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Joint Program Office

Cooperative Intersection Collision Avoidance System Limited to Stop Sign and Traffic Signal Violations (CICAS-V)

Concept of Operations

Final Phase I Release v3.01

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Virginia Tech Transportation Institute
3500 Transportation Research Plaza (0536)
Blacksburg, VA 24061
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The Cooperative Intersection Collision Avoidance Systems for Violations (CICAS-V) project aims to develop and field-test a comprehensive system to reduce the number and severity of crashes at intersections due to violations of traffic signals and stop signs. The purpose of this document is to provide a Concept of Operations (ConOps) for the CICAS-V project. The document is intended to guide the initial deployment of CICAS-V by describing how the system will function when it is in operation, and the basic needs that are satisfied by the system. It discusses key assumptions regarding the CICAS-V system operation and any necessary constraints that limit the flexibility of CICAS-V system design or implementation. This document serves as the basis for the development of the CICAS-V system requirements and detailed design.</td></tr>
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Table of Contents

List of Figures

List of Tables

1 Scope

The purpose of this document is to provide a Concept of Operations (ConOps) for the Cooperative Intersection Collision Avoidance System (CICAS) for Violations (CICAS-V), a system that involves both infrastructure and in-vehicle elements, working together, to reduce the number of crashes at controlled intersections within the United States. The document is intended to guide the initial deployment of CICAS-V over the next four to six years by describing how that system will function when it is in operation, and by describing the basic needs that the system must satisfy. It discusses key assumptions made in describing the CICAS-V system operation and any necessary constraints that limit the flexibility of CICAS-V system design or implementation. This document serves as the basis for the development of the CICAS-V system requirements and detailed design.

The CICAS-V system is being developed under a cooperative agreement program between the Crash Avoidance Metrics Partnership (CAMP) Vehicle Safety Communications 2 Consortium (Mercedes Benz Research and Development North America, Inc., Ford, GM, Honda and Toyota), hereafter referred to as VSC2, along with the Virginia Tech Transportation Institute (VTTI), the Intelligent Transportation System (ITS) Joint Program Office (JPO) of the Research and Innovative Technology Administration (RITA), the National Highway Traffic Safety Administration (NHTSA), and the Federal Highway Administration (FHWA). The program recognizes that there are significant synergies between CICAS-V and the Vehicle Infrastructure Integration (VII) Initiative. This document, therefore, makes reference VII as needed, but is intended as a standalone description of the CICAS-V ConOps.

The document[1] has the following structure:

- Section 1 covers the purpose for implementing the system, the system's major objectives and goals, assumptions and constraints of the system, the intended audience, CICAS-V system boundaries, and the overall vision for CICAS-V.
- Section 2 provides the references used in developing this document.
- Section 3 is a user-oriented operational description of CICAS-V, discussing which users are part of CICAS-V and the user responsibilities within CICAS-V.
- Section 4 discusses the operational needs that drive the requirements for CICAS-V.
- Section 5 is an overview of the CICAS-V system, providing more detail on what comprises the system.

[1] This document follows the guidance given in a recent FHWA pooled fund study, Developing and Using a Concept of Operations in Transportation Management Systems, which is based on the American National Standards Institute (ANSI)/ American Institute of Aeronautics and Astronautics (AIAA) standard, Guide for the Preparation of Operational Concept Documents. Common usage in systems engineering has the terms “Concept of Operations Document” and “Operational Concept Document” as interchangeable terms.

- Section 6 discusses the operational and support environment needed by CICAS-V.
- Section 7 describes operational scenarios, which illustrate how the system operates under different conditions.
- The List of Acronyms contains all of the acronyms used in this document and what they stand for; the Glossary of Terms defines key terms used in this document.

At a later date, this document may serve as a starting point for the development of a ConOps for an expanded CICAS, one that encompasses capabilities for addressing additional crash types and crash scenarios. At present, it is limited to CICAS-V capabilities and concepts.

1.1 Purpose for Implementing the System

The purpose of implementing CICAS-V is to reduce crashes due to violation of intersection traffic control devices—traffic signals and stop signs. When deployed, this system is intended to:

- Reduce fatalities at controlled intersections
- Reduce the number of injuries at controlled intersections
- Reduce the severity of injuries at controlled intersections
- Reduce property damage associated with collisions at controlled intersections
- Create an enabling environment that additional technologies can leverage to extend safety benefits further

There are about 9,500 fatalities in intersection area crashes in the U.S. every year with an impact of approximately $97 Billion. Out of those totals, CICAS-V has the potential to address intersection crossing path crashes that entail about 2,700 fatalities with an impact of $19 Billion.[2]

Because the application of CICAS-V is specific to violation of controlled intersections, it is important to clearly define that context. The American Association of State Highway and Transportation Officials' (AASHTO) *A Policy on Geometric Design of Highways and Streets* states that traffic control signals are devices that control vehicular and pedestrian traffic by assigning the right-of-way to various movements for certain pre-timed or traffic-actuated intervals of time. The Manual on Uniform Traffic Control Devices 2003 Edition (MUTCD) defines Traffic Signal as a power-operated traffic control device by which traffic (defined as pedestrians, bicyclists, vehicles, streetcars and other conveyances) is alternately directed to stop and permitted to proceed. The use of a traffic signal should be based on an engineering study and the satisfaction of at least one of eight warranting conditions in the MUTCD Chapter 4C. Other sources note that traffic signals are used to assign vehicular and pedestrian right-of-way and promote the orderly movement of vehicular and pedestrian traffic and to prevent excessive delay to waiting traffic.

[2] Chang et al., *CICAS-V Research on Comprehensive Costs*

Similarly, the MUTCD (Section 2B-05) stipulates that Stop signs should be used at the intersection of a less important road with a main road where application of the normal right-of-way rule would not be expected to provide reasonable compliance with the law (based on engineering judgment). Stop signs should not be used for speed control and should minimize the numbers of vehicles having to stop (MUTCD). At intersections where a full stop is not necessary at all times, consideration should be given to using a less restrictive measure such as a Yield sign. Multi-way stop control is sometimes used where the volume of traffic on the intersecting roads is approximately equal, often as an interim measure where a traffic signal is planned. Other conditions that may justify multi-way stop control are listed in Section 2B-07 of the MUTCD.

An initial analysis of relevant NHTSA crash databases shows that violation crashes have a variety of causal factors. The CICAS-V system is intended to address the causal factors that include driver distraction[3]; obstructed/limited visibility due to weather or intersection geometry or other vehicles; the presence of a recently installed traffic control (e.g., stop sign or traffic signal) at an intersection; and driver judgment errors. Driver warnings, such as those planned for CICAS-V, may prevent many violation-related crashes by alerting the distracted driver, thus increasing the likelihood that the driver will stop the vehicle and avoid the crash.

1.2 Goals and Objectives

CICAS-V is intended to provide a cooperative vehicle and infrastructure system that assists drivers in avoiding crashes at intersections by warning the vehicle driver that a violation, at an intersection controlled by a stop sign or by traffic signal, is predicted to occur. The basic concept of CICAS-V is illustrated at a high level in Figure 1 for a signalized intersection. In the figure, a CICAS-V equipped vehicle approaching a CICAS-V equipped intersection receives messages about the intersection geometry and status of the traffic signal. The driver is issued a warning if the equipment in the vehicle determines that, given current operating conditions, the driver is predicted to violate the signal in a manner which is likely to result in the vehicle entering the intersection. While the system may not prevent all crashes through such warnings, it is expected that, with an effective warning, the number of traffic control device violations will decrease, and result in a decrease in the number and severity of crashes at controlled intersections.

[3] Campbell, B.N. et al., *Analysis of Fatal Crashes.*

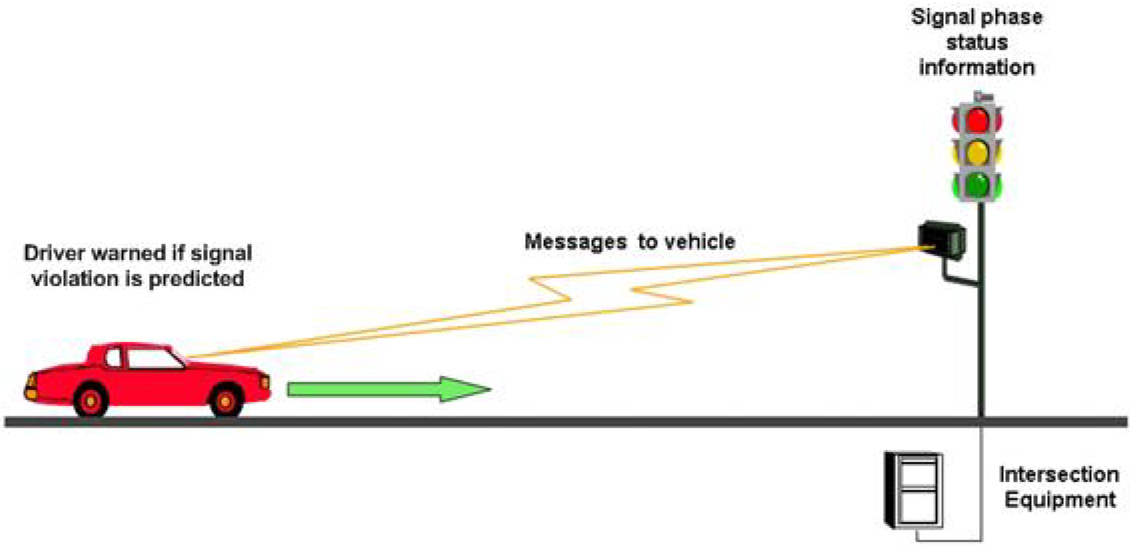

Figure 1 - Basic Concept of the CICAS-V System at a Signalized Intersection

Specific goals of CICAS-V include the development of:

- A violation warning system that will be effective at preventing violations for the purpose of reducing the number of fatal crashes, and the severity of injuries, and property damage at CICAS-V intersections
- A violation warning system that is acceptable to users
- A vehicle-infrastructure cooperative system that helps vehicle drivers avoid crashes due to violation of a traffic signal or stop sign
- A system that is deployable throughout the United States.
-

Specific measurable objectives to support national deployment of the designed system associated with the above goals for CICAS-V include:

- Reduction in frequency and severity of crashes at CICAS-V intersections
  - Measures:
    - Direct: Reduction in crash frequency and severity
    - Surrogate: Reduction in traffic signal and stop sign conflicts
- A system that drivers understand and find useful, so as to elicit a timely and appropriate response from the driver
  - Measures: Effectiveness, user acceptance, understanding, and usability
- A system that displays information consistent with other relevant established safety countermeasures, e.g., information provided by a traffic signal or a dynamic message sign
  - Measures: Effectiveness, user acceptance, understanding, and usability

1.3 Vision of CICAS-V

CICAS-V is intended to help a driver of a CICAS-V equipped vehicle approaching a CICAS-V equipped intersection to avoid crossing path crashes by warning the driver of an impending red-light violation or stop sign violation. To achieve benefits, it takes only a single equipped vehicle approaching a single equipped intersection at the proper time to activate the system. This "single vehicle" approach maximizes the probability of value being provided to drivers and departments of transportation (DOTs), while simplifying deployment issues and logistics. The benefit to society increases with growing numbers of CICAS-V equipped intersections and vehicles. Because of its relative simplicity, CICAS-V is seen as a step towards the deployment of initial vehicle safety communications as well as reliable positioning and geospatial mapping techniques. Once these technologies are available and installed in vehicles, they will enable many other safety applications, including both vehicle-to-infrastructure and vehicle-to-vehicle applications. CICAS-V will serve to promote the development of institutional relationships between the vehicle manufacturers and the DOTs. These institutional relationships may further the cause of transportation safety through the dialog that ensues.

The initial implementation of the CICAS-V system and any later enhancements are intended to work with the VII architecture. Figure 2 shows how CICAS-V would be related to the VII network.

Starting from this basic approach, several enhancements to the CICAS-V system may be possible. For example:

The vehicle might broadcast a message that an imminent crossing path violation is expected to occur. The CICAS-V intersection equipment could inform the traffic signal controller assembly[4] of the expected violation, and the traffic signal controller could choose to take some corrective action.

