Phase 1 Data Plan

Vehicle-to-Everything (V2X) Accelerator: Connecting the West – Utah Department of Transportation

www.its.dot.gov/index.htm

Final Report – August 10, 2026
FHWA-JPO-26-19

U.S. Department of Transportation

Produced by Saving Lives with Connectivity: Accelerating V2X Deployment Grant
U.S. Department of Transportation
Office of the Assistant Secretary for Research and Technology
U.S. Department of Transportation
Intelligent Transportation Systems Joint Program Office
Federal Highway Administration
Office of the Assistant Secretary for Research and Technology
Cover graphic source: U.S. Department of Transportation

Notice

Technical Report Documentation Page

1. Report No. **FHWA-JPO-26-19**	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Phase 1 Data Plan Vehicle-to-Everything (V2X) Accelerator: Connecting the West – Utah Department of Transportation		**5. Report Date** August 10, 2026 **6. Performing Organization Code**
7. Author(s) C. Toth, S. Ashraf, F. Perry		**8. Performing Organization Report No.**
9. Performing Organization Name and Address Utah Department of Transportation 2060 South 2760 West Salt Lake City, UT 84104		**10. Work Unit No. (TRAIS)** Proj No F-ST99(1014) **11. Contract or Grant No.** 693JJ324NF00003
12. Sponsoring Agency Name and Address U.S. Department of Transportation ITS Joint Program Office 1200 New Jersey Avenue, SE Washington, DC 20590		**13. Type of Report and Period Covered** Final **14. Sponsoring Agency Code** HOIT-1
15. Supplementary Notes		

16. Abstract

This Data Plan outlines the procedures and standards for collecting, storing, protecting, and sharing data generated through the Connecting the West (CTW) Program conducted as part of the United States Department of Transportation's (USDOT) Saving Lives with Connectivity: Accelerating Vehicle-to-Everything (V2X) Deployment grant program. For the purpose of meeting grant requirements and for generating performance measures, this Data Plan details roles, access controls, data use policies, storage protections, and archiving procedures to ensure responsible data handling throughout the program's life cycle. The plan also describes how data schemas and dictionaries will be maintained and clarifies that all datasets produced are open and intended for public use, with appropriate safeguards for sensitive information.

17. Keywords V2X; Vehicle-to-Everything; Accelerator; Deployment; Intelligent Transportation Systems	**18. Distribution Statement** No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312

19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 72	**22. Price**

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

Acknowledgements

The Connecting the West (CTW) team would like to thank the Federal Highway Administration (FHWA) and Noblis for their technical assistance throughout the review and editing process relating to the development of this document. The CTW team greatly appreciates the guidance and input that shaped this version of the Data Plan.

Table of Contents

List of Tables

List of Figures

List of Acronyms and Abbreviations

AES	Advanced Encryption Standard
API	Application Programming Interface
ATMS	Advanced Traffic Management System
ATSPM	Automated Traffic Signal Performance Metrics
AVL	Automatic Vehicle Location
BSM	Basic Safety Message
C2C	Center-to-Center
CAD	Computer-Aided Dispatch
CAN	Controller Area Network
CDOT	Colorado Department of Transportation
CI	Connected Intersection
CIMMS	Connected Intersection Message Monitoring System
CIPT	Connected Intersection Preferential Treatment
CISA	Cybersecurity Information Sharing Act
ConOps	Concept of Operations
CORS	Continuously Operating Reference Station
CSV	Comma Separated Value
CSW	Curve Speed Warning
CTI	Connected Transportation Interoperability
CTW	Connecting the West
CV	Connected Vehicle
DPP	Data Privacy Plan
DTI	Dynamic Traveler Information
FAST	Fixing America’s Surface Transportation Act
FHWA	Federal Highway Administration
FISMA	Federal Information Security Modernization Act
GB	Gigabyte
GCP	Google Cloud Platform
GHz	Gigahertz
GM	General Motors
GNSS	Global Navigation Satellite System
GTFS	General Transit Feed Specification
GTFS-RT	General Transit Feed Specification Real-Time
HMI	Human-Machine Interface
Hz	Hertz
I-70	Interstate 70
INC	Incident Information

IT	Information Technology
IRC	Interstate and Rural Corridor
ITIS	International Traveler Information System
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
JSON	JavaScript Object Notation
K	Thousand
KPI	Key Performance Indicator
LCW	Lane Closure Warning
LiDAR	Light Detection and Ranging
M	Million
MAP	Map Data Message
MB	Megabyte
NGS	National Geodetic Survey
ngTMDD	Next Generation Traffic Management Data Dictionary
NTCIP	National Transportation Communications for Intelligent Transportation System Protocol
NTRIP	Networked Transport of RTCM via Internet Protocol
OBE	On-Board Equipment
OBP	On-Board Processor
OBU	On-Board Unit
ODE	Operational Data Environment
OEM	Original Equipment Manufacturer
OTIS	Online Transportation Information System
PII	Personally Identifiable Information
PMEP	Performance Measurement and Evaluation Plan
PMP	Project Management Plan
PPM	Privacy Protection Module
RBAC	Role-Based Access Control
RSE	Roadside Equipment
RSM	Road Safety Message
RSU	Roadside Unit
RSZW	Reduced Speed Zone Warning
RTCM	Radio Technical Commission for Maritime Services
RWIS	Road Weather Information System
SAE	SAE International
SCM	Signal Command Module
SDD	System Design Document
SDSM	Sensor Data Sharing Message

SDX	Situation Data Exchange
SEMP	Systems Engineering Management Plan
SI	Signalized Intersection
SPaT	Signal Phase and Timing
SRM	Signal Request Message
SSM	Signal Status Message
SSS	Sensor Sharing Service
SWIW	Spot Weather Impact Warning
SyRS	System Requirements Specifications
TIM	Traveler Information Message
TLS	Transport Layer Security
TMC	Traffic Management Center
TMDD	Traffic Management Data Dictionary
TOC	Traffic Operations Center
TSC	Traffic Signal Controllers
TSCBM	Traffic Signal Controller Broadcast Message
TSP	Transit Signal Priority
TURN	The Utah Reference Network
UDOT	Utah Department of Transportation
UDP	User Datagram Protocol
U.S.C.	United States Code
USDOT	United States Department of Transportation
UTA	Utah Transit Authority
V2X	Vehicle-to-Everything
V2X MMS	Vehicle-to-Everything Maintenance and Management System
VRU	Vulnerable Road User
VRS	Virtual Reference Station
VSL	Variable Speed Limit
WKT	Well-Known Text
WYDOT	Wyoming Department of Transportation
WZDx	Work Zone Data Exchange

1. Introduction

The Connecting the West (CTW) Program is one of three recipients of the United States Department of Transportation's (USDOT) Saving Lives with Connectivity: Accelerating Vehicle-to-Everything (V2X) Deployment grant program (often referred to as the V2X Accelerator program) aiming to showcase interoperable, large-scale V2X benefits to drive Original Equipment Manufacturer (OEM) investment. The CTW Program is led by the Utah Department of Transportation (UDOT) with partners Colorado Department of Transportation (CDOT) and Wyoming Department of Transportation (WYDOT).

Deployments of V2X systems generate vast amounts of data, necessitating rigorous methods to collect, process, analyze, share, manage, and archive data to support operations, maintenance, and performance metrics development for the system. A well-structured data plan is essential for this purpose as it enables secure, organized, and accessible data storage, supporting interoperability and reliable performance analysis. An effective data management strategy ensures data integrity, minimizes duplication, and addresses data quality issues, such as erroneous or conflicting records. A robust plan also facilitates real-time data processing and long-term storage, allowing stakeholders to access historical data for trend analysis, safety assessments, and operational improvements. Additionally, a well-designed data management plan enhances data sharing across agencies and supports public access, fostering a collaborative situation that accelerates innovation and optimizes transportation outcomes.

The Data Plan for the CTW Program is intended as a guideline for the data-related processes occurring during the CTW Program life cycle. It dictates how the data collected and created will be handled, shared, and disseminated while considering data documentation, safety, and reuse. It provides a strategic framework designed to efficiently handle, secure, store, share, and utilize the vast amount of data generated by infrastructure and collected from vehicles and other connected devices while acknowledging and accounting for the progress made in Utah, Colorado, and Wyoming through platforms such as the Utah Vehicle-to-Everything Maintenance and Management System (V2X MMS), the Operational Data Environment (ODE), and the Situation Data Exchange (SDX).

1.1. Document Purpose

The deployment of V2X systems produces significant volumes of data. For example, at intersections where numerous city fleet vehicles are equipped with On-board Units (OBUs), UDOT collects between 400,000 and 600,000 Basic Safety Message (BSMs) per intersection each day. Furthermore, each intersection can produce over 86,000 Map Data Messages (MAPs) and 860,000 Signal Phase and Timing (SPaT) messages each day. In addition to these messages, Signal Request Messages (SRM), Signal Status Messages (SSM), and Traveler Information Messages (TIMs) are also produced.

As the CTW Program expands and more roadside and in-vehicle devices are deployed, data generation is expected to reach tens of billions of messages each month. Moreover, the involvement of three state agencies – UDOT, CDOT, and WYDOT – in the CTW Program brings unique requirements and constraints related to data management. These differences are carefully considered to address anticipated challenges, such as handling duplicate, erroneous, or conflicting data for the CTW Program

Data Plan. The goal is to enable widespread data sharing for operational use, program management, and public transparency—ultimately supporting the development of a coordinated and effective data strategy.

This Data Plan outlines how V2X data will be managed for use by the CTW Program partners, research institutions, the public, and other stakeholders. It supports applications such as transportation planning, performance monitoring, safety analysis, and research. The plan focuses specifically on data processes and management during Phase 2 – Operation and Evaluation of the CTW Program, which includes a 12-month operational period followed by a minimum of five years of post-deployment maintenance.

Key areas of focus include:

- **Data Collection, Archival, Management, and Distribution:** Establishing practices for capturing and sharing data from various sources to support transportation administration, policy assessment, planning, safety, operations, and research.
- **Data Formatting and Metadata:** Defining data attributes, collection conditions, and transformation processes to ensure data is interpretable and traceable.
- **Preparation for Reporting Systems:** Developing data processes and products that align with federal, state, and local reporting requirements.

The data plan is also designed to establish clear operational procedures aligned with the data-related components of several key deliverables, including:

- Concept of Operations (ConOps)
- Systems Engineering Management Plan (SEMP)
- System Requirements Specifications (SyRS)
- Performance Measurement and Evaluation Plan (PMEP)

The Data Plan also evaluates the type, volume, and frequency of data generated through deployment activities, ensuring that the data can be effectively processed and delivered end-to-end to all designated users and recipients. It also defines quality control procedures for V2X data and addresses protocols for managing data that contains personally identifiable information (PII) or other sensitive elements subject to privacy or regulatory constraints.

1.1.1. Approach

This Data Plan has been developed with a focus on capturing V2X messages and associated data that are directly tied to performance measurement activities and reporting requirements for USDOT as part of the CTW Program. Rather than following a traditional model of ingesting and storing large volumes of raw source data for post-processing, this plan is built around the operational reality of V2X systems, where raw data sources are already being actively used to generate V2X messages as part of their normal functionality. These messages—including SPaT, MAP, TIM, SRM, SSM, and Sensor Data Sharing Messages (SDSMs) —and event reports represent the processed, actionable information disseminated by the system in real time, and will also serve as the primary data captured for performance evaluation and grant reporting.

This plan acknowledges the existence of the existing underlying raw data sources and the operational processes that transform these data into V2X messages. The specific methods used to ingest, process, and distribute V2X messages are considered part of the existing and proposed systems and are thus not defined in this document. This Data Plan intentionally leverages those defined operational processes, integrating data capture activities within them wherever feasible, and provides additional workflows necessary to capture these messages and move them into data storage systems for later analysis and dissemination to the public.

1.2. Relevant Sources

The development of this Data Plan is informed by several key resources and supporting documents:

- ConOps – Developed by UDOT for the CTW Program, the ConOps outlines user needs and describes the proposed system from a user perspective. It includes use cases, operational concepts, and scenarios that provide the operational context necessary to define data needs and flows across the CTW Program life cycle.
- SEMP – The SEMP details how UDOT will oversee systems engineering activities. It establishes the technical framework for managing the CTW Program by providing a structured approach to the engineering life cycle to confirm that all systems are designed, implemented, tested, and maintained in alignment with the program's goals.
- SyRS – The SyRS describes a set of requirements that will satisfy the expressed needs of the overall CTW Program system comprised of existing systems, communications infrastructure, ITS and Connected Vehicle infrastructure, and other supporting systems.
- Project Management Plan (PMP) – The PMP defines the CTW Program's scope, objectives, schedule, roles and responsibilities, resource allocations, and governance structure.
- PMEP – The PMEP documents the goals and objectives for the CTW Program; provides performance measures and targets; and details the data inputs, methodologies, and reporting strategies. It also discusses the risks in measuring metrics and how to mitigate some of those risks.
- The USDOT Privacy Policy and USDOT Public Access Plan were reviewed to ensure the Data Plan aligns with federal requirements for data privacy and public access.
- Privacy Management Plan – The Privacy Management Plan aligns with applicable state privacy laws for the deployment region and followed by the Notice of Privacy Management Consistency.

The Data Plan is developed in compliance with USDOT policies and guidance, including:

- The USDOT Data Management Strategy.
- The USDOT Departmental Privacy Risk Management Policy.
- The FHWA Records Disposition Manual.
- 23 United States Code (U.S.C.) § 409 ("Section 409").

1.3. Project Overview

The CTW Program is one of three V2X Accelerator program sites awarded contracts by the Federal Highway Administration (FHWA) in 2024. The CTW Program is led by UDOT with partners WYDOT and CDOT. The CTW Program's efforts also include local agencies within each state, some of which are partners in the process and others as participants. General Motors (GM) will provide a V2X-equipped vehicle to the CTW Program. This vehicle will create and consume V2X data.

The focus of the CTW Program is to expand the use of existing V2X applications in Utah, Wyoming, and Colorado and to share messages among the CTW Program states. The V2X applications that are anticipated to be deployed are:

- Connected Intersection Preferential Treatment (CIPT), including transit priority and emergency vehicle and snowplow pre-emption.
- Traveler Information Messages (TIM) and driver alert delivery, such as Curve Speed Warning (CSW), Spot Weather Impact Warning (SWIW), work zones, variable speed limits (VSLs), road closures, chain law restrictions, and disabled vehicle alerts.
- Detection of Vulnerable Road Users (VRUs) at intersections coupled with in-vehicle and roadside alerts to drivers about VRU presence and intersection movements.

