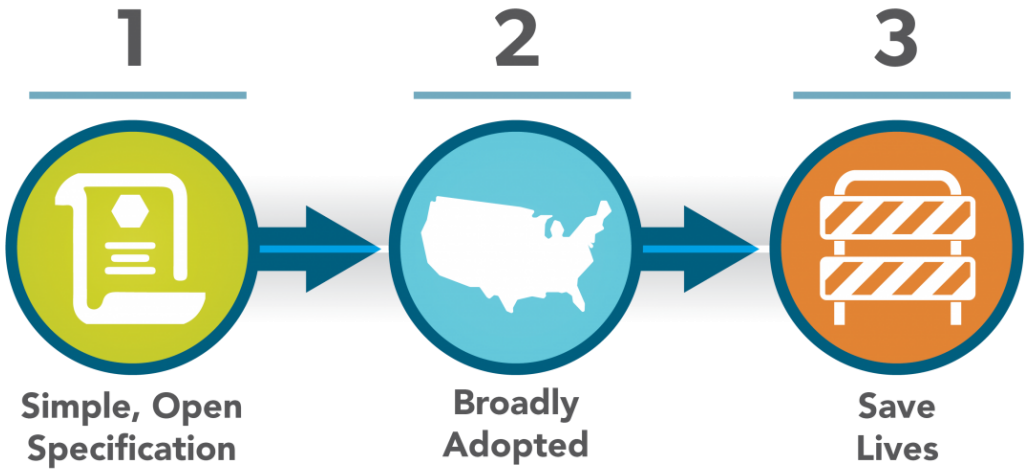
Joshua Hudson – WZDx Technical Lead

- Mr. Joshua Hudson is the Applications Modernization Manager for Washington State DOT's Information Technology Division. He has worked for WSDOT nearly 15 years with most of his development experience closely related to the business areas of Maintenance & Operations and Traffic Operations. He manages a team of about 30 application developers who architect, design, develop, support, update, and maintain web, mobile, and cloud-based applications for business areas covering many WSDOT Divisions. He oversees the IT Division's modernization goals, including adopting industry and federal standards, utilizing the latest development tools and methods, and providing open data to the public. He received his BS in Computer Science from Eastern Washington University, holds multiple Microsoft certifications and is a Novell Certified Linux Professional. His cloud migration efforts for WSDOT's HATS application received a Best of Washington Award from the State Chief Information Officer.

Overview

- Introduction
  - Big Picture/Scope/Goals
  - Common Terminology
  - Background
- WZDx Demonstration Grant
  - WZDx-Compliant Feed
  - Device/Schema Integration
  - 3rd-Party Platform
  - Partner Agency Activities
- Other WSDOT Smart Work Zone Practices
- Planned/Future Opportunities

Big Picture



USDOT's perspective:

- Mimic the success of others
  - General Transit Feed Specification started from the desire to communicate transit system schedules in a common way no matter the location
- Standard data for work zones is a priority for automated driving systems
- Funding (WZDx Demonstration grants) is a good way to provide the needed impetus

Public's perspective:

- Travelers rely on navigation apps, typically sourcing a mixture of public private data
- Nonrecurring lane closures and detours is a significant cause of travel frustration

WSDOT's perspective:

- Accurately communicate and disseminate work zone information for everyone's benefit

Common Terminology

- ADS – automated driving systems
- CAT – cooperative automated transportation
- CAV – connected/automated vehicles
- CIA – Construction Impact Analysis application for external reporting of traffic disruption projects informing local/regional partners of road closures
- GeoJSON - a format for encoding a variety of geographic data structures.
- IRT – incident response team
- NWP – North/West Passage Pooled Fund
- SAE – formerly Society of Automotive Engineers, responsible for connected vehicle message type standards
- SDX – Situation Data Exchange by Trihydro from Wyoming's connected vehicle pilot
- Trihydro – Private company steward maintaining and developing the technology platform (SDX) created for USDOT's CV pilot to disseminate WyDOT's messages
- TIM – Traveler Information Message typical of connected vehicle standards (SAE)
- TMC – Traffic/Transportation Management Center
- Vision Zero – WSDOT's crash reduction/safety goal/program
- WZDB – WSDOT's work zone database
- WZDI – Work Zone Data Initiative
- WZDx – Work Zone Data exchange

Background – National Efforts

WZDI:

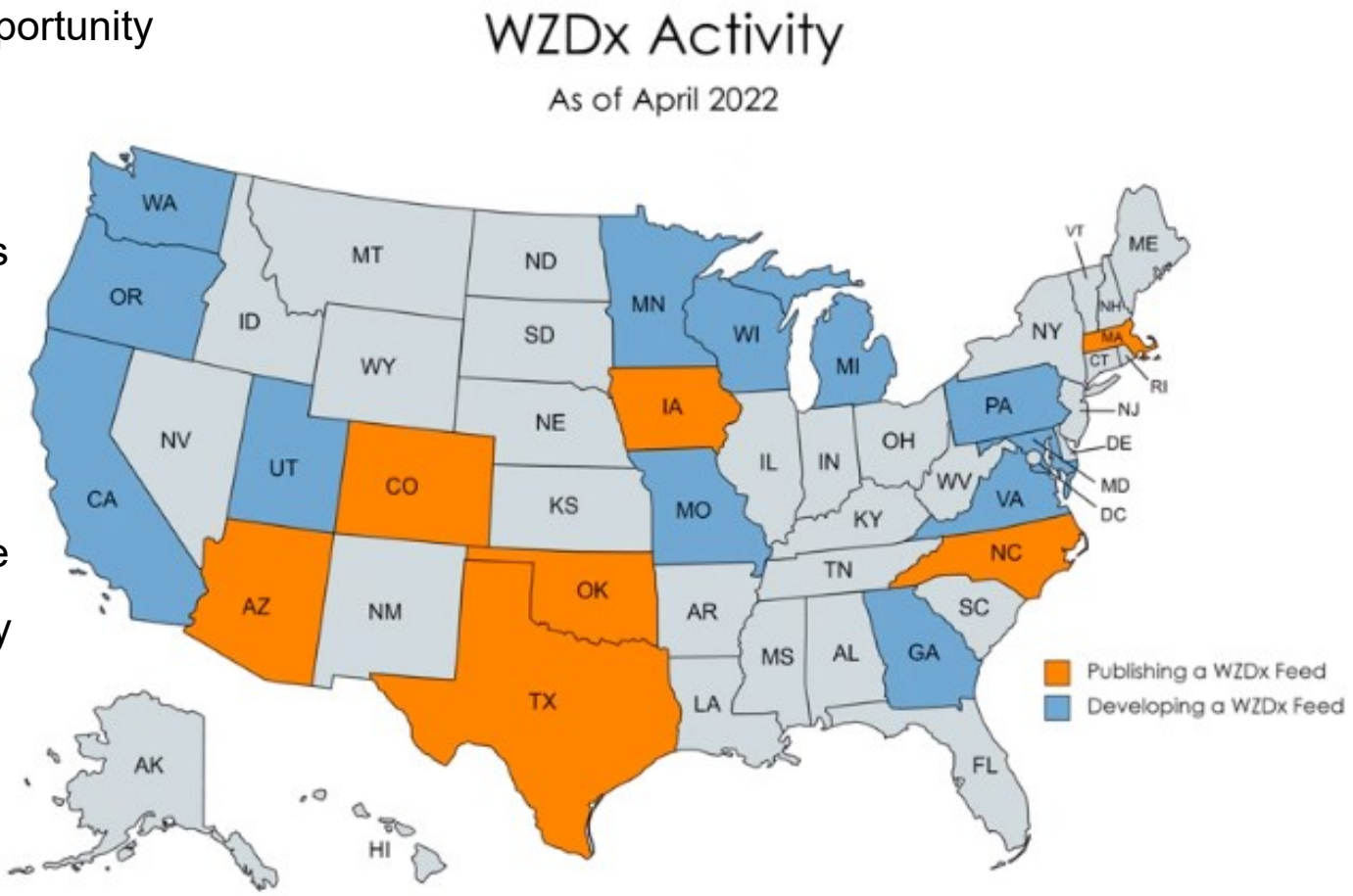
- US Department of Transportation and Federal Highway Administration establish need

WZDx:

Notice of Funding Opportunity released June 2020

Goals:

1. Publish new feeds
2. Expand area
3. Increase fields provided
4. Automate/improve process & quality



Background – Safety Case

Safety:

- Work zones are designed for safety, but they represent one of the riskiest roadway scenarios when normal conditions are, by necessity, replaced with temporary and continually changing conditions.
- All the typical factors in roadway crashes can be present in addition to highly vulnerable maintenance, construction, & utility workers and support staff.

Solution: WSDOT's *Work Zone Database* (WZDB)

- Provide for planning and coordination of work zone impacts
- Accurately communicate and disseminate work zone information for everyone's benefit

Future: CAT/ADS technologies and Smarter Work Zone strategies

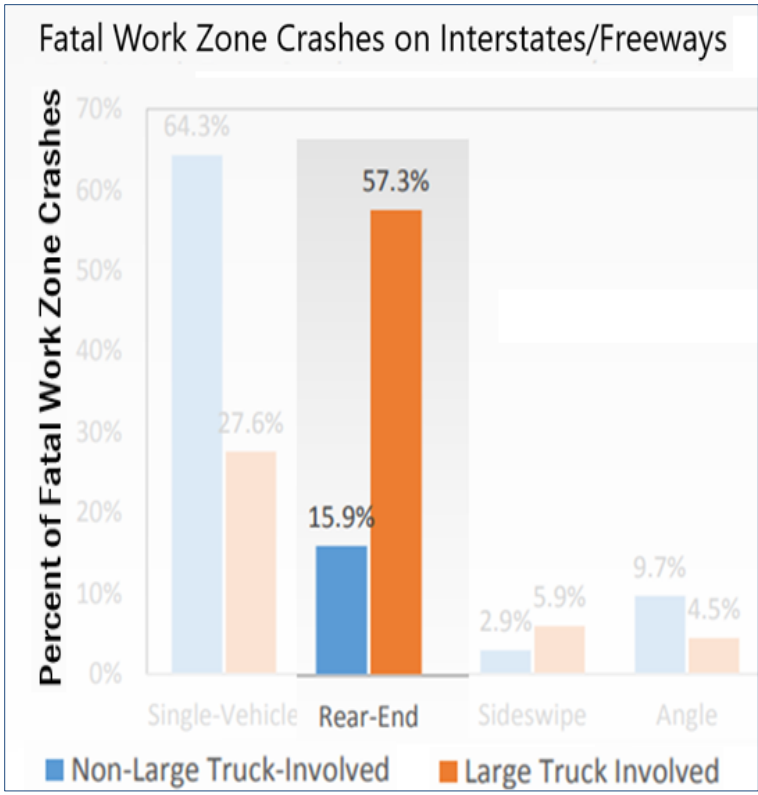
Background – Safety Case

National Work Zone Crash Statistics (2019):

- 84% of fatalities occur to road users
  - 16% to workers
- 90% of fatal crashes occur on freeways & 45+MPH
- 35% of fatalities involve large trucks
- 16% of fatalities occur to pedestrians/bicyclists

Washington-specific over the same time period:

- 7 fatalities occurred to road users
  - 3 involved large trucks
  - 0 workers, 0 pedestrians



Goal: Let's do what we can to make it better

Work zones need to have visibility and advance notice

Background – 1st Gen WZDB

Problem:

- Conflicts between construction and maintenance operations
- Missing reliable public information

Solution: WSDOT's original Work Zone Database (WZDB) –

- 1st Generation developed in early 2000s
- Provided a way to plan and coordinate work zone impacts in advance

Results:

- Conflict avoidance through better coordination using the WZDB
- Opportunities to combine multiple work zone activities and reduce driver impacts – better and more available public information

