TECHNICAL MEMORANDUM

TxDOT IAC – Technical Support to the CAV Task Force

DATE: March 3, 2025

TO: Zeke Reyna, Emerging Technology Team Lead, STR, TxDOT
                  Lauren Freriks, Strategic Management Analyst, STR, TxDOT

COPY TO: Beverly Storey, Research Scientist, TTI
                  TTI_Reports@tti.tamu.edu
                  Tim Hein, Research Development Office, TTI

FROM: Robert Brydia, Research Supervisor
                  Senior Research Scientist, Texas A&M Transportation Institute

RE: Texas CAV Full Task Force
                  December 10, 2024, Meeting Notes

Attendees: 48 in-person, 41 virtual

Voting Members Present (In Person or Virtual):	
Aiden Ali-Sullivan	Waymo
Alison Pascale	Volkswagen Group of America
Andrea Gold (for Amit Bhasin)	University of Texas Center for Transportation Research
Anne O'Ryan	AAA - Texas
Brian A. Moen	City of Frisco
Dan Goff	Kodiak Robotics
Darran Anderson	Texas Department of Transportation
Erika Kemp	Texas Department of Transportation
Jeremiah Kuntz	Aurora
Karla Taylor	City of Austin
Katie Stevens	Nuro AI
Mark Worman	Texas Department of Insurance

Michael Sanders	Lone Star UAS Center of Excellence and Innovation
Roland Luna	Texas Department of Motor Vehicles
Terri Johnson	INRIX
Zeke Reyna	Texas Department of Transportation

I. Welcome and Voting Member Roll Call – Zeke Reyna, TxDOT
- Thank you for joining this meeting of the Texas CAV Full Task Force meeting
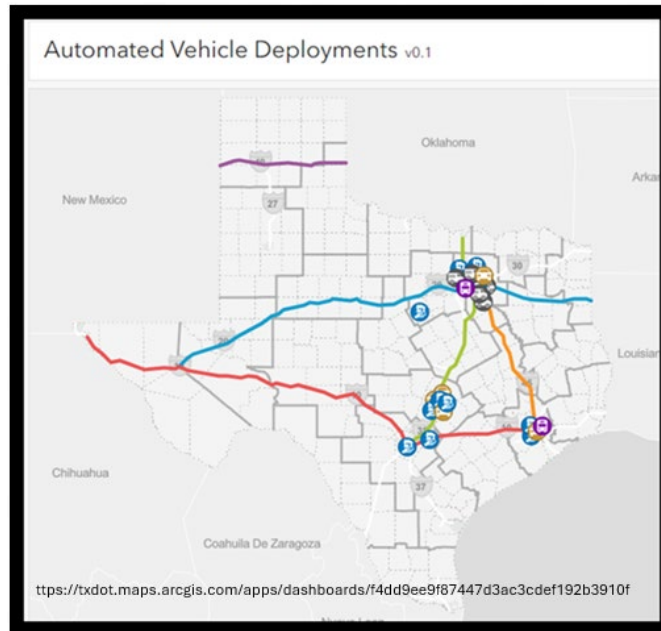- We are looking forward to what we can accomplish together

II. Opening Comments – Darran Anderson, TxDOT
- We appreciate what this task force has done toward efforts regarding clear communication of advancements in CAV technology integral to helping both the house and the senate as they consider drafting legislation in the coming session.
  - It's about facilitation of discussion between industry and the public about the progress of connected and automated technologies and how those influence and hopefully improve transportation in the state
  - Anything you can do and have done to grow the knowledge of the elected leadership is critical and is an amazing example of the collaborative spirit of this organization.
- Today's meeting will discuss the details of the Comprehensive Report, which includes the State of Autonomous Vehicles in Texas, as well as more subcommittee approved white papers. As well as:
  - a Legislative Update from TxDOT
  - a Performance Project presentation
  - an update on the Texas Trust V2X project