The scope of the CTW Program includes the following deployment activities:

- Install Roadside Units (RSUs) at signalized intersections (SIs) in Utah.
- Install RSUs at additional sites along corridors in Utah and Colorado.
- Equip additional intersections with VRU detection and warnings in Utah.
- Equip additional vehicles with On-Board Units (OBUs) and Human-Machine Interfaces (HMIs) where appropriate in Utah, including transit buses, snowplows, emergency vehicles (fire engines and ambulances), and general fleet vehicles including a GM test vehicle that will be driven by UDOT staff.
- Expand the coverage of all use cases currently being used in all CTW Program states.
- Establish the use of the SDX across jurisdictions to share event data and make event notifications and TIM messages uniform, interoperable, and available across platforms in all CTW Program states.
- Expand the use of the Connected Intersection Message Monitoring System (CIMMS) in Utah, to monitor ongoing compliance with standards.
- Establish the use of security certificates and OBU certificate top-off to facilitate interoperable communications in all CTW Program states.

The CTW Program will also:

- Perform rigorous testing to verify that Connected Intersections (CIs) meet the Connected Transportation Interoperability (CTI) 4501 and other standards and transmit interoperable messages in Utah and Colorado.
- Document and broadly share a replicable model that serves as a valuable reference implementation for interoperable connectivity.

The scope of this CTW Program is limited to the additional equipment, components, and functions that are expanding upon existing systems that are operating in Colorado, Utah, and Wyoming. The aforementioned activities are organized into seven projects described below:

- **Project 1: Utah Signalized Intersection (SI) RSUs**. This project will install RSUs at state-owned SIs in Utah (i.e., about 488 SIs) and some local agency-owned intersections. Intersections will be enabled with appropriate messages and applications.
- **Project 2: Utah Interstate and Rural Corridor (IRC) RSUs.** This project will install over 220 RSUs along major interstates in Utah at appropriate intervals to support a variety of TIM messages and along some non-interstate rural corridors to primarily support CSW and SWIW applications. Appropriate messages and applications will be enabled.
- **Project 3: Utah VRU Safety at Intersections.** This project will install Light Detection and Ranging (LiDAR)-based detection, TIM broadcasts, and electronic signs at 20 urban intersections in Utah to issue warnings about VRU presence and collision risk.
- **Project 4: Colorado Interstate 70 (I-70) Expansion and Integration.** This project will install about 43 RSUs along the remaining portions of I-70 in Colorado to the Utah border that do not have coverage. Appropriate messages and applications will be enabled.
- **Project 5: Application Integration and Interoperability Testing.** This project will bring all the agencies together to synthesize their applications, bring their applications into uniform compliance with standards and guidelines, integrate the event data into the SDX, and perform detailed testing across all the jurisdictions to identify and overcome challenges and bring systems into conformance, making them interoperable.
- **Project 6: System Performance, Measurement, and Evaluation.** This project will include the evaluation efforts to assess the performance of the CTW Program systems, report on those metrics, and account for confounding factors. A variety of testing methods and data analyses will be engaged, including using the purpose-built GM vehicle to confirm interoperability and produce data about the ultimate usefulness of our system to the end user, which is the vehicle and its driver.
- **Project 7: Project Administration, Reporting, and Outreach.** This project will include all project management functions from the creation of the PMP to the monthly reporting and participation in outreach and engagement efforts outlined in the Outreach and Engagement Plan.

1.4. Organization of the Report

The Data Plan is organized into the following chapters:

- Chapter 1. Introduction – Outlines the purpose and approach of the data plan, highlights relevant data sources, and provides an overview of the CTW Program.
- Chapter 2. Planning – Establishes the foundational framework for data management within the CTW Program by outlining data needs, illustrating data flow, and detailing strategies to ensure data privacy. It also provides a timeline for key data-related activities.
- Chapter 3. Acquire – Focuses on the acquisition of data essential to the CTW Program, detailing the sources, collection considerations, and overall compliance requirements. It provides an overview of relevant datasets, highlighting contributions from major partner agencies.

- Chapter 4. Process – Outlines the methods and standards applied to prepare, validate, and manage CTW Program data along with the procedures for managing updates and maintaining consistency across evolving datasets and formats throughout the CTW Program life cycle.
- Chapter 5. Store – Explains how CTW Program data is stored, managed, and protected across multiple platforms and provides an overview of the storage systems used by the CTW Program partner agencies. Access controls, data retention policies, and system limitations to ensure security and compliance are also briefly discussed.
- Chapter 6. Analyze – Discusses how the PMEP addresses the caveats associated with data analysis.
- Chapter 7. Reuse and Sharing – Describes the policies and practices that facilitate the effective reuse, redistribution, and sharing of CTW Program data. The metadata section highlights its importance in ensuring data is understandable and accessible, detailing the various metadata types, their structure, and the processes in place to keep them accurate and up to date.
- Chapter 8. Archive and Retire – Provides a concise overview of the data documentation process and outlines how partner agencies will manage CTW Program data.
- Chapter 9. Privacy Management Plan – Documents state and local privacy laws applicable for the data and code.
- Appendix A: Glossary

2. Planning

2.1. Data Needs Summary

The CTW Program will collect data to meet two primary objectives:

- **Compliance with USDOT Grant Requirements.** In alignment with USDOT guidelines, all datasets collected, generated, or acquired as part of the CTW Program are required to adopt an open license. For the purposes of this Data Plan, an “open license” is interpreted as a framework that permits unrestricted public access, reuse, and redistribution of datasets with minimal limitations, in alignment with federal open data policy. This interpretation draws from practices established in the Connected Vehicle Pilot program, where sanitized and anonymized data were stored in a USDOT System such as the Intelligent Transportation Systems (ITS) DataHub to support independent evaluation and public innovation. The CTW Program intends to adopt a similar approach, ensuring that V2X data collected during the operational period are made openly available under terms that promote transparency, accessibility, and broad reuse. Since the CTW Program will generate very large data sets, the team will coordinate with FHWA to identify specific, concise sets of data, which will be shared on USDOT systems for public use.
- **Generation of Performance Measures.** Data collection efforts will focus on supporting the development of performance measures that evaluate system effectiveness, reliability, safety outcomes, and operational efficiency. These performance measures will inform program reporting, system optimization, and future investment decisions.

Key data categories of data that will be collected include V2X message exchange data, data generated from V2X message processes, and other raw and supplementary data. The primary emphasis is placed on capturing V2X message exchanges between RSUs and OBUs, including message types such as BSMs, SPaT, MAP, TIM, and other communications. Data outputs produced by applications or processes that use V2X messages as inputs will also be collected. This includes event reports and weather data, for example. Additional raw data from external or ancillary sources not directly processed by the V2X system but useful for generating contextual or complementary performance measures will also be collected. These datasets will be collected, managed, and shared in accordance with USDOT open data standards and program-specific data governance practices.

The CTW Program captures V2X messages that RSUs broadcast. Furthermore, as vehicles with OBUs travel and operate, they transmit V2X messages, which are collected by RSUs and transferred to each partner agency’s Central System. The CTW Program also makes use of an SDX, which allows traveler information (in the form of event reports and TIMs) to be shared between the three partner agencies.

To support the CTW Program’s objectives of improving mobility and saving lives through V2X technology, it is essential that collected data be accurate, consistent, and reliable. Given the significant volume of data anticipated during the 12-month operational period, the Data Plan accounts for data storage needs spanning the operational period. V2X data will be shared with USDOT in accordance with the protocols outlined in this Data Plan, including associated metadata.

2.2. Data System Diagram

The data system in its entirety for CTW program is shown in Figure 1 and explained below. Each CTW Program partner (UDOT, CDOT, WYDOT) operates and maintains its own set of V2X infrastructure and supporting services and will continue to do so under this grant. The main components for UDOT are the UDOT TIM data sources, field V2X devices, field sensors, traffic signal controllers, Radio Technical Commission for Maritime Services (RTCM) data sources, and V2X MMS. The main components for CDOT are TIM data sources, field V2X devices, and ODE. The main components for WYDOT are TIM data sources, field V2X devices, and ODE. Each state's systems share traffic event data and TIM messages through the SDX and send V2X data to the USDOT's system.

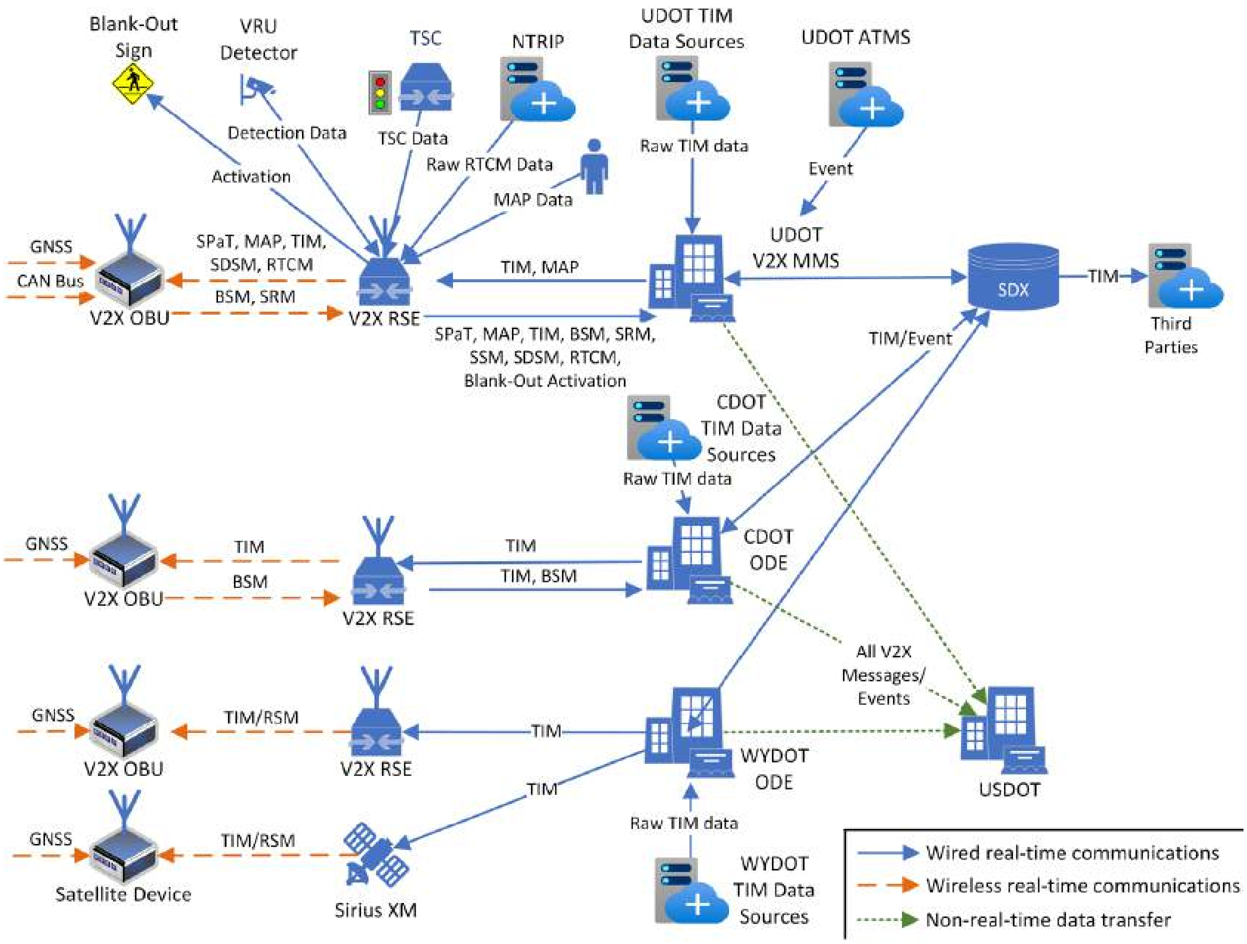

Figure 1. Site Data System Diagram
Source: WSP, January 2026

Each CTW Program partner agency operates its own V2X Roadside Equipment (RSE) and Central System platforms, and each partner agency's V2X RSE is responsible for processing data and broadcasting and receiving V2X messages over a Direct V2X interface to enable V2X applications.

Each agency's RSE is connected to a respective agency-managed network through secured firewall configurations, enabling two-way data traffic between field devices and the Central Systems. As far as Central Systems go, UDOT used the Cirrus platform developed by Panasonic up through late 2025 and will replace that system with the iNET platform developed by Parsons and Taplane in early 2026. These two platforms provide very similar capabilities; the transition does not represent any significant changes. This new system will be known as "Connected Utah." Although iNET has many Advanced Traffic Management System (ATMS) functions, UDOT will be leveraging only the V2X-related modules in iNET. While Cirrus was referenced regularly in earlier versions of this Data Plan, most of those references now reflect a more generic term: the UDOT V2X MMS, which includes both Cirrus and iNET / Connected Utah. CDOT and WYDOT use their respective ODE systems, both developed by Trihydro. The information below explains the data environment in the context of this program.

UDOT's V2X MMS platform is a cloud-based V2X system that supports CIs by collecting and storing V2X messages sent and received by RSE, providing monitoring and management support for CI operations, and ingests TIM data to generate and distribute TIM/event reports. Event data reports are also generated by the UDOT ATMS system. The UDOT V2X MMS sends these event reports to SDX, a common data hub used by all three agencies and by third parties. UDOT V2X MMS currently has V2X message storage capabilities that will be used to store V2X messages associated with the CTW Program that are broadcast and received by UDOT RSE during the CTW Program operational period.

UDOT RSE transmits, receives, processes, and relays a variety of messages including SPaT, MAP, TIM, BSM, SRM/SSM, SDSM, and RTCM. They also interface directly with Traffic Signal Controllers (TSCs), VRU detectors, and blank-out signs to receive the information necessary to populate these V2X messages and to otherwise provide the functionality necessary to enable V2X applications.

The CDOT ODE supports CI operations by providing monitoring and management functions, ingesting TIM data to generate and distribute TIM/event reports and storing both BSMs and TIM/event reports. TIM/event reports generated by CDOT are shared with the SDX, while reports received from the SDX are used to create and broadcast TIM messages through Colorado's RSE. The RSE, in turn, transmit TIMs to OBUs and collect BSMs from OBUs, forwarding them back to the CDOT ODE. The CDOT ODE currently has V2X message storage capabilities that will be used to store V2X messages associated with the CTW Program that are broadcast and received by the CDOT RSE during the CTW Program operational period.

Similarly, the WYDOT ODE provides monitoring and operational support for CI activities, ingests TIM data to produce and distribute TIM/event reports, and stores these reports locally. WYDOT shares its TIM/event reports with the SDX, while also receiving event reports from the SDX to generate and disseminate TIM messages via Wyoming's RSE and SiriusXM. WYDOT's RSE broadcast these TIMs to OBUs in the field, while SiriusXM distributes the messages to its subscriber network. The WYDOT ODE currently has V2X message storage capabilities that will be used to store V2X messages associated with the CTW Program that are broadcast and received by the WYDOT RSE during the CTW Program operational period.