Background – NextGen WZDB

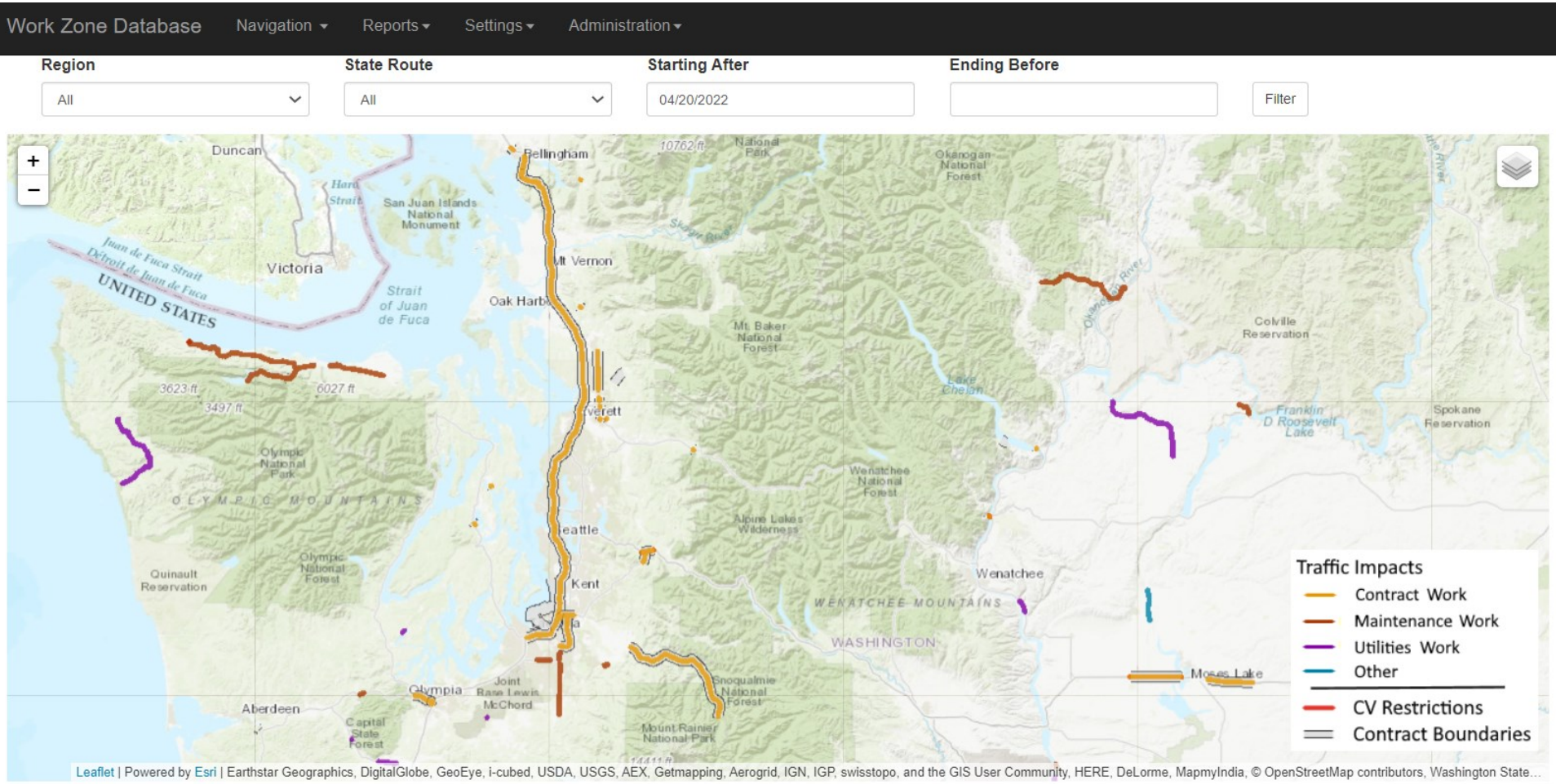
Statewide application and deployment

- Original WZDB developed in one region – grew to be recognized as essential statewide
- 2017 – Multiple major project impacts around the state
- Growing interest from multiple WSDOT regions with an identified need to communicate better between jurisdictions
- Recognition that internal boundaries don't resonate with drivers – OneDOT

NextGen WZDB Milestones:

- NextGen WZDB re-development to SQL database backend capable of being
- shared and used across other platforms - Late 2017
- Basic forms and reports complete July 2019
- Initial Implementation in Fall 2019
- Dynamic Mapping/Visualization tool available Spring 2020
- Future: Integration with commercial permitting and other public-facing systems

Background – NextGen WZDB



- Dynamic Mapping/Visualization tool available Spring 2020
- Future: Integration with commercial permitting and other public-facing systems

Background – Device pilots

iCone pilot project

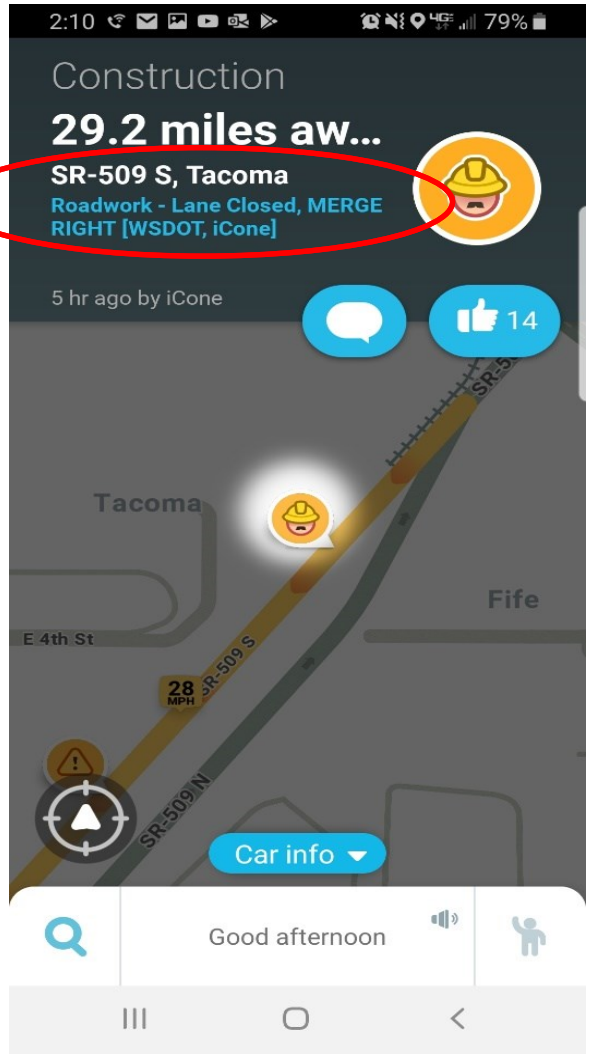
- Equip dedicated work zone crews in Olympic and SW Region with a few connected arrow board and iPin devices
- MAP Team was being reported as police in Waze

Pros

- WSDOT was able to inject our label into the Waze notification by working with iCone
  - Increased the authority of the event in a crowd-sourced environment
  - Anecdotally increased move-over/slow-down behavior

Cons

- Limited data dissemination/usage
- iPin may not fit the cones you have

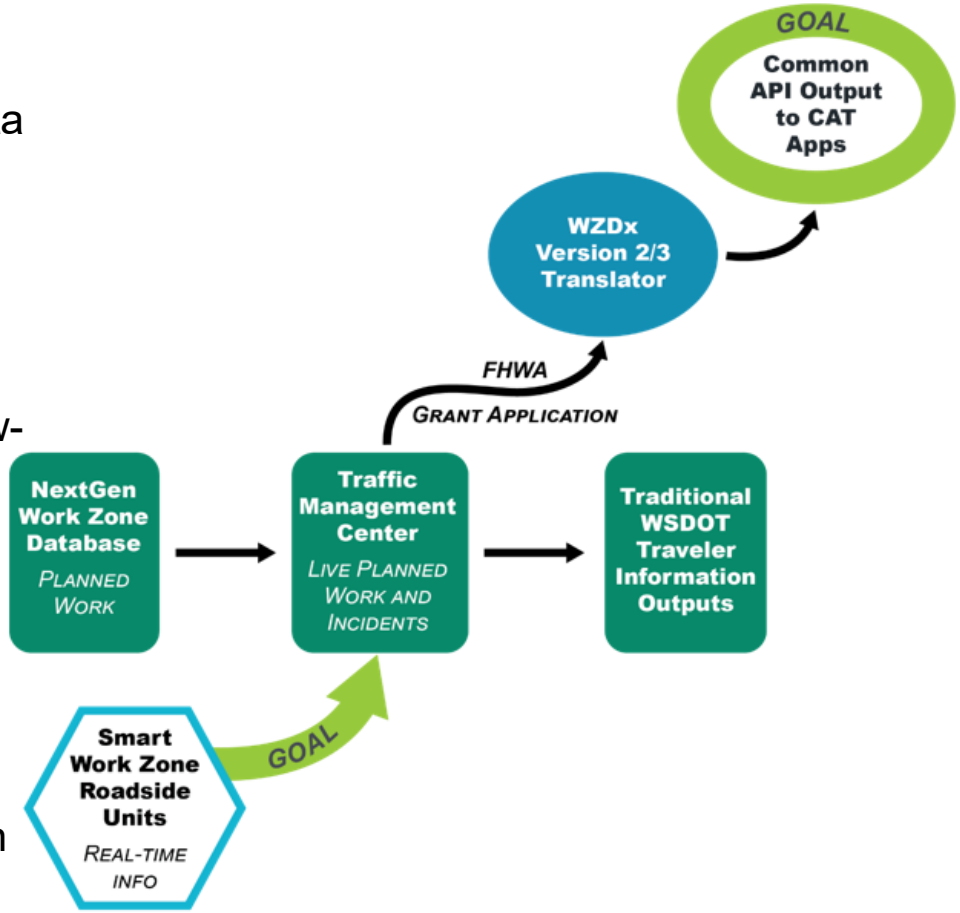


Background – Adapting Work Zone Best Practices for WSDOT

1. **Build on existing WSDOT applications and workflow:**
   Build automated connectivity into the system so that existing and future data sources can ingest the planning level information into real-time use (and eventually historical data collected)

2. **Use existing off-the-shelf products:**
   Test and integrate devices through low-risk pilot projects with available technology

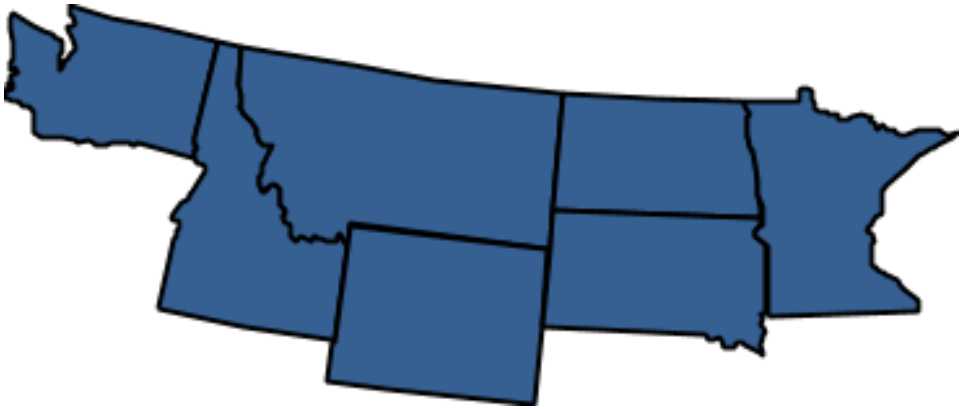
3. **Learn and develop specifications:**
   Take existing lessons learned and institutionalize proven products and practices into daily activities and promote widespread use and adoption of smarter work zone technologies