Once there is a sufficient level of vehicles and intersections equipped with communications and positioning capabilities, it may be possible to move beyond simple violation warning. The option exists to move towards control strategies in the vehicle such as automated braking to avoid rear-end collisions. This would require the knowledge of other vehicles stopping at the stop line in front of the warned vehicle and it requires more reliability than is expected from the initial system, but may be feasible in the future. It will also be necessary to consider the risk of drivers becoming dependent on the system and, therefore, less attentive to the task of driving.

[4] As defined in Appendix B, the "traffic signal controller assembly" represents the entire collection of traffic signal control modules, including the actual "traffic signal controller units". Both expressions are somewhat cumbersome for the reader, and "traffic signal controller" will be used throughout the remainder of the document, unless "assembly" or "unit" is specifically indicated by the context.

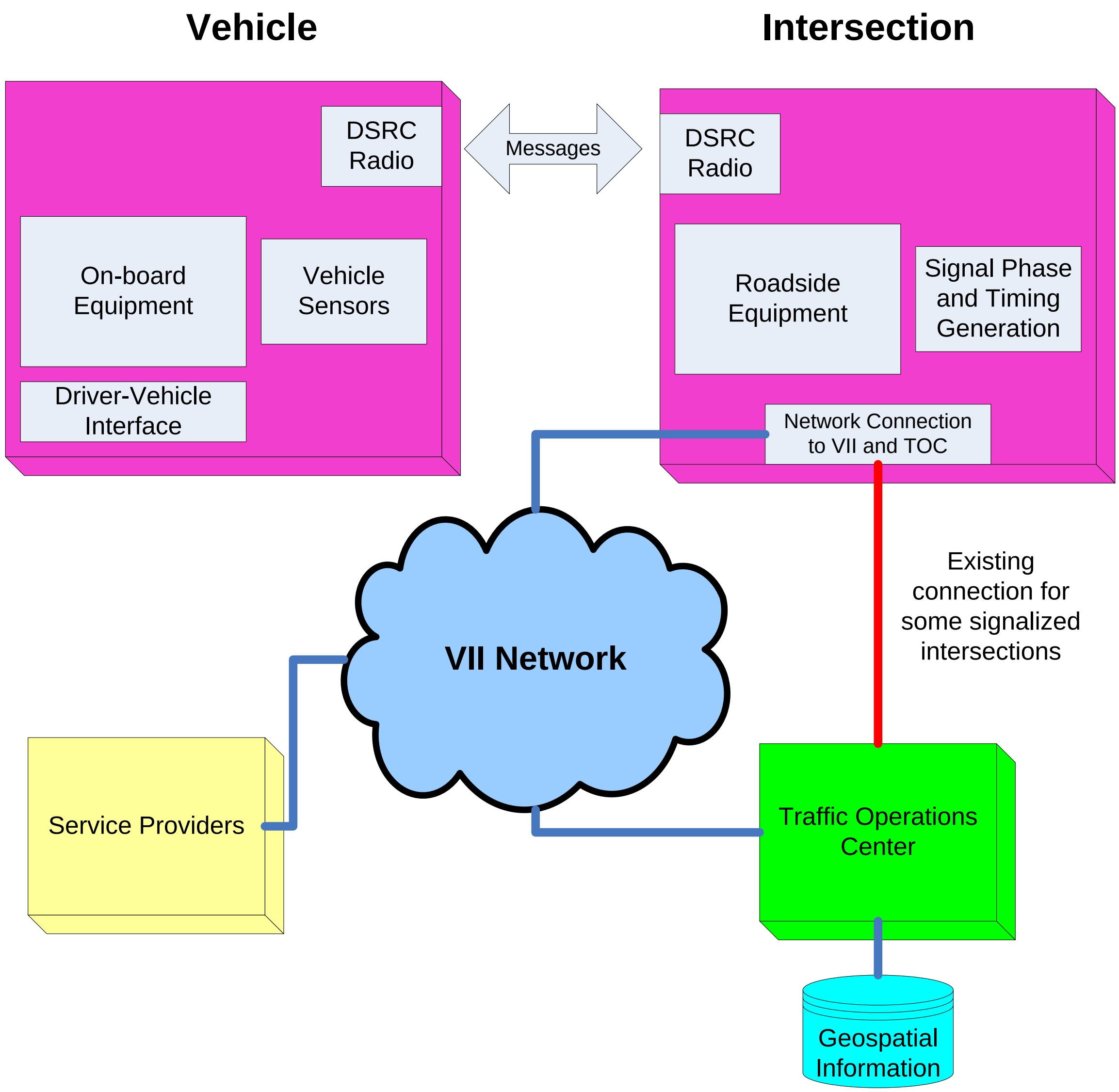

Figure 2 - CICAS-V Conceptual Framework

With increased infrastructure-based sensing equipment and/or higher dedicated short range communications (DSRC) vehicle fleet penetration, crashes beyond those caused by violations can be addressed and enhanced crash avoidance systems can be implemented. Figure 3 shows the evolution of CICAS capabilities that might be possible after the initial system has been deployed.

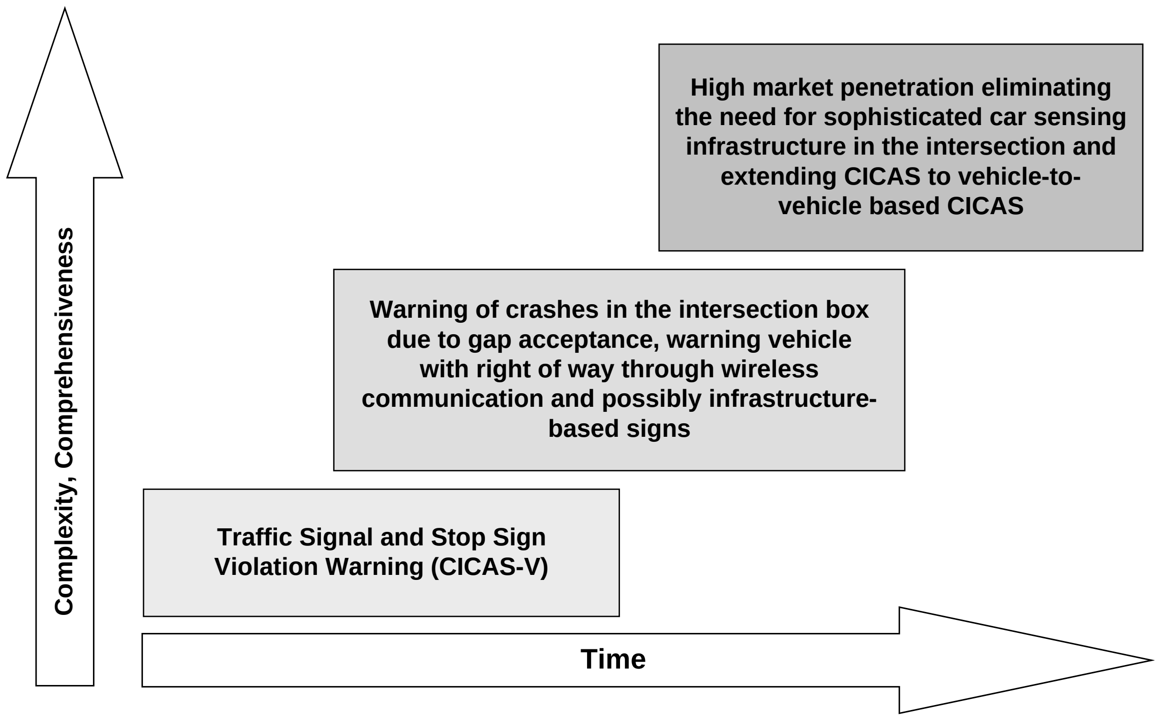

Figure 3 - Evolution of CICAS Systems

Increased DSRC market penetration and deployment of vehicle-sensing equipment at intersections to detect non-equipped vehicles will enable the development of cooperative systems that help avoid crashes based on erroneous gap acceptance, such as left turn crossing path crashes. Through the DSRC link, these cooperative systems would also warn the driver of the vehicle that has the right of way.

Ubiquitous deployment of DSRC might eliminate the need for sophisticated car sensing infrastructure at the intersection. Since virtually all vehicles would communicate with each other, vehicles could, through vehicle-to-vehicle communication, sense impending collisions and take appropriate countermeasures.

1.4 Assumptions and Constraints

1.4.1 Assumptions

CICAS-V will have a narrow focus in its initial implementation. Although it is intended as the first step in developing a full-scale cooperative system for reducing the likelihood and severity of intersection crashes, the desire to develop a capability that automotive original equipment manufacturers (OEM) and state and local DOTs can implement within the next four to six years has led to certain agreed-upon limitations. Assumptions about the initial CICAS-V implementation include:

1. Due to the large number of signalized intersections and the time and cost associated with identifying them as CICAS-V intersections, not all signalized intersections will have CICAS-V capabilities. State and local DOTs in cooperation with the United States Department of Transportation (USDOT) must

determine which signalized intersections warrant CICAS-V and prioritize their installation.

2. Due to the large number of stop sign controlled intersections and the time and cost associated with identifying them as CICAS-V intersections, not all intersections with stop signs will have CICAS-V capabilities. State and local DOTs in cooperation with the USDOT must determine which intersections with stop sign controls warrant CICAS-V and prioritize their inclusion in the geospatial database.
3. CICAS-V will be capable of using VII as its enabling foundation.
4. Not all VII-equipped intersections will have CICAS-V capabilities.
5. Not all CICAS-V intersection equipment will have continuous network connectivity. As such, the CICAS-V intersection equipment will not necessarily have continuous access to backend services (such as for security validation and software updates).
6. The initial CICAS-V deployment is targeted toward passenger vehicles. Passenger vehicles include light trucks and sports utility vehicles (SUVs). This group of vehicles is also called "light duty vehicles."
7. Not all vehicles will be CICAS-V equipped.
8. CICAS-V will not include automatic braking. However, brake *assist* is being considered as part of the initial prototyping and testing. Test results will determine whether this function remains as part of an initially deployable system.
9. Any vehicle with an in-vehicle CICAS-V system implemented will be able to inform the driver when the in-vehicle CICAS-V system is not working.
10. Pedestrians may benefit, but CICAS-V has no specific countermeasure(s) to protect pedestrians, bicyclists, or other vehicles. CICAS-V will not attempt to recognize the presence of pedestrians, bicyclists, and other vehicles moving in and around the intersection.
11. CICAS-V will not attempt to warn the driver if the vehicle has safely stopped at the intersection and subsequently accelerates such that a violation occurs.
12. All intersections (i.e., both signalized and with stop signs) to be CICAS-V equipped will:
    a. Have adequate positioning system coverage on all controlled approaches to the intersection.
    b. Have geometric intersection description (GID) that includes clear stopping locations (stop lines) for each lane in the intersection.
13. All signalized intersections to be CICAS-V equipped will:
    a. Have a GID that includes clear correlations between each lane and each signal indication at the intersection.
    b. Use a standard method for associating approaching vehicles with signal heads and signal faces.

   c. Have intersection approaches mapped with sufficient accuracy so that vehicles can clearly resolve which signals or signal heads apply to which vehicles.

14. For any shared means of communication, messaging standards will allow assigning priorities to messages such that safety-enhancing messages will have priority over non-safety-enhancing messages.

15. The owner of the intersection (or a contractor operating on the owner's behalf) will maintain an accurate and up-to-date GID for a CICAS-V enabled intersection.

16. The CICAS-V system will not include any driver-specific customization or learning feature in the initial deployment. The violation warning will not be tailored to drivers' individual driving habits.

1.4.2 Constraints

The currently known constraints are the following:

1. Radios used in the CICAS-V equipped vehicle and in CICAS-V roadside equipment will use the Wireless Access in Vehicular Environments (WAVE) standards, based on the DSRC standard approved by the Federal Communications Commission (FCC) for use by automotive safety systems. This document refers to these radios as WAVE radios. The WAVE radios used both in the CICAS-V equipped vehicle and in CICAS-V intersection equipment will transmit at a frequency of 5.9 GHz and have a range limited to about 1000 meters. Their range radius may be reduced in urban environments where radio communications are affected by buildings or other signal-blocking structures.