The USDOT Data Repository provides a final destination for CTW Program messages and event reports that are to be publicly shared with an open license. This centralized platform collects and stores transportation-related data, making it accessible to the public. By offering an open license, the repository ensures that the data can be freely used, modified, and distributed, fostering innovation and collaboration within the transportation community.

2.3. Data Privacy Plan

The CTW Program is committed to safeguarding the privacy and security of all data collected, transmitted, and managed as part of its connected vehicle (CV) and transportation technology deployments. As the program involves the collection of data from vehicles, roadside infrastructure, and other transportation systems, it is essential to ensure that PII and other sensitive data are adequately protected. This Data Privacy Plan (DPP) outlines the policies, procedures, and technical safeguards the program will implement to address data privacy risks and comply with applicable federal, state, and local privacy regulations.

The plan includes a Privacy Assessment section, which evaluates the types of data collected, identifies any potential privacy risks, and documents mitigation strategies to address those risks. In addition, a Security Requirements section establishes the standards and protocols for protecting data throughout its life cycle from collection and transmission to storage, access, and eventual disposal. Together, these components form the foundation of the CTW Program's approach to responsible, secure, and transparent data management.

2.3.1. Privacy Assessment

Although the CTW Program does not intentionally collect or store PII, it is important to carefully assess any data elements that could, directly or indirectly, be associated with a person or an identifiable object linked to them, such as a vehicle. The principle of confidentiality is central to the CTW Program's approach to privacy protection, particularly for location-based data collected from CVs and VRUs. While the CTW Program does not collect explicit PII, it recognizes the potential privacy implications associated with location-based data from CVs and VRU detection systems. The privacy risks associated with the data collected and the mitigation measures the CTW Program will implement to protect individual privacy are further detailed in Section 2.3.2.

2.3.2. Security Requirements

2.3.2.1. Data Sensitivity Classification

To properly manage privacy risks, the CTW Program has established a data classification process that groups these data types based on sensitivity. Data are categorized by the potential privacy concerns they present if improperly accessed or disclosed. Data that could potentially raise privacy concerns include information originating from a vehicle or data that contains details about the location of individuals detected. With the exception of the BSM and SDSM, all other V2X messages are considered low risk.

BSMs present a risk of exposing PII, since location along with other data in the BSM could potentially be linked back to individual drivers or vehicles to infer personal movement patterns if improperly handled. While vehicles equipped with OBUs as part of the CTW Program are publicly owned agency vehicles, which typically limit the need for privacy protection for these vehicles, other V2X-equipped vehicles may be present in the geographic area covered by the CTW Program and may produce V2X messages that are captured. Therefore, the CTW team must be prepared to handle this data accordingly.

Similar to BSMs, SDSMs contain geolocation details that, while not directly containing names or personal details, could theoretically be pieced together to infer personal movement patterns if measures are not taken.

Even though an SRM contains a location and a vehicle identifier similar to BSM, they are not typically broadcast on a continuous basis and are considered low risk. However, any request for priority or preemption is considered active engagement with the operating agency, so any vehicle that sends an SRM to request priority (even those outside of the CTW Program) is considered public in nature. It is important for an agency to understand the requests being made at its intersections, as these requests have the potential to significantly affect the operational performance of the system and the overall traffic flow. UDOT policy requires knowledge about which vehicles' priority or preemption is being provided to. By capturing SRMs, an agency can gain valuable insights into these impacts and make informed decisions to optimize the system's efficiency and effectiveness.

2.3.2.2. PII and Re-identification Risk

There are two primary types of data collected by the CTW Program that have the potential to be indirectly associated with individuals or vehicles: SDSM from VRU detections and BSMs from vehicles.

The SDSM is generated using data from roadside sensors designed to detect VRUs, such as pedestrians or cyclists. While these messages include geographic location data indicating where a pedestrian or VRU is detected, they do not contain explicit PII such as photos/images, names, phone numbers, or unique device identifiers. The geographic scope of these detection systems is intentionally limited to the immediate vicinity of a single intersection. Sensors are configured not to detect VRUs outside of the public right-of-way and are not positioned closely enough to one another to allow for continuous tracking of a pedestrian throughout a transportation network. As a result, detections remain anonymous and localized, without the ability to infer origins, destinations, or travel patterns across multiple locations.

BSMs broadcast by OBUs represent other data that have potential privacy implications. While a single BSM does not contain explicit PII, sequences of BSMs from the same vehicle, especially when cross-referenced with other available datasets, could be used to reconstruct vehicle trajectories or identify travel patterns. While these OBUs have security certificates that rotate and are designed to rotate the vehicle identifier in the BSM (every 5 minutes), a dataset that contains streams of BSMs from vehicles as they traverse an agency's roadway network (or any location within communications range of its RSUs) has the potential to be used to reconstruct trips taken by individuals.

For the CTW Program, all OBUs currently deployed and those planned for deployment are installed on public agency fleet vehicles, for which there is no expectation of personal privacy. However, it is possible that BSMs from privately owned vehicles may be captured by the system. Because these BSMs may expose location data associated with a small subset of the population like vehicles traveling to sensitive locations or engaging in identifiable travel patterns, privacy protections must be carefully applied to mitigate the risk of unintentional disclosure.

2.3.2.3. Data Transmission and Storage Security

All data communicated over each agency's physical network layer are encrypted using secure communication protocols, such as Transport Layer Security (TLS), to prevent unauthorized interception. Both UDOT and CDOT utilize a closed-system fiber backhaul from the RSUs to the Central Systems (V2X

MMS and ODE, respectively), and WYDOT uses a combination of fiber and cellular communications to enable system communications.

When data are stored, encryption techniques like Advanced Encryption Standard (AES-256) are applied to ensure that stored information remains protected against unauthorized access. Data storage is protected with physical security, like locked server rooms, and digital safeguards, such as firewall, access controls, and security monitoring for secure cloud servers. Access logs to Central Systems are maintained to monitor access to data. Personnel will be assigned to oversee data access and ensure that no irregularities occur due to any user, with reviews conducted at least monthly.

2.3.2.4. Data Anonymization and De-identification

Each of the three partner agencies already collects V2X data as part of its current operations and will continue to do so once the grant operational period goes into effect. Current data collection practices conform to the privacy policies and security protocols that govern each agency's V2X data storage and handling. No changes to existing privacy protection practices are planned for data stored on partner agency Central Systems during the operational period.

However, before any of this data is transmitted to the USDOT repository for public release under an open license, additional measures will be implemented to remove or obfuscate any elements that could allow individual vehicles, infrastructure assets, or travel patterns to be identified. This process will include the removal of direct identifiers (e.g., device IDs, vehicle IDs), spatial and temporal aggregation to prevent tracking of specific trips, and application of data smoothing or masking techniques to reduce the risk of re-identification from repeated patterns. These steps are necessary to ensure the resulting datasets are privacy-preserving while still retaining sufficient fidelity to support research, innovation, and public use in alignment with USDOT's open data objectives.

To address the potential risks associated with V2X data, the CTW Program will implement a series of anonymization and de-identification techniques prior to data being sent to the USDOT repository, including:

- **BSM Privacy Protection.** All BSM data collected for long-term storage and performance measure generation on each of the three partner agencies' Central Systems will be processed through a privacy filtering mechanism prior to being sent to the USDOT repository. This mechanism reviews BSMs and determines whether each message should be retained or suppressed based on its location relative to designated geofences. For retained messages, certain fields are redacted (such as vehicle size) or masked (such as the vehicle identifier) to reduce the risk of associating individual messages with a person or private vehicle. The de-identification process occurs in near real-time as data flows into the storage system. Similar approaches are already in operational use by other agencies, such as the Privacy Protection Module (PPM) implemented by WYDOT.
- **SDSM Privacy Protection.** Roadside sensors for VRU detection are deployed with deliberate constraints. Their detection zones are limited to the immediate intersection area and public right-of-way, and sensors are positioned such that continuous detection or tracking of a pedestrian or cyclist beyond a single location is not possible. This strategy ensures that SDSM data remains anonymous and cannot be used to reconstruct travel paths or link detections to identifiable individuals. To ensure that any SDSMs representing VRU locations outside of transportation corridors are properly handled,

a similar privacy filtering mechanism is applied to review each message and determine whether it should be retained or suppressed based on its location relative to designated geofences.

- **SRM Privacy Protection.** As described previously, agencies have an operational need to monitor priority and preemption requests being made at their intersections and retaining full details of these messages in their Central Systems is essential for traffic management and system performance analysis. However, for the USDOT repository, the same level of detail is not necessary and SRM data should be treated as potentially private. Therefore, before being sent to USDOT, each SRM will be processed through a privacy filtering mechanism similar to that applied to BSMs to determine whether the message should be retained or suppressed based on its location relative to designated geofences. For retained messages, certain fields will be masked (such as the vehicle identifier) to reduce the risk of associating individual messages with a specific person or vehicle.

2.3.2.5. Data Control

2.3.2.5.1. Data Access

Only authorized individuals have access to the sensitive data managed by the CTW Program — that is, V2X data stored on partner agency Central Systems. Roles have been clearly defined to ensure that access to raw or sensitive data is limited to those whose duties require it. For example, program analysts may review anonymized system performance data, while system administrators responsible for maintaining the servers can access back-end logs without accessing identifiable message content.

Access to these systems is managed through role-based access control (RBAC), where permissions are tied to specific job functions. Authentication tools, including strong password policies and multi-factor authentication, further protect against unauthorized access.

Data access to the USDOT repository (outside of the scope of the CTW Program) is expected to be in accordance with providing an open license for data sharing.

2.3.2.5.2. Data Use Policies

To protect privacy throughout the program's life cycle, data use agreements are in place for anyone handling sensitive information including V2X messages stored on partner agency Central Systems. These agreements detail how data may be used, privacy expectations, who can access it, and when it must be deleted or returned. This ensures that sensitive information is handled consistently and responsibly, even when shared with contractors, partner agencies, or academic researchers.

Data use policies for the USDOT repository (outside of the scope of the CTW Program) are expected to be in accordance with providing an open license for data sharing.

2.3.2.6. Compliance with Privacy Laws and Regulations

The CTW Program is committed to complying with all applicable federal, state, and local privacy requirements. Federal laws such as the Privacy Act, the Fixing America's Surface Transportation (FAST) Act, the Cybersecurity Information Sharing Act (CISA), and the Federal Information Security Modernization Act (FISMA) guide how transportation data are collected, stored, and shared. UDOT, CDOT, and WYDOT also have state- or agency-specific data privacy mandates, and those regulations must also be followed (ee Section 9). The Privacy Management Plan itself will be reviewed on a routine basis (and updated if needed) to ensure it remains effective and reflects current privacy expectations.

To further protect against privacy risks, the CTW Program will conduct regular audits of datasets to check for the possibility of re-identifying individuals. If a risk is identified, corrective measures will be taken immediately to adjust data processing techniques and strengthen anonymization protocols.

When users access the CTW Program data stored on partner agency Central Systems, they will be required to acknowledge their awareness and adherence to state- and agency-specific privacy mandates. This ensures that everyone involved in the program understands their responsibilities, the importance of protecting personal privacy, the risks of handling sensitive data, and why careful management is crucial.

The CTW Program partners will develop and maintain comprehensive data schemas and dictionaries for all datasets generated through the CTW Program. These resources will ensure consistent, clear documentation of the data's structure, contents, and organization, supporting both internal data management and public data release requirements at the conclusion of the CTW Program.

Each dataset will be accompanied by a data schema that defines the organization and structure of the data, including field names, data types (e.g., integer, string, and timestamp), units of measure, and any relationships between fields or tables. Alongside each schema, a data dictionary will provide detailed descriptions of each data element, including definitions, acceptable value ranges, and notes on any special handling or limitations. Where appropriate, the schema and dictionary may be combined into a single document for ease of use.

The CTW Program benefits from the involvement of three partner agencies, each of which maintains existing data repositories and has experience managing V2X and other transportation data from prior deployments. Where data collected or generated as part of the CTW Program aligns with existing data types and practices, current schemas and data dictionaries will be utilized to maintain consistency and efficiency in data management. This approach ensures alignment with proven data handling procedures and reduces duplication of effort.

For any new or modified data types or datasets unique to the CTW Program, new data schemas and dictionaries will be developed for each respective deployment site as needed. These new resources will follow the same standardized methodology for defining, documenting, and maintaining data structures and element descriptions.

All schema and dictionary documents will be maintained and accessible to CTW Program partners throughout the program's life cycle. The repository location and naming conventions will be documented in the program's data management records.

For data required to be submitted to USDOT as part of the grant, a final, public-release version of each corresponding data schema and dictionary will be prepared at the end of the CTW Program in accordance with USDOT ITS Joint Program Office (JPO) DataHub Submission Guidelines. These resources will be transferred to the USDOT alongside the applicable datasets for public access. This ensures that external users have the necessary documentation to understand, interpret, and responsibly use the publicly released data.

2.4. Data Schedule

Phase 1 of the CTW Program involves development of the PMP, systems engineering documentation, PMEP, and Data Plan. It also includes the design and deployment of V2X hardware and applications. In Phase 2, the system must be maintained in an operational state for the purpose of determining operational impacts, costs, and technical insights. The collection of data related to the impact of the deployment cannot be less than 12 months and no more than 24 months.

The timeframe covered by this Data Plan corresponds to the pre-deployment data collection as part of Phase 1 and data collection during Phase 2 operational period. The CTW Program phases defined by the USDOT in their Notice of Funding Opportunity include the following key events or deliverables (see also Figure 2):

- Phase 1: Finalize Design, Build, and Test (months 0 to 18):
  - Months 0 (award) to 6: Kickoff, PMP, and the beginning of the interoperable connectivity cohort participation (which extends through the Post-Deployment phase).
  - Months 6 to 12: Systems engineering documents, PMEP, and Data Plan.
  - Months 12 to 18: Design/Test Webinar and testing results, ending the phase at the Go/No-Go decision point.
- Phase 2: Operate and Evaluate (months 18 to 30):
  - Months 18 (Go/No-Go decision point) to 24: Performance reports.
  - Months 24 to 30: Multi-site interoperability test results and Operate/Evaluate Webinar, ending the phase at the transition to post-deployment.
- Post-Deployment: Operate and Maintain (months 30 and extending a minimum of 5 years):
  - No noted key events or deliverables, as the focus is on operation and maintenance post-deployment.