Work Zone Data Exchange Demonstration Grant

Scope

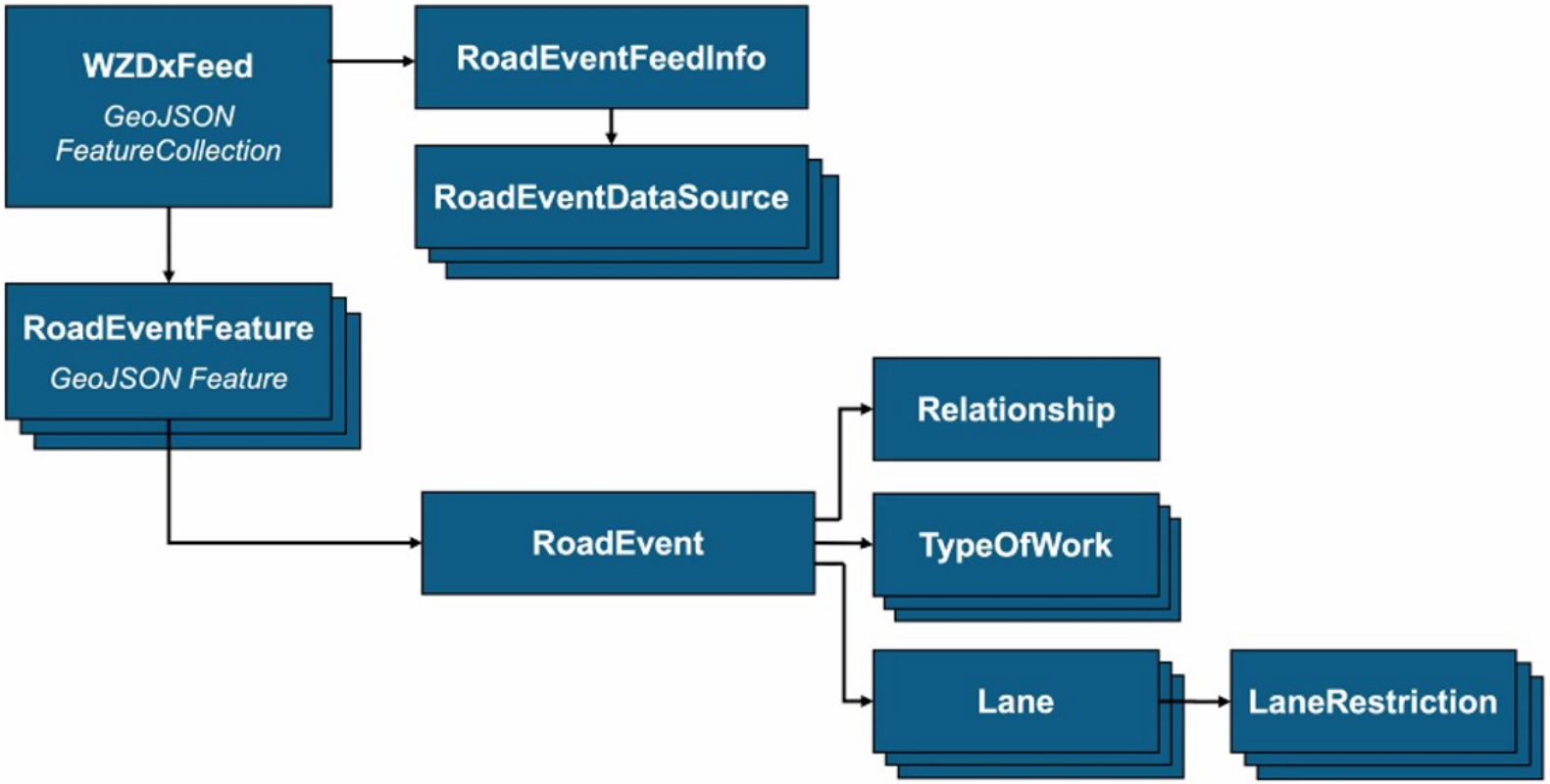
- Publish WZDx-compliant feed (Project Category A & Challenge Area 1)
- Expand pilot project to facilitate real-time confirmation of work zone events (Challenge Area 2)
  - $25,000 for new devices to equip IRT trucks
  - Use existing smart work zone products
  - Other connections?
- Collaborate with NWP private partners for testing WZDx-compliant feed
  - Trihydro push out WZDx/TIM
- Collaborate with NWP member states
  - Conversion of ND GeoJSON feed



WZDx Demonstration Grant – Publishing Compliant Feed

Task 1

- Publish WZDx-compliant feed (Project Category A & Challenge Area 1)



WZDx–Compliant Feed Development

What is the WZDx standard?

- The Work Zone Data Exchange (WZDx) Specification enables infrastructure owners and operators (IOOs) to make harmonized work zone data available for third party use. The intent is to make travel on public roads safer and more efficient through ubiquitous access to data on work zone activity. Specifically, the project aims to get data on work zones into vehicles to help automated driving systems (ADS) and human drivers navigate more safely.

  Improving access to work zone data is one of the top needs identified through the US Department of Transportation (USDOT) Data for Automated Vehicle Integration (DAVI) effort.

- WZDx defines the structure and content of multiple distinct data feeds.

- Each feed is distributed as a single GeoJSON file with the defined WZDx schema which makes it easy to map and consume.

WZDx–Compliant Feed Development

GeoJSON

GeoJSON is a format for encoding a variety of geographic data structures.

```
{
  "type": "Feature",
  "geometry": {
    "type": "Point",
    "coordinates": [125.6, 10.1]
  },
  "properties": {
    "name": "Dinagat Islands"
  }
}
```

GeoJSON supports the following geometry types: `Point`, `LineString`, `Polygon`, `MultiPoint`, `MultiLineString`, and `MultiPolygon`. Geometric objects with additional properties are `Feature` objects. Sets of features are contained by `FeatureCollection` objects.

The GeoJSON Specification (RFC 7946)

In 2015, the Internet Engineering Task Force (IETF), in conjunction with the original specification authors, formed a GeoJSON WG to standardize GeoJSON. RFC 7946 was published in August 2016 and is the new standard specification of the GeoJSON format, replacing the 2008 GeoJSON specification.

WZDx–Compliant Feed Development

Show WZDX GitHub - Demo

- https://github.com/usdot-jpo-ode/wzdx

  All development and collaboration with the standard happens on this site.

  They are already taking suggestions for version 4.1 which will be unchanged for 18 months after launch and version 5.0 which will be the next major version.

- Show: https://github.com/usdot-jpo-ode/wzdx/blob/main/Creating_a_WZDx_Feed.md

WZDx–Compliant Feed Development

- Started project when WZDx 3.1 was the released version.

  Mid-project WZDx 4.0 was released:

  WZDx version 4.0 implements clean up and small additions in functionality to the WZDx feed and added the **SwzDeviceFeed** and **RoadRestrictionFeed** feeds.

  Until version 4.0, the WZDx specification defined only one feed, the **WZDxFeed**.

- 4.0 was a significant change and added time to our project to adopt the new standard. However, it was important for us to launch our effort using the latest version of the feed.

- Our data consumers may not yet support 4.0 so we have endpoints for both 3.x and 4.x versions of the WZDxFeed.

  Let's take a look at each of the feeds and who they are for.

WZDx–Compliant Feed Development

Feed Name	Description	Producer	Consumer	Uses
`WZDxFeed`	Provides high-level information about events occurring on roadways (called "road events"), primarily work zones, that impact the characteristics of the roadway and involve a change from the default state (such as a lane closure). The `WZDxFeed` is the original work zone data exchange feed.	Agencies responsible for managing roadways and road work, typically state and local DOTs.	Traveling public via third parties such as mapping companies and CAVs.	Route planning; increased awareness; "put work zones on the map".

WZDx–Compliant Feed Development

Feed Name	Description	Producer	Consumer	Uses
`RoadRestrictionFeed`	Provides information about sections of roadways that have restrictions. Restriction types described by this specification are listed in the RestrictionType enumerated type.	Transportation Authorities like Tribal, Local, State, or Federal Agencies.	Traveling public via third parties such as mapping companies and CAVs.	Increased awareness; Route planning; Driver, Passenger, and Road-User Safety; Increased Efficiency; Reduced Damage to Infrastructure.

WZDx–Compliant Feed Development

Feed Name	Description	Producer	Consumer	Uses
`SwzDeviceFeed`	Provides information (location, status, live data) about field devices deployed on the roadway in work zones.	Smart work zone equipment manufacturers or vendors.	Agencies responsible for managing roadways and permitting work, typically state and local DOTs. Third-parties such as mapping companies and CAVs may also be interested in field device information.	Simplifies design process for agencies wanting to interface with equipment manufacturers; aids in dynamically generating a `WZDxFeed` with accurate information; reduces effort for manufacturers to conform to different agencies requirements.

WZDx–Compliant Feed Development

Validation, testing, publishing – What did we do

- Created puller processes from our 3 current data sources (WZDB, Construction Impact Analysis Application and a vendor device [Pi-lit] to pull all data that will go out in the feed into a shared database that always holds the current data going out in the view.

- We don't store historical information in this database, that data is the responsibility of the source system, so the database and feed should always show the current and planned data.

- Created a WZDx validator for feed validation and testing, based off the schema provided by the WZDx project.

- Created code models to be able to build up a WZDx feed in both 3.x and 4.x specifications. These allow us to publish a feed. More on this later in this presentation.

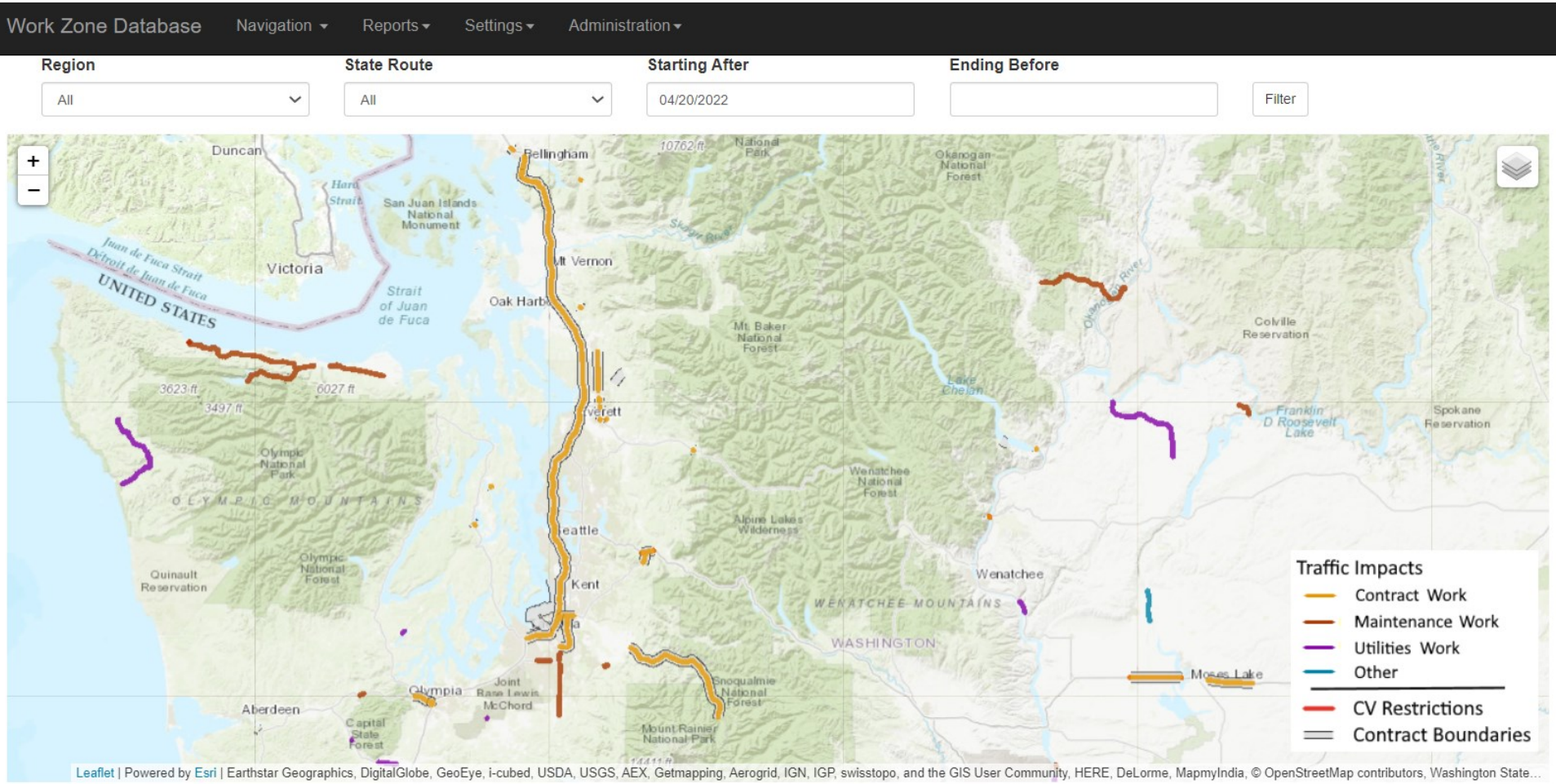
- WSDOT will be hosting our final WZDx feed in our Azure cloud environment.

