Initial Concept of Operations for the I-710 Zero Emissions Freight ITS Corridor

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Prepared for:  Gateway Cities Council of Governments
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1.0 Concept of Operations Overview

1.1 INTRODUCTION

This document describes the Concept of Operations (ConOps) for the proposed I-710 Zero Emissions Freight Corridor (ZEFC) Intelligent Transportation Systems (ITS) project, which is now under the planning and environmental process. Figure 1.1 shows the I-710 corridor location in Southeast Los Angeles County and the corridor study area in Gateway Cities. Gateway Cities is located in southeast Los Angeles County as shown in Figure 1.2. Gateway Cities includes 28 cities and unincorporated Los Angeles County and the Port of Long Beach (POLB). As shown in Figure 1.2, the Port of Los Angeles (POLA) is also at the southern end of Gateway Cities. The operations of the two ports dominate the industry in Gateway Cities. The I-710 freeway improvements include improvements to the existing general purpose lanes from Ocean Boulevard to SR 60 freeway (approximately 18 miles). A Zero Emission Freight Corridor is proposed to be built next to general purpose lanes. This is a limited access facility for zero emission trucks only. The Freight Corridor project involves the addition of zero emission truck-only lanes on I-710 between Pico Avenue in Long Beach and Washington Boulevard in Commerce, a total of 16 miles, alongside existing general purpose lanes. The zero emission truck-only lanes project would feature technology to enable zero emissions operations, autonomous truck conveyance control, electronic tolling, automated truck enforcement, truck platooning, and enhanced freight traveler information in truck lanes, as required by one of the major alternatives of the I-710 Environmental Impact Report (EIR)/Environmental Impact Statement (EIS). The ConOps includes the development and phased implementation of assisted and autonomous truck control that also uses emerging commercial vehicle technologies to decrease headway between trucks and increase safety, which provides increased throughput and reliability for trucks in the Corridor. The ConOps will eventually lead to full autonomous control for zero emission trucks in the Corridor.
Figure 1.1  I-710 Corridor Project Area
Figure 1.2  Gateway Cities Boundary
The I-710 Zero Emission Freight Corridor (ZEFC) ITS project addresses corridor needs indicated in previous studies, including increasing the capacity and throughput of trucks, improving travel time reliability, improving safety, and decreasing emissions. The project will build upon the unique operational environment and potential partnerships of the Gateway Cities subregion to promote and enhance autonomous commercial vehicle research by bringing together the applications of Connected Vehicle technologies with autonomous control technologies and with the real-world operational realities of a heavily congested truck corridor. The technology application to the I-710 ZEFC is based on previous ITS technology reports for goods movement developed by Gateway Cities. Those reports can be accessed from the Gateway Cities web site.

While the benefits of automated truck operation could extend well beyond I-710 to the Ports, the freight industry, the Gateway Cities, and Southern California, this Concept only considers operations the I-710 ZEFC alongside the I-710 general purpose lanes. Potential benefits include more efficient port and freight industry operations, reduced neighborhood impacts, improved safety, reduced emissions, and economic benefits from making Southern California a global center for automated vehicle research and deployment.

Objectives

This project has several objectives that will address both traffic concerns and economic development issues that include:

- Helping ensure the future economic viability of the Ports and Gateway Cities region through improved throughput, reliability, and dependability of truck access to the Ports via the new I-710 dedicated ZEFC;
- Building upon ongoing and rapidly advancing intelligent vehicle technologies for trucks to define an effective conveyance of trucks on the I-710 freight corridor that will safely maximize the throughput of trucks operating with zero emissions in the ZEFC;
- Helping Southern California establish a leadership position in Connected Vehicle technologies industry that will enhance the local economy;
- Establishing an ongoing partnership and environment that attract additional funding opportunities to bridge the gap between research efforts and effective real-world solutions for a real-world ZEFC;
- Separating corridor auto traffic from truck traffic as much as possible; and
- Providing improved safety, throughput, and reliability for drayage operations in the corridor.

Key Assumptions and Technology Requirements

A high level of traffic management and incident management will be required to effectively manage the ZEFC. For now, the Concept assumes that California
Department of Transportation (Caltrans) District 7 will continue to own the I-710 freeway, and Los Angeles County Metropolitan Transportation Authority (Metro) will provide a higher and more active level of management and monitoring of the I-710 ZEFC daily operations. Tolling of the I-710 ZEFC is being considered. Tolls will likely be fully automated with tolls collected electronically by Metro. There will not be any manual toll collection. A separate study is evaluating various forms of ownership that could be employed to deploy Zero Emission Trucks (ZET).

This ConOps assumes that trucking companies and truck owner/operators will own and must register their vehicles and obtain certification that each vehicle using the ZEFC lanes is a zero emissions vehicle, and that the ZET is operating in zero emissions mode while in the ZEFC. The zero emissions certification will be checked electronically for each vehicle entering the ZEFC lanes. It is also likely that the zero emissions technology will be in the Connected Automated Commercial Vehicle Management System and roadway, or roadside equipment would not likely be provided to power the vehicle, though that has not been finalized. The implementation of ZET is being studied separately in a zero emission truck commercialization study. That study should be referenced for implementation strategies and ZET types.

The ConOps assumes an estimate of 2025 for completion of the ZEFC construction, and that some level of technology for autonomous control functions in instrumented corridors will be available and implemented in the next 12 to 15 years. This assumes an evolutionary phasing of autonomous driving and connected vehicle functionality over the next 10 to 15 years. This phasing is described in the Concept along with the fully autonomous control scenario.

The implementation of this project includes a staged operational testing of likely technologies and operational policies over time in order to understand and develop the specific design and operational methods for the I-710 ZEFC. The results of these tests will provide valuable inputs to the design approach for the I-710 ZEFC freeway development project that will increase truck throughput, reduce truck volumes and congestion, and improve safety on the adjacent I-710 general purpose lanes and local arterial streets.

Another technology aspect for the I-710 ZEFC will be truck enforcement. A separate study and report on the Truck Enforcement Network System (TENS) have been developed for truck enforcement. TENS will include deployment for automated truck enforcement in the I-710 ZEFC that will include:

- Weigh-in-Motion (WIM) at all on-ramps;
- Virtual WIM at all on-ramps;
- Virtual inspection stations (at on-ramps and other locations);
- Automated signs to direct trucks to permanent truck enforcement inspection site;
- Virtual credential monitoring; and
- Virtual monitoring for the Zero Emission operational mode.

A technology element also included in the I-710 ZEFC will be collection and distribution of freight-only (in addition to general traffic information) traveler information in the I-710 corridor. This advanced traveler information, currently referred to as the GoFreight system, will be supplied to truck drivers, dispatchers and terminator operator or freeway operations, travel times, and truck locations and operations. This information will be used by these freight industry representatives, as they see fit, to improve or enhance their operations to make them more efficient. This will be particularly important as container volumes increase at the two ports.

Benefits

The I-710 ZEFC ITS will provide numerous benefits to both the trucking industry in the Los Angeles region and the general public. Benefits will accrue to the Ports and freight industry stakeholders in the region by providing increased capacity on the proposed I-710 ZEFC. The vision is to achieve maximum effective, safe capacity (throughput) within the physical constraints of the region’s key truck corridors in a zero emission mode of operation. This will reduce congestion, increase reliability, improve air quality, and result in more cost-effective and safe freight operations. By use of the I-710 ZEFC and safely increasing the capacity of the I-710 ZEFC, fewer trucks will be inclined to use the arterial system, reducing the negative impacts of truck traffic on Gateway Cities communities.

For the intermodal trucking industry, travel time across the I-170 corridor will be substantially improved, as will travel time reliability and freight-related traveler information. The number of crashes involving trucks should be reduced to nearly zero while using the I-710 ZEFC. The combined benefits of faster, more reliable drayage trips and virtually no crashes will provide a significant positive cost saving for the trucking industry in Southern California.

For the general public, there will also be positive benefits from the deployment of the I-710 ZEFC ITS. The reduction in the number of trucks using the I-710 general purpose lanes will reduce congestion and delay in the I-710 corridor. Also having a more homogeneous mix of traffic (mostly autos and light trucks) will reduce the number and intensity of truck-related crashes on the freeway’s general purpose lanes. Perhaps most importantly, the zero emissions component of the I-710 ZEFC ITS will improve air quality in the I-710 corridor, the Gateway Cities subregion, and the Los Angeles basin.
Relationship to the Gateway Cities Technology Plan for Goods Movement

This report is the ConOps for the I-710 ZEFC ITS project and the recommended approach for implementation. A ConOps provides a view of how the project is anticipated to operate and how the system meets user needs. The I-710 ZEFC ITS project is centered on developing a transportation system and ITS required to meet the zero emissions mandate for the future I-710 corridor. This includes the addition of zero emission truck-only lanes, physically separated, but adjacent to, the existing I-710 general purpose lanes. Furthermore, ITS technologies will be used on this dedicated ZEFC to enable autonomous control, electronic tolling, automated truck enforcement, and enhanced freight traveler information. The Concept includes the development and phased implementation of automated truck control that uses emerging commercial vehicle technologies to decrease headway between trucks and increase safety and efficiencies, which provides increased throughput and reliability (and cost savings) for trucks in the Corridor. The Concept will eventually lead to full autonomous control for trucks in the Corridor.

The Gateway Cities Council of Governments (GCCOG) began planning for the use of advanced technology in the Gateway Cities subregion and the I-710 corridor in 2006; and a report, *Gateway Cities Integration Plan for Goods Movement* was completed in August 2008.\(^1\) The Integration Plan described 14 potential plan elements, which were further studied in a follow-on planning effort beginning in 2011. This follow-on plan addressed the new truck-only facility on I-710 and ITS as an element of the broader program of individual technology projects based on the *Gateway Cities Technology Plan for Goods Movement*.\(^2,3\) These projects include the following:

1. Freight Transportation Information System and Data Fusion;
2. Freight Traveler Information Dissemination;
3. Arterial Smart Corridors for Freight;
4. Freeway Smart Corridors for Freight – Complete Freeway ITS Deployment;
5. Container Moves Productivity Improvements;


6. Automated Truck Research Project (I-710 Technology Plan); and
7. TENS.

This report focuses on the Automated Truck Research project, but each of the other six technology projects will also impact the I-710 ZEFC, and will require coordinated project development and implementation.

The Concept document concludes with several operational scenarios that illustrate how various I-710 Corridor stakeholders would use the planned technologies to achieve the goals and objectives of the overall project. If supported by the ITS Working Group (stakeholders), the logistics community, and GCCOG (in partnership with Metro, Caltrans, and Federal Highway Administration (FHWA)) will continue to develop this Concept in more detail, and develop engineering designs toward implementation of the I-710 ZEFC ITS project.

1.2 PROJECT IDENTIFICATION

The Caltrans project designation for the I-710 Corridor project is:
- EFIS Number is 0700000443, EA 07-249900, LA -710-04.9 / 24.9.

1.3 STAKEHOLDER IDENTIFICATION

Table 1.1 shows a listing of the stakeholders involved in project development and their roles in systems planning, operations, and maintenance.

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<td>Regional and local agencies: GCCOG, LA Metro; Southern California Association of Governments (SCAG); Southern California Air Resources Board; Cities of Los Angeles, Long Beach, and other cities in the Gateway Cities area; Los Angeles County</td>
<td>Regulate, plan, operate, and maintain roadway facilities</td>
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<tr>
<td>Caltrans District 7 and Central Office</td>
<td>Owner of I-710 and other regional freeways and state highways; operate and maintain those roadways</td>
</tr>
<tr>
<td>California Highway Patrol (CHP)</td>
<td>Conduct law enforcement and respond to incidents on regional freeways</td>
</tr>
<tr>
<td>POLA and POLB</td>
<td>Operate and manage the Ports</td>
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<tr>
<td>Federal entities: FHWA, ITS Joint Program Office (JPO) (Connected Vehicles Program), Homeland Security, Environmental Protection Agency (EPA)</td>
<td>Provide planning, oversight, and funding of transportation facilities</td>
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1.4 DOCUMENT OVERVIEW

This ConOps document includes 11 sections:

- 1.0 Concept Overview;
- 2.0 Referenced Documentation;
- 3.0 Current System Background and User Needs;
- 4.0 Justification and Nature of Changes;
- 5.0 Concepts for the Proposed Systems;
- 6.0 Operational Scenarios;
- 7.0 Summary of Impacts;
- 8.0 Analysis of the Proposed System;
- 9.0 Notes;
- 10.0 Definition of Terms; and
- 11.0 Glossary.

1.5 SYSTEM OVERVIEW

The I-710 ZEFC ITS project is envisioned as a ZET-only limited access facility that runs in parallel with the general purpose lanes of the I-710 freeway. The I-710 Corridor refers to both the existing general purpose lanes and the ZET-only lanes that will be added (see Figure 1.1). The Freight Corridor refers only to the truck
lanes. The ZEFC may be a tolled facility that will include automated truck enforcement and a freight-focused traveler information system. It will also be a zero emission facility; meaning the trucks would be powered by a zero emissions truck conveyance system. Finally, and relevant to this report and project, in an effort to increase capacity, reliability, and safety, the I-710 truck lanes will be an autonomous truck corridor; meaning the trucks themselves are planned to ultimately be under autonomous control – without driver intervention – with vehicle-to-vehicle communication and vehicle-to-infrastructure communications.
2.0 Referenced Documentation

The following is a listing of relevant local, state, and national documents and standards used in preparing this report.


• *Vehicle Information Exchange Needs for Mobility Applications*, U.S. DOT RITA ITS JPO, August 2012.

• Gateway Cities Air Quality Action Plan, GCCOG/LA Metro, October 2011.

• Self-Driving Cars: The Next Revolution, Center for Automotive Research and KPMG, January 2012.

• Platooning With IVC-Enabled Autonomous Vehicles: Strategies to Mitigate Communication Delays, Improve Safety and Traffic Flow, IEEE Transactions on Intelligent Transportation Systems, Volume 13, Number 1, March 2012, Pedro Fernandes, Member, IEEE, and Urbano Nunes, Senior Member, IEEE.

3.0 Current System Background and User Needs

In June 2012, Caltrans and Metro completed the initial I-710 Corridor Draft EIR/EIS and Section 4(f) Evaluation. This section provides a summary of the existing conditions and a description of needs for the I-710 corridor, as referenced in the Draft EIR/EIS document. The DEIR/DEIS is currently being revised and updated based on the comments received and new information and assumptions that need to be evaluated and included. The Revised DEIR/SDEIS will be recirculated in 2014.

The I-710 is a major north-south interstate freeway connecting the City of Long Beach to central Los Angeles. Within the I-710 Corridor Project Study Area, the I-710 corridor serves as the principal truck transportation connection for goods movement between POLA and POLB, (located at the southern terminus of I-710) and the Burlington Northern Santa Fe (BNSF)/Union Pacific (UP) Railroad rail yards in the Cities of Commerce and Vernon near SR 60 and destinations further inland.