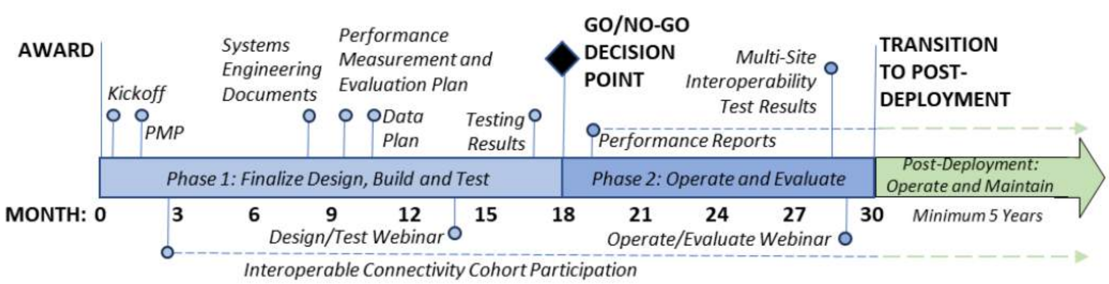

Figure 2. Phases of the CTW Program Initiative
Source: USDOT, October 2023

During the execution of Phase 1, UDOT asked for, and the USDOT granted, two extensions to the Phase 1 period of performance. These extensions increased the duration of Phase 1 from 18 months to 24 months. This pushes the beginning of Phase 2 until month 25. For UDOT, Phase 2 is expected to span 12 months, beginning in October 2026, marking the start of the deployment data collection activities required for the grant. All data processes related specifically to grant reporting are scheduled to conclude at the end of this 12-month operational period.

As shown in Figure 3, Phase 1 began in April 2025. Through May 2026, UDOT will develop both the draft and final Data Plan and PMEP. June 2026 through September 2026 will be dedicated to pre-deployment baseline data collection and performance reporting to support the Phase 2 operational deployment.

In October 2026, Phase 2 will begin, and deployment data will be collected and performance reported. Phase 2 and data collection will end a year later in October 2027. From November 2027 and beyond, data will be shared from the deployment and then the data will be archived/retired.

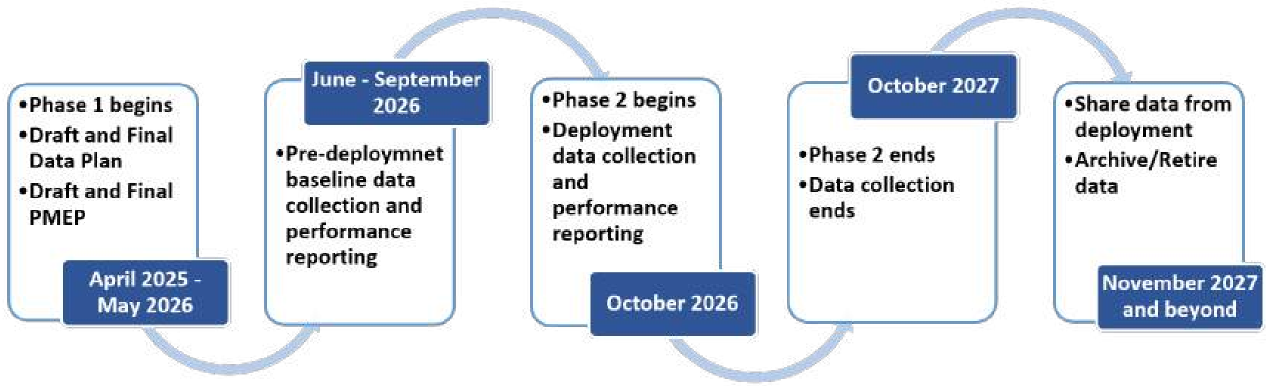

Figure 3. Data Schedule
Source: WSP, January 2026

Some data collection and processing activities may continue beyond Phase 2 to support ongoing operations and maintenance. These efforts are expected to extend through the minimum five-year maintenance period following the required operational period. If needed, UDOT may choose to develop a post-deployment data plan to continue evaluating the system's effectiveness.

3. Acquire

3.1. Acquired Data

The major input data flows into each agency's system either from direct data collection or from acquiring data from external sources. Such sources include V2X data and non-V2X data. V2X data is collected as it gets received. The major sources used by UDOT and its partners for the CTW Program are provided in this section.

3.1.1. UDOT NTRIP RTCM Data Source

UDOT provides high precision Global Navigation Satellite System (GNSS) data using The Utah Reference Network (TURN) that utilizes the Trimble Pivot Virtual Reference Station (VRS) Platform. TURN delivers data via the Networked Transport of RTCM via Internet Protocol (NTRIP). Utah CIs access the NTRIP server for RTCM messages. However, the TURN system is limited by how many UDOT devices can request position correction data.

The Continuously Operating Reference Station (CORS) provides GNSS data supporting three-dimensional positioning, meteorology, space weather, and geophysical applications. Metadata is provided in HTML and XML. The stations are independently owned and operated by agencies. Each agency shares their GNSS carrier phase, code range measurements, station metadata with National Geodetic Survey (NGS), which are analyzed and distributed free of charge. The CTW Program pulls CORS network data for RTCM.

3.1.2. UDOT TIM Data Sources

Already existing UDOT TIM data sources are utilized for the CTW Program applications. UDOT provides access to various traffic-related data through its Traffic Developer Portal with the Application Programming Interface (API) supporting 10 calls every 60 seconds. This API allows information extraction from TIM data sources such as Road Weather Information Station (RWIS), ATMS VSL, General Transit Feed Specification (GTFS), and Work Zone Data Exchange (WZDx).

The UDOT center-to-center (C2C) feed supports standardized data formats, including the Traffic Management Data Dictionary (TMDD) and National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) 2306, ensuring interoperability with other traffic management systems. UDOT's C2C feed allows for the integration of real-time traffic data into external applications and systems, improving situational awareness and decision-making for users such as navigation apps, emergency responders, and traffic management centers (TMCs). The TIM data sources relevant to the CTW Program are provided below.

UDOT RWIS Network. The RWIS network is composed of weather-related sensors strategically positioned across the state. These stations measure various meteorological and road parameters including but not limited to wind speed and direction, present weather conditions (e.g., rain and snow), snow depth and solar radiation, visibility, and road temperature, and condition (e.g., dry, wet, or icy).

The data collected is integrated with the UDOT Traffic Operations Center (TOC), the 511 travel information line, and the UDOT traffic website and mobile app. Public access to real-time road weather conditions are available through the UDOT Traffic website and the 511 travel information line.

Forecasts are regular and can be accessed via the UDOT Traffic website and the UDOT Traffic mobile app. UDOT V2X MMS obtains RWIS data from the C2C feed.

UDOT ATMS. The UDOT system is managed by the UDOT TOC and utilizes data from road sensors, weather stations, and traffic cameras to assess conditions and adjust speed limits within specific zones to improve safety and maintain traffic flow. UDOT V2X MMS gathers data from VSL algorithms through the ATMS to generate VSL TIMs.

UDOT CAD/ AVL.[1] UDOT has employed Computer-Aided Dispatch (CAD) and Automatic Vehicle Location (AVL) systems to monitor real-time vehicle locations by tracking the exact positions of fleet vehicles, such as snowplows. This enables efficient dispatch of maintenance and emergency response vehicles. The CAD/AVL systems also facilitate seamless communication between field personnel and control centers, enhancing coordination during operations. The CAD/AVL data from Logan City will be used by the CTW Program.

GTFS Analytics Data. The Utah Transit Authority (UTA) offers comprehensive GTFS data on its transit services, including routes, stops, schedules, and fare information. This publicly available data on UTA’s developer portal can be accessed via GTFS Static Feed and GTFS-RT (Real-Time) Feeds. The GTFS-RT data will be feeding into the CTW Program to be used in analytics. The Connect Transit system, a bus system in Logan, Utah, also provides a GTFS-RT feed. This data is used to support the transit signal priority (TSP) triggering process for Connect Transit.

UDOT WZDx. UDOT WZDx will be sharing real-time work zone data to facilitate the dissemination of information about road events, such as lane closures and detours, through TIM messaging and to third parties like navigation apps and automated driving systems. UDOT's work zone data feed is registered with the USDOT's WZDx Feed Registry, which lists feeds from various jurisdictions that meet the WZDx specifications. This registry provides access to up-to-date metadata on work zone feeds and is part of the USDOT ITS DataHub, with the data pertaining to standards as stipulated by USDOT.

[1] See UDOT’s article “UDOT Secures Funds to Implement More Efficient Digital Construction Technology,” published March 19, 2024.

3.1.3. UDOT Traffic Signal Controllers

The signal controller maintains a time clock and provides the Traffic Signal Controller Broadcast Message (TSCBM). The TSC at each CI outputs the current status of the signal controller (i.e., which signal groups are in green, yellow, and red phases and the time to the next phase change) using the TSCBM. Information output by the TSC reports the time from the time clock.

The TSC also grants priority or preemption calls (for the CIPT application) and uses NTCIP 1202 to provide data to the UDOT RSE, which is used to populate the SSM.

3.1.4. UDOT Field VRU Detection System

The UDOT field VRU detection system generates detection data from LiDAR scanners for populating the SDSM when a VRU is detected. VRU detection data is then sent to RSE, which generates, signs, and broadcasts the SDSM.

VRU/vehicle detections are also used internally to activate blank-out signs to warn of potential VRU-vehicle collisions.

3.1.5. GNSS and/or OBU Internal Sensors

GNSS provides time and location services for both RSUs and OBUs. OBUs primarily rely on GNSS signals to determine their precise latitude and longitude coordinates, enabling accurate positioning for CV applications. In addition to supporting location determination, GNSS also ensures time synchronization between OBUs and RSUs, which is essential for the coordination and timing of V2X messages and events across the system. Accurate time and location data are foundational to maintaining interoperability, safety, and performance in CV deployments.

GNSS provides updated time and position information only once per second. To achieve higher-resolution positioning, the OBU uses internal sensors—including, but not limited to, an accelerometer and gyroscope—to interpolate the position, speed, and heading at a rate of 10 times per second. Accelerometer data is used to populate acceleration fields (lateral, longitudinal, vertical, and yaw).

3.1.6. CDOT TIM Data Sources

CDOT V2X data comes from the RSUs and OBUs in their jurisdiction. The TIM data sources include:

CDOT ATMS. CDOT ATMS monitors and manages traffic flow across the state by integrating technology and infrastructure with TOCs acting as the management centers. A variety of traffic data can be obtained from the Online Transportation Information System (OTIS). Real-time and historical data on traffic signal performance is offered via the Automated Traffic Signal Performance Metrics (ATSPM) system.

Work Zone Speed Limit Reporting Forms. CDOT utilizes Form 568, known as CDOT Temporary Speed Limit, to document and authorize temporary speed limit reductions in work zones. The NueGOV application centralizes the submission, approval, and record-keeping processes.

The details reported in the form include reduced and regular speed limits, traffic direction, mile points (from and to), and the start and end times. The reasonable and safe prima facie speed limits authorized and declared in the form for the specified State Highway route or portion during the CTW Program period, when traffic is not otherwise regulated by special work area controls (e.g., flagger's warnings), supersede any previous conflicting declarations when official signs are posted. The data from these forms will likely be used to identify work zone locations and develop TIMs related to corresponding work zone speed limit restrictions.

CDOT WZDx. CDOT uses WZDx translator to convert work zone feed data into pseudo-TIM JavaScript Object Notation (JSON) messages. CDOT ODE then converts these into encoded TIM messages, which can be sent to the SDX or directly to RSUs. CDOT is currently working on transitioning over to a newer data feed (Connected Work Zone).

Weather and Road Conditions. The COtrip Traveler Information System provides comprehensive real-time data from RWIS, weather alerts, live traffic cameras, and construction and incident updates. The CTW Program accesses weather and road condition data using a specific CDOT feed.

Incident Feeds. COtrip Traveler Information System is a valuable resource for real-time traffic incident updates that collect data from live traffic cameras and weather-related alerts. The COtrip Planner app offers on-the-go access to real-time traffic information.

HAAS Alert. HAAS Alert is a real-time, cellular-based, digital alerting platform (Safety Cloud) designed to enhance roadway safety by notifying drivers of nearby hazards, such as emergency vehicles, work zones, and other roadside incidents. It delivers electronic notifications directly to drivers through navigation apps like Waze and in-vehicle infotainment systems in compatible vehicles. It also initiates responder-to-vehicle and responder-to-responder alerts. Fleet managers can monitor the location and alert status of equipped vehicles in real-time. CDOT utilizes information from HAAS Alert as one of its sources. A data feed from HAAS Alert supports TIM generation for the CTW Program.

SDX for sharing TIM messages across states. The TIM and event data stored in SDX by other agencies are retrieved by CDOT to generate TIMs.

3.1.7. WYDOT TIM Data Sources

WYDOT uses a variety of V2X and non-V2X data sources for populating TIM messages. The non-V2X data sources include RWIS (sensors mostly located to support VSL operations), National Weather Services, 511, Highway Patrol, and Citizen reports. Details about these sources can be found in the WYDOT Data Management Plan for the Connected Vehicle Deployment Program – Phase 2.

The incident and road closure TIMs and event reports are sent to the SDX, which are used to generate TIMs by Utah and Colorado. Event reports in the SDX are stored in the format described in Section 4.2.5. They use a select group of messages (based on location state border, severity, storm, etc.) for their respective TIMs.

3.1.8. Situation Data Exchange

The SDX serves as a central clearinghouse for the CTW Program, providing a platform for exchanging standardized TIM and event report data among partner agencies. It facilitates the distribution of these messages to partner Central Systems, which use the event reports to generate TIM messages that are spatially and temporally relevant within their respective states and then distribute them to the appropriate RSE for local broadcast.

In addition to supporting partner agency operations, the SDX enables the broader delivery of TIM messages to approved third-party data services, including smartphone navigation applications — helping extend traveler information beyond the roadside area. Throughout the CTW Program's operational period, the SDX could potentially function as a reliable, coordinated mechanism for message dissemination until the final datasets are provided to USDOT after the conclusion of Phase 2.

3.1.9. Compliance Considerations

There are no requirements. However, there is a privacy filtering mechanism associated as a function of each data center. It can be used to process BSMs, SDSMs, and SRMs before they are sent to the USDOT repository for public consumption, as described in Section 2.3. If there are private vehicles operating within the geographic area covered by the CTW Program, there is an approach in place to limit the accessibility to PII or individual vehicle information by such private vehicles. A privacy-preserving mechanism greatly reduces such data risks.

4. Process

4.1. Processing Overview and Flow

4.1.1. Transformation and Formatting

Data processes undertaken by the system and the inputs and outputs to each are outlined by components in the subsections below. These processes are described here to provide context; the exact transformations applied to the data are either part of existing workflows or, where new, will be formally defined within the SyRS and System Design Document (SDD). Additional steps have been included as needed to support the capture and storage of data for performance measurement and reporting purposes.

4.1.1.1. UDOT V2X MMS

UDOT V2X MMS serves as the primary repository for all data generated through the UDOT portion of the CTW Program deployment and provides monitoring and operational support for RSUs and other V2X devices. In addition to serving as the primary data repository, V2X MMS also plays a key role in processing and distributing data. It ingests real-time data feeds from data sources and RTCM position correction feeds and converts them into message payloads that are transmitted to RSUs. The role also includes storing the messages formulated for broadcast by the RSUs and storing the messages (and related data) received by the RSUs.