1.5 Intended Audience

The audience for this document includes:

- Federal, state, county and city DOTs
- Public safety community
- Passenger vehicle manufacturers / light vehicle OEMs
- Traffic operations managers and planners who will make decisions regarding where to deploy CICAS-V
- Designers of CICAS-V systems
- CICAS-V component suppliers
- Traffic control system manufacturers
- Traffic signal systems integrators
- Voluntary standards organizations that will be involved in standardizing the various elements of the CICAS-V system
- Research and development centers that conduct research on future enhancements of CICAS systems

1.6 Logical System Boundaries for CICAS-V

Figure 4 below addresses logical system boundaries for CICAS-V. These boundaries are discussed further in the following sections. Items inside the dashed "CICAS-V Boundaries" are discussed in the remaining sections of this document. Items depicted outside the boundaries are outside the scope of this document.

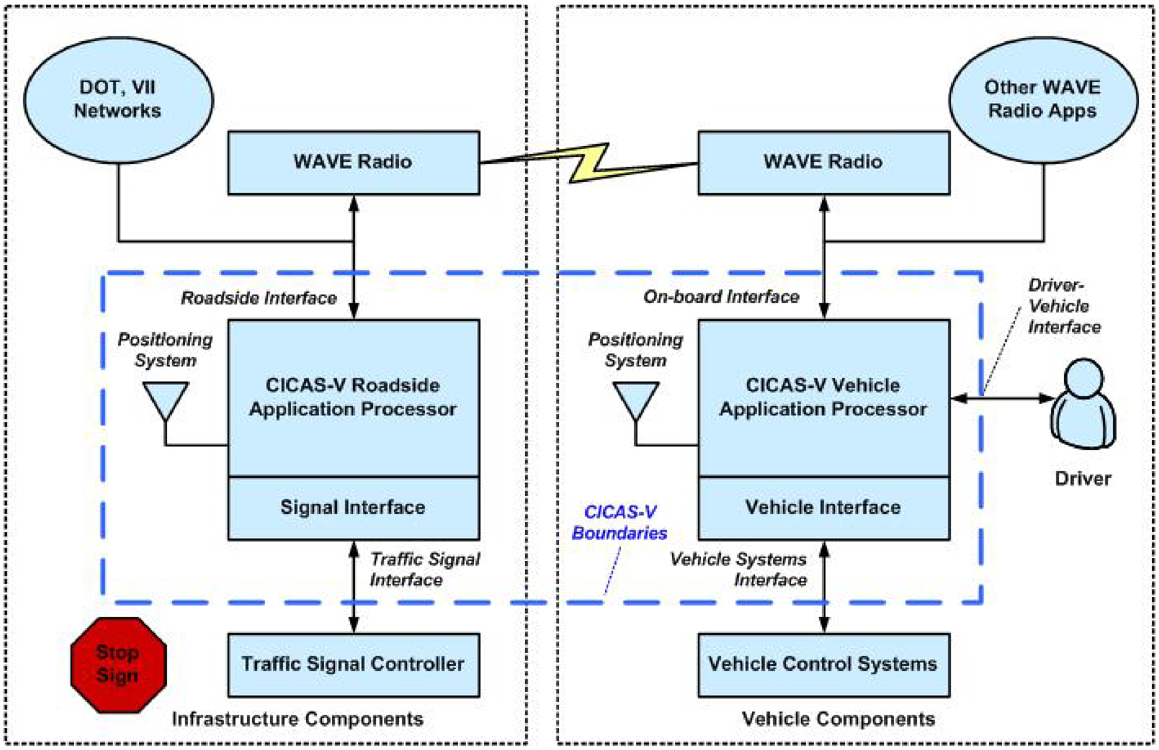

Figure 4 - CICAS-V Logical System Boundaries

1.6.1 Traffic Signal Controllers

Although CICAS-V requires signal phase and timing data from a signalized intersection, the traffic signal controller assemblies themselves are outside of the boundaries of CICAS-V. Signals are part of CICAS-V only at the point of the interface to the VII-provided roadside equipment (RSE). CICAS-V may also send a notification message to the traffic signal interface that a warning has been issued to a driver. The traffic signal controller response is outside the boundaries of CICAS-V.

1.6.2 Stop Sign Controlled Intersections

At stop sign controlled intersections with local RSEs, all electronics and algorithms in the infrastructure are within the CICAS-V boundaries. CICAS-V stop sign controlled intersections without local RSEs will be represented in the geospatial database that is sent to the vehicle as it drives past selected RSEs. The CICAS-V information broadcast by those RSEs is within the CICAS-V boundaries.

1.6.3 Communications to DOT and VII Networks

The CICAS-V roadside application may generate and receive messages (such as GID updates and system health and status) from one or more systems outside the CICAS-V application boundary. The messages are part of CICAS-V. The messages may be delivered through the VII network or through existing communication links by state and local DOTs. Both networks are outside the CICAS-V boundaries.

1.6.4 Positioning

All forms of positioning support (e.g., roadside unit-based or wide area differential global positioning system (DGPS)) are considered within the CICAS-V boundaries.

1.6.5 WAVE Radio Communications

The CICAS-V message sets, message formats, and communication requirements are within the boundaries of the CICAS-V system. However, the standardization, implementation of security protocols, and development of the radios are not.

1.6.6 Other WAVE Radio Applications

CICAS-V will be compatible with and operate in conjunction with other services using the WAVE radio data link; however, modifications to other services or applications are outside of the boundaries of CICAS-V as long as they do not interfere with the functioning of the CICAS-V safety application.

1.6.7 Vehicle Control Systems

Messages from the vehicle control systems received are within the CICAS-V boundaries, although the control systems themselves are not. The CICAS-V system will interface with the vehicle control systems.

1.7 Other Boundaries

1.7.1 Legal Boundaries

Any violation enforcement actions at CICAS-V equipped intersections are outside the scope and boundaries of the CICAS-V system.

Privacy issues associated with data used by the CICAS-V system are outside the boundaries of the system.

1.7.2 State and Local Government Policy and Legislation Affecting CICAS-V Deployment

Legislation may be necessary to deploy CICAS-V. Development of legislation or public policy regarding CICAS-V deployment is outside the boundaries of the system.

1.7.3 Non-CICAS-V Equipped Vehicles and Infrastructure

Non-CICAS-V equipped vehicles and non-CICAS-V equipped intersections are outside of the boundaries of CICAS-V.

1.7.4 Aftermarket Suppliers of CICAS-V Equipment

Aftermarket suppliers of CICAS-V equipment are outside the boundaries of CICAS-V.

1.7.5 Pedestrians, Bicyclists, and Other Vehicles

CICAS-V does not have countermeasures that attempt to recognize the presence of others at the intersection. This includes other vehicles, pedestrians, bicyclists, and other users of the intersection. While preventing violations at CICAS-V equipped intersections may reduce the potential for harm to pedestrians and others who occupy the intersection, detecting pedestrians remains outside the boundaries of CICAS-V.

2 Relevant Documents

CICAS-V builds on a body of prior work, both technical and analytical, such as the Enhanced Digital Maps (EDMap) project that provided the foundation for the positioning work, the Vehicle Safety Communications I (VSC) project that laid the foundation for the DSRC technology that CICAS is using, as well as the work by the Volpe National Transportation Systems Center regarding intersection crash statistics and causal factors. The documents relevant to CICAS-V include:

A Policy on Geometric Design of Highways and Streets. 5th ed. Washington, DC: American Association of State Highway and Transportation Officials, 2004.

CAMP-Vehicle Safety Communications Consortium. *Vehicle Safety Communications Project: Task 3 Final Report: Identify Intelligent Vehicle Safety Applications Enabled by DSRC*. Washington, DC: National Highway Traffic Safety Administration, 2005.

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Najm, W.G., J.D. Smith, and D.L. Smith. *Analysis of Crossing Path Crashes*. Washington, DC: National Highway Traffic Safety Administration, 2001.

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Straight Crossing Path Collisions. Charlottesville, VA: Virginia Transportation Research Council, 2006.

Vehicle Safety Communications Project - Final Report. Washington, DC: National Highway Traffic Safety Administration, 2006.

3 User-Oriented Operational Description

This section was developed based on input from CICAS-V stakeholders who include members of the USDOT, vehicle manufacturers, and state and local DOTs. The descriptions represented here are subject to change as the CICAS-V operational concept is refined.

3.1 CICAS-V Users

Users of CICAS-V include the organizations, agencies, and individuals that are necessary for installing, maintaining, operating, and interacting with a functioning CICAS-V system. The primary users of CICAS-V are:

- Automobile OEMs – responsible for original equipment, and for vehicle-related equipment and software actions necessary to establish and maintain the in-vehicle CICAS-V system.
- State and local governments and their DOTs – responsible for all infrastructure-related actions except those handled by the VII Network Operating Entity, necessary to establish and maintain CICAS-V systems
- USDOT – responsible for developing high level guidance to state and local agencies in the deployment and operation of CICAS-V systems.
- Vehicle drivers – responsible for the decisions made when approaching and entering an intersection. Drivers are also responsible for the following:
    - Familiarization with the vehicle safety features
    - Vehicle maintenance, especially of the CICAS-V components
    - Assessing the traffic situation when an alert is issued and making a decision
- Traffic control equipment manufacturers – responsible for the development and maintenance of infrastructure equipment and software that can interface with CICAS-V (and other related safety systems, as they are fielded).
- VII Network Operating Entity – responsible for the overarching foundation network that will supply the communications that support CICAS-V.
- Organization responsible for CICAS-V guidelines and standards – responsible for rules and procedures necessary for CICAS-V systems and components to become operational.

There may be other secondary users (stakeholders) of CICAS-V. They are not addressed in this version of the ConOps.

3.2 Additional User Roles

The CICAS-V safety application represents a new class of safety system that depends on cooperation between infrastructure systems and in-vehicle systems, linked by communication. By its very nature, it requires changes in the roles of state and local DOTs, traffic control equipment manufacturers, and vehicle manufacturers. Later in the deployment cycle/timeline, aftermarket equipment providers and integrators as well as independent vehicle repair businesses will have to acquire the necessary skills to install, maintain, and repair cooperative safety systems. This ConOps only discusses the necessary changes in the roles for infrastructure operators, traffic control equipment manufacturers, and vehicle manufacturers.

3.2.1 Automobile OEMs

Automobile OEMs may incorporate their role into existing organizational structures. There are additional roles that they will assume to help ensure that CICAS-V remains in operation over the long-term. These include:

- Development of standards and certification procedures
- Training of personnel in CICAS-V systems
- CICAS-V hardware and software installation in new vehicles

3.2.2 State and Local DOTs

Since, state and local DOTs currently have the responsibility for intersection safety; therefore, they are viewed as having the primary role for the installation and maintenance of CICAS-V equipment at intersections.

State and local DOTs may incorporate the operation and maintenance of CICAS-V infrastructure-side applications and equipment into their existing transportation management organizations. Additional roles that they may assume include:

- Planning, identifying, and selecting CICAS-V intersections
- In conjunction with other state and local DOTs and traffic control equipment manufacturers, maintenance of test beds for testing enhancements and changes to CICAS-V infrastructure-side software and equipment
- Development of maintenance plans for CICAS-V equipment at intersections
- Installation of CICAS-V equipment at selected intersections
- Installation and maintenance of connectivity between the CICAS-V equipment at intersections and the traffic signal controller
- Validation and maintenance of CICAS-V operation at equipped intersections
- Installation of backend connectivity from roadside equipment to Traffic Control Centers, if needed or desired
- Generation, maintenance, and updates of GID and other geospatial information. Note that responsibility for this item is to be determined, and the state and local DOTs may choose to delegate this role to another entity.
- Participation in standards development activities
- Training of personnel in CICAS-V systems
- Implementation and maintenance of connectivity from the VII backbone network to state and local DOT centers

3.2.3 USDOT

The USDOT may incorporate its role into its existing organizational structures. There are additional roles it may assume to enable the success of a nationwide deployment of CICAS-V. These roles include:

- Development of guidelines to assist state and local agencies in the installation, operation, and maintenance of CICAS-V systems.
- Development of training materials and training courses related to CICAS-V system installation, operation, and maintenance.
- Development of automated tools that can be used to assist in the design of CICAS-V at specific intersections and in the performance monitoring of CICAS-V systems.
- Participation in joint working groups and standards activities to continually assess stakeholder needs with respect to CICAS-V and VII.

3.2.4 Vehicle Drivers

The vehicle drivers will not have to assume any additional roles. The vehicle drivers will experience the CICAS-V system when approaching CICAS-V controlled intersections as described in Table 1 and Table 2.