III. State of AV in Texas – Bob Brydia, TTI
- Overview: Texas Connected and Automate Vehicles Task Force
  - Provide the state with a single, unified resource for information regarding the coordination and advancement of CAV technologies across the state
  - Membership is national in scope, including representatives from other state agencies and public entities, as well as key industry stakeholders
  - Six topic-specific subcommittees
    - White Papers and Reports
    - Workshops and Focus Groups
    - Projects and Resources
- State of AV in Texas
  - Texas provides a welcoming environment for innovation companies to focus and hone CAV technologies
  - Leading the eventual transformation of the surface transportation system
  - 25+ AV companies are currently deploying /testing /planning /operating in Texas
- Texas Leading the Way
  - Fostering a safety-first culture thorough testing, scaling, and development of best practices.
  - Business-friendly economic base eager to advance new technologies

- o Large potential market for AV development
- Stakeholders
  - o State and Local Transportation Agencies
  - o Public Sector Agencies
  - o Infrastructure Owners/Operators
  - o Transportation Planners
  - o Law Enforcement
  - o First Responders
  - o Regulatory Bodies
  - o General Public
- Stakeholder Involvement - Provides all stakeholders the opportunity to learn and grow these innovations into a formidable market presence in the future.
  - o Developing continued knowledge base growth
  - o Infrastructural and operational requirements
  - o Workforce and upskilling needs
  - o Provisioning large scale data accessibility to enhance all aspects of transportation
  - o Focus on enhancing the educational information to all with the public and private sector
- Current AV Applications
  - o Long-haul Freight (over 250 miles)
  - o Short-haul Freight (within 150-mile radius, i.e., local/regional)
  - o Passenger (shuttles, ride-hailing/robo- taxis)
  - o Last Mile Delivery (distribution center to residence/business)
  - o Personal Delivery Device (robot delivery)
- Where are AVs Operating?
  - o Currently testing SAE Levels 4 and 5 vehicles on Texas public roadways and private roads.
  - o Several AV trucking companies recently announced plans to remove safety drivers from some vehicles on some routes.
  - o Long-haul systems operate exclusively between freight terminals along or near Interstate Highways.
  - o Short haul and delivery robots operate on city streets and roads.
  - o Port and terminal facilities use automated cranes and other systems involved in moving shipping containers.
- CAV Task Force Interactive Map
  - o CAV Task Force maintains an interactive map showing the AVs operational description, status (testing or deployed), and locations.
  - o https://www.arcgis.com/apps/dashboards/f4dd9ee9f87447d3ac3cdef192b3910f

Automated Vehicle Deployments v0.1

ttps://txdot.maps.arcgis.com/apps/dashboards/f4dd9ee9f87447d3ac3cdef192b3910f

- Collaborative Efforts
  - Freight pre-inspection pilots
  - Law enforcement engagement with AV companies
  - Work done with customs and border patrol check points within El Paso region
- Looking Towards The Future
  - Ensuring that the regulations are adaptive to technological advancements can help attract future deployments.
  - Collaboration amongst all stakeholders is crucial to the continued development, testing, and operations that an autonomous future can provide to the citizens of Texas

IV. **Subcommittee White Paper Readouts – Bob Brydia, TTI**
- **Data -** *Cybersecurity in Connected and Autonomous Vehicles (CAVs)*
  - Introduction
    - Increased connectivity introduces significant cybersecurity risks.
    - White paper focuses on six core areas:
      – CAV penetration vulnerabilities
      – Communication frameworks
      – Proximity access
      – Human Awareness
      – Regulatory frameworks
      – Trust in industry
  - Key Risks
    - Expanded Attack Surface:
      – Increased interconnectivity amplifies vulnerabilities.
      – Legacy systems pose integration challenges
    - Data Privacy Concerns:
      – Risk from sensitive data from V2X communication
    - Proximity Access Weakness:

- Relay attacks exploit keyless entry systems
  - Countermeasures
    - Technical Measures:
      - Multi-layered defenses with firewalls and intrusion detection.
      - Encryption and OTA updates to protect communication
    - Human Awareness:
      - Education on phishing, password hygiene, and secure practices
  - Role of Artificial Intelligence
    - Risks:
      - AI systems potentially vulnerable to adversarial attacks
      - Privacy concerns from data collection
    - Innovations:
      - AI-enhanced monitoring for real-time threat detection
      - Predictive analytics for proactive security
  - Building Trust
    - Challenges:
      - Transparency gaps between OEMs and users
      - Media coverage impacts public perception
    - Countermeasures:
      - Clear communication about cybersecurity measures
      - Collaboration across stakeholders for unified standards
  - Opportunities for Texas
    - Unified Framework:
      - Centralized cybersecurity standards for CAVs
    - Industry Collaboration:
      - Shared threat intelligence and public-private partnerships
    - Continuous Education:
  - Public awareness campaigns to build trust

- **Freight and Delivery -** *First Responder Interactions with Automated Freight*
  - Priority Topics
    - How should autonomous freight vehicles interact with first responders?
    - Should emergency response procedures be standardized and published?
    - Should first responder agencies standardize training on these procedures?
  - Automated Freight
    - What is it?
      - SAE Level 4/5 Vehicles
      - Short-haul truck services
      - Long-haul truck services
      - Last-mile delivery robots operating on roadways
      - Automated terminals and ports
    - Who does it?
      - Aurora Innovation, Inc.
      - Bot Auto TX
      - Gatik
      - Kodiak Robotics

- Nuro
- Torc Robotics
- Waabi
- Stack AV
- Priority Topic
  - Encapsulates results from RTI Project 0-7199, First Responder Interactions with Automated Vehicles
  - Identified responder interaction scenarios and examined opportunities for enhancement
    - ✓ Utilized 0-7199 workshops results
    - ✓ Robust discussions and collaboration
    - ✓ Methods for working together
- Automated Freight Interactions with First Responders on Texas Roadways
  - TxDOT RTI Project 0-7199 Activities
    - ✓ Held a First Responder Interactions with Automated Vehicles Summit, April 30-May 1, 2024
    - ✓ Is defining 19 Interaction Scenarios and Best Practices
    - ✓ Cataloged and reviewed First Responder/Law Enforcement Interaction Plans and Emergency Response Guides
    - ✓ Final deliverable will be a First Responder Guide to AV Interactions and AV Recognition Guide
- o Opportunities
  - Implementation of scalable solutions for the inspection of automated CMVs in various situations and improved education for CMV enforcement, border, and USDA inspection stations.
  - Increased awareness and education for law enforcement officers reporting vehicle crashes on SAE levels of automation, CR-3 reporting codes for autonomy, AV recognition, and determination of autonomy status at the time of the crash.
  - Creation of a single point of contact training source for first responders on AV interactions and safety that provides credit to responders for their professional licensing requirements under the TCOLE and TCFP established training standards.
  - Development of a communication mechanism for the exchange of information between law enforcement and AV developers that allows both to work collaboratively to resolve problems encountered by first responders when interacting with AVs.
  - Development of a centralized traffic management system in Texas from which AV freight operators could obtain real-time roadway condition information regarding temporary closures, detours, or debris in the roadway that might affect their operations.
  - Coordination between AV developers and first responders to strengthen training for humans directing traffic with AVs present.

- **Licensing and Registration - *Current Connected and Autonomous Vehicle Regulations and Legal Frameworks***
  - o 2024 Licensing and Registration Subcommittee Activities