V2X MMS is also responsible for interfacing with the SDX, sending both event report and TIM messages to the SDX. Moreover, it uses event reports posted by other agencies on the SDX to generate TIM payloads, which are then delivered to the appropriate RSUs to support broader regional and cross-jurisdictional coordination.

V2X MMS formulates TIM messages that are sent to the Field Equipment for broadcast. The input, data processes, and outputs involved with the functions performed by V2X MMS are provided below. The UDOT V2X MMS processes are for the following functions:

- Weather information generation from BSM – see Table 1.
- TIM Generation (from weather information and data sources) – see Table 2.
- TIM generation (from SDX event reports) – see Table 3.
- Storing and archiving V2X message exchanges – see Table 4.

Table 1. UDOT V2X MMS Processes for Weather Information Generation from BSM
Source: WSP, January 2026

Function	V2X MMS Activity
Input	BSM from UDOT RSU
Process	1. Receive J2735 BSM from RSU 2. Store J2735 BSM 3. Generate weather information 4. Store weather information
Output	Weather information stored on V2X MMS

Table 2. UDOT V2X MMS Processes for TIM Generation (From Weather Information, Data Sources)
Source: WSP, January 2026

Function	V2X MMS Activity
Input	Weather data (from V2X MMS) and TIM data (from UDOT TIM data sources)
Process	1. Receive and process data from UDOT traveler information data sources and from BSM-based weather data 2. Generate J2735 TIM and event report 3. Determine which RSU(s) J2735 TIM should be broadcast from 4. Send J2735 TIM to RSU(s) 5. Send J2735 TIM and event report to SDX 6. Format J2735 TIM and event report 7. Store J2735 TIM and event report
Output	1. J2735 TIM messages and event report to applicable UDOT RSUs 2. J2735 TIM messages and event report stored on V2X MMS 3. J2735 TIM messages and event report to SDX

Table 3. UDOT V2X MMS Processes for TIM Generation (From SDX Event Reports)
Source: WSP, January 2026

Function	V2X MMS Activity
Input	Event report from SDX
Process	1. Receive event report from SDX 2. Use event report to generate J2735 TIM 3. Determine which RSU(s) the J2735 TIM should be broadcast from 4. Send J2735 TIM to applicable RSU(s) 5. Send J2735 TIM to SDX 6. Format J2735 TIM 7. Store J2735 TIM and event report

Function	V2X MMS Activity
Output	1. J2735 TIM messages to applicable UDOT RSUs 2. J2735 TIM messages and event report stored on V2X MMS 3. J2735 TIM messages to SDX

Table 4. UDOT V2X MMS Processes for Storing and Archiving V2X Message Exchanges
Source: WSP, January 2026

Function	V2X MMS Activity
Input	J2735 messages forwarded from UDOT RSU
Process	1. Format the received data in the preferred format 2. Generate metadata 3. Store and archive data 4. Perform deduplication of “repeated” messages
Output	J2735 messages and metadata stored on V2X MMS

4.1.1.2. CDOT Operational Data Exchange

The CDOT ODE serves as the primary repository for all data generated through the CDOT portion of the CTW Program deployment. In addition to serving as the primary data repository, the CDOT ODE is also responsible for interfacing with the SDX, sending both event report and TIMs to the SDX. Furthermore, it uses event reports posted by other agencies on the SDX to generate TIMs, which are then delivered to the appropriate RSUs to support broader regional and cross-jurisdictional coordination.

All CDOT data is processed through CDOT’s Google Cloud Platform (GCP) infrastructure using JPO ODE and Kafka, which is then stored in MongoDB (short-term, 3 months) and BigQuery (long-term, indefinitely). BigQuery stores data in a well-known text (WKT) format and requires translation for visualization. RSUs forward messages over User Datagram Protocol (UDP) to CDOT’s internal network (capturing both BSM and TIM), where the GCP endpoint runs JPO Open Data Environment. Kafka then process messages into different formats, like GeoJSON, to create mappable data. Data translator services are hosted in Kubernetes Engine clusters.

The rest of this section describes the data processes involved with CDOT ODE that are relevant in the context of the CTW Program. The CDOT ODE processes are for the following functions:

- Weather information generation from BSM – see Table 5.
- TIM generation (from weather information and TIM data sources) – see Table 6.
- TIM generation (from SDX event report) – see Table 7.
- Storing and archiving V2X message exchanges – see Table 8.

Table 5. CDOT ODE Processes for Weather Information Generation from BSM
Source: WSP, January 2026

Function	ODE Activities
Input	BSM from CDOT RSU
Process	1. Receive J2735 BSM from RSU 2. Store J2735 BSM 3. Generate weather information 4. Store data
Output	Weather information stored on CDOT ODE

Table 6. CDOT ODE Processes for TIM Generation (From Weather Information, TIM Data Sources)
Source: WSP, January 2026

Function	ODE Activities
Input	Weather data (from CDOT ODE) and TIM data (from CDOT TIM data sources)
Process	1. Receive data from traveler information data sources 2. Generate J2735 TIM and event report 3. Determine which RSU(s) the J2735 TIM should be broadcast from 4. Send J2735 TIM to RSU(s) 5. Send J2735 TIM and event report to SDX 6. Format J2735 TIM and event report 7. Store J2735 TIM and event report
Output	1. J2735 TIM messages and event report to applicable CDOT RSUs 2. J2735 TIM messages and event report stored on CDOT ODE 3. J2735 TIM messages and event report to SDX

Table 7. CDOT ODE Processes for TIM Generation (From SDX Event Report)
Source: WSP, January 2026

Function	ODE Activities
Input	Event report from SDX
Process	1. Collect event report from SDX 2. Use event report to generate J2735 TIM 3. Determine which RSU(s) the J2735 TIM should be broadcast from 4. Send J2735 TIM to applicable RSU(s) 5. Send J2735 TIM to SDX 6. Format J2735 TIM 7. Store J2735 TIM and event report
Output	1. J2735 TIM messages to applicable CDOT RSUs 2. J2735 TIM messages and event report stored on CDOT ODE 3. J2735 TIM messages to SDX

Table 8. CDOT ODE Processes for Storing and Archiving V2X Message Exchanges
Source: WSP, January 2026

Function	ODE Activities
Input	J2735 messages forwarded from CDOT RSU
Process	1. Format the received data in the preferred format 2. Generate metadata 3. Store and archive data 4. Perform deduplication of "repeated" messages
Output	J2735 messages and meta data stored on CDOT ODE

4.1.1.3. WYDOT Operational Data Exchange

The WYDOT ODE serves as the primary repository for all data generated through the WYDOT portion of the CTW Program deployment. In addition to serving as the primary data repository, the WYDOT ODE is also responsible for interfacing with the SDX, sending both event report and TIMs to the SDX. Furthermore, it uses event reports posted by other agencies on the SDX to generate TIMs, which are then delivered to the appropriate RSUs to support broader regional and cross-jurisdictional coordination.

These functions already exist in WYDOT systems, and it is described here since other systems use the WYDOT outputs. The WYDOT ODE processes are for the following functions:

- TIM generation (from weather information and TIM data sources) – see Table 9.
- TIM generation (from SDX event report) – see Table 10.

Table 9. WYDOT ODE Processes for TIM Generation (From Weather Information, TIM Data Sources)
Source: WSP, January 2026

Function	ODE Activities
Input	TIM data (from WYDOT TIM data sources)
Process	1. Receive data from traveler information data sources 2. Generate J2735 TIM and event report 3. Determine which RSU(s) the J2735 TIM should be broadcast from 4. Send J2735 TIM to RSU(s) 5. Send J2735 TIM and event report to SDX 6. Format J2735 TIM and event report 7. Store J2735 TIM and event report
Output	1. J2735 TIM and/or J2945/4 road safety message (RSM to applicable RSUs 2. J2735 TIM and/or J2945/4 RSM to SiriusXM 3. J2735 TIM message and event report stored on WYDOT ODE

Table 10. WYDOT ODE Processes for TIM Generation (From SDX Event Report)
Source: WSP, January 2026

Function	ODE Activities
Input	Event report from SDX
Process	1. Collect event report from SDX 2. Use event report to generate J2735 TIM 3. Determine which RSU(s) the J2735 TIM should be broadcast from 4. Send J2735 TIM to applicable RSU(s) 5. Send J2735 TIM to SDX 6. Format J2735 TIM 7. Store J2735 TIM and event report
Output	1. J2735 TIM and/or J2945/4 RSM to applicable RSUs. 2. J2735 TIM and/or J2945/4 RSM to SiriusXM 3. J2735 TIM message and event report stored on WYDOT ODE

4.1.1.4. UDOT Roadside Equipment

UDOT's RSE consists of two primary components: The RSU, which provides radio communication capabilities, and the Signal Command Module (SCM), which supports localized roadside processing. Although these components are physically separate, they are treated as a single logical entity within this Data Plan for simplicity.

In general, the RSE collects data from other system components, processes this data as needed to generate V2X messages, and passes those messages to the RSU for broadcast over the air as well as to V2X MMS for storage. Before transmission, RSUs attach the appropriate security credentials to each V2X message.

When receiving V2X messages from OBUs, RSUs first perform credential verification to ensure message authenticity and integrity. Validated messages are then forwarded to the SCM, which processes the data as needed and issues commands or forwards messages to other system components to support application-level functionality. These messages are also immediately forwarded to V2X MMS for storage.

The tables below, organized by message type, provide an overview of the inputs, processing steps, and outputs associated with UDOT's RSE. Each table identifies the source component for each input and the destination component for each output. All processing steps listed are performed by the RSE itself and are generally presented in a chronological fashion.

The UDOT RSE processes in the tables below are for the following message types: BSM (Table 11), SRM (Table 12), SSM (Table 13), SPaT (Table 14), MAP (Table 15), TIM (Table 16), RTCM (Table 17), and SDSM and blank-out signs (Table 18).

Table 11. UDOT RSE Processes for BSM
Source: WSP, January 2026

Function	RSE Activities
Input	J2735 BSM (over-the-air)
Process	Immediate Forward to V2X MMS (data not stored)
Output	J2735 BSM to V2X MMS.

Table 12. UDOT RSE Processes for SRM
Source: WSP, January 2026

Function	RSE Activities
Input	J2735 SRM (over-the-air) Priority/preemption plan configuration
Process	1. Immediate Forward to V2X MMS (data not stored) 2. Check priority/preemption eligibility based on data in message 3. Determine eligibility of request and determines which plan to call on the TSC (based on configuration)
Output	1. J2735 SRM to V2X MMS 2. NTCIP 1202 priority request to TSC (if eligible)

Table 13. UDOT RSE Processes for SSM
Source: WSP, January 2026

Function	RSE Activities
Input	NTCIP 1202 data from TSC
Process	1. Process NTCIP 1202 data and generate J2735 SSM 2. Immediate Forward to RSU for signing and broadcast (data not stored) 3. Immediate Forward to V2X MMS (data not stored)
Output	1. J2735 SSM (over-the-air) at 10 Hertz (Hz) 2. J2735 SSM to Cirrus

Table 14. UDOT RSE Processes for SPaT
Source: WSP, January 2026

Function	RSE Activities
Input	TSCBM from TSC
Process	1. Process TSCBM and generate J2735 SPaT 2. Immediate Forward to RSU signing for broadcast (data not stored) 3. Immediate Forward to V2X MMS (data not stored)

Function	RSE Activities
Output	1. J2735 SPaT (over-the-air) at 10 Hz 2. J2735 SPaT to V2X MMS

Table 15. UDOT RSE Processes for MAP
Source: WSP, January 2026

Function	RSE Activities
Input	J2735 MAP (ser input)
Process	If a new MAP is received by the RSE: • Stop signing and broadcasting the previous MAP (over-the-air) • Stop forwarding the previous MAP to UDOT V2X MMS • Begin signing and broadcasting the new MAP • Begin forwarding the new MAP to UDOT V2X MMS
Output	1. J2735 MAP (over-the-air) at 1 Hz 2. J2735 MAP to V2X MMS

Table 16. UDOT RSE Processes for TIM
Source: WSP, January 2026

Function	RSE Activities
Input	J2735 TIM (from UDOT V2X MMS)
Process	If a new TIM is received by the RSE: • Begin signing and broadcasting the J2735 TIM. • Begin forwarding the TIM to UDOT V2X MMS Once a given TIM has elapsed its expiration period: • Stop signing and broadcasting the TIM • Stop forwarding to UDOT V2X MMS Note: Multiple TIMs can be stored and be active at the same time
Output	1. Sign and broadcast J2735 TIM (over-the-air) at 1 Hz 2. J2735 MAP to V2X MMS

Table 17. UDOT RSE Processes for RTCM
Source: WSP, January 2026

Function	RSE Activities
Input	Position correction data (from NTRIP RTCM data source)
Process	If a new data from NTRIP server is received by the RSE: • Stops signing and broadcasting the previous RTCM (over-the-air) • Stops forwarding the previous RTCM to UDOT V2X MMS • Processes data from NTRIP server and generates J2735 RTCM message • Begins signing and broadcasting the new RTCM as a store and repeat message • Begins forwarding the new RTCM to UDOT V2X MMS Note: Updates from NTRIP server are expected to occur at configurable intervals (e.g., 1 minute or 5 minutes)
Output	1. J2735 RTCM (over-the-air) at configured interval 2. J2735 RTCM to V2X MMS

Table 18. UDOT RSE Processes for SDSM and Blank-Out Signs
Source: WSP, January 2026

Function	RSE Activities
Input	VRU detection data (from UDOT Field VRU Detection System)
Process	1. Process VRU detection data and generate J3224 SDSM message 2. Immediate Forward to RSU for signing and broadcast (data not stored) 3. Immediate Forward to V2X MMS (data not stored) 4. Determine if vehicle/VRU interaction is imminent 5. If so, activate blank-out sign – send activation record to V2X MMS
Output	1. J3224 SDSM (over-the-air) at 10 Hz 2. J3224 SDSM to V2X MMS 3. Activation instruction to blank-out sign 4. Activation record to V2X MMS

4.1.1.5. CDOT Roadside Equipment

CDOT's RSE includes the RSU, which provides radio communication capabilities. In general, the RSE collects data from other system components, processes this data as needed to generate V2X messages, and broadcasts the messages over the air as well as to ODE for storage. Before transmission, RSUs attach the appropriate security credentials to each V2X message.

When receiving V2X messages from OBUs, RSUs first perform credential verification to ensure message authenticity and integrity and then forward the messages to the ODE for storage.

The tables below, organized by message type, provide an overview of the inputs, processing steps, and outputs associated with CDOT's RSE. Each table identifies the source component for each input and the destination component for each output. All processing steps listed are performed by the RSE itself and are generally presented in a chronological fashion.

