Smart Roadside Initiative Gap Analysis

Trucking Technology Literature Review

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16. Abstract

The Smart Roadside Initiative (SRI) was designed to breakdown information silos at the roadside in order to improve motor carrier safety and mobility, as well as the operational efficiency of motor carriers and the public-sector agencies that regulate them. Jointly conceived by the Federal Highway Administration (FHWA), the Federal Motor Carrier Safety Administration (FMCSA), and public- and private-sector stakeholders, SRI was envisioned to extend and enhance the benefits associated with a myriad of Federal, state, and private-sector programs/technology deployments (e.g., Commercial Vehicle Information Systems and Networks (CVISN), truck size and weight enforcement technologies, Wireless Roadside Inspection, truck parking systems, Connected Vehicle Program (e.g., "FRATIS"), weather information, electronic toll collection systems, carrier-based communication technologies)

To support the continued advancement of the SRI program, USDOT has commissioned the SRI Gap Analysis project, in order to:

- Document the currently available and emerging roadside technologies for commercial vehicle operations (CVO);
- Analyze the functionality being developed as part of the Smart Roadside Prototype; and
- Identify gaps where functionality are absent or may be insufficient to support the Smart Roadside Initiative (SRI) within the USDOT's Connected Vehicle program.

This document is designed to summarize the use of on-board technologies that are used by motor carriers. Results from this effort will inform future work being done by this project in that it will help to identify whether the SRI architecture should be modified to accommodate recent advances and/or deployment of advanced technologies.

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Executive Summary

Background

The Smart Roadside Initiative (SRI) was designed to breakdown information silos at the roadside in order to improve motor carrier safety and mobility, as well as the operational efficiency of motor carriers and the public-sector agencies that regulate them. Jointly conceived by the Federal Highway Administration (FHWA), the Federal Motor Carrier Safety Administration (FMCSA), and public- and private-sector stakeholders, SRI was envisioned to extend and enhance the benefits associated with a myriad of Federal, State, and private-sector programs/technology deployments (e.g., Commercial Vehicle Information Systems and Networks (CVISN), truck size and weight enforcement technologies, Wireless Roadside Inspection, truck parking systems, Connected Vehicle Program (e.g., "FRATIS"), weather information, electronic toll collection systems, carrier-based communication technologies) through additional collaboration, coordination, and data sharing. During the 2008 SRI workshop, stakeholders identified a total of 42 functional capabilities and 22 specific projects within four operational environments (urban, multistate/long-haul, intermodal/port, and international border crossing) that could advance the Smart Roadside vision.

A great deal has changed since the initial SRI vision was developed in 2008. For instance, technology has become more widely deployed by both public-sector stakeholders and motor carriers. The majority of States have now deployed advanced technologies, such as mainline screening systems and virtual weigh stations, at the roadside to improve commercial vehicle safety and in many cases have begun to deploy second- or third-generation systems that utilize technologies that were just becoming commonplace in 2008 (e.g., license plate readers, U.S. Department of Transportation (DOT) number readers) or were still conceptual at that time (e.g., cellular phones to support electronic screening). The private sector also has embraced the use of technology and has deployed in-vehicle sensors and communication systems more widely in the past five years. Stakeholders in major metropolitan areas (e.g., Southern Florida, Los Angeles, Dallas-Fort Worth) and at State regulatory/enforcement sites also are actively planning technology deployments that integrate enforcement and mobility applications at the roadside. These deployments will make the SRI vision an operational reality.

A great deal has changed at the Federal level as well since 2008. FHWA has advanced the SRI program through the development of the Smart Roadside Concept of Operations (ConOps) and architecture, as well as the development of a Smart Roadside prototype system. The Connected Vehicle program also has matured greatly in recent years and what was once solely a research project is now being actively tested through the Safety Pilot in Michigan. The pace and depth by which technology deployments have changed in recent years make now the ideal time to analyze the SRI concept, identify any gaps that may exist, and identify how the program can be advanced further.

