Consensus Recommendation

for

Using Third Parties to Deliver Infrastructure-to-Vehicle (I2V)

Version 1.0

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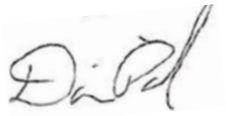
Prepared by  **Date** 04/16/2020
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Revision History

Version	Date	Author (s)	Comment
0.1	03/19/2020	SwRI	Initial Draft
1.0	04/16/2020	SwRI	Release Version

1. Document Overview

This document provides a summary of the salient elements of the Concept of Operations (ConOps), System Requirements Specification (SysRS), and Interface Control Document (ICD). It also captures the action items required to support the next steps for the project in order to achieve formal standardization of the Connected Vehicle (CV) Data Framework (CVDF).

2. Summary

2.1 Concept of Operations

The following bullets capture the development of the ConOps taking into consideration stakeholder engagement through email and walkthrough efforts:

- Based on stakeholder feedback the following data constraints and considerations were identified as necessary to provide useful CV data to third parties to guide initial system engineering:
    - Constraints
        - Data reliability
        - Data timeliness
        - Time synchronization
    - Considerations
        - GPS resolution and accuracy
        - Data rates
        - Security
- The following five applications were identified as representative of those offered by the majority of third-party data consumers and targeted for initial support through the CVDF. See Appendix A for details on these applications.
    - Red light violation warning
    - Pedestrian and cyclist warning
    - Eco-approach
    - Extended eco-approach
    - Data sharing by third parties
- The following functions and features of the CVDF were identified as necessary to provide data to third parties:
    - Functions
        - Provide data directly from devices
        - Provide enhanced data
        - Manage access to data
        - Verify contents/security of data from devices

        - Secure the connections to third parties
        - Provide the ability to archive data
    - Features
        - Web-based application programming interface (API)
        - User Interface for configuration and data management
        - Internal data store
        - Schemas
- The following use cases were identified:
    - CV Data Framework provides data directly with no modification
    - CV Data Framework provides data directly after algorithm enhancements
    - CV Data Framework provides aggregated data
    - Any valid combination of the above bullets

2.2 System Requirement Specification

The following bullets capture the development of the System Requirement Specification (SyRS) including differences from the initial system design within the ConOps based on stakeholder feedback:

- Original Equipment Manufacturers (OEMs) and third parties utilize the same interface and should be treated the same
- The system requirements do not define the internal structure of the CV Data Framework
- The System Integrator user was removed
- The original concept of the CV Data Framework having direct access to field devices was modified to abstract that access; the CV Data Framework may receive data from systems that integrate with field devices
- Main focus for features was on the API and the applicable schemas provided to stakeholders for feedback, which was then used when developing the ICD

2.3 Interface Control Document

The following bullets list the final elements of the initial ICD and capture differences from the requirements provided in the SyRS, based on stakeholder feedback:

- An API was established to define the interaction between data providers and data consumers
- Standard organizations were leveraged to provide the foundation for data including SAE, National Transportation Communications for Intelligent Transportation System Protocol (NTCIP), and Traffic Management Data Dictionary (TMDD).
- The following standard message sets and data elements were identified as most relevant to the applications identified in the ConOps:
    - SAE J2735

        - SPaT
        - MAP
        - BSM
        - PSM
        - MessageFrame
    - NCTIP 1202
        - ASC SPaT (time information regarding synchronization source is identified in NTCIP 1202v3)
        - Coordination parameters
        - Overlap parameters
        - Phase parameters
        - Ring parameters
        - Channel parameters
        - Unit parameters
    - TMDD v3.03d
        - Intersection signal
        - Time
- A reference API implementation of this ICD was created supporting SAE J2735 using a OpenAPI JSON document and was provided to the CV PFS panel as well as available online
    - SwRI will expand the reference OpenAPI implementation to add support for NTCIP 1202 and TMDD elements according to the ICD
    - Based on data communication budget concerns, the reference API could be improved to support encoding of a message in a variety of formats including JSON, ASN.1 UPER, ASN.1 XER, and YAML
- Event Streaming was prioritized for inclusion in the ICD to support high frequency messages such as SPaT and BSMs. Other internal features defined in the SyRS such as Access Manager, Data Curator, Data Archive, Message Validator, and Data Feed were not expanded in the ICD

3. Action Items

The list of recommended action items to support the development of a CVDF standard are indicated in the bullets below. For each of the major action items, the recommended executor(s) of the action item is listed in square brackets [].