The CDOT RSE processes in the tables below are for the following message types: BSM (Table 19) and TIM (Table 20).

Table 19. CDOT RSE Processes for BSM
Source: WSP, January 2026

Function	RSE Activities
Input	J2735 BSM (over-the-air)
Process	Immediate Forward to CDOT ODE (data not stored)
Output	J2735 BSM to CDOT ODE.

Table 20. CDOT RSE Processes for TIM
Source: WSP, January 2026

Function	RSE Activities
Input	J2735 TIM (from CDOT ODE)
Process	If a new TIM is received by the RSE: • Begins signing and broadcasting the J2735 TIM. • Begins forwarding the TIM to CDOT ODE Once a given TIM has elapsed its expiration period: • Stops signing and broadcasting the TIM • Stops forwarding to CDOT ODE Note: Multiple TIMs can be stored and be active at the same time.
Output	1. Sign and broadcast J2735 TIM (over-the-air) at 1 Hz. 2. J2735 MAP to CDOT ODE.

4.1.1.6. WYDOT Roadside Equipment

WYDOT's RSE includes the RSU, which provides radio communication capabilities. In general, the RSE collects data from other system components, processes this data as needed to generate V2X messages, and broadcasts the messages over the air as well as to ODE for storage. Before transmission, RSUs attach the appropriate security credentials to each V2X message.

The table below provides an overview of the inputs, processing steps, and outputs associated with WYDOT's RSE for TIM messages and also identifies the source component for each input and the destination component for each output. All processing steps listed are performed by the RSE itself and are generally presented in a chronological fashion.

The WYDOT RSE processes in the table below are for the TIM message type (Table 21).

Table 21. WYDOT RSE Processes for TIM
Source: WSP, January 2026

Function	RSE Activities
Input	J2735 TIM (from WYDOT ODE)
Process	If a new TIM is received by the RSE: • Begins signing and broadcasting the J2735 TIM • Begins forwarding the TIM to WYDOT ODE Once a given TIM has elapsed its expiration period: • Stops signing and broadcasting the TIM • Stops forwarding to WYDOT ODE Note: Multiple TIMs can be stored and be active at the same time
Output	1. Sign and broadcast J2735 TIM (over-the-air) at 1 Hz 2. J2735 MAP to WYDOT ODE

4.1.1.7. UDOT Fleet Vehicle On-Board Unit and GM Vehicle On-Board Unit

UDOT fleet vehicles (specifically snowplows, maintenance supervisor vehicles, and some other agency fleet vehicles); UTA transit vehicles; and municipal emergency vehicles equipped with OBUs provide GNSS data and broadcast BSMs—and, in some cases, SRMs (for signal preemption and priority). They also receive and process RSU broadcasts (SPaT, MAP, SSM, TIM, and RTCM) and make the information available to the on-board processor. Some of these vehicles also have an On-Board Processor (OBP) which supports on-board message creation and data handling. Although these components are physically separate, they are treated as a single logical entity, referred to as On-Board Equipment (OBE) within this Data Plan for simplicity.

A GM vehicle to be purchased by UDOT will be capable of broadcasting a full BSM since it will have access to all elements in the vehicle Controller Area Network (CAN) bus. It will also receive and process RSU broadcasts (SPaT, MAP, TIM, and RTCM).

The data processes employed by UDOT OBUs can generally be categorized as:

- **Generate and Broadcast BSMs.** Only a portion of the UDOT fleet is equipped with OBUs that have access to the CAN bus, and the data available from the CAN bus is often limited in scope. All these vehicles broadcast BSMs, but the range of data fields populated in the BSM varies. At a minimum, the data fields populated by the GPS (location, heading, speed, and acceleration) are always populated.
- **Receive and Process TIMs.** In a small number of UDOT fleet vehicles, OBUs in the Vehicle Systems receive TIMs and make the TIMs accessible to drivers through an HMI display.
- **Request and Receive CIPT.** UDOT snowplows, UTA transit vehicles, and municipal emergency vehicles send SRMs when they are actively plowing, running behind schedule, or responding to an emergency call, respectively, to request signal preemption or priority and receive SSMs to confirm that the SRM was received by the CI.

The UDOT OBE (and, for the GM vehicle, OBU) processes below are for the following message processing functions: Partial BSM generation for a non-GM vehicle (Table 22), Full BSM generation for the GM vehicle (Table 23), TIM display (Table 24), V2X Message receipt and processing (Table 25), CIPT (Table 26), and VRU warnings (Table 27).

Table 22. OBE Processes for Partial BSM Generation and Broadcast (Non-GM Vehicle)
Source: WSP, January 2026

Function	OBE Activities
Input	1. GNSS data (from satellite) 2. Internal sensor data (from OBU) 3. CAN bus data (from Vehicle System) (select vehicles) 4. OBU BSM configuration
Process	1. Process GNSS data, sensor data, CAN bus data (if available), and internal configured values to populate position (latitude and longitude), speed, acceleration, and heading in the J2735 BSM 2. Populate all other data elements with a value of unknown in the J2735 BSM 3. Send J2735 BSM to OBU radio for signing and broadcast (data not stored)
Output	J2735 BSM (over-the-air) at 10 Hz

Table 23. OBU Processes for Full BSM Generation and Broadcast (GM Vehicle Only)
Source: WSP, January 2026

Function	OBU Activities
Input	1. GNSS data (from satellite) 2. Internal sensor data (from OBU) 3. Vehicle data (from Vehicle System CAN bus) 4. OBU BSM configuration
Process	1. Process GNSS data, sensor data, and internal configured values to populate position (latitude and longitude), speed, acceleration, and heading in the J2735 BSM 2. Populate all other data elements using data from the Vehicle System 3. Send J2735 BSM to OBU radio for signing and broadcast (data not stored)
Output	J2735 BSM (over-the-air) at 10 Hz

Table 24. OBE Processes for TIM In-Vehicle Application (Select OBUs)
Source: WSP, January 2026

Function	OBE Activities
Input	1. TIM (from RSU) 2. GNSS data (from satellite) 3. Internal sensor data (from OBU)
Process	1. Determine whether to provide the information to driver 2. Determine if vehicle's location (GNSS and/or sensor data) falls within the applicable geometry (TIM) 3. Determine if vehicle's heading (GNSS and/or sensor data) falls within the selected heading slices (TIM) 4. If yes, provide an alert to the driver that corresponds to International Traveler Information System (ITIS) codes (TIM)
Output	In-vehicle information to the driver (via HMI)

Table 25. OBE Processes for Receiving and Processing V2X Messages (All OBUs)
Source: WSP, January 2026

Function	OBE Activities
Input	V2X messages (SPaT, MAP, RTCM, etc.) (from RSU)
Process	Specific processes to support V2X applications
Output	Outputs to support V2X applications

Table 26. OBE Processes for CI Preferential Treatment (CIPT)
Source: WSP, January 2026

Function	OBE Activities
Input	1. MAP (from RSU) 2. GNSS data (from satellite) 3. Internal sensor data (from OBU) 4. SSM (from RSU)

Function	OBE Activities
Process	Generate SRM: 1. Receive MAP and GNSS data 2. Determine whether to generate SRM a. Determine if vehicle's location falls within any of the MAP lane geometries b. Determine if other conditions are present to issue SRM c. As the OBU progresses and passes through the intersection, broadcast SRM cancellations to indicate to the RSU to cancel the preemption or priority calls 3. If yes, generate SRM 4. Sign and broadcast SRM Receive SSM Provide notification to the driver about the request status (optional)
Output	J2735 SRM (over-the-air) at 10 Hz

Table 27. OBE Processes for VRU In-Vehicle Application
Source: WSP, January 2026

Function	OBE Activities
Input	1. SDSM (from RSU) 2. GNSS data (from satellite) 3. Internal sensor data (from OBU)
Process	1. Determine whether to provide the information to driver a. Determines if the vehicle's path of motion (GNSS and/or sensor data) will be in conflict with the VRU (SDSM) b. If yes, provide in-vehicle warning to the driver
Output	In-vehicle information to the driver (via HMI)

4.1.1.8. CDOT OBU

CDOT OBUs use V2X communications to send and receive messages when in range of RSUs. These OBUs generate and broadcast BSMs with the data available from the OBU (i.e., no access to the vehicle CAN bus to extract vehicle generated data). They broadcast SRMs and also receive and process SPaT, MAP, and SSM messages from the RSU.

The applications supported by CDOT OBUs are fewer than those supported by UDOT OBUs, but the processes that are followed by CDOT OBUs are the same as those used by UDOT OBUs for similar applications. Specifically, CDOT OBUs support partial BSM generation and broadcast (see Table 22, above); TIM in-vehicle application (see Table 24, above); and receiving and processing V2X messages (see Table 25, above).

4.1.1.9. WYDOT OBU

WYDOT OBUs use V2X communications to send and receive messages when in range of RSUs and SiriusXM communications to receive messages statewide. These OBUs generate and broadcast BSMs with the data available from the OBU (i.e., no access to the vehicle CAN bus to extract vehicle-generated data). They also receive, process, and display TIMs that they receive.

Similar to CDOT OBUs, the applications supported by WYDOT follow the same processes as the UDOT OBUs, including partial BSM generation and broadcast (see Table 22, above); TIM in-vehicle application (see Table 24, above); and receiving and processing V2X messages (see Table 25, above). However, the TIM in-vehicle application is relevant for both direct and satellite (SiriusXM) V2X communications. In contrast, the partial BSM generation and broadcast and receiving and processing V2X messages are applicable to only direct V2X messages.

4.1.2. Validation and Verification

Validation and verification activities within the CTW Program are essential to ensuring the accuracy, reliability, and operational effectiveness of the data generated through both existing and newly developed functionalities.

First, a series of pre-deployment verification processes will be conducted at each site prior to activating new or updated functionalities. These processes are designed to validate the accuracy of both the data elements and the processes used to generate messages that will be stored or transmitted as part of the CTW Program. This includes verifying the correctness of intersection geometry, phase timing details, traveler information, signal priority/preemption request processes, etc. These validation steps help ensure that message content accurately reflects real-world conditions and that the systems supporting message generation are properly configured prior to deployment.

Another component of this process that will be used by UDOT is the Connected Intersections Message Monitoring System (CIMMS) for monitoring SPaT and MAP message data quality. CIMMS is open source[2] and continuously evaluates SPaT and MAP messages from RSUs and provides real-time notifications to system operators when discrepancies or anomalies are detected, such as mismatches between message content, and inconsistencies with traffic signal controller data and vehicular movements (based on BSMs). Upon receiving these notifications, system operators investigate the root cause of the issue, whether it stems from a change to the existing infrastructure, incorrect data inputs, configuration errors, or system process issues. Operators are then able to make necessary adjustments to the input data, configuration, or system processes to correct the problem. Once the discrepancy is resolved, CIMMS notifications

[2] Open source code can be accessed via the following: 1) Ingest VM, jpo-ode; 2) Database VM, jpo-conflictmonitor; and 3) Application VM, jpo-conflictvisualizer.

should cease, confirming resolution and restoration of expected message performance. Remedy of any issues that significantly affect system performance will be logged.

4.2. Data Standards and Practices

V2X data are captured and transmitted at the roadside by the RSU. For the purposes of this document, V2X data is defined as raw and metadata associated with message sets as part of the latest editions of SAE International standards J2735 (Surface Vehicle Standard), SAE J3224 (V2X Sensor-Sharing for Cooperative and Automated Driving), and J2945 (Road Safety Applications), USDOT TIM Guidance, and CTW Program TIM Generation Guidance. All datasets generated as part of the CTW Program and covered in this Data Plan are considered open (non-proprietary) and available for public use once transferred to USDOT, subject to applicable privacy protections. Sensitive data will be properly anonymized or restricted as needed before any public release.

4.2.1. SAE J2735 V2X Communications Message Set Dictionary

The message sets specified in SAE J2735-202409 can be used by an application to send information using V2X communications to peer instances of that application. Applications enabled by J2735 include collision avoidance, work zone alerts, signal timing optimization, emergency vehicle preemption, and pedestrian and VRU safety. The messages given in Table 28 are relevant for CTW Program deployment.

Table 28. SAE J2735 V2X Communication Messages
Source: SAE J2735, September 2024

Message Type	Description	Explanation	Open/ Proprietary
BSM	Basic Safety Message	Broadcast by an OBU, BSM conveys safety information about a vehicle, including its size, position, speed, heading, and brake system status. It supports safety-critical applications through frequent data transmission. It can also be received by RSE for use in monitoring and management activities.	Open
MAP	Map Data Message	Broadcast by and RSU, MAP contains intersection geometry, including lane layouts, crosswalks, and connections (from one lane to another) through the intersection. It helps position vehicles with respect to roadway geometries and contains data that can be used to link with signal state data (in SPaT messages) to support intersection-related applications.	Open
SDSM	Sensor Data Sharing Message	Broadcast by an RSU to communicate objects detected from roadside sensors, an SDSM focuses specifically on perception of objects in the sensor's vicinity and collaborative awareness. J2735 cross-references J3224 for defining the SDSM (see Section 4.2.2.).	Open

Message Type	Description	Explanation	Open/ Proprietary
SPaT	Signal Phase and Timing Message	Broadcast by an RSU to communicate the signal state of an intersection, including signal groups and their event states, a SPaT contains data that can be used to link signal states with the physical layout of the intersection (conveyed in MAP messages) to support intersection-related applications.	Open
SRM	Signal Request Message	Broadcast by an OBU to request either priority or preemption depending on how the data elements in the message are populated, each SRM request defines a path through the intersection, which is desired in terms of lanes and approaches to be used. Each request can also contain the time of arrival and the expected duration of the service. Multiple requests to multiple intersections are supported.	Open
SSM	Signal Status Message	Broadcast by an RSU to convey the statuses of ongoing priority or preemption requests acknowledged by the controller.	Open
RTCM	Radio Technical Commission for Maritime Services Corrections	Broadcast by an RSU, the RTCM delivers real-time corrections to improve GNSS-based vehicle positioning accuracy, enhancing precision for V2X applications requiring lane-level or higher accuracy.	Open
TIM	Traveler Information Message	Broadcast by an RSU, the TIM is used to communicate various types of information (e.g., advisory and road sign) and their applicable geometries, headings, and applicable times to equipped devices. It makes heavy use of the ITIS encoding system to send well-known phrases but allows limited text for local place names.	Open

4.2.2. SAE J3224 V2X Sensor-Sharing for Cooperative and Automated Driving

SAE J3224-202208 describes the concept of operation, use cases, and message flows to create a Sensor Sharing Service (SSS) that enables RSUs and V2X vehicles to share information about their localized driving conditions. The standard defines the SDSM message structure, V2X entity requirements, and elements needed within the message to describe detected objects. It also describes the security management components of the message.

There are six use cases anticipated for the SSS. These include:

1. Detection of an unequipped vehicle by a host vehicle.
2. Detection of an unequipped vehicle by an RSU.
3. Detection of an unequipped VRU by a host vehicle.
4. Detection of an unequipped VRU by an RSU.