To support the continued advancement of the SRI program, U.S. DOT has commissioned the SRI Gap Analysis project, in order to:

- Document the currently available and emerging roadside technologies for commercial vehicle operations (CVO);
- Analyze the functionality being developed as part of the Smart Roadside Prototype; and
- Identify gaps where functionality are absent or may be insufficient to support the Smart Roadside Initiative (SRI) within the U.S. DOT's Connected Vehicle program.

This document is designed to summarize the use of on-board technologies that are used by motor carriers. Results from this effort will inform future work being done by this project in that it will help to identify whether the SRI architecture should be modified to accommodate recent advances and/or deployment of advanced technologies.

Methodology

Researchers at the American Transportation Research Institute (ATRI) reviewed literature relevant to the Smart Roadside Initiative (SRI), intelligent transportation systems, motor carrier technology trends, and commercial vehicle technologies. Though publication date parameters were set to the previous 10 years of research (2003-2013), one research study older than 10 years was included due to its relevance to the literature review topics.

Detailed below are the databases, sites, publications and terms used to conduct the literature review.

The researchers completed the literature review by performing searches of the following:

- The Transportation Research Board's (TRB) Transport Research International Documentation (TRID) database;
- National Cooperative Highway Research Program (NCHRP) publications;
- National Cooperative Freight Research Program (NCFRP) publications;
- EBSCO Information Services On-line database;
- Google and Google Scholar search engines.

The researchers included the following SRI-oriented terms when searching for relevant literature:

- **Smart Roadside:** smart roadside, smart roadside and trucks, smart roadside and commercial vehicles, smart roadside technology, smart roadside technology and trucks, smart roadside technology and commercial vehicles, smart roadside initiative, smart roadside initiative and trucks, smart roadside initiative and commercial vehicles, smart roadside initiative and technology.
- **Intelligent Transportation Systems:** intelligent transportation systems, intelligent transportation systems and trucks, intelligent transportation systems and commercial vehicles, intelligent transportation systems in trucking, intelligent transportation system technology, connected vehicle technology, vehicle-to-vehicle communications, vehicle-to-vehicle communications and trucks, vehicle-to-vehicle communications and commercial vehicles.
- **CVO/CMV:** commercial vehicle operations, commercial vehicle technology, trucking technology, technology in trucking.

- **On-board Safety Technology:** On-board safety technology, on-board safety technology and trucks, on-board safety technology and commercial vehicles, on-board safety systems, on-board safety systems and trucks, on-board safety systems and commercial vehicles, truck safety systems, commercial vehicle safety systems.

The reports included within the literature review are a combination of peer reviewed articles, government research publications, and research organization's publications. Studies from peer reviewed journals are identified in the literature review by the notation *(Peer Reviewed)*.

Each report was placed into one of the following categories based on the topic(s) discussed:

- Industry Background;
- Intelligent Transportation Systems;
- Safety Technology;
- Technology Utilization.

In addition, the researchers noted the technology categories addressed in each report. The following technology categories map to those in the Trucking Technology Utilization Spreadsheet:

- Backroom Systems;
- Routing and Dispatch;
- Vehicle-Based Systems;
- Asset Management;
- Technology-Based Programs.

As a capstone to Task 2.3, key findings from this report, as well as the Industry Webinar have summarized in the Private-Sector Technology Utilization document. The Utilization report is designed to ensure that the results from the webinar and this literature review can be seamlessly integrated into the broader SRI Gap Analysis project and analyses.

Overview of Findings

Across the literature findings indicate that motor carrier adoption of commercial vehicle technologies is dependent upon return-on-investment, ease of technology integration, and perceived benefits. In addition, motor carrier operational characteristics (e.g., sector, size) are significant factors in technology adoption. Addressing motor carrier size, it was found that medium to large carriers were more likely to deploy commercial vehicle technologies than smaller carriers. This finding may be due variables such as financial constraints or the lack of need for the technology among smaller operations.