- Task 3 - Development of Common Interfaces and Data Approaches
    - [SwRI] Update the reference implementation of the Swagger JSON to add support for NTCIP 1202 and TMDD data elements as identified in the ICD
    - [SwRI] Re-release the Survey of the Current Status with updates and stakeholder interviews that were gathered after the initial release

        - [SwRI] Identify a point of contact within CARMA, and determine the mutual fit for CARMA Cloud as a 3rd party implementation of a CVDF
- Task 4 - Submission of Recommendations to SDO (4/3/2020 -6/11/2020)
    - [CV PFS] Support standardization of the CVDF and creation of standardized documents in conjunction with a standards development organization (SDO)
        - [All] (ASAP) Identify the most appropriate SDO for this effort moving forward
            - International Organization for Standardization (ISO) Technical Committee 204, Working Group 1 - "Architecture"
            - Ken Vaughn is the convener
            - Committee members include subject matter experts across international government agencies, universities, commercial companies, and consultant engineering firms
            - WG 1 is developing standards for common information and methods in the ITS sector, including shared terminology, the standardization of data representation formats, architectures for sharing service and system concepts, as well as risk assessment methods and the benefits of services.[1]
            - WG 1 has the mission of: "…developing standards for common information and methods in the ITS sector, including shared terminology, the standardization of data representation formats, architectures for sharing service and system concepts, as well as risk assessment methods and the benefits of services."[2]
                - Pros:
                    - SwRI has strong existing relationships with key decision makers on this working group (including the chairperson)
                    - Architecture working group overlaps very closely with our efforts
                    - National Research Council (NRC) Canada can provide support for international engagement

[1] https://www.jsae.or.jp/01info/org/its/its_2019_en.pdf

[2] https://www.jsae.or.jp/01info/org/its/its_2019_en.pdf

    - Cons:
        - State agencies' engagements with ISO TC 204 are limited
        - Additional international interest is valuable in order to get ISO backing
- ITE, AASHTO, and NEMA (funding through USDOT)
    - Pros:
        - Current efforts exist similar in scope:
            - https://www.ite.org/technical-resources/standards/connected-signalized-intersection/
        - Federal Highway Administration (FHWA) has been contacted, awaiting information
    - Cons
        - Would require outreach to third parties
        - SwRI does not have existing relationships with key decision makers
- SAE
    - Pros
        - Integration with J2735
    - Cons
        - Third party engagement with SAE is low

- [All] The process to decide on an SDO should include
    - Identification of appropriate points of contact (PoC) with various SDOs
    - Do the PoCs agree that this is a topic of interest to the relevant SDO
    - Identify actual steps, timeline, communication plan (with identified team members for interfacing with SDO), and associated amount of effort (for SwRI and CV PFS) to bring standard forward for each SDO
    - Iterating over the possibilities between CV PFS team members via email, utilizing a decision matrix
    - Remote meeting with open discussion period
    - Make a decision regarding the SDO
- [SwRI] Support inclusion of documents (ConOps, SyRS, ICD) into standardization efforts
    - The value of data normalization should be noted

        - Normalization of data within the context of the CVDF would involve establishing a single stakeholder-approved representation of all data pertaining to the Connected Vehicle domain. The goal would be that the normalized data elements would allow for comparisons across different datasets and standards.
        - As an example, all data would be formatted/normalized relative to an SAE J2735 frame of reference wherever possible, using existing J2735 data elements, converting from TMDD and or NTCIP data elements as needed. When no corresponding J2735 data element exists, a recommendation to expand J2735 can be provided to the committee members.
        - This is a separate effort and should be preformed by coordinated with the SDO
    - [CV PFS] Supported data types and encodings need to be included as part of the standardization progress as they are identified by the larger SDO engagement group
- Tasks to execute after the Using Third Parties to Deliver I2V project has ended
    - [CV PFS] Support utilization of the reference OpenAPI implementation
    - [CV PFS] State agencies can provide the reference OpenAPI implementation to data framework implementers as appropriate. For example, TxDOT may host it on their ITS Code Hub.
    - [CV PFS] Support prototype implementations of a CVDF using the OpenAPI reference
        - Companies or agencies that implement a CVDF can work towards integrating the server stubs into production portals
        - Based on the data and network budget, decide on the encoding and aggregation requirements for each message
    - [CV PFS] Support third parties as they integrate the OpenAPI into their offerings
        - Require the OpenAPI implementation for future projects
            - Require adherence to the ICD for third parties that are requesting data
        - Third parties should be directed to start with the foundation of the client stub code
            - This client shall be used as the agreement between parties to define how data is provided and consumed