5. Detection of an obstacle by a host vehicle.
6. Detection of an obstacle by an RSU.

An SDSM message can be sent via broadcast mode or as a groupcast. The basic protocol in the SDSM includes object detection and SDSM transmission. SAE J2945/4 Surface Vehicle Standard

4.2.3. SAE J2945/4 Surface Vehicle Standard

SAE J2945/4 defines RSM based on the SAE J2735 TIM to reflect the lessons learned from various deployments. This standard does not define a single, generic, broadcast application for infrastructure systems, but a message set and structures to support the following applications:

- CSW
- Reduced speed zone warning (RSZW)
- Lane closure warning (LCW)
- Dynamic traveler information (DTI)
- Incident information (INC)

4.2.4. TIM Interoperability

As part of the design process, the CTW team (specifically Trihydro) has led a process to define guidelines for the consistent and unambiguous creation and exchange of TIMs. The goal of this effort was to facilitate interoperable TIM use across the three CTW Program states and, ultimately, nationwide. These interoperability guidelines, if followed, will enable central V2X systems across the United States to create consistent and interoperable TIMs and enable OBUs to receive these messages and present appropriate, uniform messages to drivers.

Additional TIM design decisions are included in the following documents developed by the CTW Program team:

- **Use of the Traveler Information Structure to Build Standard Traveler Information Messages.** A document developed by the CTW Program team that describes the data elements of the SAE J2735 TIM structure and how these data elements are projected to be used for TIMs generated for the CTW Program effort.
- **Detailed TIM Definitions.** Documentation (in progress) still being developed by the CTW Program team of detailed definitions for each of the TIMs prioritized for development as a part of the CTW Program's effort for interoperable use.
- **TIM Summary Table.** A summary table developed by the CTW team to describe the content and conditions for the initial TIMs prioritized and developed as a part of the CTW Program's effort for interoperable use.

For more information about these documents, see the CTW Program SSD.

4.2.5. Event Report

The event report data structure used by the CTW Program systems to share traffic events will follow the Next Generation Traffic Management Data Dictionary (ngTMDD) specification. This new specification leverages a recent revision to a well-known data structure used by many transportation agencies for C2C communication. Because of its widespread use, the CTW team chose to use the ngTMDD specification's data structure to share event reports.

The ngTMDD standard contains a very broad set of data elements, many of which are not applicable to the V2X event reports that the CTW Program system uses. The V2X system primarily uses the "EventInformationResponse" object within the specification. Table 29 provides a description of the primary data elements defined within the ngTMDD specification that are applicable to traffic Event Reports shared in this system.

Table 29. Event Report Data Structure

Source: ngTMDD Data Schema, March 20, 2026

Data	Description
eventMessageHeader	Header information for event messages.
eventReference	Unique identifier for the event associated with the reference.
eventElementDetails	Requirements for each aspect of event information, provided in an array. Data elements include eventTime, eventSource, eventDescription (which includes eventITISCodes and locationReference), eventLocation, eventName, and eventLane, eventConfidenceLevel.
informationAccessRestrictions	NA
eventIndicator	Provided in an array.
otherReferences	Provided in an array.
eventComments	Event comment information including commentTimestamp, operatorId, and commentText.

4.3. Versioning

Versioning is important to ensure consistency and compatibility across datasets and processes throughout the CTW Program. The CTW Program will utilize the same version of each standard and guidance specified in Section 4.2 throughout the operational period, minimizing the need for updates or concerns about versioning.

For the event data capture in UDOT V2X MMS and SDX that carry new metadata fields and new versions over time, the existing architecture can deploy simple if/then logic statements to capture the new information.

5. Store

5.1. Storage Systems

Each CTW Program partner agency will continue to maintain its own data repository to support performance measurement, operational analysis, and other agency needs. The partner agency Central Systems that host CTW Program data storage systems are pre-existing, secure, and access-controlled systems designed to support internal performance measurement and operational needs. However, in their current configuration, these systems do not meet USDOT's open license requirement for public access to data generated by federally funded deployments. Rather than requiring partner agencies to modify their existing secure, access-controlled systems which could introduce security risks or invest in costly new infrastructure to support public access, the CTW Program will utilize a centralized data repository specifically designed for public dissemination that USDOT has indicated will be available.

In order for this approach to be effective, each partner agency will need to perform initial data quality and validation procedures prior to submitting data to USDOT. These procedures will include verifying dataset completeness, ensuring consistency with defined data formats and field structures, and identifying and removing duplicate or invalid records. This process will help ensure consistency between data streams generated by each partner agency so that all data transmitted to the USDOT repository are accurate, uniform, and comparable. While the specific tools and methods may differ between partner agencies, all partner agencies will apply a consistent set of quality control criteria to maintain alignment across all datasets submitted to USDOT.

The USDOT repository will serve as the official platform for releasing CTW Program V2X data under an open license, ensuring compliance with federal open data mandates. By leveraging this centralized system, the CTW Program preserves the integrity and security of agency-managed repositories while fulfilling its obligation to make grant-funded data publicly accessible.

While this section outlines the role of the USDOT system in enabling public access, its primary focus is on the storage infrastructure managed by each partner agency and the process by which this locally stored data is transferred to the USDOT repository. This ensures compliance with federal open data requirements while supporting the operational needs of individual deployments.

A preliminary data storage estimate provided in this section is a high-level evaluation intended to support both operational needs and future program assessments. For the purposes of this Data Plan, only data directly associated with the CTW Program is considered in scope. CTW Program data includes any V2X messages broadcast or received by RSUs deployed as part of this effort. Data from existing RSUs that support existing functionalities will not be collected, ensuring that the scope of this plan remains limited to CTW Program-specific activities.

Because a central concept of the CTW Program is the use of the SDX to share and exchange traveler information in the form of event reports and to generate and broadcast TIMs based on those reports, all TIMs and event reports are considered part of the CTW Program. These will be captured from both existing RSUs and newly deployed RSUs participating in the CTW Program. This ensures that all traveler information exchange activities central to CTW Program operations are represented in the collected dataset, while excluding unrelated RSU functions.

The volume of data generated from V2X interactions is largely influenced by how frequently vehicles operate within a range of one another, RSUs, and exchange information. In areas with frequent V2X interaction, data volumes could become substantial. However, vehicle-level data storage is limited by the capacity of OBUs.

The approach to estimating storage requirements is based on an initial analysis of anticipated event frequencies and represents the total projected data storage needed across all vehicles during the 12-month operational period. The frequency of data collection varies based on the data type as well as system capabilities and operational constraints. Collection intervals may range from continuous, real-time data streams to data captured on an as-needed basis. The messages that are broadcasted continuously drive the storage requirements. These messages include BSMs, SPaT, and MAP.

5.1.1. UDOT V2X MMS

As depicted in Figure 1 in Section 2.2, V2X MMS is the Central System for UDOT. Up through October 2025, the V2X MMS was Cirrus by Panasonic, but that system is being replaced in early 2026 by iNET, developed by Parsons and Taplane, with the operational name "Connected Utah". V2X MMS stores all V2X message exchanges with UDOT RSUs. It shares TIMs and event reports with SDX, which in turn can be accessed by the CDOT ODE and WYDOT ODE. Raw data is stored in its original format; processed and decoded versions of data are also stored for analytics and reporting convenience.

The V2X MMS also collects data from road weather information system (RWIS, via C2C data feed rather than directly obtained from the source), VSL algorithms, and event data from the ATMS described in Section 3.1.2. Access by UDOT staff to data stored by the V2X MMS Platform is based on individual approved account permissions, with logging and monitoring of all user activities.

For estimating the total number and size of V2X messages that will be generated and stored by UDOT as part of the CTW Program, several data inputs and assumptions include:

- Number of new RSUs at SIs.
- Number of new and existing RSUs along roadway corridors that will leverage improved TIM capabilities from sharing of event reports between partner agencies.
- Estimated number of OBU-to-RSU interactions.
- Estimated file size of BSMs, frequency, and total number of BSMs generated.
- Estimated number and size of TIMs and event reports.
- Estimated number and size of SPaT and MAP messages.
- Estimated number and size of SRMs and SSMs.
- Estimated RTCM messages and configure frequency.
- Estimated number and size of SDSM.

Through CTW Program, UDOT will be adding:

- 150 new RSUs (in addition to the 53 existing RSUs) along roadway corridors that support the dissemination of traveler information.
- 450 new RSUs at SIs that will support SPaT and MAP broadcast and signal priority and preemption applications and capturing V2X messages broadcast by vehicles; 20 of these intersections will be equipped with VRU detection systems to support VRU safety.
- 215 new OBUs will be deployed on transit and snowplow vehicles to support signal priority and preemption applications and will be broadcasting safety messages. Around 600 existing OBUs will also be operating in Utah.

Table 30 provides a summary of the message types, the typical size range of each message, an estimated number of messages that will be generated each day (by message type), and the anticipated daily storage requirements for each message. Assumptions are listed in the table to support the daily generation and storage estimates. The number of messages that may be generated and the estimated storage requirements for those messages do not account for deduplication, metadata, or compression of messages.

Table 30. UDOT V2X MMS V2X Message Storage Estimates for CTW Program
Source: WSP, January 2026

Message	Assumptions	Size Range (Bytes)	Daily Generation Estimate (Number of Messages)	Daily Storage Estimate
BSM	Current estimates 400K-600K BSMs per intersection/day, 480 new intersections, with the number of equipped vehicles increasing from 327 to ~800.	50–200	450 million (M)–650M	20 gigabytes (GB)
SPaT	488 new intersections, broadcast continuously at 10 Hz.	100–400	415M	77 GB
MAP	488 new intersections, broadcast continuously at 1 Hz.	400–1400	42M	38 GB
TIM	97 existing + 220 new freeway locations, 2 TIMs broadcast simultaneously for 6 hours a day on average, broadcast at 1 Hz.	50–150	15M–20M	2 GB
Event Report	97 existing + 220 new freeway locations, 2 TIMs broadcast simultaneously for 6 hours a day on average, broadcast at 1 Hz.	450-550	To be determined	To be determined
SRM	215 new vehicles, average vehicle passes 20 intersections/day – 45 seconds/intersection, broadcast at 1 Hz.	50–200	150 thousand (K)–250K	19 megabytes (MB)
SSM	Broadcast at 10 Hz, in response to SSM.	50–200	1.5M–2.5M	190 MB
RTCM	100 new intersections. Broadcast at variable rate.	100–400	To be determined	To be determined

Message	Assumptions	Size Range (Bytes)	Daily Generation Estimate (Number of Messages)	Daily Storage Estimate
SDSM	20 new intersections, 200 pedestrians per day per intersection, 120 seconds per pedestrian, broadcast at 10 Hz.	50–100	4M–6M	350 MB

5.1.2. CDOT Operational Data Environment

The CDOT ODE, as part of the CTW Program, collects and archives all TIM, event report, BSM, and weather data. It shares TIMs and event reports with the SDX, which in turn can be accessed by UDOT V2X MMS and WYDOT ODE.

For estimating the total number and size of V2X messages that will be generated and stored by CDOT as part of the CTW Program, several data inputs and assumptions include:

- Number of new RSUs that will capture BSMs.
- Number of new and existing RSUs that will leverage improved TIM capabilities from sharing of event reports between partner agencies.
- Estimated number of OBU-to-RSU interactions.
- Estimated file size of BSMs, frequency, and total number of BSMs generated.
- Estimated number and size of TIMs and event reports.

Through the CTW Program, CDOT will be adding 50 new RSUs along I-70 in eastern Colorado that support the dissemination of traveler information. Around 128 existing OBUs will be operating in Colorado.

Table 31 provides a summary of the message types that will be generated in Colorado, the typical size range of each message, an estimated number of messages that will be generated each day (by message type), and the anticipated daily storage requirements for each message. Assumptions are listed in the table to support the daily generation and storage estimates. The number of messages that may be generated and the estimated storage requirements for those messages do not account for deduplication, metadata, or compression of messages.

Table 31. CDOT ODE V2X Message Storage Estimates for CTW Program
Source: WSP, January 2026

Message	Assumptions	Size Range (Bytes)	Daily Generation Estimate (Number of Messages)	Daily Storage Estimate
BSM	42 new freeway locations, vehicle in range of RSU for 90 seconds, 100 vehicles pass each RSU each day. Broadcast at 10 Hz.	50–200	12M–15M	650 MB
TIM	360 existing + 42 new freeway locations, 2 TIMs broadcast simultaneously for 6 hours a day on average, broadcast at 1 Hz.	50–150	15M–25M	2 GB
Event Report	360 existing + 42 new freeway locations, 2 TIMs broadcast simultaneously for 6 hours a day on average, broadcast at 1 Hz.	To be determined	900–1100	To be determined

5.1.3. WYDOT Operational Data Environment

WYDOT has 72 RSUs operational along WYDOT-operated highways that broadcast TIMs. No new RSUs will be deployed as part of the CTW Program effort. WYDOT also supplements the C-V2X RSUs by delivering TIMs to OBUs through SiriusXM satellite dissemination, effectively covering the entire WYDOT road network.

TIMs and events are generated at the TMC and stored at both the TMC and SDX. The WYDOT ODE, as part of the CTW Program, collects and archives all TIM and event reports and shares them with the SDX, which in turn can be accessed by UDOT V2X MMS and CDOT ODE.

Table 32 provides a summary of the message types that will be generated in Wyoming, the typical size range of each message, an estimated number of messages that will be generated each day (by message type), and the anticipated daily storage requirements for each message. Assumptions are listed in the table to support the daily generation and storage estimates. The number of messages that may be generated and the estimated storage requirements for those messages do not account for deduplication, metadata, or compression of messages.

Table 32. WYDOT ODE V2X Message Storage Estimates for CTW Program
Source: WSP, January 2026

Message	Assumptions	Size Range (Bytes)	Daily Generation Estimate (Number of Messages)	Daily Storage Estimate (GB)
TIM	72 existing freeway locations, 2 TIMs broadcast simultaneously for 6 hours a day on average, broadcast at 1 Hz.	50–150	2.5–3.5M	300 MB
Event Report	72 existing freeway locations, 2 TIMs broadcast simultaneously for 6 hours a day on average, broadcast at 1 Hz.	To be determined	120–160	To be determined

5.1.4. USDOT Data Storage System

To support open license requirements and ensure public accessibility of grant-funded data, USDOT is planning to establish a centralized data repository for projects under the CTW Program. In accordance with the USDOT Public Access Plan, which promotes transparency and public sharing of federally funded research data, this platform will act as the primary mechanism for storing and disseminating datasets, enabling timely and periodic uploads from participating agencies. The approach is expected to build on existing USDOT infrastructure such as the ITS DataHub, which supported previous initiatives like the Connected Vehicle Pilot deployments.