WZDx–Compliant Feed Development – Cloud Hosting

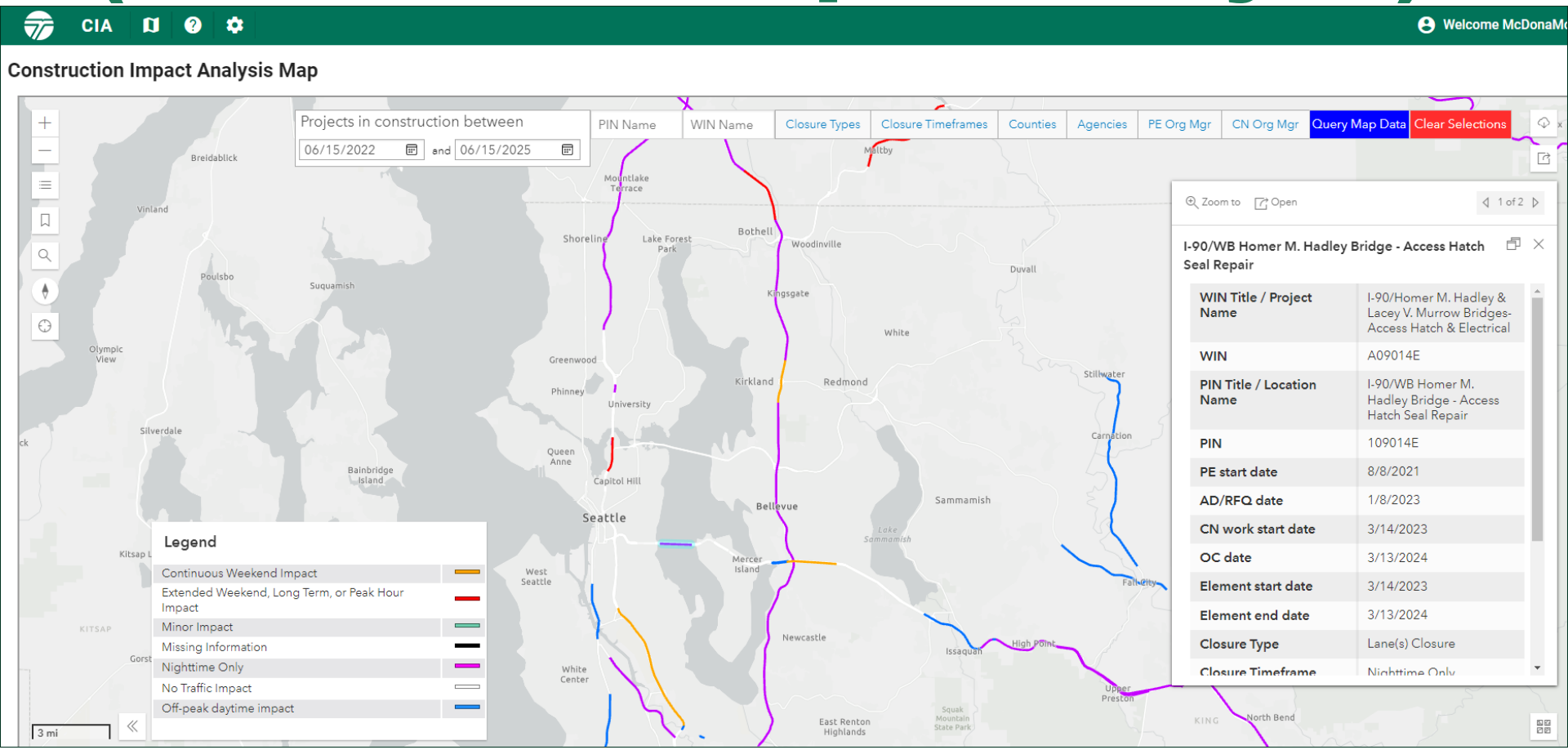
- **From WZDx:**
- Though all DOTs have infrastructure capabilities to host a WZDx feed, it is recommended that the feed be cloud hosted on a trusted platform due to the following reasons:
- Security: Trusted cloud hosted providers such as Amazon Web Services, Google Cloud Platform, and Microsoft Azure all have hardened physical security as well as digital security best practices already in place.
- Dedicated Denial of Service (DDoS) Prevention: DDoS attacks remain a very common form of hacking that are still used today. Cloud providers have built solid solutions that can handle DDoS attacks and prevent downtime.
- Scalable: As WZDx feeds become more widely used, they may be hit much more frequently than other endpoints. Cloud hosting allows DOTs to easily scale to accommodate for more hits or usage of the endpoint.
- Load Balancing Solutions: Along with scaling physical hardware, load balancing allows DOTs the ability to scale the number of endpoints serving up WZDx data feeds.

For WSDOT: The cloud is a big part of our continuous modernization strategic goals so when releasing a new data feed the Cloud was a logical hosting platform.

Source 1 At Launch: WZDB



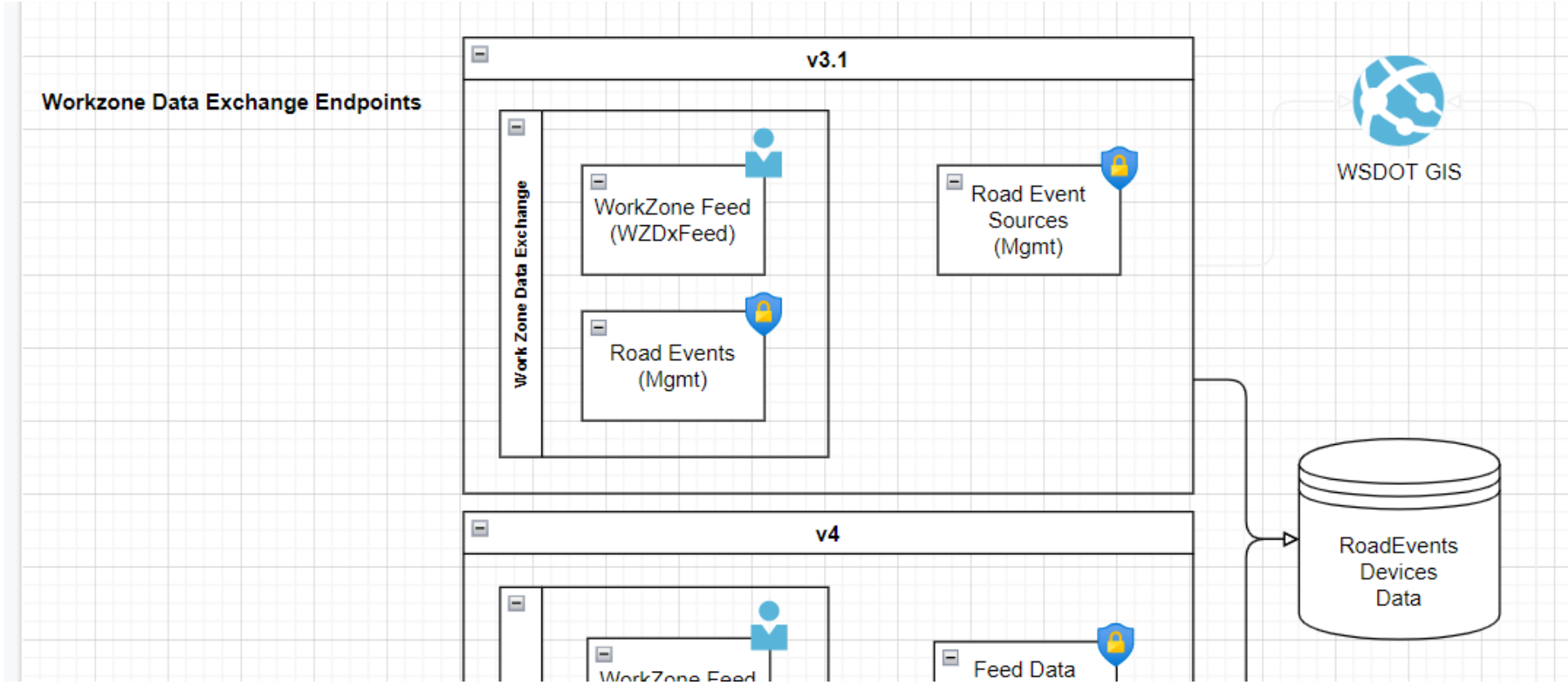
Source 2 At Launch: CIA (Construction Impact Analysis)



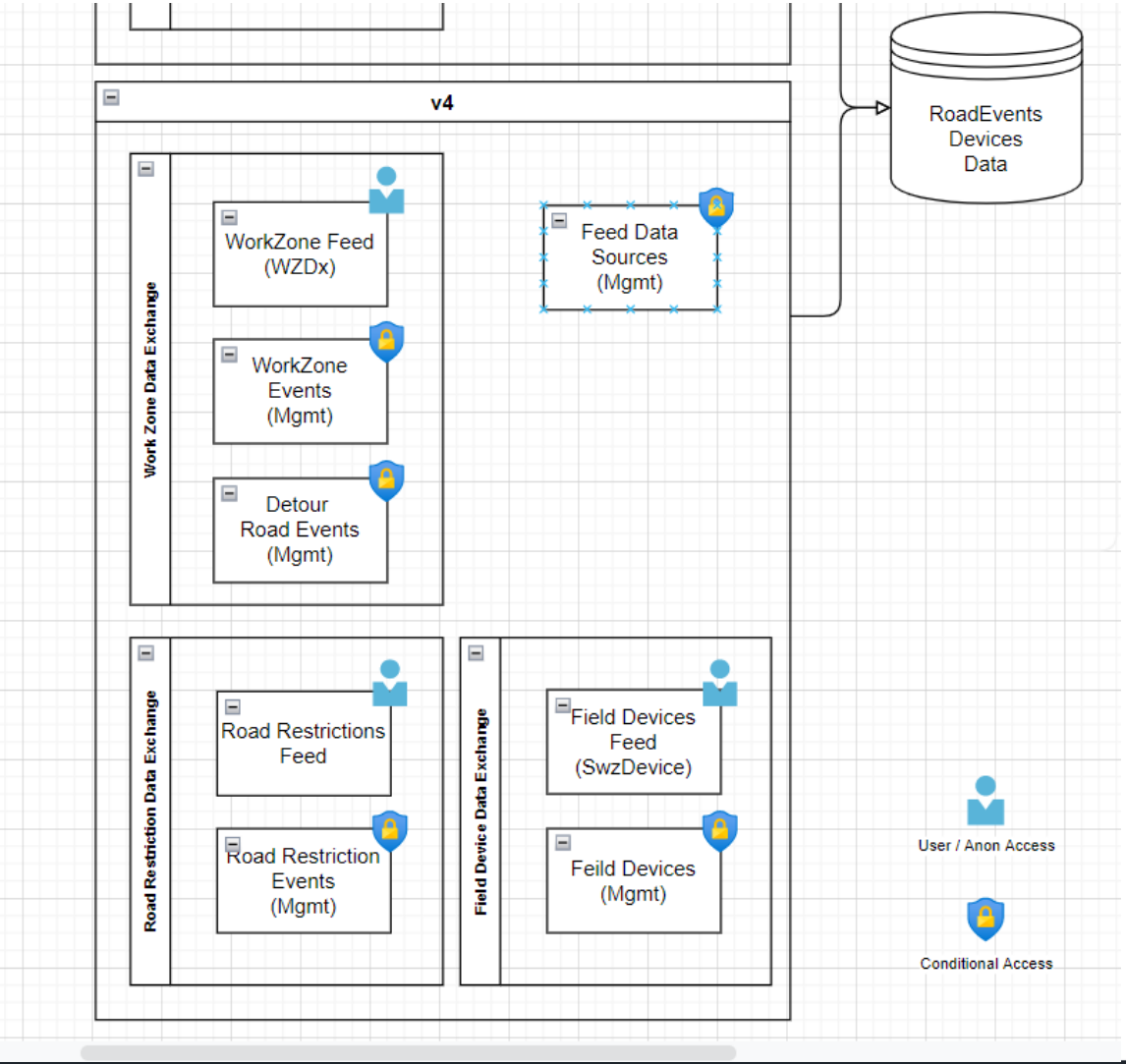
Source 3: Pi-lit Devices


```
{
    "feed_info": {
        "update_date": "2022-06-15T19:29:26.548Z",
        "data_sources": [
            {
                "organization_name": "pi-lit",
                "data_source_id": ""
            }
        ],
        "version": "0.0",
        "publisher": "pi-lit"
    },
    "type": "FeatureCollection",
    "features": [
        {
            "geometry": {
                "type": "Point",
                "coordinates": [
                    -122.6342195,
                    41.7324786
                ]
            },
            "type": "Feature",
```