Table 1 - Driver Interface Concepts for the CICAS-V System – Signalized Intersection

CICAS-V Traffic Signal Controlled Intersections				
No.	**Scenario**	**User Experience**	**Timing**	**Example Physical Interface**
1	Vehicle approaches a signal-controlled intersection that is CICAS-V equipped	Driver receives indication that the vehicle is approaching a CICAS-V equipped intersection	As early as signal detected (or perhaps slightly later)	Continuous (non-flashing) blue visual indicator on High Head-Down Display
2	Appears driver will violate signal	Driver receives multi-modal warning of potential impending violation	Timing should be effective at assisting the driver in avoiding a potential collision by stopping at an appropriate location (as determined by the driver). Timing should not result in frequent alerts perceived as "too early"	Flashing red visual indicator on High Head-Down Display AND audible and/or brake pulse(s)
3	Vehicle approaches a signal-controlled intersection that is CICAS-V equipped, but the system is not operational	Driver receives indication that the CICAS-V system is not operating properly	As soon as determined	Continuous (non-flashing) red visual indicator on High Head-Down Display

Table 2 - Driver Interface Concepts for the CICAS-V System – Stop Sign Intersection

CICAS-V Stop Sign Controlled Intersections				
No.	**Scenario**	**User Experience**	**Timing**	**Example Physical Interface**
1	Vehicle approaches a stop sign controlled intersection that is CICAS-V equipped	Driver receives indication that the vehicle is approaching a CICAS-V equipped intersection	As early as stop sign detected (or perhaps slightly later)	Continuous (non-flashing) blue visual indicator on High Head-Down Display
2	Appears driver will violate stop sign	Driver receives multi-modal warning of potential impending violation	Timing should be effective at assisting the driver in avoiding a potential collision by stopping at an appropriate location (as determined by the driver). Timing should not result in frequent alerts perceived as "too early"	Flashing red visual indicator on High Head-Down Display AND audible and/or brake pulse(s)
3	Vehicle approaches a stop sign controlled intersection that is CICAS-V equipped but the system is not operational	Driver receives indication that the CICAS-V system is not operating properly	As soon as determined	Continuous (non-flashing) red visual indicator on High Head-Down Display

3.2.5 Traffic Control Equipment Manufacturers

Traffic control equipment manufacturers may enhance and modify their organizations to incorporate CICAS-V into their product lines. This role includes ensuring that CICAS-V (and other related safety systems) remains in operation over the long term. Specifically:

- Development and production of new traffic control equipment that includes CICAS-V capability
- Retrofitting existing traffic control equipment to accommodate CICAS-V functionality
- Participation in standards activities
- Development of test and installation procedures for CICAS-V infrastructure-side equipment in conjunction with state and local DOTs
- Training of personnel in CICAS-V systems
- Training of state and local DOT personnel in the operation and maintenance of CICAS-V infrastructure-side equipment
- Application software updates for CICAS-V infrastructure-side equipment

The roles of manufacturers' trade support and standards organizations are represented in Section 3.2.7 below.

3.2.6 VII Network Operating Entity

The VII program is in the process of defining the role of a VII Network Operating Entity. This entity will be tasked with the implementation and management of all aspects of the VII network that include: the wireless communication between a CICAS-V equipped vehicle and the VII RSE, communications across the backbone network, connectivity to VII Network end users, central processing systems required for network and applications support, and nationwide operation centers. The elements of the VII Network Operating Entity's role that are important to CICAS-V include:

- Implementation and maintenance of the VII backbone network to include transmission equipment, computing systems, and operations centers that may be necessary to sustain the nationwide network
- Establishment and management of standards activities that are related to WAVE communications
- Establishment, management, and enforcement of policies related to the use of and access to systems that are part of the network; as well as data transmitted using the VII network
- Establishment, implementation, and management of a security program that addresses both physical and logical threats to the system
- Certification of software for compliance with the Federal Information Security Management Act (FISMA) and other applicable regulations

3.2.7 Organization Responsible for CICAS-V Guidelines and Standards

The organization that will be responsible for CICAS-V guidelines and standards has not yet been identified. The guidelines and standards organization will define the rules and procedures used to determine that CICAS-V equipped intersections are ready for operational use. At a minimum, when the CICAS-V system is ready for operational use at an intersection it means that the CICAS-V infrastructure-side equipment, the interfaces between CICAS-V and the traffic signal controller assembly, and all other related equipment are performing to specified system level parameters. The guidelines and standards organization will specify the system level performance parameters, the guidelines for certification, and the guidelines for any diagnostic procedures. These roles are part of a set of issues that need to be resolved as part of the VII program.

3.3 Interaction between Stakeholders

The cooperative aspect of CICAS-V represents a level of interaction between vehicles and the roadway that is unprecedented. The need for information exchange between individual vehicles and roadside equipment may require the establishment of new working relationships among those responsible for the design, development, operation, and maintenance of vehicle and roadway systems. Some of the more traditional roles will be retained within organizations such as automobile OEMs; federal, state, and local transportation agencies; the traffic signal systems industry; and standards organizations. Interaction between these stakeholders has to date been facilitated through organizations such as AASHTO, Institute of Transportation Engineers (ITE), National Electrical Manufacturers Association (NEMA), SAE International (SAE), and American Association of Motor Vehicle Administrators (AAMVA). In some cases to be identified, new organizations or new joint working groups within existing organizations will need to be established to ensure that the national interests in CICAS-V are appropriately managed.

4 Operational Needs

The following are the operational needs for CICAS-V:

- CICAS-V needs to alert potential violators of traffic control devices in time for the driver to take action to avoid a potential crash.
- CICAS-V needs to take into account the full range of drivers, including inexperienced (e.g., teenaged) drivers and older drivers (e.g., slower reflexes, impaired hearing).
- CICAS-V needs to work in and with all types of passenger vehicles.
- CICAS-V needs to function in all weather and lighting conditions.
- CICAS-V needs to perform effectively in urban, suburban, and rural areas.
- CICAS-V needs to work at intersections controlled by traffic signals.
- CICAS-V needs to work at intersections controlled by stop signs.
- CICAS-V needs to function for a wide range of different intersection approach geometries.
- CICAS-V needs to work with transit signal priority and emergency vehicle signal preemption. Signal priority and preemption present a dynamic change in the signal timing plan with the exception of the yellow phase duration.
- CICAS-V needs to know the current signal phase and timing information from the traffic signal controller at a signalized intersection.
- CICAS-V needs to work with both fixed and traffic-actuated signal timing.
- CICAS-V needs to have an acceptable rate of false alarms and missed alarms when an alarm should have been issued.
- CICAS-V needs to use alerts that are effective and compatible with automotive human factors guidelines and OEMs' driver-vehicle interface principles and practices.
- CICAS-V needs to consider driver-vehicle interfaces that follow Human Factors guidelines issued by the FHWA and the NHTSA.
- CICAS-V needs to provide continuous diagnostic self-testing.
- CICAS-V needs both in-vehicle and infrastructure self-diagnostic tools that allow the system to take itself off-line in case of malfunctions.
- CICAS-V needs to report the off-line status of any of its components to the owner/operator of that component if and when that component takes itself off-line as the result of a self-diagnosed fault.
- CICAS-V needs to be able to indicate a CICAS-V vehicle system malfunction to the vehicle's driver.
- CICAS-V, since it is a safety-enhancing system, should strive for a high degree of reliability and availability.

- CICAS-V components need to be installed with sufficient physical security to minimize unauthorized access and to allow owners/operators of the components to know that unauthorized access has been attempted.
- CICAS-V communications need to have sufficient communications security to ensure the authenticity of all its messages.
- CICAS-V message authentication needs to be fast enough to support the crash reduction objectives.
- CICAS-V system upgrades need to be backwards compatible with previous versions of the CICAS-V system.
- The CICAS-V warnings need to be disabled when vehicle speed is below a to-be-determined threshold to avoid nuisance alerts and increase user acceptance.
- CICAS-V needs to be positionally accurate enough to create alerts when warranted and to avoid false positive alerts.
- CICAS-V must be compatible with other collision avoidance systems, e.g., rear-end collision avoidance, lane change collision avoidance, roadway departure collision avoidance.
- The CICAS-V system must not preclude interoperability and integration with current in-vehicle safety systems, with other future VII-enabled systems, and other future in-vehicle safety systems.

5 System Overview

The CICAS-V systems components and interfaces are depicted at a high level in Figure 5.

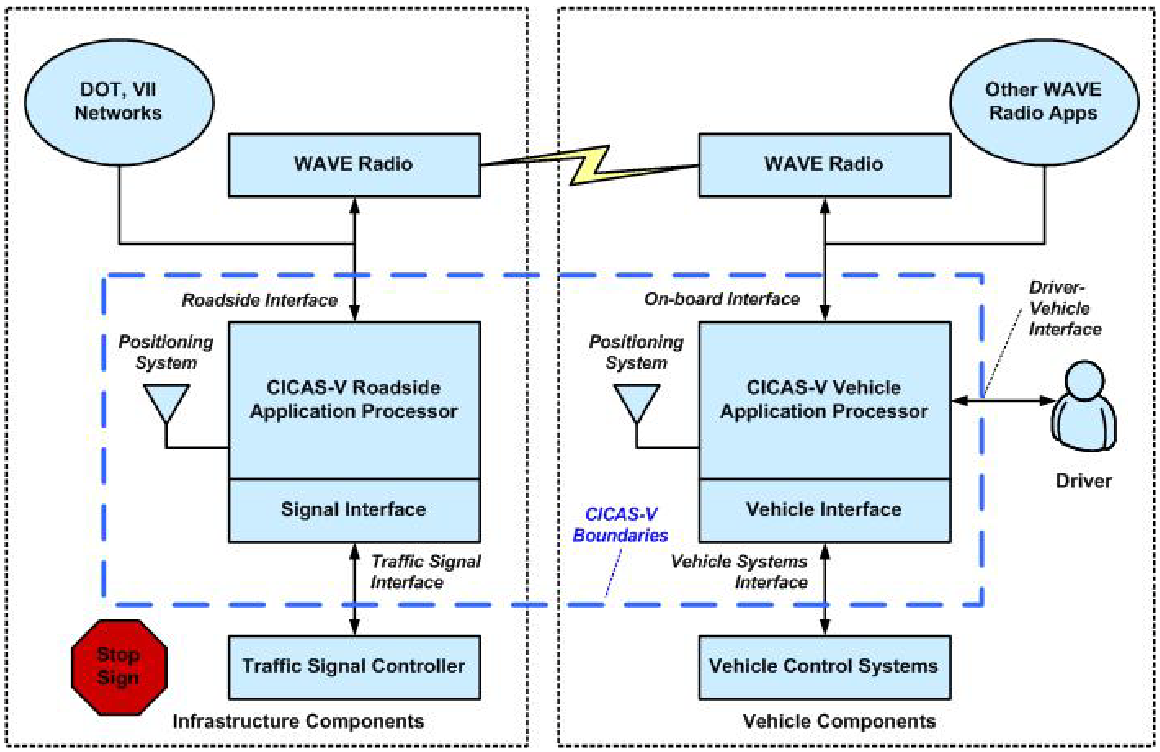

Figure 5 - CICAS-V Interfaces

The high level system components are as follows:

CICAS-V Vehicle Components

- CICAS-V Vehicle Application Processor (for example, Location Processor)
- Vehicle Interface
- Driver-Vehicle Interface (DVI)

CICAS-V Infrastructure Components[5]

- CICAS-V Roadside Application Processor
- Traffic Signal Interface

Further information about these components is found in Section 6. The following material describes the interfaces to these systems components and their capabilities.

[5] CICAS-V Infrastructure Components will be incorporated into existing roadside cabinets, where possible.

5.1 Interfaces

There are five interfaces, discussed below, between CICAS-V and its operating context. These are illustrated in Figure 5. For all of these interfaces, low-level interface details, such as the inner workings of the radio, are defined outside the CICAS-V system.

5.1.1 Roadside Interface

This is the interface between the CICAS-V application running at the roadside and the communications device that relays messages both to vehicles and to the VII Network or the DOT Traffic Control Center. The information that is generated and/or stored within the intersection CICAS-V system (signal phase and timing information, GID, positioning correction) will be passed to the WAVE radio through this interface.