- The top priority for this subcommittee in 2024 was to better understand the AV regulatory environment, licensing, and enforcement and their potential impacts in Texas.
- A white paper compiling information available on national AV deployments, existing regulatory frameworks, and impacts on and lessons learned from stakeholders was completed and approved by the Licensing and Registration Subcommittee in November 2024.
- TxDOT's CAV Deployment Dashboard
  - Current AV deployments by:
    - Delivery Vehicles
    - Long-Haul Freight
    - Short-Haul Freight
    - Passenger Vehicles
    - Shuttles
    - https://www.arcgis.com/apps/dashboards/f4dd9ee9f87447d3ac3cdef192b3910f
- Current CAV Regulations and Legal Frameworks White Paper
  - An overview of existing international, federal, and state regulations, including current listings of state regulations (in the appendices).
  - Case study examples of AV deployments and regulatory impacts in Nevada, California, and Michigan.
  - Lessons learned from AV deployments, additional stakeholder needs, and impacts on additional groups.
  - Future opportunities related to AV regulations.
  - Hyperlinks to recent publications and current AV regulatory frameworks by state.
- Highlighting the Need for Standardized Terminology
  - Universal definitions and terminology need to be used among AV manufacturers, operators, users, and other stakeholders.
  - Standardized terminology is also critical when it comes to design, licensing, and registration.
  - Excellent resources available to help with terminology:
    - SAE J3016 (2021) – universal definitions
    - https://www.sae.org/standards/content/j3016_202104/
    - SAE Best Practice for Core Automated Vehicle Safety Information
    - https://www.sae.org/standards/content/avsc-d-02-2024/
- Opportunities in the AV Regulatory Environment
  - AVs will need to be considered by states in how they will be inspected. Inspectors may need special education to understand AV operations and safety aspects.
  - The departments of motor vehicles can program the registration records to indicate if the vehicle is an AV and its level of automation. This could provide clarity to first responders and law enforcement so they can understand the automated features of a given vehicle.

- **Safety, Liability, and Responsibility -** *Automated Vehicle Safety: Traffic Citations, Incidents, and Future Laws*
  - o Purpose
    - ▪ Assist Texas in developing future guidance, policies, and recommendations so that testing and deployment of AVs can continue safely and efficiently in Texas
    - ▪ Three primary topic areas:
      - – Assess existing framework for issuing citations for traffic violations and tracking incidents involving AVs
      - – Review traffic laws regarding AVs
      - – Assess potential for AVs to improve incident detection
  - o Activities Involved
    - ▪ Reviewed incidents involving AVs being tracked at national level
      - – NHTSA issued a SGO requiring manufacturers or operators to report certain crashes involving vehicles equipped with ADS or level 2 ADAS
    - ▪ Reviewed AV information being gathered on crash reports
      - – Texas Peace Officer's Crash Report (CR-3)
      - – Model Minimum Uniform Crash Criteria (MMUCC)
      - – Other States (e.g., Illinois, Kansas, California)
    - ▪ Reviewed law enforcement's need and ability to communicate with AVs during traffic stops
    - ▪ Discussed differences between issuing citations and complaints
  - o Analysis
    - ▪ Law enforcement currently has ability to issue citations for traffic violations involving AVs, but process could potentially be streamlined and simplified
      - – Consider having AV companies identify a responsible agent in their Law Enforcement Interaction Plan when no physical operator/driver is present
      - – Consider developing online system for law enforcement to complete citation/complaint forms
      - – Have law enforcement capture and codify similar information recorded on crash reports (i.e., automation system levels in vehicle and level of engaged automation at time of violation)
    - ▪ Information that could be considered considered relevant for increasing ability to assess safety impacts includes:
  - o Automation system(s) in vehicle and level of engaged automation at time of violation
    - – Complications that occurred while pulling over driver/vehicle and/or during traffic stop
    - – Information from AV companies to normalize data on violations and incidents
    - – Information from AV companies about how to recognize vehicle is in autonomous mode
    - – Information about responsible agent that AV companies identify in their Law Enforcement Interaction Plan for issuing a citation/complaint
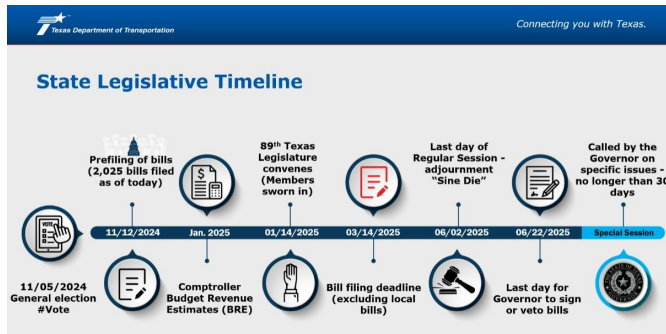 - o Opportunities