WZDx–Compliant Feed Development – 3.x Architecture



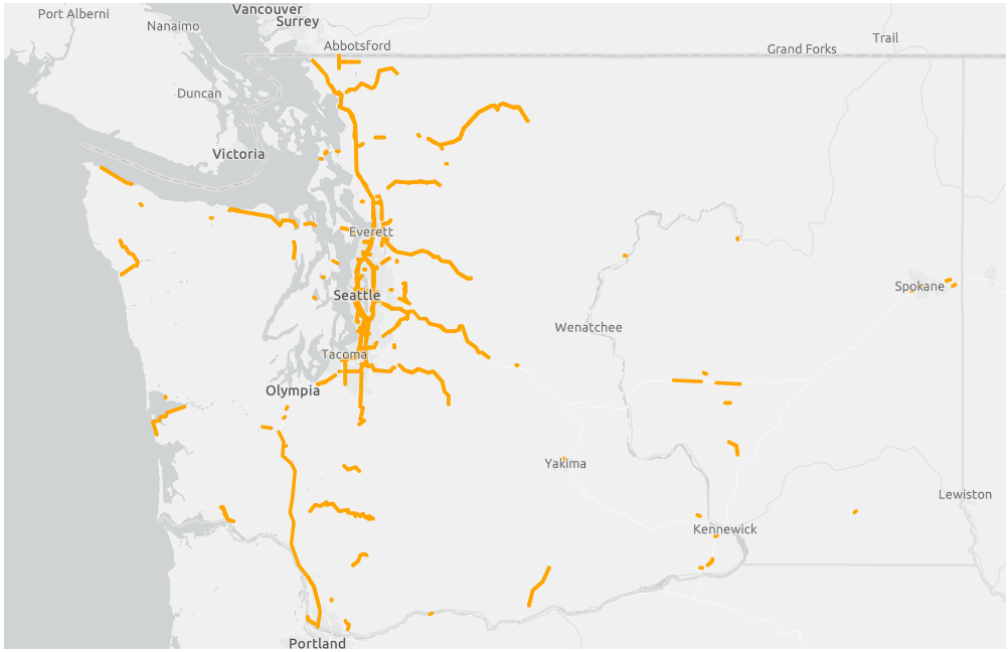
WZDx–Compliant Feed Development – 4.x Architecture



WZDx–Compliant Feed Development

Current Feed/Map Example/API Swagger Demo

The feed locations at the time of this demo are not final and will be published in both the WSDOT Traveler API pages and the Federal WZDX registry in the near future.



WZDx–Compliant Feed Development

Challenges related to…

- Lane labeling
- Push vs Pull, Staging vs Runtime (how to store source data and get data into the feed)
- Geospatial/linear referencing system (mileposts, ahead/back, lat/long)
- Other development realities (programming language limitations)
- Data Storage (document vs relational)

WZDx Demonstration Grant – Device/Schema Integration

Task 2

- Expand pilot project to facilitate real-time confirmation of work zone events (Challenge Area 2)
  - Procure new devices to equip IRT trucks
  - Use existing smart work zone products
  - Other connections?

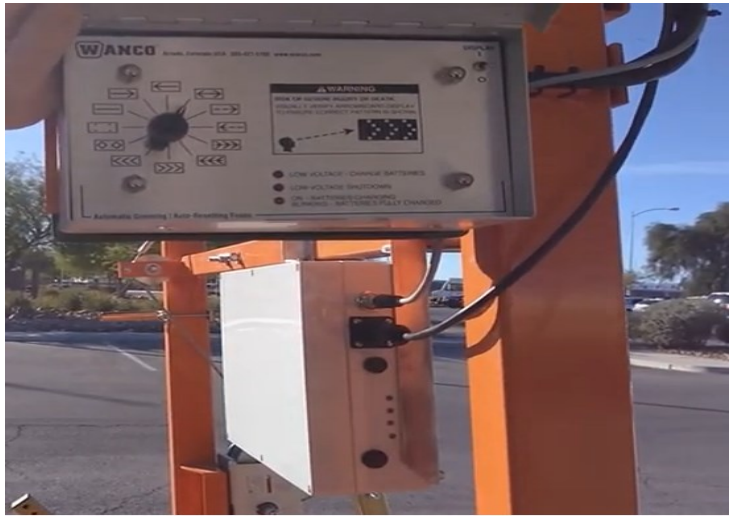
WZDx Device/Schema Integration and Development

Challenges related to…

- Devices
- Data (available and methods for pulling differ)
- Confirmation of live status of real time events

Collaboration with…

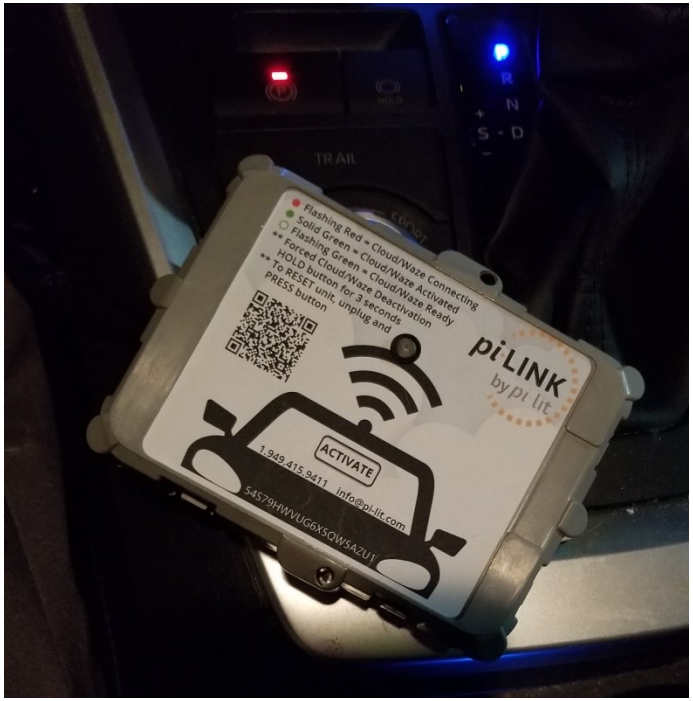
- iCone
- Pi-Lit
- Haas Alert



WZDx Device Details – pi-lit and pi-LINK

Use cases considered

- Incident response teams
- Responder-2-Vehicle connections



Pi-Link Vehicle/Flare to Cloud Technology

Pi-Link

- Gateway to transmit Pi-Lit device GPS location via cellular modem to cloud
- 12-V DC / 110-240 V regulator options
- Deactivates if it travels ¼-mile away from activation point

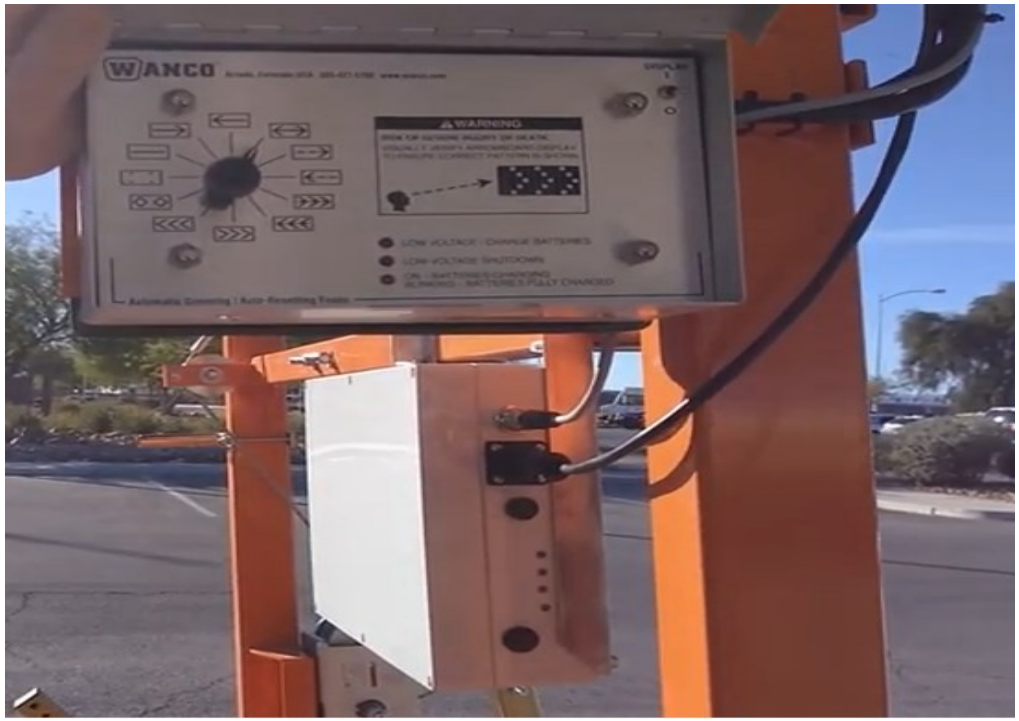
Pi-Lit Sequential Flares

- Gravity controlled light output with tilt sensor automatically directs light output to optimize driver awareness
- 4 flash patterns with automatic synchronization
- 20 hour run time with Li-ion battery
- Attach each magnetically to structure, place under cones to illuminate, or lay flat on ground

WZDx Device Details – iPin and Connected Arrow board kits

Use cases considered

- Construction crews
- WSDOT MAP teams (surveying/mapping)
- Incident response



iCONE ConnectedTech

iPin

- Transmits GPS location and ‘ON’ status of the device indicating “end of work zone” or other work zone features such as boundaries of where vulnerable workers are present.
- Solar/battery powered
- Dimensions: 26 in long, 1.5 in diameter
- Material: Polycarbonate (PET-G)

Arrow Board Kit

- Transmits GPS location and ‘ON’ status of the Board
- Once activated, status of your arrow board is posted to XML within 2 minutes
- Upon deactivation, status posted to XML within 60 seconds
- Transmits Arrow Panel status every 15 minutes
- Re-transmits location and status if the Arrow Panel moves more than 300 ft