5.1.2 On-board Interface

This is the interface between the CICAS-V application running in the vehicle and the communications device that relays messages to and from the roadside infrastructure and, in the future, other vehicles.

5.1.3 Driver-Vehicle Interface (DVI)

The DVI is the means by which CICAS-V conveys information to the driver. The CICAS-V vehicle application processor determines what information is necessary and passes it to the DVI which then provides it to the driver. The DVI can use several different modalities in conformance with the DVI policies of each OEM. CICAS-V must meet specific criteria, which include:

- Minimizing nuisance and/or false alarms
- Eliciting appropriate driver response (e.g., braking instead of steering)
- Minimizing negative consequences
- Affordability

5.1.4 Vehicle Systems Interface

The CICAS-V vehicle data interface connects the in-vehicle CICAS-V system to the vehicle data bus, sensors, and actuators on the vehicle such as wheel speed sensors, anti-lock brake sensors, electronic stability systems, etc. The information on the vehicle data bus will be used in the calculation of the warning.

5.1.5 Traffic Signal Interface

Every CICAS-V equipped signalized intersection will have a traffic signal interface for message exchange between the CICAS-V roadside application processor and the traffic signal controller. This interface will provide the current state of all signal indications and the time to the next state change if it can be calculated[6]. The interface can also be used to

[6] Options being considered for interfacing with the traffic control system include interfacing to the signal controller unit, the conflict monitor, or load switch/channel sensors (e.g., a signal sniffer). The different types of interfaces could provide varying levels of information to CICAS-V and may ultimately be a local implementation decision depending on the legacy traffic control system and the level of CICAS-V functionality desired.

provide a warning status from CICAS-V to the traffic signal controller. The warning status message could be used by the signal controller to initiate or extend an all-red phase.

5.2 System Capabilities (Functions)

CICAS-V capabilities are dependent on *co*-operation of infrastructure (roadway intersection) and vehicle components. Although the system can be architecturally viewed and concisely described in terms of the physical distribution of the components, it is important to reiterate that both the infrastructure and vehicle components are necessary for CICAS-V to achieve its operational objectives. The system's capabilities are therefore described here as aligned with the major components, but summarized in terms of cooperative capabilities in Table 3.

5.2.1 Infrastructure Component Capabilities

As described in Section 4, CICAS-V needs to work at both signalized and stop sign controlled intersections. Because of the signal system interface, a signalized CICAS-V intersection will always have CICAS-V intersection equipment, while a stop sign controlled CICAS-V intersection may or may not have CICAS-V equipment. The sections below discuss what capabilities are present when CICAS-V equipment is deployed at an intersection, and the additional capabilities that are needed when that CICAS-V intersection is also a signalized intersection. For CICAS-V intersections where there is no equipment deployed, all CICAS-V functions are performed within the vehicle.

5.2.1.1 General Infrastructure Component Capabilities

For each CICAS-V intersection with an infrastructure component, the CICAS-V roadside application processor broadcasts WAVE messages that include, but are not limited to, the following:

1. A CICAS-V service announcement (i.e., an announcement that the intersection has information for the vehicle)[7]
2. A positioning correction message
3. Geospatial information messages
4. Road surface information and other weather-related data if available

The content of these messages has not been finalized. The following briefly describes the contents of each of these messages. The final message sets may include additional or different information

Service Announcement: The service announcement provides vehicles with the intersection's identification (ID) code number and indicates whether the intersection's CICAS-V capability is operational. It also states whether GID or area-wide geospatial information is available, the version number of the currently available geospatial information (both GIDs and area-wide), and the channel on which the geospatial information is broadcast.

[7] This is the equivalent to the WAVE Service Announcement (WSA) used in other VII contexts.

Positioning Correction Message: This message contains the positioning correction information that the vehicle uses to improve its positioning accuracy.

Geospatial Information Messages: There are two types of geospatial information that may be broadcast.

The first type is the *intersection* GID, consisting of the following:

GID version

Intersection ID

Road/lane geometry for all approach roads

Location of the intersection stop lines

A lane numbering scheme that corresponds to the numbering of traffic signals and the geometry of any obstacles, dividers, etc. in the intersection box

The second type of geospatial information that may be broadcast is the CICAS-V *area* geospatial information consisting of the following:

Geospatial information version ID

Intersection IDs for all CICAS-V intersections within a specified area

Intersection type IDs (e.g., signalized intersection, stop sign controlled intersection) for all CICAS-V intersections within the specified area

Intersection GID detail for all CICAS-V controlled intersections in the specified area

The vehicle uses the GID version ID to determine if it needs to download a new version of the GID; it only does so if the GID version ID indicates that this GID is more up-to-date than the one currently stored in the vehicle's data store. The vehicle uses the intersection ID to match itself to the correct intersection in case it receives simultaneous messages from multiple intersections. The vehicle needs the road/lane geometry to match itself to the approach road and the specific lane[8] on the approach road, if such accuracy is needed. The vehicle uses the location of the intersection stop lines, which could be different for different lanes, to determine the distance from the stopping location. This distance is an important parameter for the warning calculation. The lane numbering scheme has to correspond to the traffic signal phase and timing scheme so that the vehicle can determine which signal information is pertinent.

An intersection's CICAS-V equipment must be placed at a point along the travel path to the intersection where it can complete transmission of GID updates in time for basic safety assessment algorithms to decode the information and calculate the likelihood of a traffic control violation. It must also be placed such that it can complete the download of the area CICAS-V geospatial information before the vehicle leaves the equipment's transmission range.

Road Surface Information and Other Weather-Related Data: CICAS-V equipment might transmit information to the vehicle about the road surface coefficient of friction at

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[8] Examples of different lane types that need to be identified are: dedicated left/right turn lanes and bicycle lanes that can be used as turn lanes. Other types exist.

the intersection, weather related data such as dew point, temperature, visibility, rain, etc. that might help the in-vehicle CICAS-V system to adjust the warning timing to take reduced friction into account.

5.2.1.2 Infrastructure Component Capabilities Specific to Signalized Intersections

At signalized intersections, the CICAS-V infrastructure-side equipment broadcasts an additional message containing traffic signal phase and timing data. The signal phase and timing message contains information and current status on the phase and timing of all the signals for each approach in the intersection. This message, together with the intersection GID, will enable the vehicle to determine which signal indication applies to it and use this information for determining whether a warning is warranted.

5.2.2 Vehicle Component Operation

When a CICAS-V equipped vehicle approaches a CICAS-V equipped intersection, the actions that the vehicle performs depend on whether the intersection is signalized or has a stop sign and on whether the intersection has CICAS-V infrastructure components. Table 3 summarizes what occurs in the vehicle as it approaches a CICAS-V equipped intersection. In all cases, the assumption is that the vehicle has previously received a download of GID information that identifies the CICAS-V intersection. If it has not received that download, the actions described in the column for "Stop Sign Controlled Intersections without Equipment" cannot be performed.

In addition to the steps discussed in Table 3, if the intersection has CICAS-V equipment, the vehicle also has to determine whether it has detected any problems with that equipment. If, for example, the vehicle does not receive a service announcement at an intersection that its internal geospatial information memory identifies as a CICAS-V equipped intersection, the vehicle should store the information about a malfunctioning CICAS-V intersection and broadcast this information to the next functional CICAS-V intersection equipment that it encounters. Not receiving expected messages constitutes an error condition that the vehicle should report at the next functional CICAS-V intersection equipment it encounters.

Table 3 - Summary of Action Sequences at CICAS-V Intersections

Step No.	CICAS-V Signalized Intersection	CICAS-V Stop Sign Intersection with Equipment	CICAS-V Stop Sign Intersection without Equipment
1	Vehicle approaches a CICAS-V equipped intersection.	Vehicle approaches a CICAS-V equipped intersection.	Vehicle approaches a CICAS-V intersection.
2	When in range of the RSE, vehicle receives a CICAS-V service announcement on the control channel indicating the availability of the intersection's GID, area geospatial information, the status of the intersection, and positioning corrections if needed.	When in range of the RSE, vehicle receives a CICAS-V service announcement on the control channel indicating the availability of the intersection's GID, area geospatial information, and positioning corrections if needed.	N/A. (This may occur at a different location, where a CICAS-V RSE exists.)
3	Vehicle decides if it needs either the GID or the area geospatial information broadcast, or both.	Vehicle decides if it needs either the GID or the area geospatial information broadcast, or both.	N/A. (This may occur at a different location, where a CICAS-V RSE exists.)
4	If necessary, the vehicle switches to the service channel to receive the intersection's GID and/or the area geospatial information.	If necessary, the vehicle switches to the service channel to receive the intersection's GID and/or the area geospatial information.	N/A. (This may occur at a different location, where a CICAS-V RSE exists.)
5	Vehicle receives the intersection's GID and/or the geospatial information.	Vehicle receives the intersection's GID and/or the geospatial information.	N/A. (This has occurred previously at a different location, where a CICAS-V RSE exists.)
6	Vehicle stores the new GID and/or geospatial information in its data store, replacing older versions.	Vehicle stores the new GID and/or geospatial information in its data store, replacing older versions.	N/A. (This may occur at a different location, where a CICAS-V RSE exists.)

Step No.	CICAS-V Signalized Intersection	CICAS-V Stop Sign Intersection with Equipment	CICAS-V Stop Sign Intersection without Equipment
7	Vehicle decodes the intersection GID and performs geospatial matching to locate itself relative to the intersection at the road or lane level, whichever is appropriate.	Vehicle decodes the intersection GID and performs geospatial matching to locate itself relative to the intersection at the road or lane level, whichever is appropriate.	Vehicle decodes the intersection GID and performs geospatial matching to locate itself relative to the intersection at the road or lane level, whichever is appropriate.
8	Vehicle informs the driver that it is approaching a CICAS-V intersection.	Vehicle informs the driver that it is approaching a CICAS-V intersection.	Vehicle informs the driver that it is approaching a CICAS-V intersection.
9	Vehicle determines from available parameters (e.g., GID, position, speed, driver behavior, signal phase and timing) if a violation is likely to occur.	Vehicle determines from available parameters (e.g., GID, position, speed, driver behavior) if a violation is likely to occur.	Vehicle determines from available parameters (e.g., GID, position, speed, driver behavior) if a violation is likely to occur.
10	If a violation is likely to occur, as determined by the warning parameters in the vehicle's safety assessment algorithm, vehicle issues a warning to the driver through DVI.	If a violation is likely to occur, as determined by the warning parameters in the vehicle's safety assessment algorithm, vehicle issues a warning to the driver through DVI.	If a violation is likely to occur, as determined by the warning parameters in the vehicle's safety assessment algorithm, vehicle issues a warning to the driver through DVI.
11	Driver reacts to the warning and takes appropriate action.	Driver reacts to the warning and takes appropriate action.	Driver reacts to the warning and takes appropriate action.
12	Vehicle may broadcast that a warning has been issued to the driver (optional).	N/A.	N/A.
13	Vehicle may broadcast CICAS-V diagnostic messages.	Vehicle may broadcast CICAS-V diagnostic messages.	N/A.

6 Operational and Support Environment for CICAS-V

6.1 Facilities

There are no new facilities necessary for the operation and management of the CICAS-V systems, although some users may choose to construct new facilities. Existing traffic management and maintenance facilities might need additional equipment and network connectivity to CICAS-V equipped intersections.

6.2 Equipment

The equipment needed to run CICAS-V at an intersection falls into two categories:

- Equipment common to all CICAS-V intersections with VII RSEs
- Additional equipment required at CICAS-V signalized intersections

The RSE is not required at stop sign controlled intersections that are CICAS-V enabled, so no additional CICAS-V intersection equipment would be needed.