To ensure compatibility, the CTW Program team will coordinate with USDOT to understand any limitations related to storage capacity, supported data formats, and access protocols and make necessary adjustments (such as selective data sampling) to align with repository requirements. Prior to uploading, all data (particularly BSM, SDSM, and TIM messages) will be processed through a privacy filtering mechanism to remove or redact sensitive data and metadata, safeguarding personal privacy and removal of any potential sensitive agency information. Data uploads to the USDOT repository will occur on a recurring schedule (daily, weekly, monthly, or as otherwise agreed upon with USDOT) to maintain timely and consistent data availability. By submitting data in an agreed-upon format and at a defined frequency, each CTW Program partner agency ensures compliance with USDOT's open license requirements. This process serves as the formal mechanism by which the program fulfills its obligation to make V2X data generated through the grant-funded portions of the CTW Program deployment publicly accessible.

The total storage needs for the CTW Program is estimated based on information found in Table 30, Table 31, and Table 32 and are provided in Table 33. Total data storage could be smaller if selective data sampling is agreed upon by the USDOT and does not account for deduplication, metadata, or compression.

Table 33. V2X Message Storage Estimates for CTW Program
Source: WSP, January 2026

Message	UDOT V2X MMS Daily Storage Estimate	CDOT ODE Daily Storage Estimate	WYDOT ODE Daily Storage Estimate	Total Storage Estimates
BSM	20 GB	650 MB	None	20.65 GB
SPaT	72 GB	None	None	72 GB
MAP	36 GB	None	None	36 GB
TIM	1 GB	2 GB	300 MB	3.3 GB
Event Report	To be determined	To be determined	To be determined	To be determined
SRM	19 MB	None	None	19 MB
SSM	190 MB	None	None	190 MB
RTCM	None	None	None	None
SDSM	350 MB	None	None	350 MB

5.2. System Restrictions

Data access and sharing of the CTW Program data contain restrictions, as appropriate, to ensure they are not re-used without specific policies in place. The CTW Program data update frequency and access criteria are provided in Table 34.

Table 34. The CTW Program System Restrictions
Source: WSP, January 2026

Data Storage System Name	Data Storage System(s) Type	Frequency of Update	Access Criteria
UDOT V2X MMS	CTW team – restricted system	Continuously as data are received by RSUs in real time	Member of the CTW team who will analyze and process the data for key performance indicators (KPIs) and information technology (IT) managers responsible for maintaining the system.
CDOT ODE	CTW team – restricted system	Continuously as data are received by RSUs in real time	Member of the CTW team who will analyze and process the data for KPIs and IT managers responsible for maintaining the system.
WYDOT ODE	CTW team – restricted system	Continuously as data are received by RSUs in real time	Member of the CTW team who will analyze and process the data for KPIs and IT managers responsible for maintaining the system.
SDX	CTW team – restricted system	Continuously as data are received by RSUs and Central Systems in real time	Member of the CTW team who will analyze and process the data for KPIs and IT managers responsible for maintaining the system.

Data Storage System Name	Data Storage System(s) Type	Frequency of Update	Access Criteria
USDOT Repository	Open license	To be determined	Any member of the public can access this data without restrictions or required user authentication.

5.3. Backup and Recovery Policies and Procedures

Each CTW Program partner will adhere to their existing backup and recovery policies and procedures for managing V2X data within their respective systems. No new backup protocols will be introduced for the CTW Program, but partners will remain responsible for maintaining reliable data protection processes throughout the operational period in alignment with their agency standards.

6. Analyze

The detailed analysis methodologies, statistical techniques, and performance measures for the CTW Program will be outlined in the PMEP. This Data Plan focuses on ensuring the collection and storage of the data necessary for these analyses conforms to the policies of each CTW Program partner and is made available for analysis. While preliminary performance measures were proposed in the CTW Program grant application, the PMEP expanded and refined those measures. The PMEP will cover the hypotheses or research questions guiding the analysis, the tools and software to be used for data analysis, and the processes for validating and ensuring the quality of the data and results. Additionally, the PMEP will define the methods for visualizing and reporting the analytical outcomes, including the types of charts and dashboards that will be generated and reported. Since the performance measurement details are covered comprehensively in the PMEP, this Data Plan will only address the data collection and storage requirements to support these analyses. The PMEP should be referred to for analysis processes.

7. Reuse and Sharing

The CTW Program involves the deployment of existing CV functionalities at new locations as well as the development and implementation of new functionalities at both existing and new deployment sites. Each state within the CTW Program will independently manage and share its data. Data collected through this effort will be used to assess the performance of all deployed functions, as defined in the PMEP, including both existing and newly developed capabilities. While performance measures and summary evaluations derived from this data will be made publicly available, only the datasets associated with the new or updated functionalities developed as part of this CTW Program are planned for public release. Raw operational data generated through pre-existing processes is not intended for public sharing unless specifically required by USDOT.

7.1. Reuse, Redistribution, and Derivative Products Policies

The primary data that will be publicly shared on the USDOT repository include captured V2X messages and event reports exchanged between CTW Program partners, as these data products represent the core operational changes made as a result of the CTW Program deployment effort. The USDOT repository allows this data to be made available under an open license, which allows for unrestricted copying, publishing, distribution, transmission, citation, and adaptation of the data. Any code that is developed to update the current system as part of the CTW Program will be made open source and available in the USDOT Code hub.

Additionally, it is anticipated that no specialized or proprietary software will be required for external parties to access, view, or analyze the shared performance measures, TIM, and event report datasets. All data will be provided in open, widely supported formats such as Comma Separated Values (CSVs) and JSON to ensure ease of access and reuse.

The CTW Program acknowledges that each partner's Central System currently manages and stores V2X data according to their established operational practices. These existing data management processes will remain in place, with efforts focused on aligning the final data outputs to a common format to meet reporting, performance measurement, and data sharing requirements. The intent is not to change how each site captures or stores V2X data within their systems, but rather to apply post-processing steps, where appropriate, on a recurring basis to provide privacy protections and to standardize data formats and content for integration and transfer to the USDOT repository.

7.2. Metadata

Metadata is descriptive information that provides context about data, detailing attributes such as the time of collection, source, format, and processing history. It plays a critical role in ensuring that data is accurately interpreted, consistently managed, and effectively utilized by users of the data. By capturing details about the origin, structure, and purpose of data, metadata supports transparency and traceability. This section describes the types, structure, and the update process for metadata for the CTW Program.

7.2.1. Metadata Types

For the CTW Program, metadata will be used to document and provide essential context for the performance measure data and V2X message data — specifically TIM and event report data — that are collected, processed, and shared in compliance with the requirements of the grant. The use of standardized metadata ensures that data users can accurately interpret, trace, and appropriately use the shared datasets. The following metadata types will be employed as part of this program.

Standard Metadata. The CTW Program will associate a standardized set of metadata with each type of data collected as part of performance measurement and reporting activities. This metadata includes descriptive information such as the type of message (e.g., BSM), the source of the message (such as an RSU or OBU), and the outcome of any security validation processes, if performed. It also captures technical details including the message format and schema version. Additional metadata indicate the time the message was created by the source device and when it was received by the system's data collection platform. Serialization information may be included to indicate the message's position within a data stream or batch, allowing for clear tracking and organization of large volumes of data. When relevant, the metadata may also include operational context, such as location data or network routing details, to support analysis and troubleshooting.

Descriptive Metadata. Descriptive metadata facilitates the discovery, identification, and understanding of data resources. For CTW Program data submissions, this includes elements such as dataset title, abstract, author/organization, key words, and date of data creation. These elements help external users quickly assess the relevance and scope of the data.

Licensing Metadata. Licensing metadata provides information regarding the permitted uses of the data, including any restrictions on copying, publishing, distributing, transmitting, citing, or adapting the data. This ensures that any data shared for public access or government reporting complies with applicable intellectual property policies and data-sharing agreements

Technical Metadata. Technical metadata captures critical information about the structure and technical specifications of the data. This includes file format, file size, data compression methods (if applicable), and system-specific technical details necessary for correct data interpretation and use. Typical documentation outlines the structure, data types, and definitions for each data element, ensuring consistency across partner agencies and deployments. The CTW Program data schema and accompanying data dictionary will be provided to the USDOT when data is provided to the USDOT during Phase 2. A data change log will track any modifications to the data during the collection and processing period. It captures any changes in data values, structures, or formats that deviate from expected patterns, providing transparency into when, why, and how data was adjusted.

Static Project Data. Static project data describes fixed or mostly unchanging attributes related to the CTW Program's operational environment. For the purposes of the data that will be made available, this is expected to primarily include information about the location of RSE. This information is expected to be provided as a supplemental dataset that will sit alongside the metadata structure.

The CTW Program recognizes that each partner's Central System already employs established metadata standards for their respective V2X message and performance data management processes. While these existing practices will continue, the program will work to align metadata outputs to a common set of formatting guidelines to support consistent reporting and data sharing requirements. It is acknowledged that not every metadata element currently generated at each site may be provided in the final dataset; only those elements deemed necessary and valuable for the intended data users will be included. The intent is not to alter how each site currently associates metadata with stored data within their operational systems, but rather to employ post-processing steps where needed to reformat or extract relevant metadata in a standardized structure suitable for integration, archiving, and delivery to the USDOT. This approach ensures operational continuity for the sites while meeting the interoperability and documentation expectations of the program.

7.2.2. Metadata Update Process

An effective metadata update process is crucial for maintaining the accuracy, relevancy, and usefulness of metadata over time. The CTW Program team will manage metadata updates through a structured, event-driven process. Metadata associated with performance measures and V2X message data will be reviewed and revised whenever new data is added, significant changes occur to data collection processes, or adjustments are made to the data storage structure. Updates will be coordinated by each partner's data management lead to ensure consistency and accuracy across sites. All changes to metadata will be logged and version-controlled to maintain a clear record of modifications throughout the CTW Program's operational period.

8. Archive and Retire

At the conclusion of the Phase 2 operational period, the CTW Program will formally end active data collection and performance measure reporting. It is anticipated that final performance measure calculations will occur within approximately 60 days following the end of the Phase 2 operational period.

Although the program will continue operations for five more years, data submissions to the USDOT repository and formal calculation of performance measures will stop at the end of Phase 2, thereby fulfilling grant requirements for data sharing and public transparency. By completing the upload of V2X data to federally designated repositories at this time, the program ensures that the collected information is securely archived and remains accessible to support future research, evaluation, and accountability even as operational activities continue beyond this phase.

Following the transfer of the required data to the USDOT and the calculation of performance measures that use this data, each CTW Program partner agency will independently determine how to manage any remaining project data stored within their Central Systems. Options for handling this data include deleting the data, archiving it for internal records, transferring ownership within their organization, or continuing to use the data as part of routine system operations during the subsequent five-year continued operational period. It is recognized that some of the systems and data processes developed for the CTW Program may remain valuable for ongoing operational use, and partners may choose to retain certain data for those purposes.

9. Privacy Management Plan

The CTW team developed a Privacy Management Plan, which documents all the state and local privacy laws for the data and code. A letter (body below) provided to the USDOT confirms that the CTW Program team is aware of and adheres to the established Privacy Management Plan.

> *In accordance with the requirements outlined in the DPP, the CTW team affirms that a comprehensive Privacy Management Plan has been developed and completed specifically for data handled as part of the CTW Program. The Privacy Management Plan has been prepared in compliance with all relevant state and local laws applicable to the deployment locations and serves as the guiding document for privacy management within the project.*
>
> *The Privacy Management Plan establishes policies and procedures to ensure the responsible collection, use, storage, and protection of data while adhering to all applicable privacy regulations. It provides a structured approach to addressing privacy risks, defining roles and responsibilities, and maintaining transparency in data handling processes.*
>
> *The CTW team is committed to implementing the privacy protections outlined in the Privacy Management Plan and ensuring consistency with the overall data privacy strategy for the duration of the CTW Program. Should additional information or clarification be required, further details can be provided upon request.*

The relevant state data privacy laws and policies considered are as follows:

- The State of Utah – Privacy Policy (applicable to data stored on UDOT systems).
- CDOT – Procedural Directive 1215.1: Protection of Personally Identifiable Information (applicable to data stored on CDOT systems).
- Wyoming Enterprise Technology Services – Internal Policy 8100-P166: Data Protection for Electronic Government Services (applicable to data stored on WYDOT systems).

Appendix A. Glossary

Table 35 includes terms that are integral to the Data Plan and their definitions.

Table 35. Glossary
Source: WSP, January 2026

Term	Definition
Connected Intersection Message Monitoring System (CIMMS)	Developed by the Connected Vehicle (CV) Pooled Fund Study (PFS) to monitor the operation of CIs by comparing vehicle movements through the intersection with the active Signal Phase and Timing (SPaT) and MAP messages to identify inconsistencies. This open-source tool gives the unprecedented capability to assess real-time operations of intersections.
Cirrus	A scalable and cloud-based V2X MMS platform developed by Panasonic that helps agencies manage the broader V2X ecosystem, collect and manage data, create TIM messages, and monitor system health.
iNET	A scalable and cloud-based V2X MMS platform developed by Parsons and Taplane that helps agencies manage V2X systems, including collecting and managing data, creating TIM messages, and monitoring system and component health. In Utah, this system is known as "Connected Utah."
Operational Data Environment (ODE)	The ODE is an open-source set of tools used for backend systems in Colorado and Wyoming that support the encoding and decoding of Abstract Syntax Notation One (ASN.1), RSU management, privacy protection, and interfacing with third-party systems.
Situation Data Exchange (SDX)	A centralized data retention and distribution source by Trihydro for connected and autonomous vehicle (CAV) information, such as TIMs.
Subsystem	Subsystems refer to the self-contained software and/or hardware solutions that comprise the overall CTW Program system. The subsystems can operate independently but will be interconnected and interdependent with the other CTW Program subsystems to collectively comprise the entire system. CTW Program subsystems are expected to include (as a minimum) the UDOT V2X MMS, the Trihydro SDX, the Trihydro ODE, the Helix Innovations Signal Command Module (SCM), and the Helix Innovations On-board Processors (OBPs).
Systems Engineering	A methodical interdisciplinary approach for the planning, design, implementation, technical management, operations, and retirement of a system.
Traffic Management Center (TMC)	Agency-owned center that collects traffic information, monitors and operates transportation networks and systems, and informs the public about changing travel conditions.

Term	Definition
V2X Maintenance and Management System (V2X MMS)	A generic term for a cloud-based V2X platform that helps agencies manage V2X systems. In this document, the V2X MMS refers to UDOT's use of both Cirrus and iNET / Connected Utah.

U.S. Department of Transportation
ITS Joint Program Office – HOIT
1200 New Jersey Avenue, SE
Washington, DC 20590

Toll-Free "Help Line" 866-367-7487

www.its.dot.gov

FHWA-JPO-26-19

U.S. Department of Transportation