- Have AV companies, within 5 to 7 days of the incident, provide information on level of engaged automation at the time of the incident to law enforcement agencies so law enforcement officers can accurately complete and submit a CR-3 within 10 days of the incident
- Have AV companies provide information that can be used to normalize data on incidents and violations (e.g., approximate miles of travel by ADS-engaged AVs and the type of roadway that the majority of testing occurred on)
- Have AV companies provide information on how to recognize that the vehicle is in autonomous mode
  - Other Potential Regulatory Review
    - Following too closely (primarily to address ADS truck platooning)
    - Other road user behavior near an ADS (e.g., drivers at an intersection not allowing an ADS to proceed)
    - Safety belt usage, child passenger restraints, distracted driving, driving under the influence, and occupancy and age requirements for passengers or automated vehicles
  - Potential Ways that AVs Can Improve Incident Response
    - Effective traffic incident management (TIM) practices are essential to minimize impact of incidents
    - Introduction of CAVs into TIM strategies can achieve two key objectives:
      - Rapid and safe incident resolution
        - ✓ Use CAV technologies to enhance incident detection accuracy and facilitate faster response times by emergency services
      - Enhanced incident management response
        - ✓ Leverage capabilities of CAVs by providing real-time updates to vehicles and traffic management centers, allowing for proactive measures to be taken

- **Education, Communication, and User Needs**
  - Current Activities
    - Initiated development of education modules for public sector agencies and employees
- **Future Workforce and Economic Opportunity**
  - Current Activities
    - Developing comprehensive document of job positions and requirements
    - Will be published as a separate document

V. Voting Membership Consideration of Final Report – Zeke Reyna, TxDOT
- Motion to approve
- Second to motion made
- Third Comprehensive Report of the Texas CAV Task Force approved unanimously by voting members

VI. State Legislative Update and Discussion – Cory Henrickson, TxDOT
- State Legislative Timeline

- Election Results
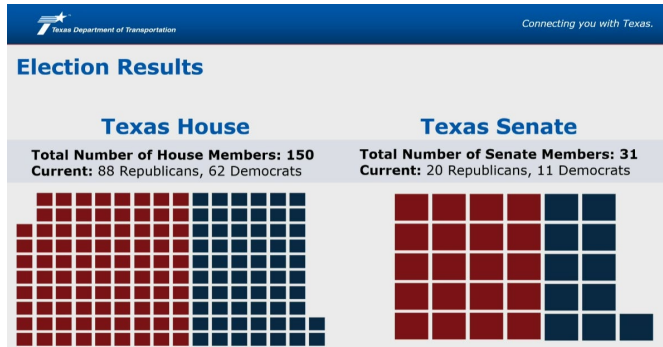
- TxDOT Interactions with the Legislature

- Budget Sources FY 2026-27
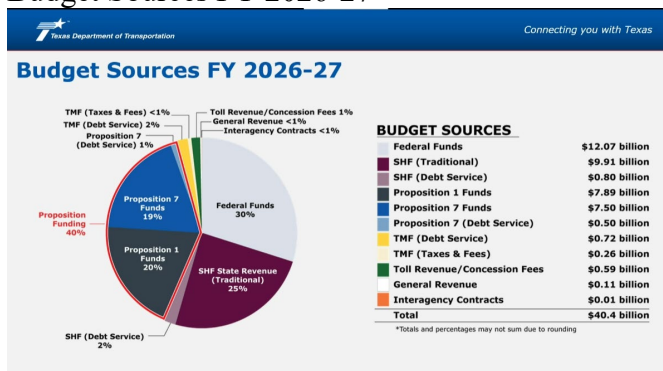
- Budget Uses FY 2026-27
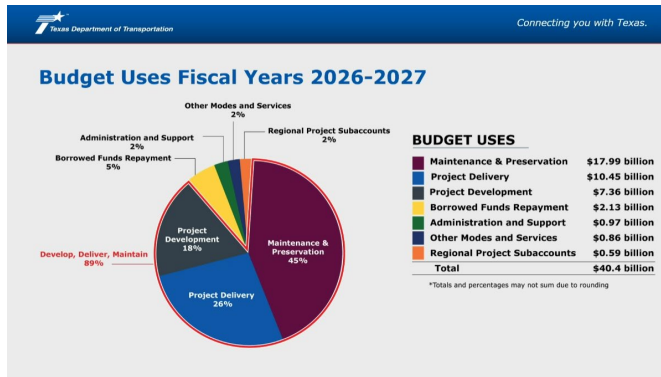
- Exceptional Items Discussion

