MODEL CONNECTED VEHICLE (CV) DATA ARCHITECTURE PRIMER:

VISION, OPPORTUNITIES, AND IMPACTS OF CV DATA

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VISION AND EVOLVING ROLE OF CV DATA

The big picture vision for connected vehicles (CVs) has long been to enable a transportation future with improved safety, mobility, and system efficiencies through direct two-way communications between vehicles, as well as two-way communications between infrastructure systems and vehicles or vulnerable road users (i.e., pedestrians, bicyclists).

The Connected Vehicle Pooled Fund Study (CV PFS) researched current and emerging CV data activities to [develop a model CV Data Architecture] to support Infrastructure Owner Operators (IOOs) as they make decisions and implement processes for ingesting and/or providing CV data – including guidance for both ***direct*** *and* ***indirect CV data communication***. While the big picture vision for CV impacts is still not a reality, the findings of this project revealed numerous examples of CV data exchanges benefiting IOOs and travelers. From these examples, a series of use cases, requirements, and concepts were defined to be a resource for agencies as they plan for and manage CV data.

CV DATA COMMUNICATIONS

CV data communications may occur directly between roadside infrastructure and vehicle on-board units via cellular vehicle-to-everything (C-V2X) communications. However, CV data also includes private vendors and aggregation portals that serve as third parties to communicate CV data in one or both directions between IOOs and vehicles, as illustrated in Figure 1.

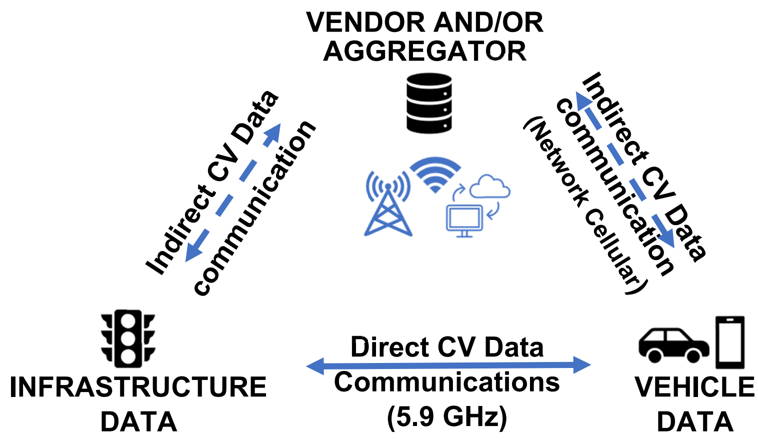

Figure 1: CV Data Communications

CV data is defined in this effort as real-time, near real-time, or historical data that is communicated either directly or indirectly between IOOs and vehicles.

KEY TERMS

Direct CV data communications: The movement of data directly between IOO infrastructure and vehicles, typically using C-V2X communications.

Indirect CV data communications: The two-way movement of data between vehicles and the infrastructure with the assistance of intermediary systems or services, typically through vendors or aggregation service providers and use of the cellular network.

TRENDS IN 2023

- Most CV data received by IOOs today are through indirect communications, with data provided as part of procured service agreements with vendors.
- Substantially more benefits are expected as direct CV data communications expand, especially if a harmony of automobile manufacturers increasing production of connected vehicles coincides with expanded connected infrastructure.
- IOOs have had successes developing national approaches and standards for ingesting and sharing CV data. The Connected Transportation Interoperability (CTI) family of standards and the Work Zone Data Exchange (WZDx) are examples.

EXAMPLES OF CV DATA THAT ORIGINATES FROM THE INFRASTRUCTURE AND VEHICLES

INFRASTRUCTURE DATA

Examples of the data that IOOs communicate to vehicles include:

- Signal Phase & Timing Status
- Position Correction Data
- Roadway/Intersection Geometry
- Road Geometry
- Advisory Speeds
- Road Weather Conditions
- Commercial Vehicle Restrictions

VEHICLE DATA

Examples of individual vehicle data communicated to IOOs includes:

- Vehicle Position
- Vehicle Speed
- Friction Between Tires & Road
- Occurrences of Harsh Braking

Vehicle data may be aggregated by vendors and delivered to IOOs as:

- Average Segment Speeds
- Origin-Destination Tables

The Model CV Data Architecture can be found on the Connected Vehicle Pooled Fund Study website at: https://engineering.virginia.edu/labs-groups/cvpfs

OPPORTUNITIES AND BENEFITS

Critical needs can be addressed by CV data and benefits recognized by IOOs and travelers. Example use cases for both IOO ingest of CV data and IOO provisioning of CV data to vehicles are described below.

Use Cases: IOO Ingest of CV Data

- In Utah, CV data is communicated from transit vehicles and snowplows to the infrastructure to request signal priority or preemption, improving vehicle on-time status and snowplow efficiency.
- Minnesota DOT receives CV data aggregated into average travel speeds to display current travel times on dynamic message signs (DMS), reducing reliance on detector data.
- The Kentucky Transportation Cabinet uses crowdsourced data to identify road weather hazards and monitor work zone performance.
- Maricopa County DOT in Arizona uses CV data to perform signal timings, reducing the need for floating car surveys.
- Maryland DOT accesses CV data through an aggregation portal to support post-event analyses and planning for managing future events.
- Many agencies ingest vendor data to provide speed data on traveler information maps.

Use Cases: IOO Sharing of CV Data

- Multiple IOOs share work zone data using the WZDx data specification via API data feeds.
- Multiple IOOs share event and condition data with Original Equipment Manufacturers (OEMs) and third parties to communicate to travelers and provide in-vehicle alerts.
- Connected intersections operated by IOOs in Utah, Ohio, and Georgia are being tested against current standards to ensure they will be trusted to share data to support in-vehicle red light violation warning (RLVW) applications.
- Current signal status reported on Internet feeds by centralized signal controllers in multiple cities are received by private vendors and communicated to vehicles to support green light optimization applications to reduce fuel consumption.