Together, POLB/POLA is one of the largest container ports in the world, and container volumes are projected to triple by 2035. Existing and increasing container volumes will increase demand for transport of goods by truck in the I-710 Corridor. The I-710 Corridor also provides key interstate commerce connections to east-west freeways (I-405, SR 91, I-105, I-5, SR 60, and Interstate 10 (I-10)) and I-5. GCCOG, Metro, and Caltrans have completed (or are in the process of completing) numerous studies to improve all of these freeways and the transportation system in their corridors. Additionally, the proposed Gerald Desmond Bridge Project, which is directly connected to the I-710 Corridor Project at its south end, would replace the existing bridge.

The existing I-710 Corridor has elevated levels of health risks related to high levels of diesel particulate emissions, traffic congestion, high truck volumes, high accident rates, and many design features in need of modernization (the original freeway was built in the 1950s and 1960s).

The I-710 Corridor is a vital transportation artery, linking the communities along it and the POLA and POLB to the Southern California logistic facilities in Gateway Cities and beyond. An essential component of the regional, statewide,
and national transportation system, it serves both passenger and goods movement vehicles. As a result of population growth, employment growth, increased demand for goods movement, increasing traffic volumes, and aging infrastructure, the I-710 Corridor experiences serious congestion and safety issues. The existing I-710 freeway has basic six and eight general purpose lanes. The 18-mile corridor currently has 20 interchanges. The annual average daily traffic (AADT) in corridor ranged from 136,000 to 209,000 in counts taken in 2009; and the current traffic volumes average between 20 to 30 percent trucks in the peak hours.

Many segments of the I-710 mainline currently operate at level of service (LOS) E or F (100 percent of capacity) throughout the day, creating chokepoints and causing congestion on other segments of the mainline, as well as on parallel arterial highways. A unique factor affecting the capacity of the I-710 corridor is the large numbers of intermodal heavy-duty trucks (i.e., drayage fleet trucks) that use the I-710 corridor to travel between POLB, POLA, and the rail freight intermodal yards located near I-5 and to the transloading, warehousing, and distribution points scattered throughout Gateway Cities and the Southern California urban area.

Combined port activity in the study area is expected to increase from the handling of 14.1 million annual twenty-foot equivalent units (TEU) (two TEUs are equal to one 40-foot container) in 2013 to as much as 41 million annual TEUs by 2035, which represents the port cargo growth scenario adopted by the I-710 Corridor Project Committee in April 2009, and confirmed again by them in 2013. This forecast is consistent with SCAG’s recently adopted 2012 Regional Transportation Plan (RTP)/Sustainable Communities Strategy (SCS). The I-710 corridor is, and is expected to remain, a primary route for drayage trucks carrying containers to and from the Ports, and other intermodal cargo, trade, and distribution-related facilities. This indicates that the existing transportation problems on the I-710 mainline and other study area roadways will get worse, which, in turn, have the potential to adversely affect the competitive position of the Los Angeles region in the global economy.

By 2035, study area population is forecast to grow by 11 percent, and study area employment will grow by 7 percent. These increases in population and employment, along with increasing container volumes at the Ports and resulting truck trips between now and 2035, will lead to more traffic (autos and trucks) on the I-710 freeway and on the streets and roadways within the study area as a whole. This increased traffic will be above and beyond the increased goods movement traffic described above.

High traffic volumes, existing antiquated freeway design, freeway congestion, and the interaction between cars and the high volume of trucks in the traffic stream on the I-710 mainline are contributing factors to the existing high accident rates. In the study area, according to the Caltrans Traffic Accident Surveillance and Analysis System (TASAS), truck-related accidents range from 29 to
36 percent of the total number of accidents within the I-710 mainline study segments, which is significantly higher than the state average.

The I-710 freeway was designed in the 1950s and 1960s, before the dramatic increase in intermodal containerized trade with Asia and before extensive population growth in Southern California. In general, the I-710 freeway has remained relatively unchanged from when it was originally constructed. Due to growth in overall traffic volumes and the high level of truck traffic that has occurred in recent years, many portions of the freeway design do not operate efficiently due to the heavy truck traffic and the size and relative lack of maneuverability of those trucks and the large auto volumes.

In summary, the purpose of the I-710 Corridor Project is to:

- Improve air quality and public health;
- Improve traffic safety;
- Modernize the freeway design;
- Address projected traffic volumes; and
- Address projected growth in population, employment, and activities related to goods movement.

### 3.1 Objectives and Scope of the I-710 ZEFC ITS Project

This project is focused primarily on the future operational needs of the I-710 ZEFC, which is now under the planning and environmental process. However, the benefits of ZEFC are expected to extend beyond I-710 to the Ports, the freight industry, the Gateway Cities region, and the entire Southern California region. Potential benefits include:

- More efficient port and freight industry operation;
- Improved freight-focused traveler information;
- Reduced congestion;
- Increased throughput of trucks;
- Increased travel time reliability;
- Automated truck enforcement;
- Reduced emissions;
- Improved safety;
- Reduced neighborhood impacts; and
• Economic/job creation benefits that could accrue from making Southern California a global center for automated vehicle research and deployment.

This project will build upon the unique operational environment and potential partnerships of the Gateway Cities region to promote and enhance truck autonomous commercial vehicle research by bringing together the applications of autonomous commercial vehicle technologies with the real-world operational realities of a heavily congested freeway corridor with large volumes of trucks. The project will provide staged operational testing (demonstration tests) over time progressing the specific design and operational requirements for the future development of the I-710 and its approaches. It is expected that autonomous truck testing will begin in 2014 or 2015, followed by operational-level testing in the port region in 2015 and 2016. The results of these tests will provide valuable inputs to the design approach for the I-710 freeway technology development project.

This project has several objectives that will address both traffic concerns and economic development issues:

• Helping ensure the future economic viability of the Ports and Gateway Cities region through improved throughput, reliability, real-time traveler information, safety, and dependability of truck access and drayage operations for the Ports via the new I-710 dedicated ZEFC;

• Building upon ongoing and rapidly advancing intelligent vehicle technologies for trucks to define an effective conveyance of trucks on the I-710 ZEFC that will safely maximize the throughput of trucks operating with zero emissions in the corridor;

• Helping Southern California establish a leadership position in Connected Vehicle technologies industry that will enhance the local economy; and

• Establishing an ongoing partnership and environment that attract additional funding opportunities to bridge the gap between research efforts and implementing effective real-world solutions in a real-world freight corridor.

Benefits will accrue to the Ports and freight industry stakeholders in the region by providing increased capacity and safety in the proposed I-710 ZEFC. The vision is to achieve maximum effective capacity within the substantial physical constraints the I-710 corridor. The ZET-only lanes added to the I-710 Corridor will increase capacity; however, over time, the ZEFC will also become congested. The use of connected vehicle technologies and autonomous systems will increase throughput and improve safety in it. By safely increasing the capacity of the I-710 ZEFC, fewer trucks will be inclined to use the arterial system (or the general purpose lanes of the freeway), thus, reducing the negative impacts of truck traffic on Gateway Cities communities.
3.2 **CURRENT OPERATIONAL CONSTRAINTS**

The existing corridor consists of the I-710 freeway general purpose lanes and several parallel and connecting arterial roadways. These roadways are constrained in that adding capacity will be difficult without purchasing expensive, adjacent right-of-way. The I-710 freeway was designed in the 1950s and 1960s, before the dramatic increase in imports from Asia and the containerization of ocean-going freight increased the cargo traffic at POLA and POLB, and before extensive population growth in Southern California since 1960. In general, the I-710 freeway has remained relatively unchanged from when it was originally constructed. Due to growth in overall traffic volumes and the high level of truck traffic that has occurred in recent years, many aspects of the freeway design do not operate efficiently due to the heavy truck traffic and the size and relative lack of maneuverability of those trucks.

Design features that are most directly associated with the current operational problems in the I-710 Corridor include outdated local interchange designs, close spacing between many of the I-710 mainline interchanges with local streets, and geometric features of freeway-to-freeway interchanges that do not meet current standards. On the I-710 mainline, short weaving distances, narrow or nonexistent shoulders, narrow lane widths, varying number of through lanes, and non-uniform ramp metering, all contribute to current operational problems. Additionally, a northbound lane drop from eight lanes to six lanes at SR 91 causes frequent congestion. All these operational problems lead to congestion, particularly in peak periods and high accident rates.

Caltrans District 7 has limited resources for either additional capacity or enhanced ITS and Regional Traffic Management Center (RTMC) operations. The District has stated that they do not expect to be able to manage and operate the corridor at a higher intensity than is currently being conducted.

3.3 **DESCRIPTION OF THE CURRENT I-710 OPERATIONS AND SYSTEM MANAGEMENT**

I-710 is currently managed and operated by Caltrans District 7. Caltrans is responsible for the daily operations and maintenance of the freeway. Incident management is coordinated in partnership with CHP and local fire and rescue (with some assistance from Metro). Currently, Caltrans has some detectors, cameras, and message signs along the corridor. There are ramp meters in place in the corridor north of I-405. There are freeway service patrol beats being run daily along the freeway. The freeway service patrol responds to incidents in the corridor. It is anticipated that ITS enhancements will be a part of an I-710 corridor improvement project; and that full coverage of detectors, closed-caption television (CCTV), cameras, and changeable message signs (CMS) will be included on the general purpose and the ZEFC when the project is completed.
In the port area, the POLA and POLB have just begun operations of the Advanced Transportation, Management, Information, and Security (ATMIS) system. ATMIS provides real-time monitoring and control of connected field devices, and real-time communication with selected external systems involved in travel information dissemination and cooperative traffic management. There is a number of cameras and message signs deployed as part of ATMIS on port roadways, as well as on the southern portions of I-710. These systems aid incident management in and near the Ports and provide traffic information to truck drivers.

Arterials in the corridor are managed through local traffic signal systems in several jurisdictions. The arterials in the northern portion of the corridor are managed by the Los Angeles County Department of Public Works (LACDPW) through its Information Exchange Network (IEN) communications network. Also in northern portions of the corridor, the City of Los Angeles operates arterials through the Advanced Traffic Surveillance and Control (ATSAC) system. In the southern portion of the corridor, the City of Long Beach operates the signal systems within its jurisdiction. There are smaller traffic signal systems in cities along the corridor, including Downey, Santa Fe Springs, Southgate, Commerce, and Norwalk. The following map (Figure 3.1), based on information gathered for the Gateway Cities Technology Plan for Goods Movement, shows the existing and proposed ITS deployments along key arterials in the Gateway Cities area.

### 3.4 User Profiles

This section identifies and profiles the current users of the I-710 corridor. There are currently six categories of corridor users:

1. **Truck drivers** – Drivers of commercial vehicles in the corridor (port, nonport, intermodal, and domestic);

2. **Trucking company dispatchers** – Staff that provide assignments and information to the truck drivers;

3. **Caltrans District 7 RTMC and maintenance personnel** – Staff that operate and maintain the I-710 freeway;

4. **Incident responders** – Personnel that respond to incidents on I-710, CHP, local fire, ambulances, tow companies, freeway service patrol (Metro);

5. **Noncommercial travelers on I-710** – Noncommercial drivers and passengers using the I-710 general purpose lanes; and

6. **Law enforcement officials and commercial vehicle enforcement officials**.
Figure 3.1 Existing and Proposed ITS Deployments in the Gateway Cities Area
Truck Drivers

There are several types of truck drivers using the I-710 corridor, with many drivers either beginning or ending their trip in POLA/POLB. By far, the most common type of truck driver using the I-710 is a drayage operator, who shuttles containers between the Ports and the railyards and warehouse/distribution/transloading (WDT) centers in the Los Angeles basin. Many of the drayage trips are between the Ports and the WDT area around Del Amo Boulevard, the Alameda Corridor, the WDT areas in Commerce, and the San Bernardino/Riverside area. Other less substantial truck traffic on the I-710 Corridor includes:

- Medium- and long-haul drayage moves (intermodal containers) out of Southern California.
- Long-haul truck moves of freight in trailer-based, long-haul trucks to destinations outside of Southern California and across the U.S. (This freight is transloaded in the Gateway Cities area from containers.)
- Noncontainerized port truckloads (e.g., fuel, bulk, equipment, hazardous materials (HAZMAT)) with destinations primary in Southern California.
- Agricultural and related food product in refrigerated containers and trailers (including medium truck trips to California’s Central Valley).
- Medium-length intermodal container drayage moves with Maquiladores from the Northern Baja region (via San Diego and I-5/I-405).
- Local regional retail and other domestic deliveries by truck.
- Smaller trucks – Utility company trucks, parcel companies, etc.
- Exports/empties – In addition to distribution of cargo from imports as outlined above, truck drivers convey containers of exports and empties back to the Ports.

Most drayage drivers communicate with a fleet dispatcher or fleet manager to obtain instructions about their destination and next load. Small company and individual owner/operator truck drivers typically rely on cell phones to obtain information on destination and next loads.

Based on a previous survey, the truck drivers managed by fleets typically receive traveler information on incidents and congestion from three sources: 1) verbally, over cell phone from their dispatcher; 2) from other drivers on the roadways via real-time verbal discussions on Citizens Band (CB) radio; or 3) from traditional radio broadcasts. Currently, few of these drivers use cell phones to receive this information from 511 (Los Angeles County Service Authority for Freeways and Emergencies (LA SAFE)). The owner/operator truck drivers typically rely on broadcast radio along with the CB radio, for traveler information along the roadways. One of the focus areas of this project will be to encourage greater use of freight-related traveler information systems that will be provided. In addition,
real-time traffic data on the freeways and arterial highways is available via cell phones from various companies like Google, Tom-Tom, etc.

**Trucking Company Dispatchers/Fleet Managers**

Trucking company dispatchers (sometimes called fleet managers) typically work for medium and large trucking firms and communicate information directly to truck drivers. The dispatchers communicate with the marine terminal operators (MTO) and beneficial cargo owners (BCO) to determine the location, schedule, and destination of loads for pick-up, deliveries, and return of empty containers. They develop a plan for drivers to move those loads and communicate the assignments to each truck driver. Some companies use basic software applications (e.g., customized spreadsheets) to make these assignments, while others make assignments manually. Some dispatchers also receive traveler information on congestion, incidents, road conditions, and terminal gate queue status from LA SAFE/511 and from drivers; and disseminate this information to all the drivers - this is typically disseminated via a cell phone call to the relevant drivers.

**Caltrans District 7 Staff**

Caltrans District 7 provides operations staff in the District RTMC located near Glendale. The RTMC operators monitor traffic conditions on District 7 state highways including I-710 through the available roadside detectors and surveillance cameras. Traffic conditions, including congestion, incidents, and weather, are reported to the regional 511 program and posted on roadside CMS for public traveler information dissemination. The RTMC operators also alert the Caltrans/CHP/Metro freeway service patrol if they spot an incident or a disabled vehicle.