Among the mainstream technologies utilized or deployed by motor carriers are driver communication systems (e.g., CB radios, cellular phones, smartphones), asset management systems (e.g., transponders, trailer tracking, radio frequency identification tags), tire pressure monitoring systems, event data recorders, electronic toll collection, and preclearance systems.

Included within the growing technologies deployed by motor carriers are on-board safety systems such as lane departure warning systems, vehicle stability systems, collision-warning systems, collision mitigation systems, electronic log books, and navigation systems.

Research findings suggest that SRI technologies are innovative, yet are still evolving. According to industry researchers several user requirements and/or needs must be addressed in order for SRI technologies to be successful. Among the key user requirements are that technology uniquely identifies each truck, trailer and driver, capability of bidirectional data collection and transmittal between the technology and external systems, capability of integrating multiple data sources into one consolidated dataset, capability of data exchange between the truck and technology while vehicle is in motion, and the capability of data transmittal in a timely manner.

Among findings from the literature of successfully deployed SRI applications are electronic screening inspection sites with preclearance systems that communicate with trucks via transponders in vehicles. Messages transmitted between the preclearance systems and transponders simultaneously inform the enforcement officer if further inspection is needed and inform the driver if they are allowed to bypass the inspection site. Furthermore, smartphones have been demonstrated to be useful alternatives to GPS units, as well as being capable of providing truck parking information to drivers.

Studies on vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and infrastructure-to-vehicle (I2V) demonstrate that communication is possible between these entities. Among the proposed technologies to facilitate these communications are 5.9 GHz dedicated short-range communications (DSRC), WiFi, and cellular systems.

Though DSRC was designed to support V2V, V2I, and I2V communications, findings from the literature suggest that message transmittal concerns exist among industry subject matter experts (SME). Among the concerns are the occurrence of interrupted or false messages, the cost of equipping tractors and trailers with DSRC devices, accuracy of position estimates between two vehicles, broadcast security, and the relationship between message latency and vehicle speed. SMEs further suggest that the trucking industry lacks support, enthusiasm, and experts on DSRC, which will make it more difficult to implement. In addition suppliers and original equipment manufacturers noted that the decision to provide or equip vehicles with DSRC-capable devices would be dependent upon customer demand, return-on-investment, regulatory policies, and standardization of systems.

According to the research WiFi and cellular systems for V2V communications are limited because a vehicle's on-board equipment cannot identify the Internet Protocol addresses of surrounding vehicles. Other issues surrounding WiFi systems for message transmittal included the relationship between vehicle speed and message latency, limited data captured for I2V and V2I communications, and increased backend management of wireless networks as multiple networks may need to be accessed for V2V communications. For cellular systems, the amount of data captured is too large for I2V and V2V communications leading to the transmittal of irrelevant messages.

Overall the findings of the literature review suggest that while certain technologies are relatively stable in the trucking industry (e.g., cellular phones, transponders), hurdles exist to the mainstream use of emerging technologies, such as DSRC. Of the obstacles encountered for the new technologies are the uncertainty of the proposed safety benefits, return-on-investment concerns, vehicle-technology integrations, cost of retrofitting technology on tractors and trailers, customer demand for technology, and lack of technological experts. Despite these concerns, several research initiatives are underway to demonstrate the efficacy and applicability of the newer technologies to trucking industry stakeholders.

1.0 Industry Background

The trucking industry is a diverse business sector that is continually developing in response to several variables, including the changing economic and regulatory environments, advances in technological applications, competition and employment characteristics. The documents included in this section provide overviews of trucking industry performance metrics and descriptive demographics.

American Trucking Trends 2013. (2013). Arlington, VA: American Trucking Associations.