6.2.1 Equipment Common to All CICAS-V Intersections with RSEs

The following items are needed when a CICAS-V intersection has an RSE:

- Housing (e.g., intersection controller cabinet; where possible existing roadside cabinets will be used, to minimize potential hazards at an intersection)
- Roadside equipment consisting of a minimum of:
    - A WAVE radio, capable of broadcasting and receiving at 5.9 GHz. This includes a suitably mounted antenna
    - A CICAS-V Roadside Applications Processor that handles all information processing
    - A device capable of storing geospatial information, including GIDs
    - Power and environmental conditioning (lightning suppressants, cooling fans, etc.)
    - Positioning system service sited to permit reliable transmission, within a specified radius, of positioning system corrections to vehicles. This includes a suitably mounted positioning system device and antenna capable of providing positioning aid to vehicles approaching the intersection
- An interface to the CICAS-V management system (see Section 6.3)

6.2.2 Additional Equipment Required At CICAS-V Signalized Intersections

The additional equipment needed to run CICAS-V at a signalized intersection includes the following:

- A data-accessible traffic signal controller
- A sensor to provide signal phase change information (only at signalized intersections where the data is not available from the traffic signal controller)
- An interface to a traffic signal controller unit, conflict monitor, or a signal phase sensor

6.2.3 Equipment for CICAS-V Enabled Vehicles

Equipment needed by CICAS-V enabled vehicles includes:

- A WAVE radio and antenna, capable of broadcasting and receiving at 5.9 GHz
- A CICAS-V vehicle applications processor that performs the computations and handles all information processing within the vehicle
- A device capable of storing geospatial data that is transmitted to the vehicle from the infrastructure component
- A positioning system, including a location processor, of sufficient accuracy that enables the vehicle to lane-match itself to the intersection GID
- A driver-vehicle interface
- Other vehicle sensors with an interface to the CICAS-V application processor

6.3 Management System Hardware

Hardware needed to run a CICAS-V management system includes the following:

- Computer systems to run the monitoring and diagnostic software
- Computer systems to manage system upgrades and software downloads
- Computers running the geographic information system (GIS) software to provide geospatial data for the intersection
- Routers for handling the backend communications with the RSEs within a Traffic Operation Center’s assigned area of responsibility
- Data connection to the RSE with sufficient bandwidth

All computer systems and other hardware systems require an uninterruptible power supply (UPS) capability to permit their continued operation in case of power failure at whatever facility they are located.

6.4 Software

CICAS-V needs the software components listed in the following sections.

6.4.1 In-vehicle Software

Software needed in the vehicle to maintain CICAS-V functionality includes:

- A secure, real-time operating system to run the application and communication software
- WAVE radio communication software
- Security/authentication software to authenticate messages
- CICAS-V application software
- CICAS-V diagnostic software

6.4.2 Roadside Software

Software needed at roadside locations to maintain CICAS-V functionality includes:

- A secure, real-time operating system to run the application and communication software
- WAVE radio communication software

- Network communication software
- Security/authentication software to authenticate messages
- Scheduling software to manage the sequence of broadcasts at intersections
- CICAS-V application software
- CICAS-V diagnostic software

6.4.3 Management System Software

Software needed to manage CICAS-V functionality from a remote location includes:

- Standard computer operating systems
- Network operating software
- Firewall software
- Remote update software
- System monitoring software (health, status, and update)
- Software to provide and maintain geospatial data

6.5 Personnel

At present, it is not clear what additional personnel will be needed to operate and maintain CICAS-V once it is deployed. It is anticipated that additional skill sets and training will be required. Those needs will become clearer after experience with the prototype CICAS-V system in its field operational test (FOT).

6.6 Management and Operations Activities

This section was developed based on input from CICAS-V stakeholders who include members of the USDOT, Vehicle Manufacturers, and State and Local DOTs. The descriptions represented here are subject to change as the CICAS-V operational concept is refined.

6.6.1 Automobile OEM Activities

6.6.1.1 Participation in Standards Activities and Certification Efforts

The OEMs will interact with the USDOT and other designated national CICAS-V entities and will participate with other relevant stakeholders such as automotive suppliers and state and local DOTs to develop standards and specifications for CICAS-V systems and to ensure interoperability, reliability, and maintainability of CICAS-V systems and develop requirements for new CICAS-V capabilities.

6.6.1.2 Installation of CICAS-V Systems

OEMs will develop specifications and performance requirements for suppliers to produce CICAS-V in-vehicle systems that comply with the OEMs accepted standards and will integrate those systems into their vehicles at the time of manufacture.

6.6.1.3 Maintenance and Upgrades of Equipment and Software

The OEMs will incorporate into established channels, such as dealerships, maintenance procedures for CICAS-V systems including making software updates available to vehicle owners.

6.6.1.4 End-user Manuals and User Instruction Procedures

OEMs will incorporate CICAS-V operating instructions into their established procedures for developing owner's manuals and instructional materials.

6.6.2 State and Local DOT Activities

The following categories of activities may be performed by State and Local DOTs or their designated contractors:

- Identification of intersections to be CICAS-V equipped
- Establishment and maintenance of CICAS-V intersections
- Establishment of accurate geospatial databases for both intersection geometry and location of CICAS-V intersections
- Definition and implementation of traffic control policies at CICAS-V intersections
- Maintenance of CICAS-V infrastructure elements
- Data collection and analysis to support safety and mobility performance monitoring

No consensus exists about who will perform these activities or exactly what steps would need to occur to establish and maintain CICAS-V intersections. The following sections provide a preliminary view of these activities.

6.6.2.1 Identification of CICAS-V Intersections

Before an intersection is equipped with CICAS-V technology, a state or local agency must determine that CICAS-V technology is an appropriate solution to the intersection's safety problems. At present, state and local DOTs have guidelines for determining whether to install a traffic control device at an intersection and, if they decide to install one, what type of traffic control device to install. CICAS-V technology is an add-on to existing traffic control and traffic safety devices.

Since there are no existing guidelines that allow state and local DOTs to determine what intersections should have this capability, these guidelines must be developed. As described in Section 3.2.3, the initiative for development of those guidelines will reside with the USDOT. Given that one goal of CICAS-V is to deploy this capability nationwide, the guidelines should be uniform, such as the MUTCD.

6.6.2.2 Establishment and Maintenance of CICAS-V Intersections

To establish an intersection as a CICAS-V intersection, the responsible DOT must develop an intersection plan for each such intersection. The intersection plan will contain such information as:

1. The proposed activation date for the intersection's CICAS-V capabilities
2. The site survey for the intersection, which will include:
    a. Geographic intersection coordinates that identify the intersection's reference point (for positioning corrections)
    b. Geographic coordinates that identify the location of the stop line(s) on all approaches to the intersection

c. Positioning system coverage for the intersection approach points and the intersection itself (to account for positioning system blind spots), including the location of positioning system antennas

d. The best location for the intersection's radio antennas, to include identification of the radio coverage and any radio blind spots

e. Correlation of signal heads and faces with intersection approaches and approach lanes (signalized intersections only)

3. Additional power requirements for the CICAS-V hardware

4. Test plan for ensuring that the intersection's CICAS-V equipment works properly before its usage is activated

5. Maintenance plan, to include periodic re-testing of the intersection's CICAS-V equipment to ensure that it is working properly.

6.6.2.3 Establishment of Accurate Geospatial Databases

State and local DOTs generate, verify, and maintain the GID of intersections and create, verify, and maintain a database with the location and the geometry of CICAS-V enabled intersections. The exact means by which this will be accomplished will be determined as the CICAS-V operational concept is refined.

In general, CICAS-V needs enabled vehicles to accurately calculate location relative to position on a roadway as these enabled vehicles approach a CICAS-V enabled intersection. Location accuracy is a combination of positioning accuracy (ability of the vehicle to locate itself on the road) and geometric information accuracy (degree to which a GID reflects the physical layout of the intersection). The GID will use global coordinates and the World Geodetic System 1984 (WGS 84) reference frame.

For stop sign controlled and signalized intersections with no dedicated turn lanes, the location accuracy (which is the combined geometric information and positioning accuracy) needed is called "WhichRoad" accuracy in the CAMP's EDMap project[9].

For signalized intersections with multiple lanes and dedicated turn lanes, the location accuracy needed is "WhichLane", which means that the location error has to be less than one-half lane width.

6.6.2.4 Definition and Implementation of Traffic Control Policies

State and local DOTs define what traffic control policies will be implemented at intersections in their jurisdiction in addition to CICAS-V systems. Those policies are outside the scope of CICAS-V.

6.6.2.5 Maintenance of CICAS-V Infrastructure Elements

Maintenance of CICAS-V infrastructure elements will be the role of state and local DOTs or their designated contractors.

[9] The EDMap project defined a third level of location accuracy, "WhereInLane" accuracy, which had an absolute accuracy of less than 0.3 meters. This level of accuracy is not deemed necessary for CICAS-V.

6.6.2.6 Data Collection and Analysis

Data collection and analysis to support safety and mobility performance monitoring at CICAS-V intersections will be the role of the state and local DOTs.

6.6.3 VII Network Operating Entity Activities

The VII program is in the process of defining the roles and responsibilities of a VII Network Operating Entity. This document does not discuss these activities.

6.7 Support Necessary to Operate the Deployed System

6.7.1 Standardization

In order to be implemented in a consistent fashion by jurisdictions across North America, CICAS-V hardware and software may require certification by one or more certification authorities. CICAS-V will use message and communication standards from the SAE and Institute of Electrical and Electronics Engineers (IEEE). AASHTO and ITE may also need to be involved to develop standards for the location of RSEs.

6.7.2 Training

State and local DOTs across the United States must be trained in the deployment and maintenance of CICAS-V systems. This requires the development of consistent plans for training and continuing education of all levels of personnel.

6.7.3 System Upgrades

After the initial deployment of CICAS-V, additional functionality may be developed. System upgrades, in both hardware and software, must be deployed in a coordinated fashion on a nationwide scale. This will require procedures for testing and certifying both hardware and software upgrades before they are presented for deployment. It will also require procedures for wide-spread (nationwide) deployment of software upgrades quickly and consistently.

6.7.4 Institutional Cooperation

Institutional structures for cooperation among the USDOT, the OEMs, and other CICAS-V stakeholders (such as traffic control system equipment manufacturers) are needed for the continuing successful operation of the CICAS-V system. New working relationships may need to be established to ensure the following:

- Nationwide CICAS-V compatibility – in order to establish and maintain nationwide compatibility of CICAS-V, appropriate involvement by public and private sector entities in standards development activities will be required. This will include working within existing standards organizations such as SAE, AASHTO, and NEMA; however, new working groups or committees may need to be created within these organizations that are directly related to CICAS-V. Implementations of CICAS-V will need to adhere to the standards established by these activities.
- Development of new CICAS-V requirements – in order to identify, design, and implement future CICAS-V capabilities, appropriate involvement by public and

private sector entities in defining the requirements for expanded CICAS-V functionality will be required. This will involve representation from the CICAS-V stakeholders in a “national level” working group to set priorities and schedules for the development, testing, and implementation of future CICAS-V enhancements. Once these new CICAS-V capabilities are developed, existing standards will need to be revised to accommodate the new functionality.

6.7.5 Geospatial Data Management

As a safety application, effective geospatial data management is critical to the operational success of CICAS-V. The deployed system will need to have:

- An intersection geospatial data management system in place to keep track of all planned roadwork at CICAS-V intersections; proactively identify changes to the data sent as part of CICAS-V, in particular, installation or removal of traffic signals or stop signs; and any changes to the approach geometry or signalization of CICAS-V intersections.
- The capability to disable CICAS-V functionality at intersections where the geospatial information is considered unreliable.

7 Operational Scenarios

7.1 Startup and Intersection Validation Scenarios

Conditions: The CICAS-V Infrastructure components have been installed successfully as described in the CICAS-V Intersection installation handbook. Before the intersection is put "in service", it is put in validation mode to complete the testing of the cooperation between vehicles and the infrastructure-side equipment. Maintenance vehicles that are CICAS-V equipped will be used for validating: positioning accuracy, WAVE radio communications, messages (timeliness and correctness), signal phase and timing accuracy, and signal head/lane matching accuracy.

Once CICAS-V has been installed at an intersection, the CICAS-V system goes into Validation Mode. A service announcement communicates this state to approaching maintenance vehicles. While the CICAS-V system is in Validation Mode, the maintenance vehicles traversing the intersection will need to provide feedback to the intersection RSE on their movements through the intersection so that the CICAS-V system can correlate these movements with its internal information, including the geospatial database and the signal phase and timing information, to validate that the system is performing as expected. The intersection will normally remain in validation mode until the appropriate validation requirements are met. While the CICAS-V system is in Validation Mode, its location will be included in all relevant geospatial databases that are propagated to vehicles that regularly traverse an area.