**Incident Responders**

The Freeway Service Patrol in Los Angeles is operated by LA SAFE. These tow trucks drive routes along regional freeways to assist disabled motorists. They also receive calls from the RTMC and CHP to respond to incidents. At the incident scene, they will assist in managing traffic around the incident, and communicate with the RTMC and CHP on the incident status and response needs.

The CHP is responsible for responding to and managing all incidents and developing a traffic accident report. CHP may also contact other response agencies when warranted, such as fire, emergency medical service (EMS), heavy-duty tow trucks, medical examiners, and HAZMAT teams.

**Noncommercial Travelers on I-710**

In addition to large volumes of truck traffic, the I-710 is also used by 100,000 to 150,000 passenger vehicles per day. The I-710 serves several markets for these
travelers, including commuter access between Long Beach and downtown Los Angeles, access to jobs along the corridor, and local travel for residents in the corridor. These travelers can receive traveler information from the 511 web site, the 511 call in number, CMS on the roadside, or from their cell phones.

**Enforcement Officials**

In addition to responding to incidents, law enforcement officers travel I-710 to observe and enforce speeding regulations, traffic regulations, and commercial vehicle regulations.

### 3.5 SUPPORT ENVIRONMENT

I-710 is operated and maintained by Caltrans District 7. The District RTMC is responsible for traffic management along the corridor. There is ramp meter coverage throughout the corridor; however, detectors, cameras, and signs are only located at a few specific areas along the 20-mile corridor. The ports area ATMIS and other projects proposed in the *Gateway Cities Technology Plan for Goods Movement* will also support and enhance freight operations in the I-710 corridor. Currently, the communications network connected to the RTMC does not cover the entire corridor. One of the purposes of this project is to eventually provide complete coverage for the entire corridor. There is freeway service patrol beat coverage on the corridor using a tow truck capable of towing a commercial vehicle.
4.0 Justification and Nature of the Changes

This section describes the nature of the proposed changes from the existing operations in the I-710 corridor to the future operations of the I-710 ZEFC ITS. The justification for making these changes is also described.

4.1 Justification for Change

The following is a description of the justification for changing from the current to the proposed systems.

Air pollutant emissions have long been a major problem for the Los Angeles region. One of the methods to meet the goal of reducing pollutant emissions in the region was the requirement for the use of zero emissions technology for trucks for the proposed I-710 truck-only lanes project (freight corridor). This zero emissions requirement was included in the recently completed I-710 Draft EIR/EIS. Therefore, the zero emissions requirement will be an integral component of the I-710 ZEFC for the recirculated EIR/EIS.

To further reduce traffic congestion on freeway freight routes, the autonomous vehicle program is to demonstrate the feasibility of employing automated commercial vehicle and automation technologies to increase truck capacity, efficiency, and safety on the truck-only lanes of the I-710 freeway. The project will demonstrate new technologies in a real-world heavily congested truck corridor through a staged test (or tests) of a flow efficiency system for trucks. The results of the test will provide valuable inputs to the design approach for a related I-710 freeway development project that will safely increase truck throughput on the proposed I-710 freight corridor, reducing truck volumes and congestion on the adjacent I-710 general purpose lanes.

The Connected Automated Commercial Vehicle Management System (CACVMS), both during the test period and when in full operational mode, is expected to reduce congestion and increase throughput both for the freight corridor and the general purpose lanes. The CACVMS is also expected to reduce crashes in both the freight corridor and general purpose lanes, and is anticipated to reduce the severity of accidents due to the reduction in auto/truck conflicts.
In addition, the reduction in crashes will improve the travel time reliability in the I-710 corridor. These benefits will be achieved by implementing connected vehicle and autonomous driver systems that enable closer headway between vehicles and, at the same time, provide for virtually crash-free operations in the truck-only lanes.

4.2 DESCRIPTION OF THE DESIRED CHANGES

The proposed project will provide additional, separated lanes for trucks (freight corridor) only alongside the existing I-710 general purpose lanes. The new truck-only facility will be tolled and only zero emission vehicles will be permitted to use the facility. Any truck entering the facility must also have on-board systems that permit the automated/autonomous vehicle system to take over steering, acceleration, and braking from the driver. The project includes a certification/tolling system that any entering truck is certified as a zero emission vehicle, is operating in zero emissions mode, is operating in assisted or autonomous mode, meets current permitting and weight requirements (through TENS) and can be charged a toll. The project also includes a high level of traffic and incident management in the corridor. A more detailed description of the project is provided in Section 5.0 of the document.

4.3 CHANGE PRIORITIES

The highest priority of the I-710 ZEFC ITS is the requirement for use only by zero emissions vehicles, as one of the options stated in the original draft I-710 EIR/EIS. Another high priority is to increase the overall throughput through the freight corridor through the use of connected and autonomous vehicle controls for trucks and functions that enable trucks to enter/exit the autonomous control mode. Finally, electronic tolling, needed to help fund the project, is also a priority. Systems must be developed that will enforce the use of zero emissions technology, enforce permitting and weight requirements, automated or autonomous vehicle systems, and electronic tolling in the Freight Corridor.

4.4 CHANGES CONSIDERED BUT NOT INCLUDED

Roadway alternatives considered, but not included, in this analysis are the following:
- Additional general purpose lane capacity;
- Additional truck-only lanes concurrent and closely adjacent to the general purpose lanes; and
- A zero emission alternative using catenary electrical service for trucks.
4.5 ASSUMPTIONS AND CONSTRAINTS

Descriptions of a few of the assumptions made, although subject to change, in developing the proposed system and high-level constraints of the proposed system are listed below.

- The design of the freight corridor parallel to the existing I-710 general purpose lanes has a current target timeframe for opening of approximately 2025.

- Caltrans District 7 will continue to operate and maintain I-710 and all its implemented components. Other ownership and management operations will also be considered.

- Metro, under contract with Caltrans, will manage the daily operations of the ZEFC.

- The agencies that currently provide incident response services for the I-710 general purpose lane will continue to respond to incidents on the autonomous vehicle lanes.

- Certification and enforcement systems for zero emissions, vehicle autonomous controls, connected vehicle communications, tolling, truck enforcement, and commercial vehicle regulations are needed to ensure that only permitted trucks use freight corridor lanes.

- The connected automated system (CACVMS) on the I-710 truck lanes will be phased in over several years, with levels of vehicle automation increasing until fully autonomous truck conveyance is achieved.

- The technologies for autonomous control and zero emission trucks are evolving rapidly, and this ConOps must be flexible enough to accommodate changes in technological components of the system.

- Once the autonomous vehicle system is being designed, a detailed set of Standard Operating Procedures based on the deployed components will be developed.
5.0 Concepts for Proposed System

This section describes the background and concepts that are the basis for the I-710 ZEFC ITS project. The scope of the project, constraints, and coordination needed with other systems are outlined. A detailed description of the ConOps, the various modes in which the Concept will operate, user interfaces with the Concept, and descriptions of assumptions that went into the Concept along with implementation issues complete this section.

5.1 BACKGROUND, OBJECTIVES, AND SCOPE

The I-710 ZEFC ITS is envisioned as a ZET-only limited access facility that runs in parallel with the general purpose lanes of the I-710 freeway. The ZEFC will be a zero emission facility; meaning the trucks will be required to be powered by a zero emissions conveyance system. The ZEFC may also be a tolled facility with all trucks having to pay a toll. The toll policy will be determined later, but the toll fee may vary based on the length and the time of day of the trip, or level of congestion on the freight corridor. Finally, and relevant to this report and project, in an effort to increase capacity, reliability, and safety, the I-710 ZEFC will be an autonomous truck corridor; meaning the trucks themselves will ultimately be under autonomous control – without driver intervention, as per California Vehicle Code 38750 – with vehicle-to-vehicle communication and vehicle-to-infrastructure communications. The ZEFC will also include and deploy automated truck enforcement technology as laid out in the TENS report. Finally, the ZEFC will include a system to provide real-time, freight-related traveler information (This will also be deployed in general purpose lanes.).

This project has several objectives that will address both traffic concerns and economic development issues:

- Helping ensure the future economic viability of the Ports and Gateway Cities region through improved throughput, reliability, real-time traveler information, safety, and dependability of truck access and drayage operations to the Ports via the new I-710 ZEFC;

- Building upon ongoing and rapidly advancing intelligent vehicle technologies for trucks to define an effective conveyance of trucks on the I-710 ZEFC that will safely maximize the throughput of trucks operating with zero emissions in the corridor;
• Helping Southern California establish a leadership position in Connected Vehicle technologies industry that will enhance the local economy; and

• Establishing an ongoing partnership and environment that attract additional funding opportunities to bridge the gap between research efforts and effective real-world solutions in a real-world freight corridor.

The project includes constructing truck-only lanes (ZEFC) parallel (on one side, on both sides, or in the center at different points along the corridor) to the I-710 general purpose lanes between Ocean Boulevard in Long Beach and Washington Boulevard in Commerce, a distance of 16 miles. There will be limited access points between the freight corridor and the arterial street network. Current designs show nine sets of ramps (northbound and southbound) to/from local streets. Figure 5.1 shows the I-710 ZEFC as currently planned. Current projections indicate that these ZET-only lanes are planned be open for traffic in or about 2025. The level of assisted or autonomous control of trucks using these truck lanes will be defined by the availability of Connected Vehicle and advanced driving functionality at that time and is part of the design of the ZEFC. It is likely that the initial operation of the ZEFC will be semi-autonomous when it opens, and fully autonomous at a later date as ZET volumes increase.

5.2 OPERATIONAL CONSTRAINTS

The primary constraint to the system’s functionality will be the availability of Connected Vehicles and autonomous vehicle technologies and other relevant technologies at the time of deployment when the ZEFC is opened and in later years to accommodate technology advances. There are many components of these systems that are currently under development or need to be developed for this Concept to be implemented. Among these components to be developed are:

• Software to match a vehicle (cab, chassis, and container) and driver to their current credentialing (and other truck information) status in real time;

• Software to certify that a vehicle is a zero emissions vehicle when it is in the ZEFC;

• Systems to detect emissions and verify that a vehicle is currently operating in zero emissions mode;

• On-vehicle systems to operate securely in automated cruise control, braking, steering, and systems monitoring to enable autonomous driving and control;

• Dedicated Short-Range Communications (DSRC) operating fail safe in real time to enable vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications;

• Data management and storage systems to enable system decision-making in real time;
Figure 5.1  I-710 Corridor Layout

I-710 Freight Corridor
5.3 COORDINATION WITH OTHER SYSTEMS

The autonomous vehicle system will share data with three components of the Gateway Cities Technology Project for Goods Movement:

1. Freeway Smart Corridor,
2. Freight Traveler Information System (GoFreight), and
3. Truck Enforcement Network.

There must also be data exchanges with the Caltrans District 7 RTMC; LA SAFE/511; RIITS; ATMIS; Performance Measurement System (PeMS); and the incident management program dispatchers (CHP, tow companies, freeway service patrol). Interfaces among these systems must be developed in order to manage the various systems included in this ConOps. Generally, the interfaces will be between databases managed by the different agencies participating in the operations of roadways in the I-710 corridor. A number of Application Programming Interfaces (API) will need to be created to provide for this exchange of data among the systems. These interfaces will be defined in detail as each system is designed and deployed.
5.4 DESCRIPTION OF THE PROPOSED SYSTEM

The I-710 ZEFC ITS project is envisioned as a ZET-only limited access facility that runs in parallel with the general purpose lanes of the I-710 freeway between Ocean Boulevard in Long Beach and Washington Boulevard in Commerce (see Figure 5.1). The registered trucks will be required to certify that they will operate with zero tail pipe pollutant emissions while using the ZEFC. It may be a tolled facility with access limited to registered freight vehicles and maintenance/emergency vehicles only. The roadway will include technology that will enable semi-autonomous or fully autonomous control of instrumented trucks. Figure 5.2 shows the high-level concept for the I-710 ZEFC ITS project.

This ConOps is based on the current estimate of completion for the ZEFC project in about 2025, and the initiation of some level of assisted or autonomous driving and other technology features at that time. Autonomous driving will be enabled by two major components: Connected Vehicles technologies and Advanced Driver Assist Systems. Connected Vehicles technologies include a numbers of procedures, standards, and protocols that enable V2V and V2I communications in real time (the current standard is DSRC). Advanced Driver Assist Systems include in-vehicle systems, such as adaptive cruise control, automated braking, automated steering, lane keeping and warning, and advanced 360 degree object sensors and associated controls.

This Concept assumes that, while autonomous control for trucks will be available in the I-710 ZEFC, autonomous control will not be operational on most adjacent arterial streets or the general purpose freeway lanes by 2025. The level of assisted or autonomous technology available in 2025 cannot be known at this time. This Concept is based on the possibility that any of three implementation phases outlined herein for Connected Vehicles technology and infrastructure could be available in future years. In this concept report, we will refer to the system for managing autonomous controlled and connected trucks as the CACVMS. The functionality of trucks using the I-710 ZEFC ITS will depend upon what technology is available in the marketplace at that time. Therefore, this ConOps report will likely have to be updated frequently as transportation technologies continue to evolve, develop, and improve. There will be transition periods between these phases that continually add functionality and advance the level of automation toward the next phase. Connected vehicles systems will have to continue to be developed further in the future followed by demonstration tests to continuously update the proof of concept. This will be part of future programs outlined herein. Future testing will also be needed to determine if connected vehicles for trucks are best evolved in platooning concepts of several trucks.
Figure 5.2  High-Level Concept for the I-710 ZEFC ITS

911 Calls from travelers  \longrightarrow  CHP

Freeway Service Patrol

CCTV Surveillance Cameras

Metro/RTMC Incident Management System

Metro/RTMC Traffic Management System

Ramp Meters/ATM Systems

S11/GoFreight - TIS/Data Fusion
- Freight Trucker Info Dissemination
- Data Management

Roadside CMS

Connected Automated Commercial Vehicle Management System
- DSRC On-Board Radios/Computers (V2V and V2I)
- Roadside V2I Communications
- In-Vehicle Platooning Technologies

I-710 ZEFC Credentialing System

Truck Enforcement Network System

Zero Emissions Certification and Verification

CACVMS Certification and Verification

CVO Credentialing/Permitting and Enforcement

Electronic Toll Collection

Truck Drivers and Travelers
The three phases of Connected Automated Commercial Vehicle Management System assumed for this Concept and as defined in the NHTSA Preliminary Statement of Policy Concerning Automated Vehicles are:

- **Assisted Truck Control** - Equivalent to Level 1 Function-Specific Automation, as defined by the NHTSA Preliminary Statement of Policy Concerning Automated Vehicles. Level 1 automation involves one or more specific control functions; if multiple functions are automated, they operate independently from each other. The driver has overall control and is solely responsible for safe operation, but can choose to cede limited authority over a primary control (as in adaptive cruise control); the vehicle can automatically assume limited authority over a primary control (as in electronic stability control); or the automated system can provide added control to aid the driver in certain normal driving or crash-imminent situations (e.g., dynamic brake support in emergencies based on sensors). It is assumed for Phase I deployment roadside infrastructure (likely to be DSRC standards) will be in place. The definition of that infrastructure is included in the Gateway Cities Strategic Plan – ITS Infrastructure Impacts report.