- Legislative Resources

VII. **Framework for Quantifying Autonomous Vehicle Safety – TTI**
- Purpose of Task
  - Compare human driver response/risk to AV response/risk in pre-crash scenarios
  - Define human response variables in selected high-crash scenarios
  - Collate results from previously published studies:
    - Response times
    - Response modes (brake, steer, combination)
    - Response intensity (e.g., braking force and duration)
    - Frequency of crash occurrence within a given scenario
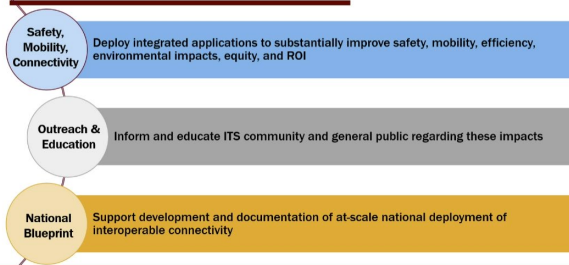- Driver Reaction Components (Braking-Only Example)
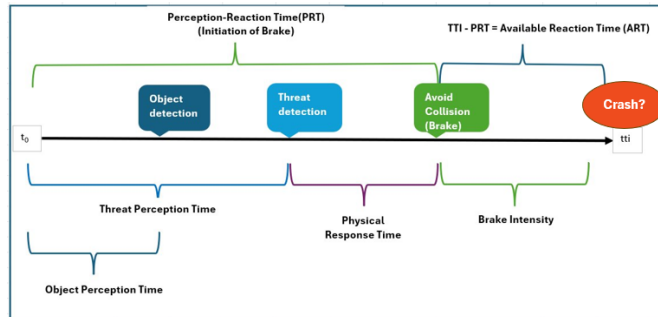
- Tasks to Date
  - Reviewed published papers on driver reaction-time studies
    - Rear-end crash scenarios
    - Angle crash scenarios
  - Collated available data from published study results
    - Study conditions/designs, scenario type
    - Means, standard deviations, number of trials/participants
  - Consulted with TTI statistician on next steps toward developing a statistical model using collected data
- Challenges for Meta-Analysis of Published Data
  - Inclusion/exclusion criteria must be more narrowly defined to minimize potential bias.
  - Number of subcategories for each crash type is likely to increase.
  - Fewer available study examples for each subcategory.
  - Not all driver-response studies include all elements (reaction times, reaction intensity/type, crash outcomes).
- Next Steps (January-February 2025)
  - Work with statistician to assess feasibility/scope of meta-analysis:
    - Define inclusion criteria and subcategories of pre-crash scenarios and variables
    - Determine:
      - If more and/or different type of data are needed
      - If sufficient data exists from published literature
      - Which crash response subcategories can be statistically modeled
    - Estimate effort level and timeline
      - Additional data mining
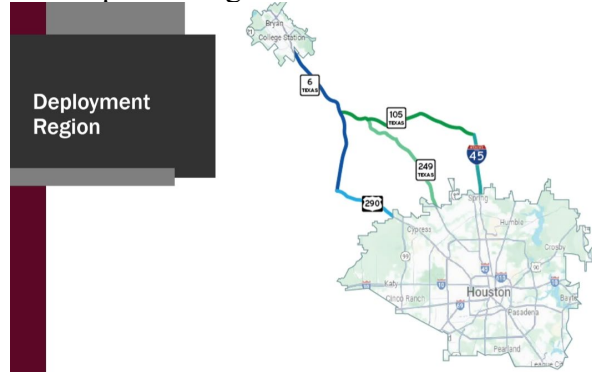   - Statistical analysis/modeling