This report provides an overview of current trucking industry demographics and trends. Among demographics examined are fleet size, industry sector and carrier and driver employment characteristics. Key trends include trucking performance metrics, truck sales, safety indicators, international truck trade, environmental impacts and diesel fuel prices.

- Of the 1.3 million U.S. Interstate motor carriers in 2011:
  - 442,338 were for-hire carriers (34.1 percent);
  - 700,300 were private carriers (53.2 percent);
  - 165,239 did not specify segment or checked multiple segments (12.7 percent).
- In 2011, the majority of motor carriers had small fleets:
  - 90.5 percent had six or fewer power units;
  - 6.8 percent had seven to 20 power units;
  - 2.8 percent had more than 20 power units.
- The number of truck drivers has fluctuated gradually over the past 11 years (Table 1-1).

Table 1-1. Truck Driver Employment Trends

Year	Truck Drivers
2000	3,088,000
2001	3,156,000
2002	3,234,000
2003	3,214,000
2004	3,276,000
2005	3,409,000
2006	3,475,000
2007	3,460,000
2008	3,388,000
2009	3,151,000
2010	3,028,000
2011	3,059,000

Source: American Trucking Trends 2013 (page 7). (2013). Arlington, Virginia: American Trucking Associations.

- The number of carrier business failures among carriers with five or more power units has fluctuated over the past 12 years (Table 1-2).

Table 1-2. Carrier Business Failure Trends

Year	Carrier Business Failures
2000	3,670
2001	3,990
2002	2,374
2003	1,850
2004	1,195
2005	2,250
2006	1,305
2007	1,985
2008	3,065
2009	1,700
2010	1,795
2011	800
2012	495

Source: American Trucking Trends 2013 (page 13). (2013). Arlington, Virginia: American Trucking Associations.

- In 2011, there were 23.7 million commercial truck registrations, 2.4 million truck-tractor registrations and 11.7 million trailer registrations.
- The number of large truck (10,001 pounds or greater) fatal crashes per 100 million vehicle miles traveled has decreased by 48.9 percent between 2000 and 2010 (Table 1-3).

Table 1-3. Large Truck Fatal Crash Trends

Year	Fatal Crash
2000	2.23
2001	2.13
2002	1.97
2003	1.99
2004	2.03
2005	2.05
2006	1.95
2007	1.38
2008	1.21
2009	1.03
2010	1.14

Source: American Trucking Trends 2013 (page 42). (2013). Arlington, Virginia: American Trucking Associations.

- The number of commercial trucks (Classes 1 to 8) sold over the last 12 years has fluctuated (Table 1-4).

Table 1-4. Commercial Truck Sale Trends

Year	Truck Sales
2000	8,123,800
2001	8,072,000
2002	7,974,400
2003	9,357,000
2004	9,792,600
2005	9,777,300
2006	9,268,200
2007	8,841,900
2008	6,679,800
2009	5,145,100
2010	6,136,800
2011	6,951,200
2012	7,544,000

Source: American Trucking Trends 2013 (page 28). (2013). Arlington, Virginia: American Trucking Associations.

- In 2011, the top three States for truck-transported trade between the U.S. and Mexico included:
  - California, Texas and Michigan for imports and exports.
- In 2011, the top three States for truck-transported trade between the U.S. and Canada included:
  - Michigan, New York, and Ohio for imports;
  - Michigan, Ohio, and Illinois for exports.
- Single-unit and combination truck vehicle miles traveled (VMT) per billions of miles and fuel consumption per billions of gallons have fluctuated over the past 10 years (Table 1-5).