WZDx Device Details – HAAS Alert HA-5

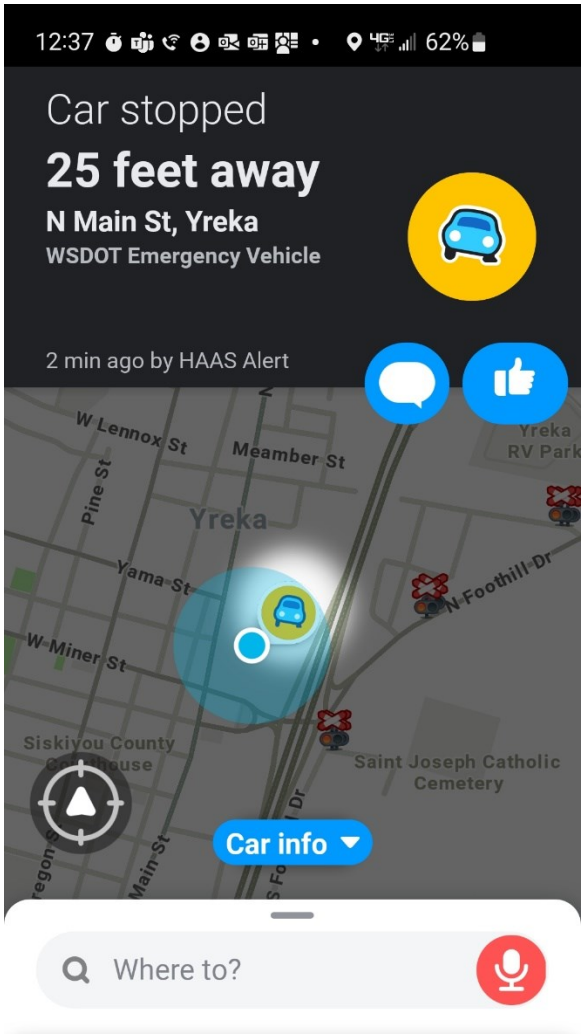
HA-5 – use case – fleet solutions / MAP teams

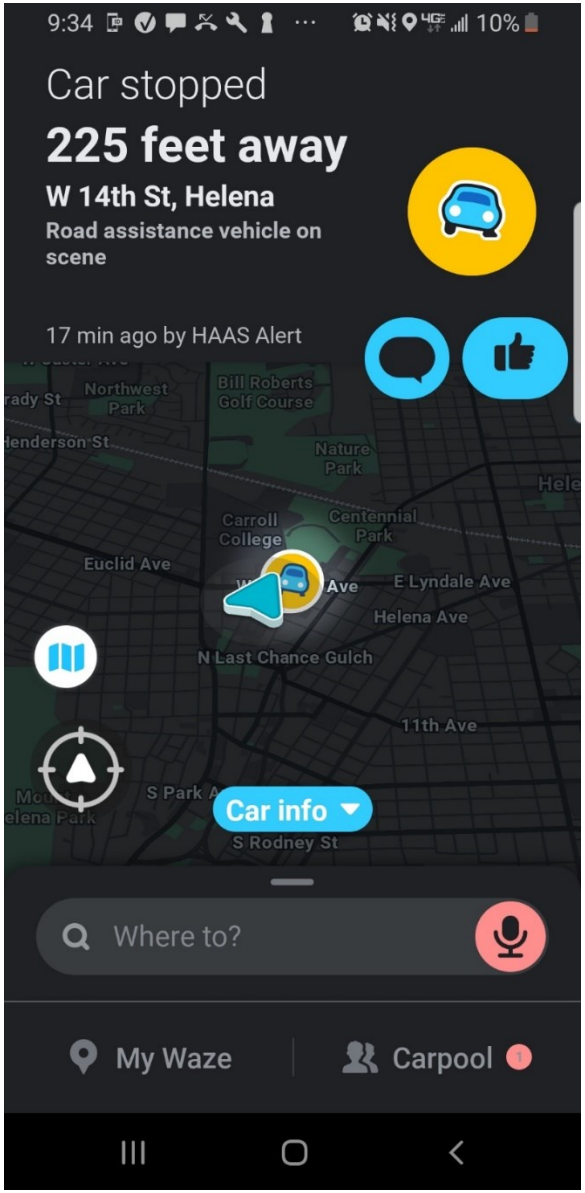
- Connects any flashing emergency lights
- Cellular 3G or 4G LTE, GPS, real-time Safety Cloud™ connectivity
- Mounts securely on the dash inside the cab of the vehicle or apparatus
- Performs best with clear sky visibility
- Dimensions: 5.4” x 2.7” x 1.3”
- Input Voltage – Power: 12.5V – 15V
- Input Voltage - Flashing Lights Main Wire (E-Master): 12V – 15V
- Amperage: 120 mA peak draw
- Operating Temperature: -40℃ to 85℃
- Weight (Ounces): 7 oz.

Integrated Device Activation and Demonstration

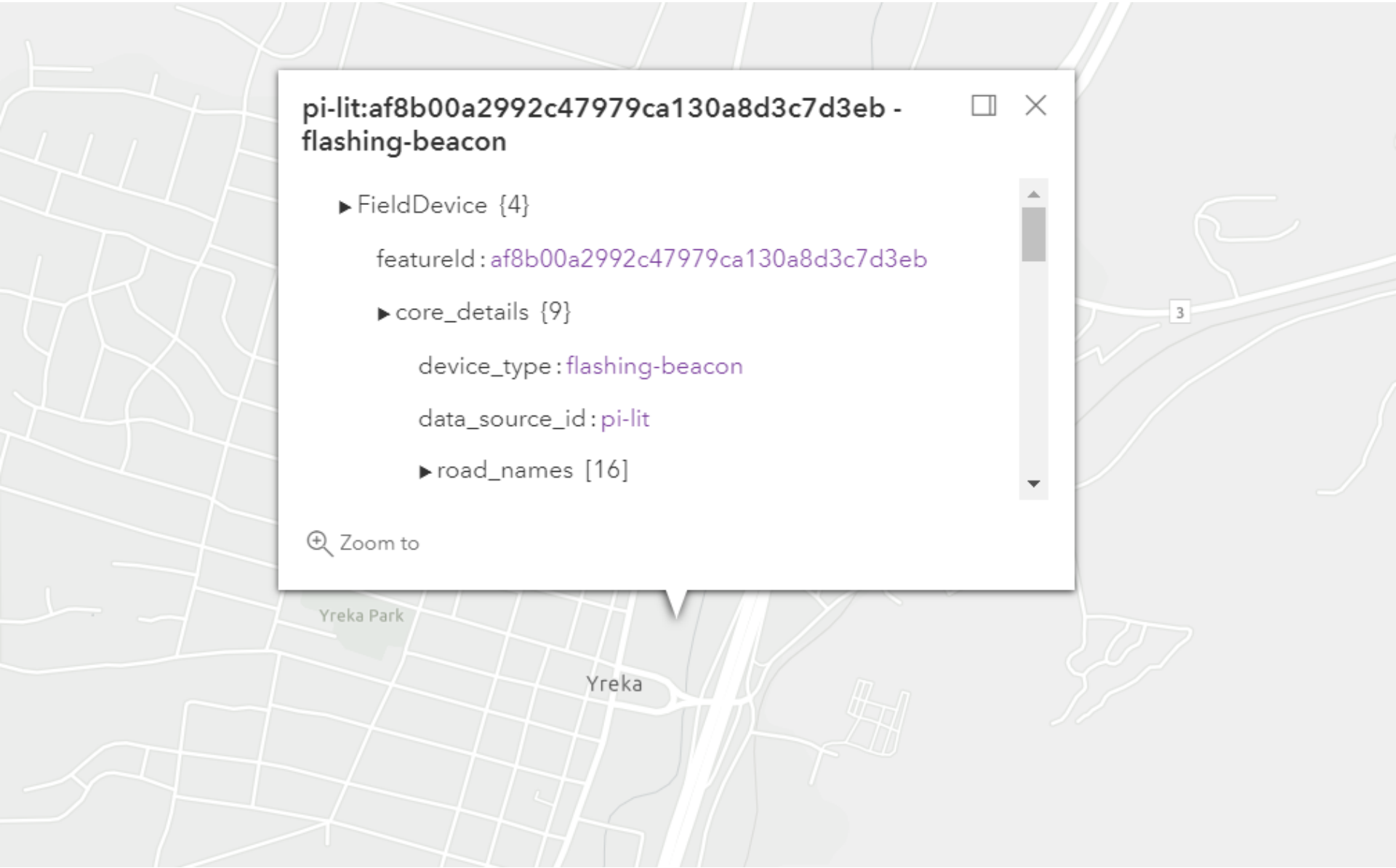
Turn on and demonstrate some aspect of device use in populating our work zone data feed

Pass around any devices we have on hand





```
  },
  "type": "FeatureCollection",
  "features": [
    {
      "properties": {
        "core_details": {
          "device_type": "flashing-beacon",
          "data_source_id": "pi-lit",
          "road_names": [
            "East Miner Street"
          ],
          "device_status": "ok",
          "update_date": "2022-06-14T19:34:37.739-07:00",
          "has_automatic_location": true,
          "status_messages": [],
          "road_event_ids": [],
          "milepost": 0
        },
        "function": "workers-present",
        "is_flashing": true
      },
      "id": "af8b00a2992c47979ca130a8d3c7d3eb",
      "type": "Feature",
      "geometry": {
        "type": "Point",
        "coordinates": [
          -122.63422,
          41.732479
        ]
      }
    }
  ]
}
```


pi-lit:af8b00a2992c47979ca130a8d3c7d3eb - flashing-beacon
▶ FieldDevice {4}
featureId : af8b00a2992c47979ca130a8d3c7d3eb
▶ core_details {9}
device_type : flashing-beacon
data_source_id : pi-lit
▶ road_names [16]
Zoom to
3
Yreka Park
Yreka

WZDx Demonstration Grant – Device/Schema Integration

Challenges

- **API Access:**

  Vendor API access varies in types, cost and coverage.

  Would love for more vendors to adopt WZDx.

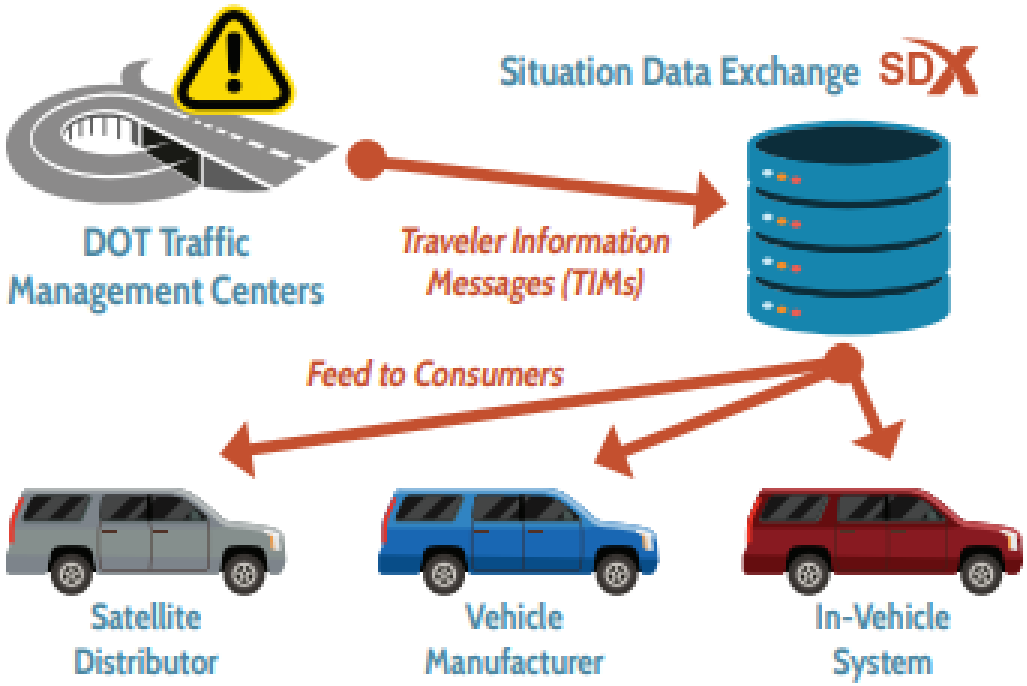
- **Real-TIme Data.**

  WSDOT plan at launch is to refresh data every minute, but we would like to move to an event driven architecture where are notified about changes so we can react and populate our feed quicker.