The specific types of data collection that will be performed as part of the validation process include the following:

Coverage Validation Data: When CICAS-V equipped maintenance vehicles detect an intersection in Validation Mode, they will record their location and a measure of data quality, such as packet error rate. They will then send this information to the intersection RSE, which will develop a coverage map for its specific transmitter. This actual coverage map will be compared to the intersection design's minimal required coverage map, which will be defined in the performance specifications. If the coverage is not better than the minimum required coverage, the intersection will remain in validation mode.

Positioning Validation Data: When CICAS-V equipped maintenance vehicles detect an intersection in Validation Mode, they will record positioning errors, number of satellites, and other available parameters that they detect as they approach that intersection. This information will be sent to the intersection RSE before the vehicle leaves the area. The actual positioning data from vehicles approaching the intersection will be compared to the coverage requirements in the CICAS-V intersection.

Geospatial Information Validation Data: When CICAS-V equipped maintenance vehicles detect an intersection in Validation Mode, they will broadcast a message containing their location, speed, and direction. These messages will show the movement of the vehicles through the intersection at the lane level and this information can be used to determine whether the GID is correct.

Phase and Timing Validation Data: When CICAS-V equipped maintenance vehicles detect an intersection in validation mode, they will broadcast a message containing their location, speed, and direction. The CICAS-V intersection RSE will receive these messages and develop a control map of the intersection. This control map will correlate movement of vehicles through the intersection with data from the traffic signal controller as to which lights are active. The CICAS-V management system will validate that the control map corresponds to the broadcast signal phase and timing from the intersection.

Once the requirements to put the CICAS-V intersection "in service" are met, the responsible organization will change the intersection from "validation mode" to "in service."

7.2 Normal Operation Scenarios

The following scenarios describe the normal operations of the CICAS-V system. In each of these scenarios, the state of the driver is unknown. The driver may be attentive, inattentive, distracted, incapacitated, or impaired. The driver may have the intent to obey or violate the traffic control he or she is approaching.

7.2.1 Simple Approaches

7.2.1.1 Simple Traffic Signal Approach

Conditions: The CICAS-V enabled vehicle is approaching a CICAS-V enabled traffic signal at a simple intersection with no dedicated turn lanes, where all vehicles on the same approach have the same traffic signal indication.

As the vehicle approaches a CICAS-V intersection and comes in range of the system's communications, the vehicle receives a CICAS-V service announcement on the control channel indicating the availability of the intersection's GID, area geospatial information, the status of the intersection, and positioning system corrections. The vehicle decides if it needs either or both of the GID or the area geospatial information broadcast. If necessary, the vehicle switches to the service channel and receives the intersection's GID and/or the area geospatial information. The vehicle stores the new GID and/or geospatial information in its data store, replacing any older information. The vehicle decodes the intersection GID and performs geospatial matching to locate itself relative to the intersection at the road or lane level, whichever is appropriate.

The vehicle then determines that the driver is approaching a CICAS-V enabled intersection with a single traffic signal indication, and that the driver has to stop at the signal, if it is red. At an appropriate distance from the intersection, the vehicle may alert the driver that a traffic signal is ahead. If the vehicle determines that the vehicle will come to a stop before a violation occurs, no warning will be issued. If the vehicle continues to approach the signal without slowing down sufficiently to stop when the light is red, the vehicle will issue a warning.

The distance and timing of the alert and warning will be calculated based on the current operating conditions of the vehicle, roadway geometry, and traffic signal state. This warning is likely to be in the form of a multi-modality alert. This multi-modality alert could include visual, auditory, and/or haptic alerts. The calculation may also include roadway conditions, if this information is available.

The alert / warning may be in the form of an audio signal, either tone or voice, possibly coupled with visual and/or haptic indications to the driver, depending on the DVI decisions made by the vehicle's OEM. Also, there may be some preparation for a possible crash in the vehicle, such as pre-tensioning of safety belts or priming of brake assistance systems, again depending on the individual decisions of the vehicle's OEM. The driver may or may not be aware of some of these crash mitigation actions.

With a driver who is willing to violate the traffic control, alerts and warnings of an upcoming traffic control may or may not have an effect on the driver's decision about stopping. For a driver who is distracted or otherwise inattentive, the alerts and warnings are intended to bring the driver's attention back to the driving situation so that the proper decisions can be made.

If CICAS-V, in the future, is implemented with traffic signal adaptation, it may improve the situation by keeping the traffic signal in an 'all-red' phase long enough to permit the violating driver to clear the intersection before the cross-traffic is permitted to enter. However, this may require a mechanism at the intersection to prevent drivers from learning that they can abuse the system.

7.2.1.2 Simple Stop Sign Approach

Conditions: The CICAS-V enabled vehicle is approaching a CICAS-V enabled, simple stop sign controlled intersection. It is presumed that the vehicle has previously obtained GID for the intersection as described in the prior scenario (Section 7.2.1.1).

The vehicle determines that the driver is approaching a CICAS-V enabled intersection with a stop sign control. At an appropriate distance from the intersection, the vehicle may alert the driver that a stop sign is ahead. If the vehicle determines that the driver is going to stop, no warning will be issued. If the vehicle continues to approach the stop sign without slowing down sufficiently to stop, the vehicle issues a warning.

The distance and timing of the alert and warning will be calculated based on the vehicle operating conditions and road geometry. This warning is likely to be in the form of a multi-modality alert. This multi-modality alert could include visual, auditory, and/or haptic alerts. The calculation may also include roadway conditions, if this information is available.

The alert or warning may be in the form of an audio signal, either tone or voice, possibly coupled with visual and/or haptic indications to the driver, depending on the DVI decisions made by the vehicle's OEM. Also, there may be some preparation for a possible crash in the vehicle, such as pre-tensioning of safety belts or priming of brake assistance systems, again depending on the individual decisions of the vehicle's OEM. The driver may or may not be aware of some of these crash mitigation actions.

With a driver who is willing to violate the traffic control, alerts and warnings of an upcoming traffic control may or may not have an effect on the driver's decision about stopping.

7.2.2 Intersections with Dedicated Left or Right Turn Lanes

Conditions: The CICAS-V enabled vehicle is approaching a CICAS-V enabled intersection with multiple traffic signal indications on the approach.

The normal operation scenario for this case is the same as the one for the simple signal approach since it is assumed that the vehicle is able to lane match itself through positioning and the intersection GID, and therefore identify which traffic signal indication pertains to its current location.

Appropriate protocols will have to be developed for the case in which a warning is needed but it cannot be determined which of the approach lanes the vehicle will take to pass through the intersection (e.g., prior to formation of the turn lane).

Figure 6 illustrates the situation where a vehicle enters a dedicated left turn lane that has a red left turn indication when the through lanes on the approach have a green indication. In the figure, the eastbound approach (left to right approach) has a vehicle that has just entered the left turn lane. The signal indications for the movements on this approach can be seen just below the approach. A red arrow is shown for left turn and green arrows are shown for the through and right turn movements.

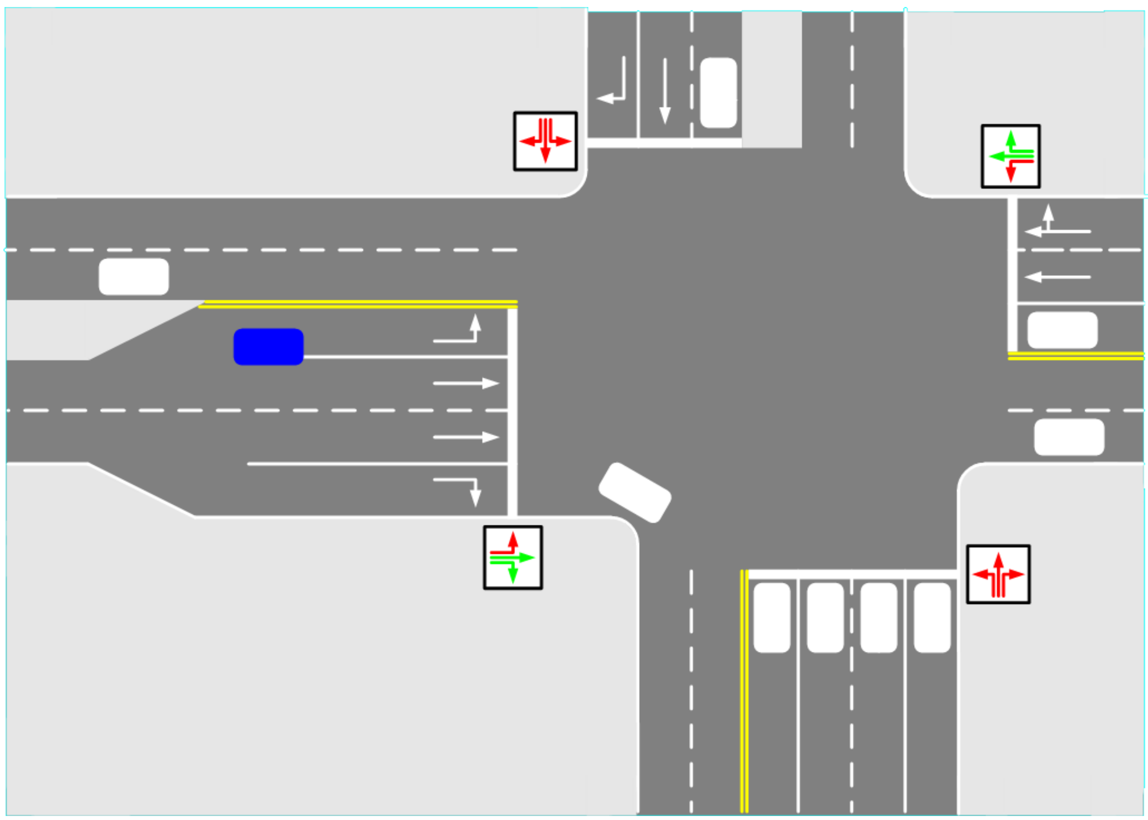

Figure 6 - Vehicle Entering a Dedicated Left Turn Lane

7.2.3 Approaching an Intersection with Limited Positioning Services

If the vehicle's positioning system is operating, there are two levels of local positioning limitations:

1. Vehicle is not able to position itself with WhichRoad precision, where needed
2. Vehicle is not able to position itself with WhichLane precision, where needed

In the first case, the vehicle's CICAS-V processes will be inactive for this intersection. In the second case, there are two possibilities, if WhichRoad positioning can be maintained:

1. The vehicle's CICAS-V processes are inactive for this intersection
2. The vehicle's CICAS-V processes will only consider the signals for the through-lanes.

The consistent inability of vehicles to position themselves at a specific intersection should be detected through ongoing monitoring and validation.

7.2.4 Flashing Traffic Signal

If a CICAS-V equipped traffic signal goes into flashing mode, the CICAS-V system will recognize the flashing indication (e.g., flashing red light) and broadcast the appropriate information in the message set sent to the vehicle. As in normal CICAS-V operation, the CICAS-V enabled vehicle will receive the message set, recognizing the flashing signal indication and react to this information as prescribed in the CICAS-V warning and alert algorithms. Drivers should treat a flashing red traffic signal as a stop sign and CICAS-V should treat the flashing red traffic signal as a stop sign (i.e., driver must stop the vehicle). On a flashing yellow, drivers should proceed with caution and be prepared to yield or stop.

7.2.5 Reduced Visibility

There are two types of reduced visibility scenarios that CICAS-V must consider. The first is when the reduced visibility is caused by weather, such as rain, snow, fog, or time of day (for darkness or sun glare). The second is when the reduced visibility is caused by obstructions in the driver's line of sight to the traffic control, e.g., vegetation, or a temporary object (such as a large parked or moving truck that blocks a driver's line of sight). In both cases, the presence of CICAS-V in the vehicle and in the intersection enables the driver to be alerted about the presence of the traffic control and alerted to the potential for a violation. The system will react in the same way as described in Section 7.2, although the driver response may differ because the driver may not be able to visually confirm the state of the traffic control device.

7.3 System Error and Failure Scenarios

This section describes some of the scenarios that may occur when various aspects of the system fail to operate.

7.3.1 Geospatial Database Errors

A CICAS-V geospatial database contains the locations of CICAS-V intersections. Appropriate information from this database will be broadcast to CICAS-V enabled vehicles entering an area, possibly covering multiple intersections. Stop sign information in this database can have two types of errors. These are discussed below.