Table 1-5. Truck Vehicle Miles of Travel and Fuel Consumption Trends

Year	Single-Unit Truck VMTs	Single-Unit Truck Fuel Consumption	Combination Truck VMTs	Combination Truck Fuel Consumption
2000	993.6	62.5	135.0	25.7
2001	1,010.1	63.0	135.4	25.6
2002	1,041.9	65.5	138.7	26.5
2003	1,061.9	67.0	140.2	23.8
2004	1,105.6	72.4	142.4	24.2
2005	1,119.5	68.4	144.0	27.7
2006	1,162.8	70.5	142.2	28.1
2007	1,194.3	71.9	145.0	28.5
2008	732.3	52.1	183.8	30.6
2009	737.7	52.0	168.1	28.0
2010	732.9	51.2	175.9	29.9

Source: American Trucking Trends 2013 (page 56). (2013). Arlington, Virginia: American Trucking Associations.

Burks, S.V., Belzer, M., Kwan, Q., Pratt, S., and Shackelford, S. (2010). Trucking 101: An Industry Primer. The Transportation Research Board of the National Academies. Transportation Research Circular E-C146. Washington, D.C.

Available On-line: http://onlinepubs.trb.org/onlinepubs/circulars/ec146.pdf

This technical brief provides an in-depth review of the trucking industry's operational characteristics, including industry segmentation, truck configurations, employment trends, transportation funding, regulations and technologies. The trucking technologies reviewed within this primer include security and safety systems.

Technologies Addressed: Routing and dispatch, vehicle-based systems, asset management.

2.0 Intelligent Transportation Systems

Intelligent transportation systems (ITS) provide advanced communication technologies which enhance the operational and safety performances of commercial motor vehicle operators. The documents in this section provide overviews of ITS within the trucking industry, including technology applications, advantages and disadvantages and user perceptions.

Anderson, M., et al. (2012). System Requirements Specifications (SyRS) for Smart Roadside Initiative. Report No.: Not Provided. United States Department of Transportation, Federal Highway Administration.

This report documents the technical development of the Smart Roadside Initiative (SRI), the relationship between SRI and various industry stakeholders (e.g., drivers, carriers, enforcement personnel), current technology system constraints and anticipated outcomes of SRI applications.

Technologies Addressed: Backroom systems, routing and dispatch, vehicle-based systems, technology-based programs.

Bayraktar, M.E., Zhu, Y., and Arif, F. (2012). Commercial Motor Vehicle Parking Trends at Rest Areas And Weigh Stations. Report No.: BDK80 977-14, Florida Department of Transportation.

Available On-line: http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_TE/FDOT-BDK80-977-14-rpt.pdf

To address the truck parking issue in Florida, researchers deployed a "smart truck parking" pilot study. Each truck parking site in the study received a rating of low, medium, or high truck capacity. Truck capacity was determined through the use of wireless ground sensors. Based on the truck data gathered, the researchers incorporated geographic information systems to develop real-time parking information maps, as well as a report generation module which provided historical parking capacity information among the various sites. The research suggests that drivers could access this information through devices such as smart phones.

Technologies Addressed: Technology-based programs, vehicle-based systems.

Belella, P., et al. (2009). The Motor Carrier Efficiency Study: Phase 1. Report No.: FMCSA-RRT-09-015, United States Department of Transportation, Federal Motor Carrier Safety Administration.

Available On-line: http://www.ntis.gov/search/product.aspx?ABBR=PB2009111146.

The following figures from Belella et al.'s report review and compare attributes across several commercial vehicle technologies, including data transfer rates, operating range, technology maturity levels, motor carrier applications and technology advantages and disadvantages. The researchers define maturity levels as high (technology standards established and accepted for five or more years and widely deployed), moderate (technology standards established two to five years, evolving to wide deployment) and low (technology standards established for less than two years, evolving deployment).