WZDx Demonstration Grant – 3rd Party Platform

Task 3

- Collaborate with NWP private partners for testing WZDx-compliant feed
  - Trihydro push out WZDx/TIM



WZDx 3rd Party Platform Collaboration – Trihydro

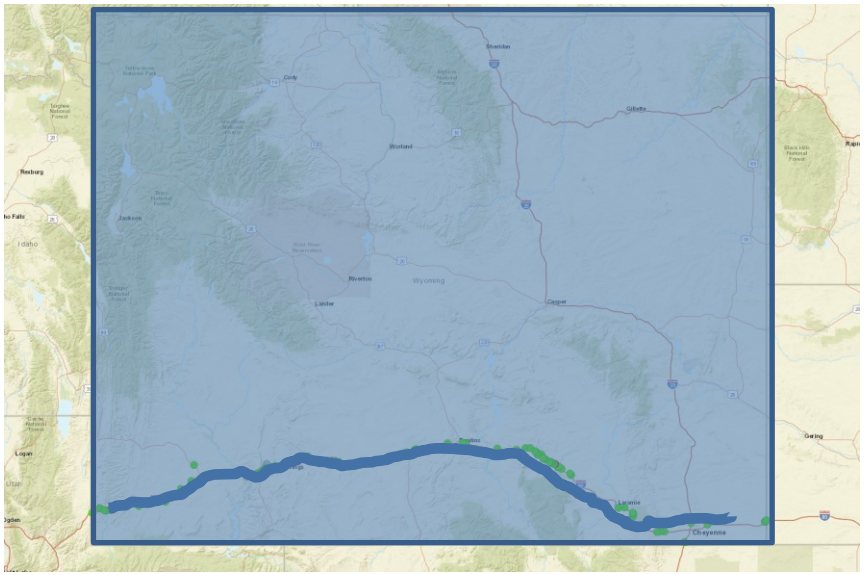
What is the SDX?

- Wyoming CV Pilot Project
- Potential for expanded use

Challenges related to…

- In/uptake
- Data/translation
- Security and other adoption considerations

Collaboration with Trihydro, WZDx, Alexa Skills



Traveler Information

by Trihydro

Rated: Guidance Suggested

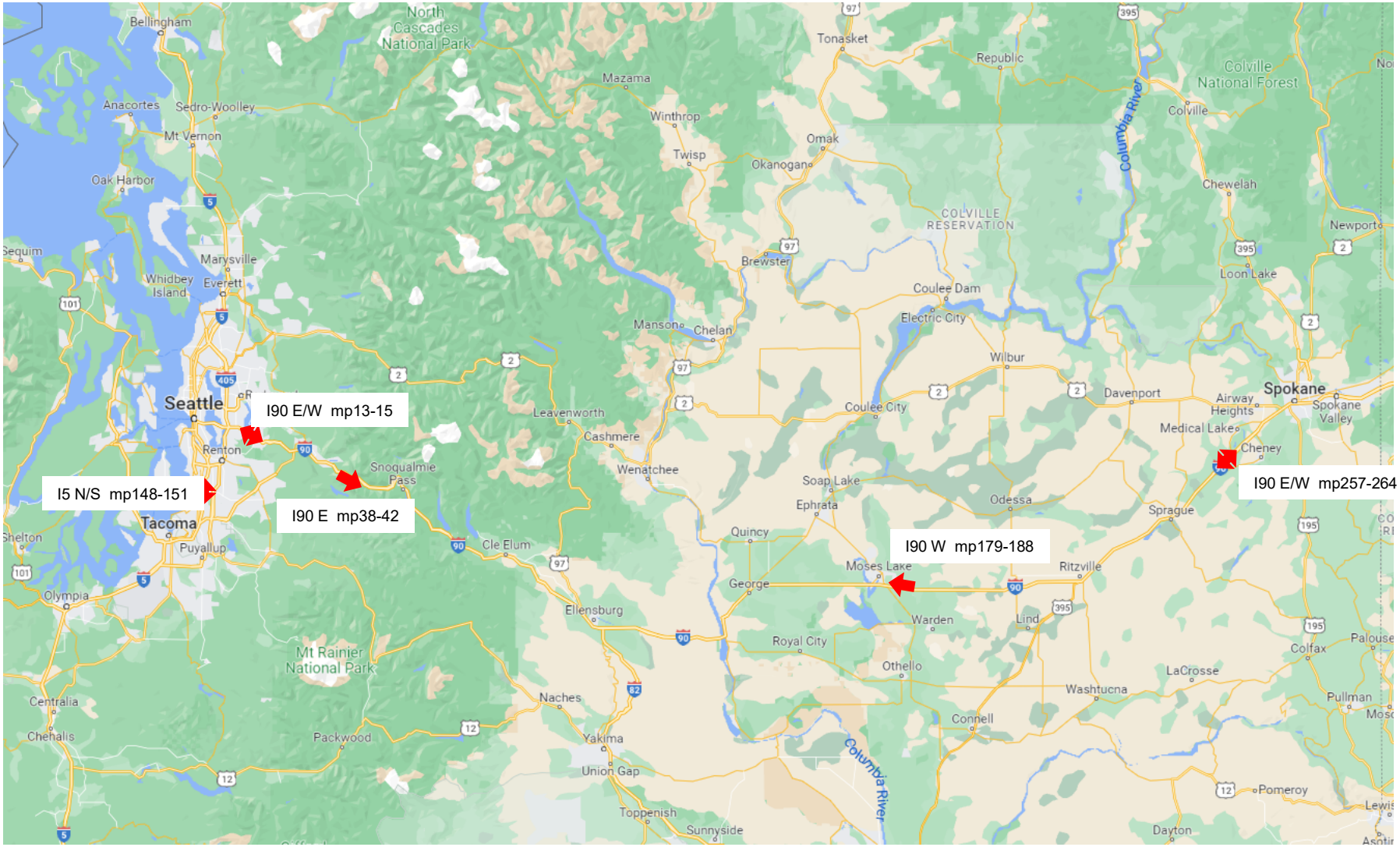
★★★★★ 1

Free to Enable

"Alexa, open traveler information"

"Alexa, ask traveler information if the roads to Cheyenne are okay"

"Alexa, ask traveler information about the roads"


I90 E/W mp13-15
I5 N/S mp148-151
I90 E mp38-42
I90 W mp179-188
I90 E/W mp257-264
Seattle
Tacoma
Spokane
Bellingham
Everett
Marysville
Renton
Puyallup
Olympia
Centralia
Chehalis
Shelton
Anacortes
Sedro-Woolley
Mt Vernon
Oak Harbor
Whidbey Island
Sequim
North Cascades National Park
Mt Rainier National Park
Leavenworth
Cashmere
Wenatchee
Chelan
Manson
Mazama
Winthrop
Twisp
Omak
Okanogan
Brewster
Tonasket
Republic
Colville
Colville National Forest
COLVILLE RESERVATION
Columbia River
Chewelah
Newport
Loon Lake
Coulee Dam
Electric City
Coulee City
Wilbur
Davenport
Airway Heights
Medical Lake
Spokane Valley
Cheney
Soap Lake
Ephrata
Odessa
Sprague
Quincy
George
Moses Lake
Ritzville
Warden
Lind
Royal City
Othello
Washtucna
LaCrosse
Colfax
Palouse
Pullman
Connell
Pomeroy
Dayton
Lewis
Asotin
Snoqualmie Pass
Cle Elum
Ellensburg
Naches
Yakima
Union Gap
Toppenish
Sunnyside
Packwood

3rd Party Platform – SDX Demonstration

Work zone data from WSDOT systems through SDX.

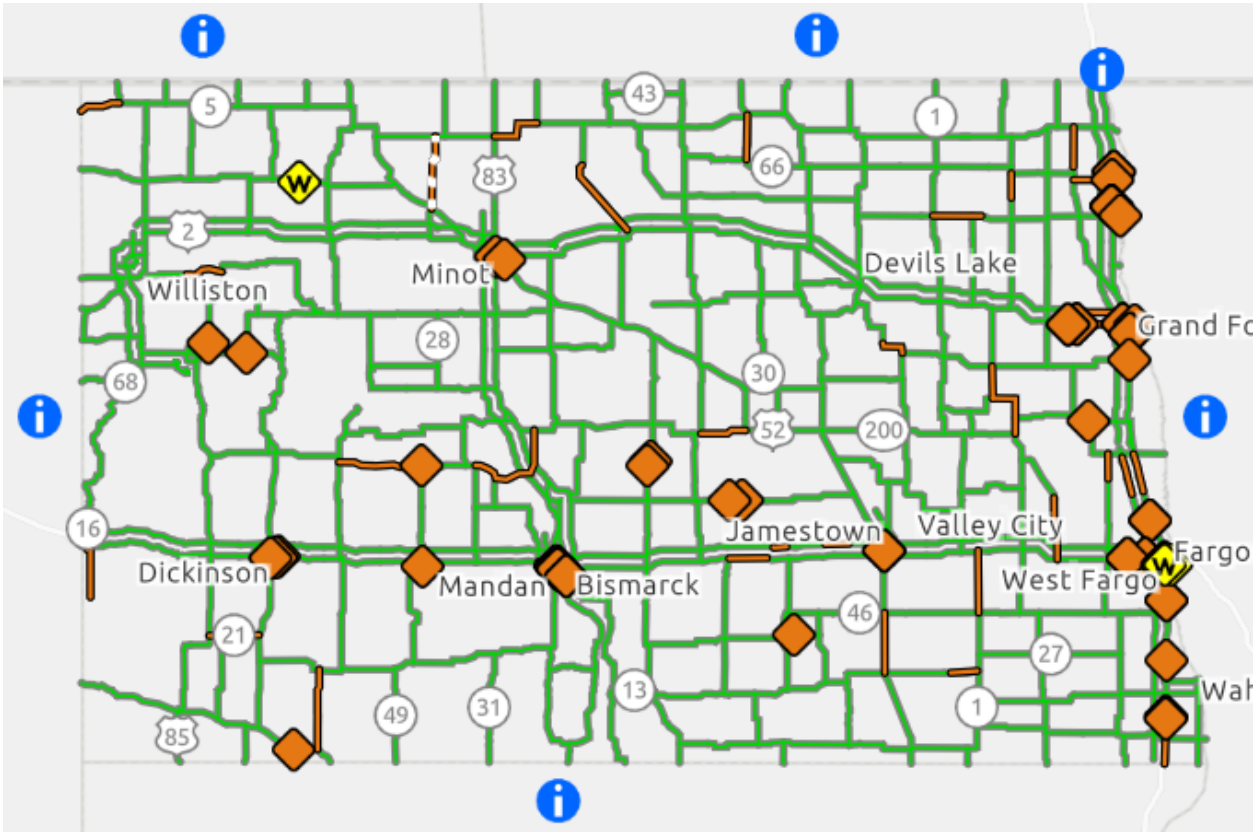
Demonstration of other capabilities TIM ➔ Alexa Skill

- SDX Explainer video: https://www.youtube.com/watch?v=GH4BFZWWVC4
- Alexa Skill video: https://www.youtube.com/watch?v=qZpgSbaFHCM

WZDx Demonstration Grant – Partner Agency Activities

Task 4

- Collaborate with NWP member states
  - Conversion of ND GeoJSON feed



WZDx Partner Agency Activities

Why is developing solution for ND a good fit?