7.3.1.1 Omission of Stop Signs

With or without support from a system such as CICAS-V, it is the driver's responsibility to stop for stop signs. For stop signs that are not in the database, there will be no CICAS-V support for the driver. Quality control systems that keep the CICAS-V geospatial database comprehensive and up to date will need to be developed in order to create and maintain driver trust in the system. Omission of stop signs from the database might be detected through statistical analysis of probe data start/stop events.

7.3.1.2 Inclusion of Nonexistent Stop Signs

Inclusion of nonexistent stop signs may increase potential traffic conflicts if drivers stop for no apparent reason. This situation will certainly lead to annoyance and reduced trust, both for the driver responding to the nonexistent stop sign warnings, and other drivers in the area trying to figure out what's going on. This might be detected through statistical analysis of probe data start/stop events as with the omission of stop signs above.

7.3.2 GID Errors

GID errors for CICAS-V intersections means that the geospatial data the vehicle receives from the intersection does not adequately reflect the actual geometry of the intersection or, for signalized intersections, the assignment of signal heads to the lanes. When a new CICAS-V intersection is put online, the validation procedures of the DOT operating the intersection should detect those errors and correct them before the intersection becomes active. However, temporary lane closures or re-routings due to maintenance or construction activities, police actions, or roadway debris will not be reflected in the geospatial information database. When this occurs, a vehicle might experience a false alert. For long term lane changes, it is the responsibility of the DOT operating the intersection to put the intersection “off-line”, i.e., in *inoperative* state, until a correct GID can be uploaded or the lanes are restored to their original states.

7.3.3 Communication Failure

Communication failure means that the vehicle does not receive some or all messages from the intersection. The cause of the communication failure may be due to the intersection’s equipment, the vehicle’s equipment, or interference from temporary, radio-blocking objects (e.g., a large truck) in the area. If the vehicle receives no messages from the intersection, it must assume that the intersection is not CICAS-V equipped.

The discussions below address the situation where the communication problem lies with the intersection and the vehicle is able to receive some messages, but not others.

7.3.3.1 Service Announcement

If the vehicle does not receive a service announcement, then it will not switch to another channel to receive a GID or geospatial information broadcast. The vehicle can determine, by its reception of other messages (such as signal phase and timing), that it is approaching a CICAS-V enabled intersection. However, the vehicle should communicate the malfunction to the next CICAS-V RSE.

7.3.3.2 Geospatial Information

If the vehicle does not receive a geospatial information broadcast (whether of the intersection GID or of area-wide geospatial information), then its actions depend on whether it has a GID of the intersection in its on-board data storage. If it has that intersection’s GID on-board, then it can use this GID, although there is a risk that the information may be inaccurate, depending on its age. Otherwise the CICAS-V processes will be inactive for this intersection.

7.3.3.3 Traffic Signal Phase and Timing

If no traffic signal phase and timing information is received for CICAS-V enabled signalized intersections, then the vehicle's CICAS-V processes will be inactive for that intersection. If one traffic signal phase and timing message is received, then the response will depend on the intersection. If the traffic signal is on a fixed schedule, then the vehicle can determine from the information contained in the message when the light is changing and can function in the default way. If it is a traffic-actuated signal, then the reaction of the vehicle will depend on the current phase and timing information it receives.

7.3.3.4 Positioning System Correction

If the vehicle does not receive a positioning system correction, then the CICAS-V response scenario will be that of an intersection with limited positioning services as described in Section 7.2.3.

7.4 Maintenance Scenarios

Conditions: The CICAS-V Intersection is "in service" and a diagnostic mode is set to trigger at an interval as set by the operating entity. This diagnostic mode is identical to the validation mode, but unlike the validation mode where there is manual intervention to put the system "in service", the CICAS-V application at the intersection automatically switches in and out of diagnostic mode.

The positioning accuracy, WAVE radio communications, messages (timelines and correctness), signal phase and timing accuracy, and signal head/lane matching accuracy of CICAS-V intersections must be periodically verified. Diagnostic data to verify that the system is functioning as required will be collected from vehicles as described in Section 7.1. Maintenance vehicles do not have to be used to communicate with the system while in diagnostic mode, however, if a problem is detected, the CICAS-V application will automatically take itself "out of service" and send notification to traffic operations that there is a problem.

Appendix A: List of Acronyms

AAMVA	American Association of Motor Vehicle Administrators
AASHTO	American Association of State Highway and Transportation Officials
AIAA	American Institute of Aeronautics and Astronautics
ANSI	American National Standards Institute
ATIS	Advanced Traveler Information System
CAMP	Crash Avoidance Metrics Partnership
CICAS	Cooperative Intersection Collision Avoidance System
CICAS-V	Cooperative Intersection Collision Avoidance System for Violations
ConOps	Concept of Operations
CVO	Commercial Vehicle Operations
DGPS	Differential Global Positioning System
DOT	Department of Transportation
DSRC	Dedicated Short Range Communications
DVI	Driver-Vehicle Interface
EDMap	Enhanced Digital Map
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FISMA	Federal Information Security Management Act
FOT	Field Operational Test
GHz	Gigahertz
GID	Geometric Intersection Description
GIS	Geographic Information System
GPS	Global Positioning System
ID	Identification or Identifier
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
IVI	Intelligent Vehicle Initiative
JPO	Joint Program Office
MUTCD	Manual on Uniform Traffic Control Devices
NEMA	National Electrical Manufacturers Association
NHTSA	National Highway Traffic Safety Administration
OEM	Original Equipment Manufacturer
RITA	Research and Innovative Technology Administration
RSE	Roadside Equipment
SAE	SAE International, an organization formerly known as Society of Automotive Engineers

SUV	Sports Utility Vehicle
TSA	Traffic signal adaptation
UPS	Uninterruptible Power Supply
USDOT	United States Department of Transportation
VII	Vehicle Infrastructure Integration
VNTSC	Volpe National Transportation Systems Center
VSC	Vehicle Safety Communications
VSC2	Vehicle Safety Communications 2
VTTI	Virginia Tech Transportation Institute
WAVE	Wireless Access in Vehicular Environments
WSA	WAVE Service Announcement
WGS 84	World Geodetic System 1984

Appendix B: Glossary of Terms

Automated Braking: Braking by control systems in the vehicle without driver initiation.

Brake Assist: Braking by control systems in the vehicle after the driver has initiated braking. The vehicle senses that the driver intends to apply a force and completes the braking for the driver.

Dedicated Short Range Communications (DSRC): DSRC or Dedicated Short Range Communications is a short to medium range wireless protocol operating in the licensed 5.9 GHz band and specifically designed for automotive use. It offers communication between the vehicle and roadside infrastructure.

Differential Global Positioning System (DGPS): DGPS is an enhancement to Global Positioning System that uses a network of fixed ground based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions. These stations broadcast the difference between the measured satellite pseudo-ranges and actual (internally computed) pseudo-ranges, and receiver stations may correct their pseudo-ranges by the same amount.

Driver-Vehicle Interface (DVI): A device within the vehicle that communicates information to the driver or alerts the driver to a situation, such as a potential violation of a traffic control.

False Alarm: An indicated fault where no fault exists.

False Alarm Rate: The ratio of the number of alarms that have no identifiable anomaly/fault/failure associated with them to the total number of alarms over some period of time.

False Negative: A case when an alarm is not triggered, or a rule is not fired, but the actual system behavior would indicate that there is a fault, or a developing failure. For CICAS-V, this is a situation when a traffic control violation warning should have been issued, but was not.

False Positive: The triggering of an alarm, or firing of a rule, when the actual system behavior would indicate that the action is not warranted. For CICAS-V, this is a situation where a traffic control violation warning was unnecessarily issued.

Geometric Intersection Description (GID): A digital representation of the geometry of the intersection that enables the vehicle to match itself to the correct approach road and to the correct approach lane on that approach road. It includes such information as the location of the stop line, a lane numbering scheme mapped to traffic signal indications, the orientation of the intersection to north, a version number and possibly other additional features.

Geospatial Database: A database with geospatial information about CICAS-V intersections. The database contains information such as the intersection IDs for all the CICAS-V intersections within a defined area, intersection type IDs (signalized, stop sign controlled) the GIDs for all CICAS-V stop sign controlled intersections in the specified area, a version ID and other information that may become important in the future.

Global Positioning System (GPS): A satellite-based navigational system allowing the determination of a unique point on the earth's surface with a high degree of accuracy and provides a highly accurate time source given a suitable GPS receiver. The network of satellites is owned by the US Department of Defense. It uses an intermediate circular orbit (ICO) satellite constellation of at least 24 satellites.

Intersection: For CICAS-V, an intersection is a junction of two or more public roads where at least one approach to the intersection is controlled by either a stop sign or a traffic signal.

Light Vehicles: The term "light vehicles" refers to passenger vehicles sold or operated legally within the U.S., including sedans, light trucks, and vans.

Roadside Equipment: A piece of equipment at the roadside or in the intersection that includes a WAVE radio and the software to operate that radio.

Stop line: Demarcated location on an approach to an intersection where a vehicle needs to stop for appropriate traffic control devices. The stop line location will be included in the geometric intersection description. For intersection approaches that do not have a stop line, an appropriate stopping location will be included in the geometric intersection description.

Traffic Control Center: A physical or virtual location where traffic control operations for local jurisdictions are monitored. A traffic control center is generally responsible for traffic operations for a specific geographic region, including traffic signals, surveillance cameras, and traffic signs.

Traffic Signal Related Terms:

- **Traffic Signal Adaptation**: Traffic signal adaptation (TSA) is a term used within the CICAS program to describe any number of applications where traffic signal timing is adjusted in response to a DSRC message sent from a CICAS-equipped vehicle to the CICAS intersection RSE. An example of a specific TSA application would be to extend an all-red traffic signal interval at a CICAS intersection upon receipt of a message from CICAS vehicle that the driver has been issued a violation warning or has not responded to a violation warning. Traffic signal adaptation is not envisioned as initial CICAS-V functionality.
- **Traffic signal controller**: Hardware located at the intersection that is responsible for controlling the traffic signal indications displayed on the traffic signal head.
- **Traffic signal controller assembly**: The complete set of components required to monitor and control the traffic signal indications displayed on the traffic signal head including: a traffic signal controller, conflict monitor, and power distribution assembly.
- **Traffic signal controller unit**: That part of a controller assembly that is devoted to the selection and timing of the display of signal indications.
- **Traffic signal indication**: The illumination of a signal lens or equivalent device.
- **Traffic signal head**: A housing that contains light sources, lens, and other components to be used for providing signal indications. A traffic signal head may contain one or more signal faces.

- **Traffic signal face**: The part of the traffic signal provided for controlling one or more traffic movements on a single approach.
- **Traffic signal cycle**: A complete sequence of signal indications.
- **Traffic signal phase**: The green, yellow, and red clearance intervals in cycle that are assigned to an independent traffic movement or combination of movements.
- **Traffic signal timing**: The amount of time allocated for the display of a signal indication.
- **Fixed time signal control**: Traffic signal timing such that the signal phase durations do not change from one cycle to the next. None of the phases function on the basis of actuation. (Also known as pre-timed control.) The fixed time intervals can vary by time of day.
- **Traffic actuated signal control**: Traffic signal timing where the initiation of a change in or an extension of some or all signal phases can be accomplished through any type of detector.

Vehicle Sensors: Sensors on a vehicle installed by the automobile original equipment manufacturer.

Vehicle-to-Vehicle Communication: Communication between vehicles using 5.9 GHz Dedicated Short Range Communications WAVE radios.

Violation: A violation is operationally defined under CICAS-V as crossing the stopping location at a stop sign before stopping or as passing the stopping location on a red light for a signalized intersection although legal definitions may vary by locality.

WhichLane: Accuracy level for the vehicle location that enables the vehicle to determine on which lane on which road it is approaching an intersection.

WhichRoad: Accuracy level for the vehicle location that enables the vehicle to determine on which road it is approaching an intersection.

Wireless Access in Vehicular Environments (WAVE): WAVE standards (IEEE 1609) provide a radio communication component to support the U.S. Department of Transportation's Vehicle Infrastructure Integration Initiative and Intelligent Transportation Systems program. IEEE 1609.3 is part of a standards family to support vehicle-to-vehicle and vehicle-to-roadside communications that will allow motor vehicles to interact with each other and roadside systems to access safety and travel-related information. See DSRC.

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

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