Table 2-1. Wireless Technologies Summary

Technology	Description	Characteristics	Maturity	Motor Carrier Applications	Summary Advantages/ Disadvantages
Wireless technology type	*Brief description of technology*	*Data transfer rate and operating range*	*Level of maturity*	*Summary of motor carrier applications*	*Advantages or disadvantages of technologies within a motor carrier's operating environment*
RFID	Low-powered radio transmitters to read data stored in a transponder (tag)	**Data Transfer:** Dependent on vendor tag/reader system environment **Range:** 1 inch to 1,000 feet (effectively depending on type of tag: active, Passive; or power level)	High	Weigh station by-pass programs, port operations, international border crossing systems, yard and gate management systems, asset management and tracking (vehicle ID, supply chain/pallet ID), security, wireless keys, cargo/container security	**Advantages:** Readable from varying distances, angles, and through certain materials. Environmentally robust. Unique object identification, authentication. Potential for real-time tracking. **Disadvantages:** range limitations, private-or facility-based infrastructure required.
Digital Cellular	Wireless network of transmission cells providing digital data communications capabilities	**Data Transfer:** 144 kbps to 3.1 megabits per second (Mbps) **Range:** Line-of-sight cellular tower infrastructure-dependent, mobile equipment reception transmission, and power-dependent	High	Personal telephone communications (cell phones), on-board computer and communications systems, remote vehicle monitoring systems (security systems, vehicle location systems), remote financial transactions	**Advantages:** High-performing "always-on" data connections in newest-generation services, extensive networks, mature technologies, continued technology advancement. **Disadvantages:** Competing, non-interoperable systems, bandwidth limitations, real time data exchange latency.
WLAN/Wi-Fi (IEEE 802.11x)	Wireless network technologies for local area network and internet access	**Data Transfer:** Rates up to 54 Mbps **Range:** 25-100 meters (depending on protocol variation)	High	Wireless local network applications, yard/dock operations, service facility hotspots, fuel facility operations	**Advantages:** Mature technology, strong connections between devices and routers or gateways, suitable for full-scale operation, fast connections, better local base station range than Bluetooth, IrDA. **Disadvantages:** More complicated network, peripherals, and connecting devices; Not designed for long-range communications.

Technology	Description	Characteristics	Maturity	Motor Carrier Applications	Summary Advantages/ Disadvantages
WiMax IEEE 802.16)	Wireless network technology for metropolitan area networks	**Data transfer:** Less than 54 Mbps **Range:** 0.5 mile (theoretical)	Low	Fleet management and monitoring applications in metropolitan/urban environments	**Advantages:** Operates over greater distances than Wi-Fi, more bandwidth, broader range of frequencies, non-line-of-sight operation. **Disadvantages:** Subject to multi-path signal interference, environmental factors, modest data transfer rates.
Bluetooth (IEEE 802.15.1)	Short-range radio frequency (RF) communications technology for enabled devices in close proximity	**Data Transfer:** Up to 2 Mbps **Range:** 1 to 100 meters	Moderate	Very-short-range device-to-device communications, data exchange, inter-vehicle communications	**Advantages:** Low cost, simplified discovery and setup. **Disadvantages:** Very-short-range operations dependent on power, no transmission control protocol/Internet protocol support.
Satellite	Global-satellite-based telecommunications network and GPS network	**Data Transfer: 75 bit/s to 4.8 kbps** **Range: Global**	High	GPS, satellite telephone systems, fleet management and monitoring systems	**Advantages:** Remote and global availability, higher data rates than older satellite technologies. **Disadvantages:** Cost of systems, equipment; latency; potential terrain interference.
Ultra-Wideband (UWB) (IEEE 802.15.3)	Short-range, high-data-rate RF communications	**Data Transfer:** 100+ Mbps in the 3.1 to 106 GHz bands **Range:** 10 Meters	Low	RFID tags, radar detection and imaging, precision geolocation systems, collision avoidance and collision warning sensors, high- speed WPAN	**Advantages:** High data transfer rates in multi-user networks, good for mobile wireless applications, simple components, low cost. **Disadvantages:** Limited commercial development due to Federal Communications Commission limitations, range limitations, disadvantages similar to those of other RF wireless technologies.
Free Space Optics (FSO) Infrared (IrDA)	Wireless infrared telecommunications technology for point-to-point data transmission, typically Infrared (IrDA)	**Data transfer:** 2.4 to 16 Mbps **Range:** 0.3 to 1 meter (depending on power)	Moderate	Primarily hand handled device communications, high bandwidth access to fiber optic networks, roadside beacons for low bridge or curve speed detection applications	**Advantages:** High data transfer rates, secure full-duplex (two directions at the same time) data transmission, low power, low cost. **Disadvantages:** Short range, subject to environmental, light and shadow conditions; subject to beam dispersion; limited to line-of-sight operations.
Two-Way Radio	Push to talk, half-duplex radio technologies that transmit and receive signals	**Data Transfer and Range:** data transfer speeds and range of operations depend on infrastructure, handheld equipment power, environmental conditions and terrain	High	Dispatch operations, large organization (public or private) two-way communications applications (law enforcement, utility fleets, emergency responders), citizens band (CB) radio	**Advantages:** In non-trunked systems, dedicated frequencies; immediate push-to-talk voice communication capability, public services such as CB radio are low radio cost with no recurring service costs. **Disadvantages:** Subject to limitations of infrastructure, handheld equipment and terrain; not suitable for data transfer.