- **Partially Autonomous** - Equivalent to Level 3 Limited Self-Driving Automation, as defined by the NHTSA Preliminary Statement of Policy Concerning Automated Vehicles. Level 3 automation enables the driver to cede full control of all safety-critical functions under certain traffic or environmental conditions and, in those conditions, to rely heavily on the vehicle to monitor for changes in those conditions requiring transition back to driver control. The driver is expected to be available for occasional control, but with sufficiently comfortable transition time. The vehicle is designed to ensure safe operation during the automated driving mode.

- **Fully Autonomous** - Equivalent to Level 4 Full Self-Driving Automation, as defined by the NHTSA Preliminary Statement of Policy Concerning Automated Vehicles. In Level 4 automation, the vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip. This includes both occupied and unoccupied vehicles. However, for this initial concept of operations, it is assumed that all ZET will continue to have a driver. By design, safe operation rests solely on the automated vehicle system.

It is assumed that all trucks using the freight corridor will have a driver as stated above. This is primarily because the driver is needed to deliver the container to its ultimate destination once the truck leaves the ZEFC.

phases with their technology and infrastructure requirements are described in more detail in Section 5.8 of this document.

The above paragraphs describe the I-710 application that is being termed the “Connected Automated Commercial Vehicle Management System.” Figure 5.3-5.6 show how the three phases of the Connected Vehicle technology will operate.

A high level of traffic management and incident management will be required to effectively manage the ZEFC. This Concept assumes that Metro will likely manage the ZEFC system. However, Metro, working with Caltrans and CHP, may alternately determine that another entity is better suited to operate and maintain the CACVMS and the other I-710 ZEFC components (zero emissions, tolling, credentialing, enforcement, etc.) The same level of monitoring and management is required whether Metro or another agency or contractor actually conducts the daily operations. Also the facility may be a tolled roadway and it is assumed that the tolls may be collected electronically by Metro; there will not be any manual toll collection.

Any trucks operating in zero emissions mode will be allowed in the ZEFC. This Concept assumes that trucking companies and truck owner/operators must register their vehicles and obtain certification that each vehicle using the ZEFC is a zero emissions vehicle. The zero emissions certification and operability will be checked electronically for each vehicle entering the ZEFC. It is also assumed (for this initial ConOps) that the zero emissions technology will be in the vehicle propulsion system; no roadway or roadside equipment (i.e., catenary wires) will be provided to power the vehicle.

Figure 5.6 illustrates the truck technology progression and summarizes some of the key I-710 operational characteristics discussed in this Concept.
In Tier 1 the I-710 ZE Freight Corridor would have traditional traffic control devices such as:

- Speed/volume detectors
- CCTV surveillance cameras
- CMS for traveler information

The more advanced trucks will come with systems to improve safety and reliability utilizing radars, cameras and other on-board safety systems. These trucks still operate independently and do not communicate with other trucks or anything on the roadside.

Features on fully equipped trucks in Tier I include:

- Adaptive Cruise Control
- Dynamic Brake Support
- Overtaking Assist
- Lane Departure Warning Systems

The driver has overall control and is solely responsible for safe operation of the truck. The driver can choose to cede limited control to the vehicle.
In Tier 2 the traditional traffic control devices would remain, although new in-vehicle systems would begin to provide much of this information.

Trucks with advanced systems would begin to penetrate the marketplace with over half the vehicles having nearly autonomous features such as Cooperative Cruise Control.

In Tier 2 some trucks now begin to have Vehicle-to-Vehicle communication sharing, thereby increasing safety significantly. Even at this level, these technologies support increased reliability and are a benefit to I-710 throughput.

The driver still has overall control and is solely responsible for safe operation of the truck. The driver can choose to cede more control to the vehicle.

Phase 2
In Tier 3 the traditional traffic control devices would not be needed any more. All traveler information (including tolling etc.) would be done in-vehicle.

Trucks with advanced systems would dominate the marketplace with the trucks having fully autonomous features. At this stage shorter headways could be utilized, thereby creating dynamic platoons of trucks and therefore greater throughput.

The driver would cede full control over to the vehicle.

Trucks now begin to have Vehicle-to-Vehicle and Vehicle-to-Infrastructure communication.

Phase 3
Figure 5.6  Connected Automated Commercial Vehicle Management System Progression

Automated Truck Types

<table>
<thead>
<tr>
<th>Assisted</th>
<th>Partially Autonomous</th>
<th>Fully Autonomous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver can cede some control to one or more specific control functions.</td>
<td>Driver can cede full control in certain operating environments but is needed for others.</td>
<td>Vehicle is designed to perform all driving functions. Driver may or may not be present.</td>
</tr>
</tbody>
</table>

Safety and Throughput Advancement

- Improved Safety
- Improved Throughput
- No Automation
- Assisted
- Partially Autonomous
- Fully Autonomous

- Significant Active Traffic Management Needed
- Moderate Active Traffic Management Needed
- Only Passive Traffic Management Needed

Corridor Operations Without Platooning

Corridor Operations With Platooning
5.5 **MODES OF OPERATION**

We define several modes of operations for the Assisted and Autonomous Vehicle systems, including:

- Normal operations;
- Operations with a minor incident;
- Operations with a lane closure incident;
- Operations with the autonomous system down or a security breach;
- Operations during construction or maintenance activities; and
- Operations under an evacuation.

**Normal Operations**

Normal daily operations of the I-710 ZEFC ITS involve several components. The ZEFC will be limited to registered vehicles and drivers only. The zero emissions restrictions, toll, and autonomous systems are always on (24/7/365). A process must be set up to certify and register trucks that use the corridor.

Since the number of trucks using the corridor is expected to increase dramatically over the next 10 to 15 years, moving trucks efficiently along the I-710 will be critical. ZET using the corridor will be required to have assisted or autonomous driving capability from the initial day the ZEFC opens (including the trucks being ZET from opening day).

The three implementation phases described previously are:

1. An initial phase (Phase I) of assisted control would include automated cruise control and crash avoidance systems with some vehicle-to-infrastructure (V2I) communications to obtain and provide traveler information;

2. A second phase (Phase II) of partially autonomous driving with vehicles capable of following a lead vehicle using vehicle-to-vehicle (V2V) communications and a minimum capability of autonomous cruise control and braking and sensor-guided steering using DSRC or a similar communications standard; and

3. A third fully autonomous control phase (Phase III) where a driver only loosely monitors driving without providing any manual control and truck platooning is used extensively.

It is not currently known which Connected Vehicle phase or systems will be available in the marketplace at the time the I-710 ZEFC is operational (currently projected for 2025). The partially or fully autonomous systems can be integrated with Advanced Traffic Management (ATM) systems (e.g., lane controls, variable speed limits) if ATM is implemented in the ZEFC project.
Each of these three phases will provide benefits to drivers, trucking companies, and the general public. In the assisted phase, drivers would be able to drive with closer headways than manual driving will allow, which would increase throughput in the ZEFC, thus, reducing congestion. The crash avoidance systems will reduce crashes, which will provide both greater safety and improved travel time reliability. Trucking companies will realize benefits by being able to schedule more trips per day for each driver due to faster and more reliable travel time in the ZEFC and by experiencing fewer crashes. Each successive phase will provide the same benefits, but to a greater extent or degree. It is assumed that the second and third phases will include DSRC roadside devices to provide data to the CACVMS so that roadway capacity and safety are maximized and information is provided to commercial vehicles. The fully autonomous phase will provide much greater automation of trucking company activities.

We also expect that significant Connected Vehicles technology will be operational in the next 10 to 15 years, which would allow trucks to communicate with other trucks on the roadway (V2V) and with equipment on the roadside (V2I). This real-time communications will reduce the need for some roadside sensors/signs and provides for safer, closer headways between trucks and for communications to nearby trucks that will allow “virtual trailering” with a truck in front of it. This would allow even closer spacing between trucks, thus, increasing capacity and reducing energy consumption. Preliminary research indicates that platooning of vehicles could increase highway lane capacity by up to 500 percent. The Concept assumes that, when the partially autonomous system is implemented, the equipment at the entrance ramp credentialing station will trigger an alert to the driver to begin initiating the autonomous mode, or possibly the alert will automatically turn on the autonomous mode. The driver will input his destination exit into the truck’s communication device, and the truck will alert the driver when the truck is nearing its exit and manual mode is about to be initiated again. This Concept assumes that the autonomous system has a “fail-safe” mode so that if a driver does not respond to the alert to take manual control (due to driver impairment or inattention), the vehicle will automatically slow down, move to the right shoulder, and stop. The in-vehicle device will also automatically alert the trucking company and the RTMC. In the fully autonomous mode, the autonomous system remains operational on all roads that are instrumented.

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4 “Platooning With IVC-Enabled Autonomous Vehicles: Strategies to Mitigate Communication Delays, Improve Safety and Traffic Flow,” IEEE transactions on ITS, Volume 13, Number 1, March 2012, Pedro Fernandes, Member, IEEE, and Urbano Nunes, Senior Member, IEEE.
In order to obtain a registration to use the lanes, an individual vehicle must be certified that it is able to operate in zero tail-pipe emissions mode while using the ZEFC. The zero emissions technology will be related to the power plant of the truck with battery electric, range extended electric with engine, range extended electric with fuel cell, hybrid battery electric or hybrid compressed natural gas (CNG) or liquid natural gas (LNG) being existing examples of zero emissions technology. A trucking company (or the ZEFC operation) may register their fleet and certify that any truck using the I-710 ZEFC is a zero emissions vehicle. The zero emissions certification process will be developed outside of the traffic management or tolling processes, perhaps through the South Coast Air Quality Management District. The zero emissions certification status will be transmitted by each truck through DSRC, cellular or other common communications standard at the entrance ramp credentialing station at each entrance to the truck lanes; and compliant trucks will be permitted access to the lane (assuming it meets all other criteria for access (e.g., weight)). The truck will also be checked at the entrance area, through sensors, that confirm that the zero emissions system is operational.

The registered vehicle must also have the ability to pay a toll electronically upon entering the truck lanes. The tolling authority, likely to be Metro, will determine the toll rates and the tolling conditions (i.e., a flat trip rate, a variable distance rate, a weight and distance rate, congestion pricing or whether subscription discounts are offered). The toll will be collected electronically through DSRC (or via other automated means) at the entrance ramp credentialing station at each entrance to the truck lanes.

All trucks using the I-710 ZEFC will be subject to automated truck enforcement. A TENS will be developed for truck enforcement. TENS in the I-710 ZEFC will include deployment for automated truck enforcement that will include the following elements:

- Virtual tractor and chassis identification;
- Virtual WIM at all on-ramps and near Truck Enforcement Facilities (TEF);
- Virtual inspection history monitoring of both tractor and chassis (at on-ramps and other locations);
- Virtual credential monitoring;
- Virtual monitoring for zero emission operational mode; and
- Automated signs to direct trucks to permanent truck enforcement inspection site.

Further into the future, when all vehicles and roads are operational for autonomous mode, it is anticipated that a driver can enter a destination at the port or drayage yard and the truck will drive the entire trip in the ZEFC autonomously. At this point, it may also be possible for “truck trains” (a convoy
of trucks with the same origin and destination) to drive completely autonomously in the ZEFC to a common destination.

Normal operation also means that the Metro or Caltrans District 7 RTMC or another operating entity is continually monitoring the truck lanes for incidents and congestion. The regional 511 and GoFreight system will be providing messages on roadside signs and information to the trucks directly on their in-vehicle devices. For the Freight Corridor project, it is not yet determined whether CMS will be needed since registered trucks will have the capability of receiving messages from GoFreight through in-vehicle devices. However, CMS may be provided at some identified locations, as not all trucks may be able to receive in-cab information, at least in the initial phases of the project.

The CACVMS, along with roadside sensors or DSRC devices, will be continually collecting data on travel times, speeds, volumes, weather conditions, and incidents. This data will be fed back to the RTMC or a Metro traffic center to a CACVMS server. That server will continuously process the data and determine if any abnormal conditions exist or are predicted to form soon. This information on travel conditions is then continually sent to the LA SAFE 511 and GoFreight systems to provide real-time traveler information to truck drivers, fleet dispatchers, and the public via web sites, cell phones, smartphone apps, in-vehicles devices, and roadside CMS.

Figure 5.7 shows a high-level diagram of normal operations in the ZEFC. Some aspects of this may also be applied to trucks (ZET or other trucks using the general purpose freeway lanes). This will be determined at a later date.

**Figure 5.7 Normal Operations Flow Chart**
Operations with a Minor Incident

In the initial two phases, incident response will be the same as conducted today, except that V2I communications may alert traffic management operators to incidents instantaneously. The traffic management operators may be alerted by freeway service patrol drivers, CHP (through 911 calls), and V2I roadside sensors (currently DSRC devices). The operators will observe the incident through the surveillance CCTV cameras and will determine severity of the incident using the cameras to pinpoint the location. The operators will alert the freeway service patrol and any other first responders (CHP, local police, fire/rescue, EMS, or tow trucks), as needed. The responders will travel to the incident scene and conduct the necessary incident scene operations to remove the disabled vehicle. The traffic management software will report the incident to 511 and to the trucking industry through GoFreight.

In the fully autonomous phase, when an incident occurs on the I-710 ZEFC, the traffic management operators will be alerted through the CACVMS by both V2I roadside sensors and the V2V communications, and they will observe the incident through the surveillance CCTV cameras. The traffic management operators may also receive messages from the freeway service patrol drivers, ZET drivers, or CHP (through 911 calls). The traffic management operators will determine severity of the incident using the cameras, and the system will pinpoint the location. The operators will alert the freeway service patrol and any other first responders (CHP, local police, fire/rescue, EMS, or tow trucks), as needed. For minor incidents, assumed to be disabled vehicles (flat tire, engine problems, etc.) since crashes are theoretically impossible with autonomous vehicles, the autonomous vehicles will stop or automatically move to the right shoulder and stop.

The responders will travel to the incident scene and conduct the necessary incident scene operations to remove the disabled vehicle. The traffic management software will report the incident to 511, which will then provide messages to the trucking industry through the GoFreight information. A minor incident on the truck lanes may not warrant an alert to the general public 511 or CMS since there will be no impact to the general purpose lanes. The trucks will be able to pass the incident without interruption since there is no obstacle in the travel lanes. As the responder vehicles and tow truck with the disabled vehicle leave the incident scene, the autonomous trucks will slow to allow these vehicles to move to the next truck lane exit. It is assumed that all responder vehicles entering the truck lanes will be precleared for entrance using a responder vehicle identification process transmitted by DSRC at the entrance ramp credentialing station.