        - Version labels will be used to ensure compatibility between consumers and providers
        - Provide feedback to the CV PFS and SwRI regarding interactions with third parties – lessons learned for example
        - Improvements on these as needed
    - [CV PFS] Support compliance verification of CVDF implementations
- [CV PFS] Infrastructure owners and operators (IOOs) need to work with their equipment providers and ITS solution providers to extract data from field equipment in a manner consistent with the reference implementation and standardization efforts
- [CV PFS] Participation on the standards bodies and support for development of standards around CVDF

4. Conclusion

This summary reflects the learning that has been gained during the development of the systems engineering documents and the corresponding stakeholder engagement. The foundational understanding was established in the ConOps. The system requirements in the SyRS document incorporated stakeholder feedback on the ConOps and established the relevant system requirements and optional recommendations. The ICD then incorporated stakeholder feedback from both the ConOps and SyRS to define a means by which the identified applications could be supported by available data elements. The action items provided will facilitate the development of the standardization based on efforts and learning from this project. The action items provided will facilitate a path towards standardization via an SDO. They will also provide the means to implement Connected Vehicle Data Frameworks and third-party client implementations that follow both the ICD and OpenAPI reference. This will allow for state entities and third parties to share data while the standardization efforts are taking place.

Appendix A
Supported Application Examples

Supported Application Examples

Following are the applications currently supported by the ICD. This is not expected to be an exhaustive list but will allow for further refinement of the capabilities offered.

Eco-Approach and Departure at Signalized Intersection

This application provides a recommended speed to vehicles that are approaching an intersection or departing an intersection. The recommended speed maximizes some metric that is valuable to the vehicle operator, such as gas mileage or total travel time. The recommended speed is calculated by third parties based on SPaT, MAP and speed limit data.

Data Considered

1) Vehicle position (externally available from BSM source)
2) Vehicle speed (externally available from BSM source)
3) Intersection geometry (MAP)
    a) Lane geometry
b) Speed Limit per approach/roadway
4) Phase time remaining (SPaT)
    a) Desired Queue length

Extended Eco-Approach at Signalized Intersection

This application is similar to the previous application but extends the scope of the applicable intersections to include intersections that are more than one light cycle away. In order to perform the appropriate calculations for a recommended speed, additional information needs to be provided to third parties through the CV Data Framework. The information allows a third party to perform long-term predictions on a light's future state.

Data Considered (inherited from Eco-Approach)

1) Vehicle position (externally available from BSM source)
2) Vehicle speed (externally available from BSM source)
3) Intersection geometry (MAP)
    a) Lane geometry
    b) Speed Limit per approach/roadway
4) Phase time remaining (SPaT)
    a) Desired Queue length

Additional Data

1) Signal light timing plan

2) Time synchronization
3) Desired device status
4) Desired vehicle call per lane
5) Desired pedestrian call

Red Light Violation Warning

This application provides a warning to vehicles that are approaching an intersection if they would be likely to enter the intersection while the light is red. The warning is calculated based on SPaT and MAP data (provided through the CV Data Framework).

Data Considered

1) Vehicle position (externally available from BSM source)
2) Vehicle speed (externally available from BSM source)
    a) Acceleration (negative for deceleration)
3) Vehicle destination (for some intersections)
4) Intersection geometry (MAP)
    a) Location of cross-bar
    b) Roadway geometry
    c) Restricted movement
5) Phase time remaining (SPaT)

Pedestrian and Cyclist Warning

This application provides a warning to vehicles that a pedestrian or cyclist may be in the crosswalk. The broadcasted warning is expressed as an estimation or known detection, based on the data sources provided to the CV Data Framework.

Data Considered

1) Push button activation
    a) Real-time
    b) Historic activations
2) Intersection geometry (MAP)
    a) Lane geometry
3) Signal phases (SPaT)
    a) Desired exclusive pedestrian phases
4) Sensor feed (if available)
    a) On the curb
    b) In the crosswalk

Data Sharing by Third-Parties

This application refers to the sharing of aggregated vehicle data (and potentially predictive analytics insights such as traffic prediction, road surface changes, or water on roadway) to states/IOOs or other third-parties. Examples of data sharing include information about system performance (SPM reporting) as well as aggregation of data from different OEMs to provide agencies with meaningful reports and insights. From an operational standpoint, there are automation opportunities for traffic signal systems (transit signal priority, system feedback, etc.) and broadcasting of desirable information (queue length, disabled vehicles, etc.) that could be enabled through data sharing by third-parties.