- ND systems overview
- Potential for expanded use

Challenges related to…

- Interoperability among states
- Overlapping agencies
- Ownership/governance questions

Collaboration with…

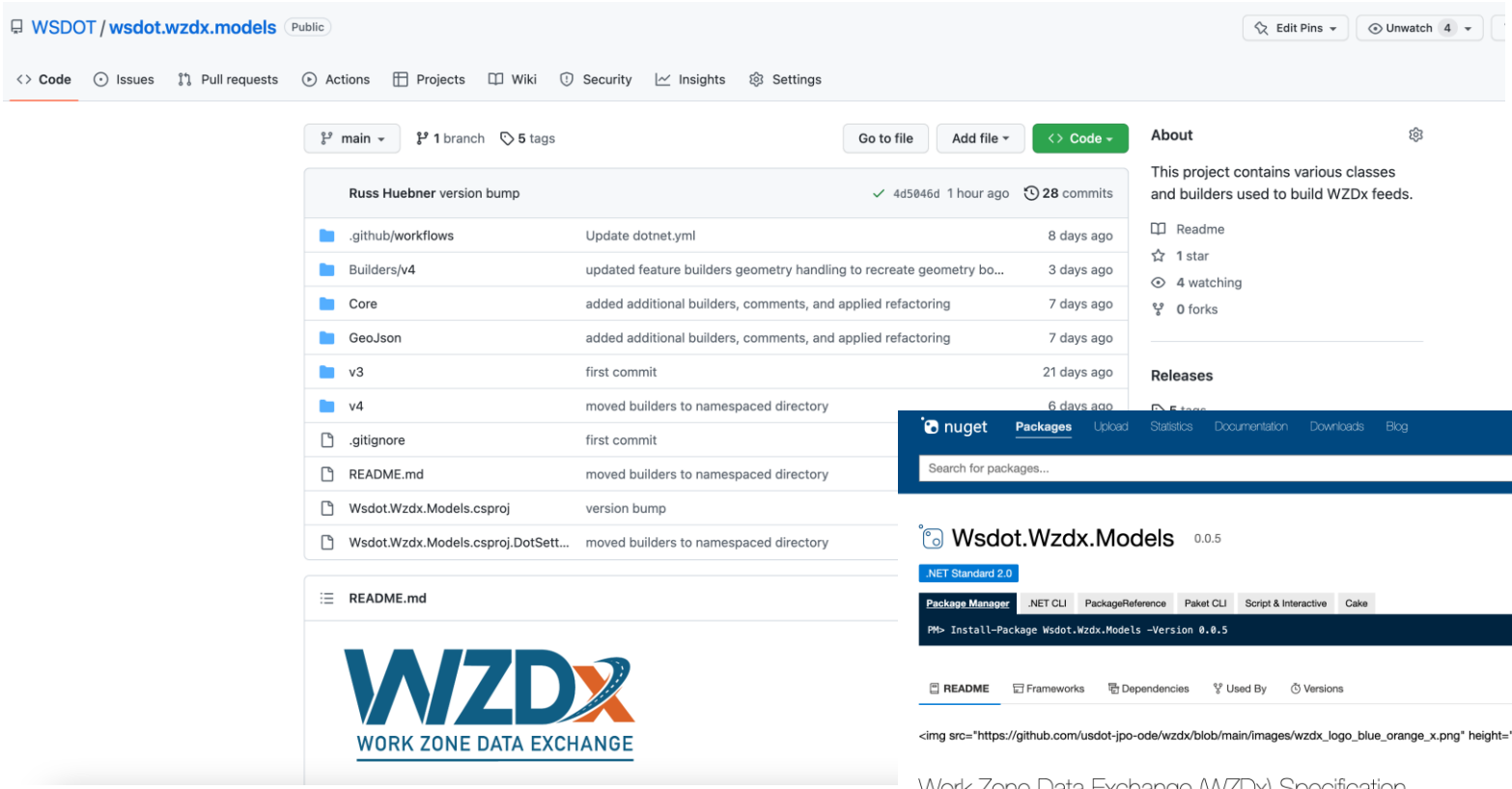
- North Dakota
- City of Seattle?
- You?

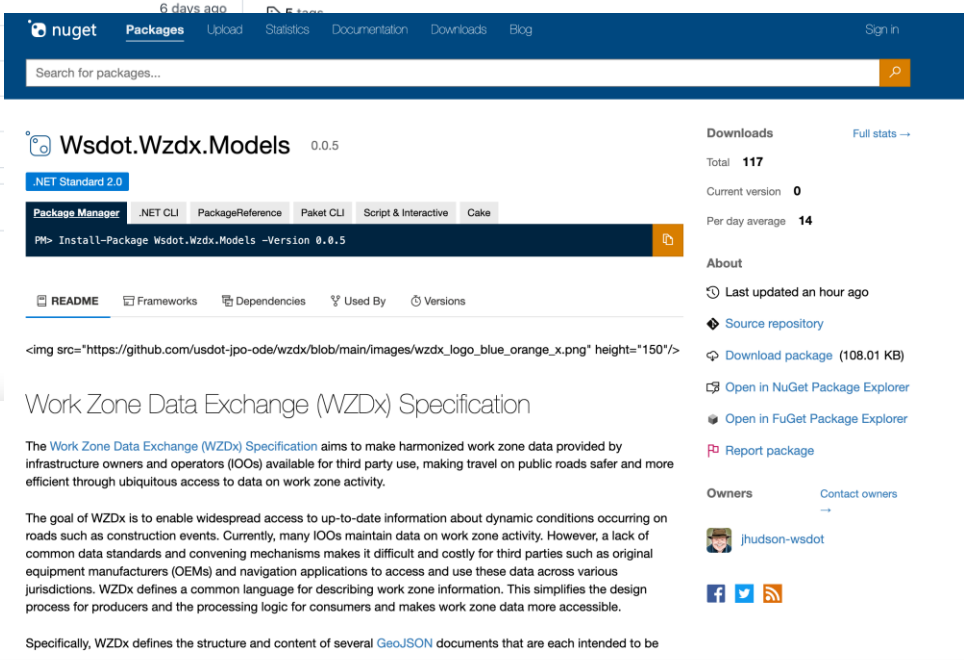
Opportunities moving forward

- Any agency or group that develops solutions in .NET can make use of our efforts for their own feed thereby increasing WZDx adoption and widespread success

WZDx .NET Core Library Demo

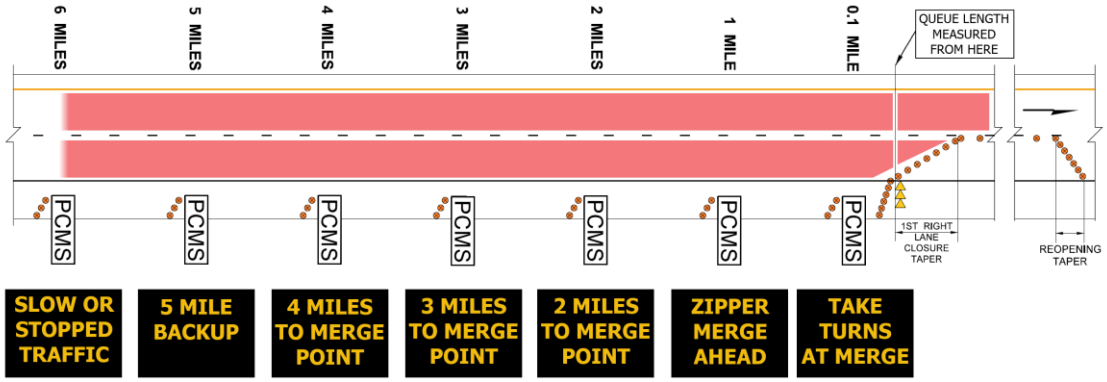
Show a demo of how the WZDx .NET core library works and where it is hosted.





Other WSDOT Smart Work Zone Practices

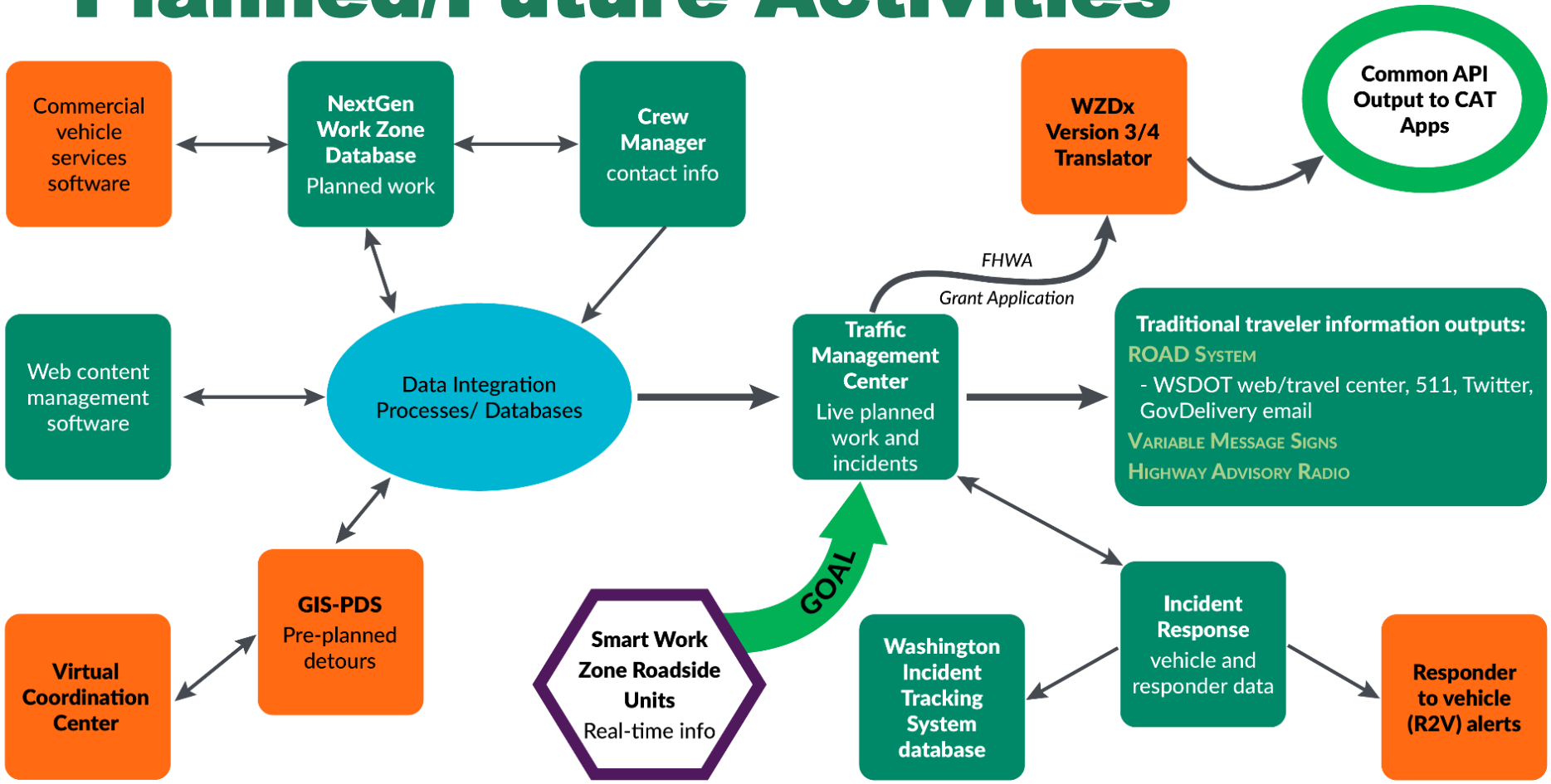
- Innovative PCMS use and queue management/smart work zone specifications



FREEWAY (2 LANES): SMART WORK ZONE SYSTEM FOR SINGLE RIGHT LANE CLOSURE (QUEUES UP TO 6 MILES)
NOT TO SCALE

- TSMO Subcommittee on Work Zones
- Standardization strategies include both grass roots and top-down

Planned/Future Activities



Lessons Learned – Start with what works and build on that

What worked:

- Communicate and collaborate along the way
  - WSDOT established a TSMO Subcommittee on Work Zones in January 2021
    - Completed an initial Capability Maturity Framework to understand ourselves
    - Forum for sharing information on available technologies as they develop
    - Institutionalize collaboration across all Divisions and Regions of the agency
    - Prepare our agency for CAT Technologies of the future
    - Update agency manuals, specifications, and guidance for work zone tools
  - Talk to vendors early and often

What didn't work:

- Timelines – be flexible
- Plans – be adaptable

Lessons Learned – Technical Considerations

Standards:

- Communicating geometry/geography differs between agencies and companies
  - Translation may be required, spatial references checked, and projection required
- Version 4.0 pushes to dynamic data structures which can be more challenging to adopt in a more static language like c#. Other languages like JavaScript handle dynamic structures better

Data feeds/storage:

- Should data pull from the sources and go right out to the feed or ETLs written to transfer data:
  - Lots of outside sources (internal and device vendors)
  - Some vendors publish today in WZDx and others do not
- Hosting architecture and the choice to migrate to cloud

Questions?


3C4-14
CLEARING ROADS
HELPING DRIVERS
INCIDENT RESPONSE TEAM
WSDOT