Figure 5.8 shows how this system would operate.
Figure 5.8 Operations with Minor Incident Flow Chart

Operations with a Lane Closure Incident

A lane closure incident assumes at least one travel lane is blocked and that roadway capacity is compromised. In all three phases, the responders will travel to the incident scene and conduct the necessary incident scene operations to remove the disabled vehicle or whatever is blocking the lanes. If congestion from the incident blocks access to the incident for the responders, the RTMC will have an option to close all lanes and stop truck traffic for a brief time to allow responder vehicles to approach the incident contra-flow and conduct the removal of the debris or vehicle blocking the lane and send out notices.

In the initial two phases, incident response will be the same as conducted today, except that V2I communications may alert RTMC operators to incidents instantaneously. The RTMC operators may be alerted by freeway service patrol drivers, CHP (through 911 calls), and V2I roadside sensors. The operators will observe the incident through the surveillance CCTV cameras and will determine severity of the incident using the cameras will pinpoint the location. The operators will alert the freeway service patrol and any other first responders (CHP, local police, fire/rescue, EMS, or tow trucks), as needed. Other responders, such HAZMAT Response and the medical examiner, may also need
to be contacted depending on the incident circumstances. The responders will travel to the incident scene and conduct the necessary incident scene operations to remove the disabled vehicle or whatever is blocking the lane. The RTMC software will report the incident to 511 and to the trucking industry through GoFreight.

In the fully autonomous phase, when an incident occurs in the I-710 ZEFC, the RTMC operators will be alerted through the autonomous system, either V2I roadside sensors or the V2V communications, and will observe the incident through the surveillance CCTV cameras. The RTMC operators may also receive messages from the freeway service patrol drivers or CHP (through 911 calls). The RTMC operators will determine severity of the incident using the cameras and the system will pinpoint the location. The operators will alert the freeway service patrol, if needed, and any other first responders (CHP, local police, fire/rescue, EMS, or tow trucks), as needed. Other responders, such HAZMAT Response and the medical examiner, may also need to be contacted depending on the incident circumstances. The truck autonomous system will instruct the trucks to slow down near the incident, and they will be able to pass the incident without interruption since there is at least one lane or shoulder open. As the responder vehicles and tow truck with the disabled vehicle leave the incident scene, the autonomous trucks will slow down to allow these vehicles to move to the next truck lane exit. It is assumed that all responder vehicles entering the ZET lanes will be precleared for entrance using a responder vehicle identification process transmitted by DSRC at the entrance credentialing station. The RTMC software will report the incident to 511, which will then provide messages to the trucking industry through the GoFreight. A major incident on the ZEFC will alert the general public since there will be the impact of additional trucks on the general purpose lanes. Messages will be needed on general purpose lane CMS to provide information the drivers in the I-710 corridor.

Figure 5.9 shows the concept for this operation.
Operations with the CACVMS Down

In the event of a catastrophic system failure, security breach, or emergency maintenance activity that forces the CACVMS to shut down for a period of time, a process is needed to operate the truck lanes in a manual mode. This scenario only applies to the partially and fully autonomous phases. In the assisted mode, there is no control system in place to be shut down. This Concept assumes that the autonomous system is monitored at the Metro traffic center or RTMC (or at other locations) so a system failure or maintenance procedure would alert the RTMC operators immediately. The RTMC software would alert the trucking industry through the GoFreight, and the general public through 511 and CMS messages. The ZET lanes would be open to trucks operating manually, since the credentialing stations at entrance ramps may also be down. Access to the lanes is still restricted to registered trucks; however, enforcement is through CHP patrols since the electronic credentialing stations are also down. The speed limits are
reduced to a lower speed (55 mph is the current speed limit per California Code) while the system is down. Zero emissions operations are still mandatory. Under this situation, it is assumed that each truck will be operated by the driver until the autonomous system operation is tested and operational.

Once the autonomous system is restored to full operations, the lanes would again be restricted to registered vehicles only. The manually operating trucks would be asked to exit at the next available location through their in-vehicle device, or they will begin operating in autonomous mode. The RTMC will alert GoFreight and 511 that the autonomous system is operational.

Figure 5.10 shows how this concept operates.

**Figure 5.10 Operations with Autonomous System Down Flow Chart**
**Operations during Construction and Maintenance Activities**

The Caltrans District 7 Construction Office or the District 7 Maintenance Office will alert the RTMC operators that a planned lane closure construction or maintenance activity will occur at a certain location for a given time period. Whenever possible, the construction and maintenance activities will be conducted at off-peak times to provide the least amount of disruption to the trucks. If necessary, the ZET lanes could be closed in the off-peak hours and the trucks can be instructed to use the general purpose lanes.

In the assisted and partially autonomous phases, the RTMC operators will be alerted by the autonomous system and observe the activity through the surveillance CCTV cameras. The RTMC software will alert the trucking industry through GoFreight and the 511 system. In most cases, the general public will not need to be alerted of ZEFC lane construction or maintenance activity. In most cases, the construction and maintenance offices will only allow one truck travel lane to be closed at a time. It is assumed that at least one travel lane and shoulder will continue to be open, allowing trucks to pass the activity site. The speed limit may need to be lowered and sent to trucks in-vehicle devices.

In the fully autonomous phase, the truck autonomous system will instruct the trucks to slow down near the construction site, and they will be able to pass the activity without interruption. As the construction vehicles enter and exit the construction site, the autonomous trucks will slow down to allow these vehicles to move to the next truck lane exit. It is assumed that all construction vehicles entering the truck lanes will be precleared for entrance using a responder vehicle identification process transmitted by DSRC at the entrance credentialing station.

Figure 5.11 shows the Concept of Operations for this operation.
Operations under an Evacuation

In the event of a major regional emergency event, such as an earthquake, tsunami, weather emergency, terrorist attack, or nuclear power plant disaster, the regional emergency management process will go into effect. The Los Angeles Regional Emergency Management Plan will need to be updated to include operations of the I-710 ZEFC lanes. This Concept assumes that the ZEFC lanes may need to be used for the evacuation; and that during the evacuation, the lanes could be used by general purpose vehicles and not just ZET. It may also be possible for all the ZEFC lanes to be operated in a single direction during the evacuation period. The California Emergency Management Agency (Cal EMA) will make the determination whether the ZEFC lanes are needed for the evacuation and how they will be used.

The autonomous system is monitored at the Metro traffic center, RTMC, and other traffic management centers so Cal EMA will alert the traffic management center that evacuation is needed at a certain time. Caltrans participates in periodic evacuation drills so the traffic management operators are familiar with the procedures to conduct the evacuation protocols. In the assisted and partially autonomous phases, the autonomous systems may be shut down during evacuation. The traffic management operators would alert the trucking industry through the GoFreight; and the general public would be alerted through 511 and CMS messages, as well as radio, television, and other media outlets. The ZET
lanes may be open to trucks and/or autos operating manually. Either Caltrans staff or law enforcement officers may be stationed at entrance ramps to help direct traffic.

In the fully autonomous phase, trucks and passenger cars may use the system at high speed and short headway to maximize the evacuation. At some point, when the autonomous vehicles saturate the subregion, then the ZEFC could be an autonomous car-only evacuation route. This would maximize the evacuation process.

Once the autonomous system is restored to full operations, the ZEFC lanes would again be restricted to registered ZET vehicles only. The manually operating vehicles would be asked to exit at the next available exit through their in-vehicle device, or they will begin operating in autonomous mode. The traffic management will alert GoFreight and 511 that the autonomous system is operational.

Figure 5.12 shows the concept for this operation.

**Figure 5.12 Operations under Evacuation Flow Chart**

![Evacuation Flow Chart](image)

5.6 **USER INVOLVEMENT AND INTERACTION**

Table 5.1 presents the descriptions of the defined users, each of their roles, and the skills required to use the proposed systems.
Table 5.1  Users of the Autonomous Vehicle System

<table>
<thead>
<tr>
<th>User</th>
<th>Role</th>
<th>Skills Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck drivers – Drivers of ZET in the corridor ZEFC</td>
<td>Operate truck, engage and disengage the autonomous controls, travel to assigned pick up and drop off locations</td>
<td>Operate with computer, verbal and map commands, follow map directions, safely operate a truck as confirmed during the driver certification process</td>
</tr>
<tr>
<td>Trucking company dispatchers – Staff that provide assignments and information to the truck drivers</td>
<td>Prioritize trips, provide information and direction to drivers, optimize driver assignments</td>
<td>Analyzing schedules, determining direction by computer, verbal and map commands, communicating directions, operating complex computer programs</td>
</tr>
<tr>
<td>Metro or ZEFC Operations – Personnel that operate and maintain the I-710 freeway/ZEFC</td>
<td>Assess incident impacts, activate response plans, post messages, monitor road conditions</td>
<td>Operating complex computer programs, visually analyze situations quickly, communicate with other responders</td>
</tr>
<tr>
<td>Incident responders – Personnel that respond to incidents on I-710, CHP, local police and fire, tow companies</td>
<td>Manage complex situations in real time, coordinate and communicate with other responders</td>
<td>Follow verbal directions and commands, understand and follow Incident Command System protocols, physical strength and stamina, communications with other responders</td>
</tr>
</tbody>
</table>

5.7 SUPPORT ENVIRONMENT

The CACVMS will be operated and maintained by Metro or another operating entity as determined by Caltrans, CHP, and Metro. The level of system monitoring, equipment monitoring, and management of real-time operations will need to be conducted at a significantly higher level than the current freeway operations. Likewise, the maintenance of equipment must be conducted to a higher standard than is currently done for standard freeway equipment.

5.8 IMPLEMENTATION ISSUES AND ASSUMPTIONS

The I-710 ZEFC ITS project is based primarily on technologies that are currently being developed or will be developed and available in the future. As these technologies come into the marketplace, Federal, state, and local governments will need to create new policies that both allow for the implementation of the technologies and develop regulation for those technologies and their operations. This means that there are many issues regarding the implementation of the project’s components that are not yet resolved or even developed. This section describes many of those issues, our assumptions in developing this Concept, and some potential alternative solutions.
Connected Automated Commercial Vehicle Management System

The CACVMS is based on two components: the automated vehicle safety systems on the vehicle itself and Connected Vehicle communications between vehicles (V2V) and to/from devices on the roadside and infrastructure systems (V2I).

Advanced Driver Assist Systems

The pace of the development of the automated vehicle safety systems or what is known as Advanced Driver Assist Systems (ADAS) is primarily up to the vehicle manufacturing companies (OEMs) and after-market developers. The sensor-based ADAS uses a combination of advanced sensors, such as stereo cameras for 360-degree awareness and long- and short-range RADAR and Laser Radar (LIDAR), combined with actuators, control units, and integrating software, to enable vehicles to monitor and respond to their surroundings. Some ADAS solutions, such as lane keeping and warning systems, adaptive cruise control, back-up alerts, and parking assistance, are available now; and many others are under development. These systems are not currently commercially available for trucks and more development will be necessary. One of the most beneficial aspects of a fully operational autonomous control system is the use of truck platooning. Platooning will be enabled by the V2V and V2I communications and the array of vehicle sensors on the trucks. Truck platooning technologies and procedures are just now being tested in the field. Significantly more demonstration and development testing (using testing results done to date) will be needed.

Vehicle-to-Vehicle and Vehicle-to-Infrastructure Communications

Connected Vehicles technologies include a numbers of procedures, standards and protocols that enable vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications in real time (the current standard is DSRC). Figure 5.13 shows a DSRC device in the field (overhead on a mast arm).
The Connected Vehicle Program is being led by the U.S. DOT ITS JPO in collaboration with the Vehicle Infrastructure Integration Coalition (VII-C), which is a collaboration among U.S. DOT, state DOTs, and vehicle manufacturers and the Crash Avoidance Metrics Partnership, a group of auto OEMs. These groups are currently testing technologies and resolving policy issues. Current research focus areas include:

- Connected Vehicle Technology platforms;
- Harmonization of International Standards and Architecture around the Vehicle Platform;
- Human Factors Research;
- Systems Engineering;
- Connected Vehicle Certification;
- Connected Vehicle Test Bed;
- Connected Vehicle Safety Applications – V2V, V2I;
- Connected Vehicle Mobility Applications – Real-time Data Capture and Management and Dynamic Mobility Applications;
- Connected Vehicle Environmental Applications – Applications for the Environment: Real-Time Information Synthesis (AERIS), Road Weather;
- Connected Vehicle Technology Policy and Institutional Issues (security, liability, insurance); and
- Connected Vehicle International Research and Standards Harmonization.
The U.S. DOT ITS JPO has stated that they plan to finalize initial V2V technologies and safety applications based on DSRC by late 2013 and continue through 2014, working with industry and government stakeholders on planning strategies and decisions; and researching and delivering a solid, analysis-based policy foundation for eventual implementation. The JPO is initiating the development of the 2015 to 2019 Connected Vehicle research program in 2013.

The current communications standards are also being tested for critical safety applications. The prevalent standard currently is based on the DSRC standards. This or other communications technologies may evolve over the next decade, so the Corridor project must keep aware of progress and changes.

The GCCOG should continue to track developments in the Connected Vehicles Initiative and ADAS by the vehicle manufacturers over the next decade. Adjustments to the autonomous control systems (as well as zero emissions policies and enforcement policies) will need to be made over time. We suggest that an autonomous vehicle control development strategic plan be developed and funded as a method of systematically addressing the new developments of the Connected Vehicles and ADAS initiatives. Consideration of demonstration tests should also be developed as part of this recommended strategic plan.

While the technical issues are being addressed by the JPO, the VII-C, and others, there are several additional institutional issues that are being addressed. Security issues also need to be fully addressed, and analyzed and developed to assure a secure technology system. The connected vehicles data transmitted among vehicles and to the roadside has life safety implications so credentialing and integrity of the real-time data must be secure. Liability and insurance issues need to be similarly assessed, analyzed, and integrated with this operational system. The GCCOG must continue to track developments for these issues, and incorporate changes and updates into the strategic implementation plan for the ZEFC.

The real benefits of autonomous vehicle controls will be achieved when these two components (V2V and V2I) converge and become seamless into one integrated system. The benefits to convergence are expected to be lower deployment costs for both the vehicle and the infrastructure, facilitation of better mimicking of human senses, reduced need for more sensors, reduced cost of sensors and for V2I investment, and functional redundancy to ensure 100-percent system reliability.

There are still a number of hurdles on the path to convergence, including:

- **Improved positioning technology** – Global Positioning System (GPS) provides locations within a +/-10-meter range, which is not accurate enough for safety critical applications. GPS error correction technologies are being developed now.

- **High resolution mapping** – Current digital mapping techniques lack the necessary detail to support self-driving applications.
• **Reliable and intuitive human machine interface (HMI)** - The interface between driver and machine is very complex. Drivers must know when to hand off and take back control of the vehicle. That process must be seamless, safe, and comfortable to the driver.

• **Standardization** - DSRC standards are fairly mature, but additional standards are needed to ensure full interoperability in real time. Real time needs to be defined for various operational scenarios. The U.S. DOT research is focusing on DSRC standards and formal government decision on the possible deployment, and rulemakings are due within the next year. The divide between standardized components and the branded experience controlled by manufacturers must also be sorted out.