VIII. Update on V2X Accelerator Grant – the Texas TRUST – TTI
- Transforming Roads: Unleashing Smart Technologies
  - Project Goals

Project Goals

- Safety, Mobility, Connectivity — Deploy integrated applications to substantially improve safety, mobility, efficiency, environmental impacts, equity, and ROI
- Outreach & Education — Inform and educate ITS community and general public regarding these impacts
- National Blueprint — Support development and documentation of at-scale national deployment of interoperable connectivity

- o Development Region

Deployment Region

- ▪ Why this Mega-Region?
  - – Significant regional challenges
    - ✓ Congestion
    - ✓ Safety
    - ✓ Mobility
    - ✓ Vulnerable road users
    - ✓ Weather impacts
    - ✓ Rural and urban environments
    - ✓ Multiple operating authorities
  - – +5 Million population
  - – Leverage existing projects
  - – Texas A&M has largest student body in the nation (2024)
  - – RELLIS Innovation Campus
  - – Partner Support
- o Use Cases
  - ▪ Houston
    - – Flood warning
    - – Signal phase and timing (SPaT)
    - – Wrong-way driving
    - – RTOR warning
    - – Emergency vehicle response
  - ▪ College Station
    - – Signal phase and timing (SPaT)
   - – Every Day a Game Day
    - – Traffic signal preemption

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- – Transit fleet integration
- – Construction worker safety
  - ▪ Roadways
    - – Hurricane evaluation / Adverse weather
    - – Alternate routes
    - – Enhanced operations
    - – Construction zones
    - – Queue warning
- o TRUST by the Numbers
  - ▪ A population area of nearly five million people
  - ▪ Leverage 1,100 SPaT-enabled 5.9 GHz C-V2X intersections and add ~85 more
  - ▪ Vulnerable road user protection in two cities
  - ▪ 300 miles (three routes) of NHS roadways
  - ▪ Leverage implementation in 50 full-size transit busses and add 50 more for complete fleet integration
  - ▪ Nuro autonomous vehicles within the operating area
  - ▪ GM and Audi test vehicles
  - ▪ Millions of pedestrians and bicyclists across the project operational timeframe
  - ▪ A 10- mile, $600M freeway expansion project
  - ▪ Construction road worker wearable protection
- o Award and Funding Details

Award and Funding Details

- • Award Number: 693JJ32450034
- • Type of Agreement: Cooperative Agreement

- • Total Funding: $24,019,240
  - • Federal Share: $19,215,392
  - • Recipient Share: $4,803,848
- • Currently funded for: $8,445,984 for 1st fiscal year

- o Project Schedule

Project Schedule
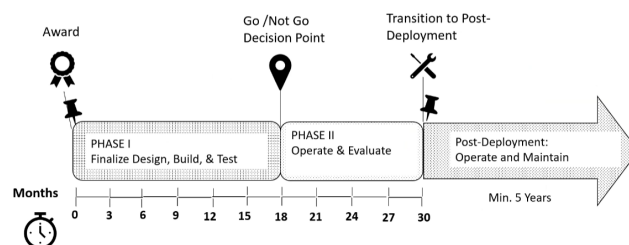
- o Post-Deployment Requirements
  - ▪ Sustainability: Sites must maintain operations for at least 5 year spost-Phase2 without federal funding

- Impact Evaluation: Continue monitoring, system evaluation, and data sharing for public transparency.
  - How Will We Ensure Long-Term Viability?
  - Partners

- **Closing Comments and Next Steps – Darran Anderson, TxDOT**
- Thank you to everyone who attended in person and online. We greatly appreciate your participation, support and expertise as we finish up this year and look forward to a new year of development.
- Next Steps
  - Last technical edit
  - Share final report with Task Force and publish on TxDOT.gov under CAV Task Force reports page.
- Upcoming Meetings in 2025
  - January 5 – 9, TRB in Washington D.C.
  - January 27 – 29, Texas Transportation Forum in Round Rock, TX
  - June 15 – 18, Texas Innovation Invitational in Fort Worth, TX