### Transition from Assisted to Full Autonomous Control

The transition from today’s sensor-based ADAS to a fully operational autonomous vehicle control system will take place over many years. We have previously described three phases in these transition-assisted, partially autonomous and fully autonomous modes. There are many technologies currently on the market that will enable assisted driving in the near future, but the fully autonomous operational system will take longer to accomplish. A recent article, titled *Self-Driving Cars: The Next Revolution*, published by KPMG and the Center for Automotive Research (CAR), indicates that adoption of autonomous driving will have enough market penetration by 2025 to enable fully operational autonomous control of vehicles.

We expect that there will be several iterations of functionality over the next decade so that automated controls available today will evolve into full automation on selected roadways in 10 to 15 years. We also expect that only certain roadways, most likely major arterial intersections and freeway segments in large urban areas (like Los Angeles), will be instrumented with V2I technology first. Given that the current implementation schedule is for the freight corridor to be operational in 2025, we expect that the V2I, V2V, and ADAS components will be sufficiently robust to enable most autonomous operations functionality on the truck lanes by that time. Other assumptions we have made for this Concept are that many arterial roads in the I-710 Corridor will not have all the V2I infrastructure by 2025 to enable fully autonomous controls, and the trucks using the I-710 ZEFC will have both autonomous and manual modes that the driver can control, as necessary. These modes will be integrated over time.

If these systems are not sufficiently developed by 2025 or whenever the ZEFC is open, the assisted operations can be phased in with the availability of technology. For example, the lanes could begin operations with trucks using the current technologies, such as advanced cruise control and lane keeping. Other components of the ultimate autonomous system can be added as they reach the market. The operating authority, which could be Caltrans, Metro, or a new
operating entity, will need to determine when to require the use of specific autonomous components to use the ZEFC lanes.

We expect that the V2V and V2I communications will be at least partially operational in 2025 so that trucks operating autonomously will be able to detect other nearby trucks in autonomous mode. It is expected that full deployment of infrastructure technology for V2I operation will be deployed for initial operation of the ZEFC the day it opens. Once a truck has identified other autonomous trucks, they may be able to link virtually in a platoon of trucks traveling at a very small headway. This Concept does not specify how that process works in detail, and that process will need to be determined over the next several years, including how many trucks to platoon together.

**Zero Emissions Technology and Policies**

As with autonomous vehicle control, zero emissions technology is becoming available, but is not commercially viable yet; however, numerous technological advances are expected over the next several years or decades. The I-710 EIR/EIS indicates that trucks in the ZEFC will be operating without producing pollutant emissions. This means that it will be a requirement for the trucks to be operating in zero emissions mode on the I-710 ZEFC when it opens and thereafter, but they may also be able to operate with California emissions standards on other freeways or arterials.

As the EIR/EIS indicates zero emissions are required, it will be assumed for this Concept. This ConOps does not prescribe a specific technology to meet zero emissions, but it states that the policy will be a requirement for use of the facility. Other parts of the project and other reports will discuss details of zero-emission technologies and approaches for development of ZET.

The I-710 ZEFC credentialing system will interact with the zero-emissions requirement by verifying that trucks entering the corridor are capable of zero-emissions operation, and are running in that mode. It may automatically engage the zero emission mode on the truck, if the truck is not a 100-percent zero-emissions operation when it enters the ZEFC. Non-zero emission trucks will be signaled to not enter. The system may also monitor emissions from the truck as it travels the corridor, and if it begins generating emissions, the truck would be signaled and/or charged a fee. Tolls can be adjusted in a similar fashion.

**I-710 Truck Lanes Tolling**

We have assumed for this Concept that the I-710 ZEFC may be financed, at least partially, by tolls. We are assuming that Metro will operate the toll lanes in the same manner as they operate other toll facilities in the Los Angeles region. We expect the trucks will be electronically tolled only; no manual tolling will be used. The toll policies, whether a flat trip rate, a variable distance rate, weight and distance rate, congestion pricing, or subscription discounts are offered, will be determined by Metro at a later date. Electronic tolling will be used by placing
tolling devices at the entrance (and possibly exit) ramps to the ZEFC. The standards for the tolling technology will be determined at a later date, but could include toll tag readers, radio-frequency identification (RFID), or DSRC. The current I-710 tolling study has recommended to Metro that a Public/Private Partnership manage the tolls and the tolls should be collected for trucks only in the ZEFC. We suggest that the tolling policy be designed to provide incentives for trucks to use the Freight Corridor as much as possible.

I-710 ZEFC Lanes Design

The I-710 ZEFC current preliminary design shows two lanes in each direction with nine ZEFC interchanges along the 16-mile roadway. The standard design for arterial to freeway interchanges includes some with diamond type ramps and others with loop ramps. We have identified a need for a credentialing station to be located along each of the entrance ramps; 18 stations will be needed. This credentialing station needs to check credentials of trucks to certify they are compliant with the zero emissions requirements, to collect tolls, to alert the vehicle that the truck is entering the autonomous driving mode, and to conduct oversize/overweight permit status and other truck enforcement inspections. The stations will likely need to have several DSRC (or other adopted communications standard) transmitter/receiver devices on an overhead gantry structure or an array of roadside devices. Design of the credentialing stations and a typical layout are included in the *Gateway Cities Strategic Plan: ITS Infrastructure Impacts Report*.

A second design issue is related to credentialing stations locations. If a truck that is not registered or does not have current certifications in place tries to enter the ZEFC lanes, the system must communicate to the driver that the truck cannot enter the ZEFC lanes. One method allowing only registered trucks to use the lanes is to flash a red light and sign asking the truck to exit before the entrance ramp to the adjacent arterials, and to then to use the I-710 general purpose lanes. An escape exit off these ramps has not been provided for in the current design. The I-710 corridor design is complex and there is little additional right-of-way available for exits from the ramps for this proposed concept. The exit lanes from the entrance ramps need to be studied to determine if such lanes are feasible. A second option to be explored is to move the credentialing stations to the arterial approaches to the ramps and design the stations so that ineligible trucks can easily drive back to the arterial system and access the I-710 general purpose lanes. Another option is to instruct the noncertified trucks to proceed to a proposed TEF, where they would be issued a ticket and usage fee or just notified, and then be required to exit the freight corridor to the I-710 general purpose lanes. In all these cases, the I-710 corridor design should include trailblazer signs providing nonregistered trucks with information to access the I-710 general purpose lanes.
Another design issue is providing a refuge area for disabled trucks, enforcement violations, or incident management. The preliminary design cross-sections for one direction of truck lanes show two 12-foot travel lanes and a 10-foot shoulder on each side of the travel lanes. A 10-foot shoulder will not provide sufficient space for a truck and the drivers and responders to safely conduct their activities. We suggest that the designers consider having a 5-foot shoulder adjacent to the left lane and a 15-foot shoulder adjacent the right lane. This 15-foot shoulder will provide for a safe, continuous refuge area along most of the corridor that will not affect operations on the travel lanes. The 15-foot shoulder provides sufficient room for trucks to change tires, repair breakdowns, for truck unloading, and for emergency vehicle use while assisting disabled vehicles.

I-710 ZEFC Access and Enforcement

Enforcement of safe driving regulations and use of the ZEFC is important to the safe and efficient operation of the I-710 ZEFC. The credentialing of trucks desiring to use the ZEFC is key to this enforcement. This Concept includes electronic credentialing station at or near each entrance ramp. If the trucks are not able to return to the arterial network and easily access the I-710 general purpose lanes, we suggest that a very large usage fee (consider $1,000 or more), in addition to the toll charge, be issued to any unauthorized vehicle entering the truck lanes (perhaps after some initial warnings and grace periods). The issuing of these fees (or warnings) will require identification of the unauthorized vehicle so that the ticket (or warning) can be sent to the owner after a predetermined grace period where the drivers are educated about this policy. Cameras and license plate readers (like those at red light running enforcement locations) could be added to the credentialing station areas. A map showing the layout of the freight corridor, the included facilities, and ITS devices is being developed as part of the Gateway Cities Strategic Plan: ITS Infrastructure Impacts Report.

Another enforcement consideration, particularly in the initial phases of the autonomous control development, is whether to allow manual mode trucks to use the truck lanes by paying a higher toll or a small fee. If the lanes are not congested, the operating authority could allow manual or automated trucks to use the lane. The drawback to this is that there will be differential speeds, headways, and driving techniques between the autonomous and nonautonomous trucks, which may impact safety and operations in the ZEFC.

It will be necessary to add automated permitting and oversize/overweight inspection areas to the credentialing stations. Scanners for truck height and width will also be located at the stations, and the ramp will include a WIM unit. The V2I communications will provide the status of any freight-related permits. Screening areas at the entrance ramps must coordinated with the Gateway Cities Technology Plan for Goods Movement project for the TENS and the operations of the TEF.
One other enforcement issue is the speed limit in the ZEFC. In order to provide incentives for trucks to use freight corridor rather than the general purposes, there must be differentiating factors. One incentive could be to allow a faster speed limit in the ZEFC. We suggest a higher limit be considered and tested because there is a homogeneous mix of vehicles using the lanes, the drivers are professional and familiar with the roadway, and the autonomous operations will eventually provide a significantly safer roadway. A safe feasible speed limit can be determined as a result of these tests.

Traffic and Incident Management on the Truck Lanes

Traffic management on the I-710 ZEFC needs to be conducted with a high level of monitoring, and incidents need to be responded to quickly in order to meet the expectations of road users on a premium facility such as the freight corridor. The traffic and incident management requirements will, however, be different than on the general purpose lanes. CCTV surveillance cameras will be needed to assess incidents as on other facilities. We expect that CMS and speed detectors may not be needed due to the V2I data provided by the ZET and the communications to drivers provided through in-vehicle devices. The in-vehicle devices may also be programmed to allow drivers to report on incidents. However, for Phase 1 deployment, CMS and speed sensors will be assumed.

The number of crashes on the freight corridor is expected to be near zero in the future with autonomous operations, and the number of disabled vehicles may also be lower than current numbers because the advanced technology trucks may have fleet maintenance monitoring capability. We expect that it will not be necessary for the freeway service patrol or CHP to provide a beat patrol on the ZEFC lanes. The freeway service patrol and other responders should be able to respond quickly from their patrols on the general purpose lanes. All response vehicles must be allowed access to the truck lanes as registered vehicles.

Another method of managing traffic and incidents is to require that any planned construction or maintenance work on the ZEFC be conducted at off-peak times so that truck traffic disruption will be minimized.

An incident management plan should be developed for the ZEFC. Responders need to know where to enter the ZEFC to respond to an incident. Also a plan for responding to major incidents where contra-flow access to the incident is needed should be developed.

The Los Angeles region and the Ports have prepared emergency management plans in case of natural disasters, weather events, or terrorist attacks. These plans will be followed in case of an emergency. These emergency management plans should be reviewed over time to incorporate the advancement of assisted and autonomous implementation phases for the ZEFC project.

The modes of operation and operational scenarios for this Concept assume that a Metro traffic management center or the Caltrans District 7 RTMC will conduct
the daily operations and management of the ZEFC and the CACVMS. There may be other models developed regionally that can manage these daily operations and management tasks. Possible models include the Metro Toll Authority, a new entity created for this I-710 ZEFC; or a joint operations center managed by Caltrans, CHP, and Metro and/or another entity, whether in the existing RTMC building or a new location.

**Connected Automated Commercial Vehicle Management System Testing**

A test plan for CACVMS is currently being developed by the Cambridge Systematics team. A draft of the Test Plan is expected by September 2013. The test plan will focus on and approach for initial Automated Truck Conveyance “Proof-of-Concept Testing” and the Fontana Speedway in late 2014; followed by “Operational Prototype Testing” in the Gateway Cities region in approximately 2016.

**Driver Training for Autonomous Vehicles**

Truck drivers that will use the I-710 ZEFC will need to be trained to properly use the autonomous controls. As part the I-710 ZEFC vehicle registration program, trucking companies and owner/operators will need to certify that each driver has passed an autonomous driver training course. The project partners (GCCOG, Metro, Caltrans, and others) will need to work with the California Department of Motor Vehicles to develop a driver training course and certification process for truck driver using autonomous controls. California state laws may be needed to be changed to enable this certification process.

**Incentives and Disincentives for Trucks Using the I-710 ZEFC**

Policies regarding tolling, zero emissions requirements, and the use of assisted and autonomous technologies should be designed whenever possible to provide incentives for trucks to use the ZEFC. The expense of purchasing zero emissions technology for a truck that may not be needed on any other roadway plus the cost of keeping up with evolving Connected Vehicle and ADAS technologies, either by purchasing new vehicles or aftermarket devices, will be a major disincentive for trucking companies and owner/operators to meet several certification requirements. Consideration should be given to phasing in requirements over time, providing differential toll rates for compliant trucks, providing increased speed limits and for creating a user-friendly certification process as part of the Corridor implementation plan. The ZET commercialization study will address many of these issues, including a program to develop a fleet of ZET prior to opening the ZEFC. Government assistance or incentives will likely be needed to ensure this fleet of ZET is operational when the ZEFC opens. Further programs for this are in the process of being developed.
Security, Liability, Insurance, and Other Institutional Issues

There are several nontechnical institutional issues that must be addressed before commercial implementation of CACVMS can be initiated. Data security issues need to be fully addressed, analyzed, and developed to ensure a secure technology system. The connected vehicles data transmitted among vehicles and to the roadside have life safety implications so credentialing and integrity of the data must be fully secure. These real-time systems will include encrypted data and firewalls to prevent breaches.

Liability and insurance issues need to be similarly assessed, analyzed, and integrated with this operational system. These issues must be addressed nationally; and the OEMs, systems vendors, and insurance companies are working through the many aspects of these issues currently.

The GCCOG must continue to track developments for these issues and incorporate changes and updates into the strategic implementation plan for the ZEFC.
6.0 Operational Scenarios

A ConOps document provides an illustration of how frontline users of a system will take advantage of system functionality to help them perform their daily work tasks. More specifically, these Operational Scenarios are provided to describe how the technologies and processes described in this ConOps interact with real-world user operations on a daily basis in the work environment. Thus, the Scenarios illustrate how people use the information and the functionality derived from the ConOps to plan trips, make decisions, collect and analyze data, and use the tools and systems to manage their business.

The following Operational Scenarios describe how dispatchers and drivers will use the I-710 ZEFC with the three levels of assisted and autonomous vehicle systems. The assisted and partially autonomous vehicle system is assumed to be only in place for the I-710 ZEFC separated truck-only lanes that are accessible at only certain entrance/exit points, and a toll is likely to be required to enter the lanes (toll is automatically collected by a toll tag or similar identification device). The fully autonomous system describes a scenario that includes only the I-710 ZEFC. The zero emission vehicles will use a conveyance technology that emits zero tail pipe pollutants; the specific technology on these vehicles has not yet been determined, but is being analyzed.

The fictional company names and employees used in the Gateway Cities Technology Plan for Goods Movement project are used again in these scenarios. Refer to the Operational Scenarios section of the Gateway Cities Technology Plan for Goods Movement ConOps document for details on any of the system functions in that Goods Movement Plan.

Phase I. Assisted Truck Control (NHTSA Level 1)

Assisted truck control is equivalent to Level 1 Function-Specific Automation, as defined by the NHTSA Preliminary Statement of Policy Concerning Automated Vehicles. Level 1 automation involves one or more specific control functions; if multiple functions are automated, they operate independently from each other. The driver has overall control and is solely responsible for safe operation, but can choose to cede limited authority over a primary control (as in adaptive cruise control); the vehicle can automatically assume limited authority over a primary control (as in electronic stability control); or the automated system can provide added control to aid the driver in certain normal driving or crash-imminent...
situations (e.g., dynamic brake assist in emergencies). In this scenario, it is assumed that V2V and V2I communications are not yet fully operational. Assisted control means that the driver is still in control of the truck; however, features such as adaptive cruise control, brake assist, and lane keeping allow vehicles to travel safer and at smaller headways than they can currently.

**Assisted Truck Control Operational Scenario**

Late Monday afternoon, Joyce, the EZ Cartage Company dispatcher, downloaded drayage orders through the MTO’s freight information management or appointment or scheduling system. She went through her daily process of assigning drivers to each load, and when completed the orders were accepted. Upon acceptance, the EZ Cartage system automatically notified the MTOs and BCOs of the times pick-ups and deliveries will be made. Simultaneously, each EZ Cartage driver and truck was notified of the day’s assignments, the pick-up and drop-off schedule, and locations.

Tuesday morning while the drivers are doing their preoperations truck inspections, Joyce checks for the latest information on queues at the gates, traffic, incidents, and construction projects through the GoFreight system. The drivers turn on their in-vehicle system and receive instructions on the first assignment, and an overview of the entire day’s assignments on a navigation screen and through an automated text to voice system. The in-vehicle system then provides them up-to-the-minute updates on traffic, weather, and roadway conditions in the area as they begin the trip. One major enhancement is that the Freight Advanced Traveler Information System (FRATIS) demonstration project in 2014, resulting in subregional automated truck routing and drayage optimization system that now automatically alerts and reroutes the drivers around congestion or incidents.

About five minutes after the trucks have pulled out, Joyce receives a new alert from GoFreight regarding an accident along SR 91, the route that Sam was going to take. All systems are in place to help Joyce manage this kind of situation, and the Gateway Cities Technology Plan added ITS coverage on the regional freeway and arterial networks to enable real-time incident information. The EZ Cartage software automatically reroutes the drivers and directs the drivers to not use SR 91 to access the I-710 ZEFC, but to travel on Del Amo Boulevard and access the I-710 ZEFC at that point. Joyce messages Sam confirming that rerouting. Sam, an EZ Cartage driver, is traveling south to pick up a load at the Ports, which will then be taken to a warehouse in Commerce.

As Sam’s truck approaches the I-710 ZEFC on ramps, it passes through entry area that has an array of sensors and readers that determine whether the vehicle attempting to enter the trucks is authorized. The readers, using DSRC reader and transmitter equipment or other proven communications standards, check the truck identification code and immediately determine that the truck is owned by EZ Cartage, that since EZ Cartage has registered that truck as a zero emissions
vehicle, in this case a battery hybrid\CNG-powered truck, verifies that the truck is currently operating in zero emissions mode, and that the toll account is up to date, then the vehicle is authorized and the trip toll is assessed to EZ Cartage. The sensors located at the entrance also record that the truck has recently passed a safety inspection, and that the truck size and weight are within allowable limits. Since EZ Cartage trucks are registered properly and pass the size/weight inspection, it is authorized to use the ZEFC. Sam receives a green light on their in-vehicle screen and on a roadside signal.

Sam accelerates up the ramp and onto ZEFC. He knows he can merge safely because the 360° sensors will alert them if another truck was in a blind spot or traveling too close. Sam then engages the adaptive cruise control system, allowing him to maintain a close spacing with the truck ahead. He is able to drive relaxed since he knows the brake assist will stop him in an emergency and the lane keeping warning will alert him if he drifts out of a lane. Sam approaches the Ports and proceeds through the terminal gate as the in-vehicle system instructs him and drives to the container location assigned to him. Sam indicates through the voice system that he has picked up his load. Joyce instructs him to proceed directly to the assigned drop-off location. He then leaves the Port and drives north on I-710 to Commerce. Sam exits at Bandini Boulevard and travels to the distribution center and drops off the container. He contacts Joyce to confirm the delivery and checks his in-vehicle device for his next assignment.

Meanwhile at the Metro traffic management center, Frank, a traffic management operator, is monitoring CCTV cameras and the speed from data received from ITS detectors on the I-710 ZEFC. Frank posts messages to 511 and GoFreight by entering incident data into the traffic management software, which automatically alerts truck drivers of incidents or congestion in the truck lanes through GoFreight for dissemination to the public and to fleet manager subscribers. The traffic management operators also can contact the Freeway Service Patrol drivers to respond to an incident or a disabled vehicle. The FSP will also respond to any incidents in the ZEFC. The FSP and any CHP vehicles are authorized to enter ZEFC as any truck would enter the lanes. Tow vehicles are allowed to enter the trucks only when needed and authorized by CHP.

If one of these EZ Cartage trucks was not properly authorized, the driver would have been alerted through in-vehicle system that he could not enter the ZEFC and to proceed back to the local streets and to the I-710 general purpose lanes or to the TEF from the ZEFC. An unauthorized truck that does not have any in-vehicle communications system would receive a red light on a roadside sign, and the sign would instruct the driver to proceed back to the local street, where he would have to enter the general purpose lanes. If the unauthorized vehicle ignored the warning, a roadside license plate reader would take a picture of the license, and a camera would take a picture of the driver and send it immediately to the CHP Commercial Vehicle Inspection Station. The unauthorized truck
would be sent an invoice (or notification) for a large usage fee for using the truck lanes illegally.

In this scenario, incidents are handled in a manner similar to what is done today. An incident (crash, debris, weather, construction, or maintenance activity), whether a lane closure or not, is reported to or observed by the traffic management center, which provides information on roadside CMS and to the 511 and GoFreight systems. Also ramp meter flow rates and Advanced Traffic Management (ATM) strategies can be changed. If there is a major incident with sustained duration and significant impact, such as a freeway segment collapse due to an earthquake, EZ Cartage Company’s Business Continuation/Disaster Recovery Plan has been constructed to handle it using all of the available technology and data. Many freight companies have worked closely with the Ports and with Metro, Caltrans, CHP, and local law enforcement agencies to devise business continuation plans for rerouting trucks, redistributing activity times, and planning other actions to ensure resumed and continued freight movement activity and recovery as soon as possible after a major disruption.

In the case of an evacuation scenario, Cal EMA will determine if the ZEFC is needed for the evacuation process. In the event of a major regional emergency event such as this, a regional emergency management process will go into effect. In some evacuation plans, all the ZEFC lanes can be operated in a single direction during the evacuation period or the southbound ZEFC lanes could continue to operate in the southbound direction to allow for emergency vehicle access to the Ports. The northbound lanes could be opened to general purpose traffic, and both sides of the I-710 general purpose lanes will operate in the northbound direction. Also the plans include the stationing of the freeway service patrol, CHP, and local police at all entrance and exit ramps to control access to the ramps and to direct traffic along the major arterials in the corridor.

**Phase II – Partially Autonomous Truck Conveyance System (NHTSA Level 3)**

Partially autonomous truck conveyance is equivalent to Level 3 Limited Self-Driving Automation, as defined by the NHTSA Preliminary Statement of Policy Concerning Automated Vehicles. Level 3 automation enables the driver to cede full control of all safety-critical functions under certain traffic or environmental conditions, and in those conditions to rely heavily on the vehicle to monitor for changes in those conditions requiring transition back to driver control. The driver is expected to be available for occasional control, but with sufficiently comfortable transition time. The vehicle is designed to ensure safe operation during the automated driving mode. Although the autonomous system implementation timeframe is not known, it is assumed this is the most likely scenario when the I-710 ZEFC is opened in approximately 2025.
**Partially Autonomous Truck Conveyance System Operational Scenario**

Late Monday afternoon, Joyce, the EZ Cartage Company dispatcher, downloaded drayage orders through the MTO’s freight information management or appointment or scheduling system. This process and the driver’s start-up process are the same as described in the Assisted Truck Control scenario above, except that the EZ Cartage system has automatically input the trip destination into the truck’s in-vehicle system. Sam, an EZ Cartage driver, will be traveling south to pick up a load at the Ports, which will then be taken to a warehouse in Commerce.

About five minutes after Sam’s truck has pulled out, Joyce receives a new alert from GoFreight regarding an accident along SR 91, the route that Sam was going to take. The EZ Cartage software automatically reroutes him and directs him to not use SR 91 to access the I-710 ZEFC, but to travel on Del Amo Boulevard and access the I-710 ZEFC at that point. Joyce messages all EZ Cartage drivers confirming that rerouting.

As Sam’s truck approaches the I-710 ZEFC on ramps, it passes through entry area that has an array of sensors and readers that determine whether the vehicle attempting to enter the trucks is authorized, as described in the Assisted Truck Control scenario above. Sam receives a green light indicating that authorization is approved on his in-vehicle screen and on a roadside signal. Sam enters the southbound ZEFC lanes, in manual mode, as the truck accelerates to reach cruising speed and Sam switches his truck to autonomous mode. He approaches another truck or trucks along the roadway and the V2V system detects another truck or trucks in autonomous mode and traveling in a platoon. The autonomous system alerts Sam that a platoon or another truck that wants to platoon is nearby and asks him if he wants to engage the autonomous control. He turns on the autonomous system and the system engages with the next truck in the platoon, and the controls automatically keep the truck at a set distance from the truck ahead of it. The guidance system in the autonomous control program steers the truck to stay in the lane or to exit when required. At this point, the truck is in autonomous mode and the platoon is traveling at a steady 60 mph. Sam is able to use his in-vehicle device to review the day’s assignments, check email, and find a restaurant to have dinner with his wife that night while the ZET drives itself.

As Sam approaches the port area, the autonomous system warns him that autonomous control will end soon and to disengage the system, which Sam does. The entire platoon slows down as the trucks switch to manual mode. Sam proceeds through the terminal gate as the in-vehicle system instructs him and drives to the container location assigned to him. Sam indicates through the voice system that he has picked up his load. Joyce instructs him to proceed directly to the assigned drop-off location. He again passes through the entry area and receives authorization and then joins a northbound platoon in I-710 ZEFC and travels in autonomous mode to Commerce. As he approaches the Bandini
Boulevard exit, he acknowledges the warning that the autonomous mode is about to disengage. As Sam begins the exit process and switches to manual mode, the V2V system sends alerts to the trucks behind him and the trucks slow slightly as he maneuvers his truck into the right truck lane. If Sam had been the truck platoon leader, then his truck would alert the following truck or trucks and another truck would then become the platoon leader. As Sam approaches the exit, he is driving the truck in manual mode. Sam exits at Bandini Boulevard and drops off his container. While he is the warehouse in Commerce, the EZ Cartage system has Sam’s daily itinerary, and the system loads Sam’s next pick-up and destination locations into the truck in-vehicle device. Sam contacts Joyce to confirm his delivery and he proceeds to his next assigned trip.

If Sam was incapacitated in some way and unable to acknowledge the warning that autonomous control was about to end and manual control was going to begin, the truck would slow down, move into the right shoulder area, and stop. The same procedure would occur if Sam’s truck had a mechanical failure or other problem (e.g., tire puncture). The CACVMS would also automatically send an alert to the RTMC and CHP that the vehicle has stopped along with its location.

The trucks are able to proceed to their destination at steady speed of 60 mph, the posted speed limit on the freight corridor, which required a change in California vehicle law. This speed is assured for the ZEFC lanes since the trucks are guaranteed to operate at a high level of service.

Meanwhile at the Metro traffic management center, Frank, a traffic management operator, is monitoring CCTV cameras and the speed from data received from ITS detectors and the autonomous system on the I-710 ZEFC. Frank posts messages to 511 and GoFreight by entering incident data into the traffic management software, which automatically alerts truck drivers of incidents or congestion in the ZEFC lanes through GoFreight for dissemination to the public and to fleet manager subscribers. Additionally, the autonomous system alerts trucks operating in autonomous mode of any slow speeds or incidents automatically. The traffic management operators also can contact the FSP drivers to respond to an incident or a disabled vehicle. The FSP will also respond to any incidents in the ZEFC lanes. The FSP and any CHP vehicles are authorized to enter the truck lanes as any truck would enter the lanes. Tow vehicles are allowed to enter the trucks only when needed and authorized by CHP.

Phase III – Fully Autonomous Truck Conveyance System (NHTSA Level 4)

The Fully Autonomous Truck Conveyance System is equivalent to Level 4 Full Self-Driving Automation as defined by the NHTSA Preliminary Statement of Policy Concerning Automated Vehicles. In Level 4 automation, the vehicle is designed to perform all safety-critical driving functions and monitor roadway
conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip. This includes both occupied and unoccupied vehicles. By design, safe operation rests solely on the automated vehicle system. This Concept assumes that this scenario, occurring sometime beyond 2025, includes V2V and V2I systems that have been implemented in the I-710 ZEFC. The roads in the ports area and arterials accessing most of the major WDT centers in the Los Angeles basin are not yet instrumented for autonomous operations. For the foreseeable future, the trucks will continue to need a manual driving mode since it is unlikely that all roads and marshaling yards will have autonomous capability for many years outside of the ZEFC.

**Fully Autonomous Truck Conveyance System Operational Scenario**

Late Monday afternoon, Joyce, the EZ Cartage Company dispatcher, downloaded drayage orders through the MTO’s freight information management or appointment or scheduling system. This process and the driver’s start-up process is the same as described in the Assisted Truck Control scenario above, except that the EZ Cartage system has input the trip destination into in the truck’s in-vehicle system. Sam, an EZ Cartage driver, will be traveling south to pick up a load at the Ports, which will then be taken to a warehouse in Commerce.

About five minutes after Sam’s truck has pulled out, Joyce receives a new alert from GoFreight regarding an accident along SR 91, the route that Sam was going to take. The EZ Cartage software automatically reroutes him and directs him to not use SR 91 to access the I-710 ZEFC, but to travel on Del Amo Boulevard and access the I-710 ZEFC lanes at that point. Joyce messages all EZ Cartage drivers confirming that rerouting.

As Sam’s truck approaches the I-710 ZEFC on-ramp, it passes through entry area that has an array of sensors and readers that determine whether the vehicle attempting to enter the trucks is authorized, as described in the Assisted Truck Control scenario previously. Sam receives a green light indicating that authorization is approved on their in-vehicle screen and on a roadside signal. As he passes the entry area, a DSRC signal automatically switches his truck to autonomous mode. Sam enters the southbound lanes and the truck accelerates to reach cruising speed in the right lane; and as a gap in the left lane becomes available, the truck moves into the left lane. The truck then automatically accelerates to the autonomous speed limit of 60 mph. As the truck approaches other trucks along the roadway, the V2V system detects other trucks in autonomous mode and virtually links with them to form a platoon. The autonomous system engages with the next truck in the platoon, and the controls automatically keep the truck at a set distance from the truck ahead of it. The guidance system in the autonomous control program steers the truck to stay in the lane or to exit when required. At this point, the truck is in autonomous mode...
and the platoon is traveling at a steady 60 mph. Sam is able to use his in-vehicle device to review the day’s assignments, check email, and find a restaurant to have dinner with his wife that night.

As Sam approaches the ports area, the autonomous system warns him that autonomous control will end soon and the system will disengage, which Sam acknowledges. The entire platoon slows down as the trucks automatically switch to manual mode and he exits the freight corridor. Sam proceeds through the terminal gate in manual mode as the in-vehicle system instructs him and drives to the container location assigned to him. Sam indicates through the voice system that he has picked up his load. Joyce instructs him to proceed directly to the assigned drop-off location. He again passes through the entry area and receives authorization and then joins a northbound platoon in I-710 ZEFC and travels in autonomous mode to Commerce. As he approaches the Bandini Boulevard exit, he acknowledges the warning that the autonomous mode is about to disengage since the system knows he is to exit at Bandini Boulevard. As Sam begins the exit process and switches to manual mode, the V2V system sends alerts to the trucks behind him and the trucks slow slightly as he maneuvers his truck into the right truck lane. If Sam had been the truck platoon leader, then his truck would alert the following trucks and another truck would then become the platoon leader. As Sam approaches the exit, he is driving the truck in manual mode. Sam exits at Bandini Boulevard and drops off his container. While he is at the warehouse in Commerce, the EZ Cartage system has Sam’s daily itinerary and the system loads Sam’s next pick-up and destination locations into the truck in-vehicle device. Sam contacts Joyce to confirm his delivery and he proceeds to his next assigned trip.

Meanwhile at the Metro traffic management center, Frank, a traffic management operator, is monitoring CCTV cameras and the speed from data received from ITS detectors and the autonomous system in the I-710 ZEFC. Frank posts messages to 511 and GoFreight by entering incident data into the traffic management software, which automatically alerts truck drivers of incidents or congestion in the ZEFC through GoFreight for dissemination to the public and to fleet manager subscribers. Additionally, the autonomous system alerts trucks operating in autonomous mode of any slow speeds or incidents automatically. The traffic management operators also can contact the FSP drivers to response to an incident or a disabled vehicle. The FSP will also respond to any incidents in the freight corridor. The FSP and any CHP vehicles are authorized to enter the freight corridor as any truck would enter the lanes. Tow vehicles are allowed to enter the trucks only when needed and authorized by CHP.
7.0 Summary of Impacts

Table 7.1 shows a description of the impacts on systems users, on truck drivers and dispatchers, and on the traveling public.

Table 7.1 Summary of the Impacts of Autonomous Vehicle Systems on Users

<table>
<thead>
<tr>
<th>System Users</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck drivers – Drivers of commercial vehicles in the corridor</td>
<td>Impacts on truck drivers will be largely positive. Drivers will experience less travel time for trips using the I-710 ZEFC, and these trips will be safer and more reliable. The primary negative to truck drivers is that they must learn how to properly use new equipment on their truck and to use the autonomous vehicle system. For owner/operators and small trucking companies, the initial cost of purchasing new equipment with zero emissions, autonomous control, and other required technology will be high and, in some cases, prohibitive and may need to be subsidized. However, with full deployment of technology for goods movement, more efficiency will result leading to more turn times per truck for the driver and fewer truck trips.</td>
</tr>
<tr>
<td>Trucking company dispatchers – Staff that provide assignments and information to the truck drivers</td>
<td>Trucking company dispatchers will be able to schedule more trips for their drivers due to travel time savings and more reliable trips in the I-710 corridor. The trucking companies will experience some higher costs initially because new equipment is needed on the trucks that participate in the autonomous vehicle program. However, with full deployment of technology for goods movement, more efficiency will result leading to more turn times for trucks and a higher utilization of the dispatchers trucking companies fleet and fewer trips.</td>
</tr>
<tr>
<td>Caltrans District 7 or other operating entity – Personnel that operate and maintain the I-710 freeway</td>
<td>Caltrans or the I-710 ZEFC operating agency will likely need to add operations and maintenance (O&amp;M) staff. Due to the life safety requirements of the autonomous vehicle control systems, much higher than current standards of system monitoring, roadway monitoring, and equipment maintenance must be met.</td>
</tr>
<tr>
<td>Incident responders – Personnel that respond to incidents on I-710, CHP, local fire, tow companies</td>
<td>When the autonomous vehicle system is functioning properly, there should be fewer incidents on the autonomous lanes, with most incidents being minor. If the system is down for any reason, the autonomous lanes will need to be monitoring and incidents handled as with the general purpose lanes.</td>
</tr>
<tr>
<td>Other users in the I-710 corridors – Drivers in the general purpose lanes on I-710</td>
<td>These drivers should experience less congestion and more reliable travel times due to fewer trucks using the general purpose lanes and fewer crashes in the corridor.</td>
</tr>
</tbody>
</table>
Additionally, this project will benefit the overall economy of the ports area and Southern California by improved throughput, safety, reliability, and dependability of truck access to the Ports via the I-710 ZEFC, by reducing vehicular emissions due the zero emissions requirement, by helping Southern California establish a leadership position in Connected Vehicle technologies industry, and by establishing an ongoing partnership among agencies that attracts additional funding opportunities for real-world solutions in a real-world freight corridor.
8.0 Analysis of the Proposed System

This section provides a brief subjective analysis of the impacts and benefits of the I-710-ZEFC. A detailed analysis of the ZEFC will need to be conducted as the project moves to the preliminary engineering phase.

The I-710 ZEFC ITS project will provide numerous benefits to both the trucking industry in the Los Angeles region and the general public. For the trucking industry, safety, increased throughput, and travel time reliability in the I-710 ZEFC will be greatly improved, as will the actual travel time of most drayage trips. The number of crashes involving trucks should be reduced to nearly zero while using the I-710 ZEFC. The combined benefits of faster, more reliable drayage trips, increased throughput, and virtually no crashes will provide a significant positive cost saving for the trucking industry in Southern California.

For the general public, there will also be positive benefits from the deployment of the I-710 ZEFC ITS. The reduction in the number of trucks using the I-710 general purpose lanes and arterials should reduce congestion and delay in the I-710 corridor. Also having a more homogeneous mix of traffic (mostly autos and light trucks and reduced numbers of heavy trucks) should reduce the number and intensity of crashes in the freeway general purpose lanes. Perhaps most importantly, the zero emissions component of the I-710 ZEFC will improve air quality in the corridor, Gateway Cities subregion, and possibly the entire Los Angeles basin.
9.0 Notes
10.0 Definition of Terms

ADAS Advanced Driver Assist Systems
ADT Average Daily Traffic
AERIS Applications for the Environment: Real-Time Information Synthesis
ATM Advanced Traffic Management
ATMIS Advanced Transportation, Management, Information, and Security
ATSAC Advanced Traffic Surveillance and Control
BCO Beneficial Cargo Owners
BNSF Burlington Northern Santa Fe
Cal EMA California Emergency Management Agency
Caltrans California Department of Transportation
CAR Center for Automotive Research
CB Citizen Band
CCTV Closed-Caption Television
CHP California Highway Patrol
CMS Changeable Message Signs
CNG Compressed Natural Gas
ConOps Concept of Operations
DOT Department of Transportation
DSRC Dedicated Short-Range Communications
EIR Environmental Impact Report
EIS Environmental Impact Statement
EMS Emergency Medical Services
EPA Environmental Protection Agency
FHWA Federal Highway Administration
FRATIS Freight Advanced Traveler Information System
FSP Freeway Service Patrol
GCCOG Gateway Cities Council of Governments
GPS Global Positioning System
HAZMAT Hazardous Materials
HMI Human Machine Interface
IEN Information Exchange Network
ITS Intelligent Transportation Systems
JPO Joint Program Office
Metro Los Angeles County Metropolitan Transportation Commission
LA SAFE Los Angeles County Service Authority for Freeways andEmergencies
LACDPW Los Angeles County Department of Public Works
LIDAR Laser Radar
LNG Liquid Natural Gas
MTO Marine Terminal Operator
NHTSA National Highway Traffic Safety Administration
O&M Operations and Maintenance
OEM Original Equipment Manufacturer
PATH Partners for Advanced Transit and Highways
PeMS Performance Measurement System
PIMS Port Information Management System
POLA Port of Los Angeles
POLB Port of Long Beach
RDEIR Revised Draft Environmental Impact Report
RIITS Regional Integration of Intelligent Transportation Systems
RITA Research and Innovative Technology Administration
RTMC Regional Traffic Management Center
SCAG Southern California Association of Governments
SDEIS Supplemental Draft Environmental Impact Statement
TASAS Traffic Accident Surveillance and Analysis System
TENS Truck Enforcement Network System
TEU Twenty-foot equivalent unit
TMC Traffic Management Center
TSM&O Transportation Systems Management and Operations
UP Union Pacific
U.S. DOT United States Department of Transportation
USC University of Southern California
V2I Vehicle-to-Infrastructure
V2V Vehicle-to-Vehicle
VII-C Vehicle Infrastructure Integration Coalition
VWIM Virtual Weigh-In-Motion
WDT warehouse/distribution/transloading
WIM Weigh-In-Motion
ZE Zero Emission
ZEFC Zero Emission Freight Corridor
ZET Zero Emission Truck or Trucks
11.0 Glossary

**Arterial Road.** Any major connecting road that is not part of the interstate and/or freeway system within a given geographical area. Arterials in Broward County are usually four or more lanes, divided with a median and primarily front commercial land use.

**Collaboration.** Any cooperative effort between and among governmental entities (as well as with private partners) through which the partners work together to achieve common goals. Such collaboration can range from very informal ad hoc activities to more planned, organized, and formalized ways of working together. The collaborative parties work toward mutual advantage and common goals. They share a sense of common purpose, leverage resources to yield improved outcomes, and bridge traditional geographic, institutional, and functional boundaries.

**Concept of Operations.** A Concept of Operations is a high-level description of what the major system capabilities will be, written so that people with a wide range of technical backgrounds may easily understand it. The Concept of Operations attempts to answer the following questions:

- **What?** The known elements and the high-level capabilities of the system;
- **Where?** The geographical and physical extents of the system;
- **When?** The time sequence of activities that will be performed;
- **How?** Resources needed to design, build, and operate the system;
- **Who?** The stakeholders involved with the system, and their respective responsibilities;
- **Why?** Justification for the system, identifying what the agency currently lacks that the system will provide; and
- **Measures of Success?** The performance measures to be used in determining how well the transportation system is achieving the desired or expected outcomes.

**Congestion.** Congestion is travel time or delay in excess of that normally incurred under light or free-flow travel conditions.

**Data Archiving.** The systematic retention and reuse of transportation data that is typically collected to fulfill real-time transportation operation and
management needs. Data archiving also is referred to as data warehousing or operations data archiving. Transportation operations and their respective sensors and detectors, and other data collection processes, are a potentially rich and detailed source of data about transportation system performance and characteristics.

**Emergency Management.** Also known as Emergency Transportation Operations (ETO). The process of preventing, preparing, responding, and recovering from an emergency; where an emergency is an unexpected, or “no-notice,” large-scale, damaging event.

**Event.** An occurrence, which includes all types of incidents, emergencies, and disasters (natural or human caused), that affects the transportation system, and requires actions to maintain the safety and mobility of the system.

**Incident.** Any nonrecurring event that causes a reduction of roadway capacity. Such events include traffic crashes, disabled vehicles, spilled cargo, adverse weather conditions, highway maintenance, and reconstruction projects.

**Incident Management (also known as Traffic Incident Management).** The systematic, planned, and coordinated use of human, institutional, electrical, mechanical, and technical resources to reduce the duration and impact of incidents, and improve the safety of motorists, crash victims, and incident responders. These resources also are used to increase the operating efficiency, safety, and mobility of the surface transportation network by systematically reducing the time to detect and verify an incident occurrence; implementing the appropriate response; and safely clearing the incident, while managing the affected flow until full capacity is restored.

**Integration.** To make into a whole by bringing all parts together; unite.

**Intelligent Transportation System (ITS).** The application of advanced electronics, computers, communications, and sensor technologies - in an integrated manner - to increase the efficiency and safety of the surface transportation network.

**Intermodal.** The ability to connect, and the connections between, modes of transportation.

**Interoperability.** The ability of two or more systems or components to exchange information and to use the information that has been exchanged.

**ITS Architecture.** A framework within which interrelated systems can be built that work together to deliver transportation services.

**Maintenance.** The preservation (scheduled and corrective) of infrastructure. The preservation of the entire transportation infrastructure (e.g., highway, transit line), including surface, shoulders, roadsides, structures, and such traffic-control devices as are necessary for safe and efficient utilization of the highway/transit line.
Multimodal. The availability of transportation options using different modes within a system or corridor.

National ITS Architecture. A common framework for ITS interoperability that defines: 1) the functions associated with intelligent transportation system user services; 2) the physical entities or subsystems within which the functions reside; 3) the data interfaces and information flows between physical subsystems; and 4) the communications requirements associated with the information flows.

Operational Concept (in ITS architecture). Identifies the roles and responsibilities of participating agencies and stakeholders.

Operational Integration. The implementation of multiagency transportation management strategies, often in real-time, that promote information sharing and cross-network coordination and operations among the various transportation networks in the corridor regions, and facilitate management of the total capacity and demand of the corridor region.

Operations. All decision-making and actions necessary for the proper functioning of a system, such as information gathering (from a variety of sources), synthesis and processing, and dissemination and distribution of the decisions and information to traffic control equipment, other agencies and decision-makers (including those associated with maintenance activities), and the public.

Performance Measures. Indicators that provide the basis for evaluating the transportation system operating conditions and identifying the location and severity of congestion and other problems.

Regional ITS Architecture. A regional framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects.

Systems Engineering. A process incorporating a set of management and technical tools to analyze problems and provide structure to projects involving system development. A requirements-driven process in which user requirements are the overriding determinant of system design, component selection, and implementation.

Transportation Systems Management and Operations (TSM&O). An integrated program to optimize the performance of existing infrastructure through the implementation of systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system.

Work Zone. An area of highway or transit line with construction, maintenance, or utility work activities.

Work Zone Management. Strategies implemented for managing traffic during construction as necessary to minimize traffic delays, maintain or improve
motorist and worker safety, complete roadwork in a timely manner, and maintain access for businesses and residents.