Technology	Description	Characteristics	Maturity	Motor Carrier Applications	Summary Advantages/ Disadvantages
Zigbee (IEEE 802.15.4)	Short-range radio frequency standard for monitoring and control in mesh networks	**Data Transfer:** 20 to 250 kbps **Range:** 1 to 75 meters	Low	Possible in-vehicle applications, convenience controls similar to home automation and consumer electronics applications Industrial automation (intelligent sensor networks); active RFID asset tracking (local inventory systems); security applications (sensor networks for intrusion detection)	**Advantages:** Reliable, low power, low manufacturing cost, simple and small; very long battery life; mesh networking allows thousands of nodes per network. **Disadvantages:** Slow data transfer rates, vehicle application behavior not known; stringent standards for reliability increase downstream costs to consumer

Source: Belella, P., et al. (2009). The Motor Carrier Efficiency Study: Phase 1. Report No.: FMCSA-RRT-09-015 (pages 37-39), United States Department of Transportation, Federal Motor Carrier Safety Administration.

Technologies Addressed: *Routing and dispatch, vehicle-based systems, asset management.*

Belella, P., et al. (2012). Concept of Operations (ConOps) for Smart Roadside Initiative. Report No.: Not Provided. United States Department of Transportation, Federal Highway Administration.

The following figures are from Belella et al.'s report and provide overviews of the information requirements, outcomes, and data sources necessary for SRI to be successfully integrated among various industry members (e.g., drivers, carriers, enforcement personnel).

Table 2-2. CMV Enforcement Officer User Information Needs

Users	Accomplishments Sought	Decisions Needed	Information Requirements	Data Sources: Federal	State	Carrier	Vehicle	Other*
Uniformed CMV Enforcement Officer	• Selectivity for inspection • Screening for secondary inspection • Secondary inspection • Verification of completed actions • Communicate results • Enforcement Action	• By-pass or pull in • Release or secondary • Level of inspection • Type of remedial action • Denial of access • Enforcement action required	• Vehicle identity • Carrier Identity • Driver identity • Credential Status – carrier, driver, vehicle • Safety history – carrier, driver, vehicle • Policy and operations guidance • Vehicle weight • Vehicle dimensions • HAZMAT cargo data	• ISS • L&I • UCR • CDLIS • NLETS • NCIC • MCMIS • SAFER • HAZMAT/ Restricted Cargo Rules/ Regs • Safer past inspection data base	• CVIEW • IRP • IFTA • DMV • PUC • Law Enf/ Criminal Info Sys • OS/OW permit • In-Road/ Roadside sensors • Dispatch • CMV info support system	• DOT# • CDL# • Manifest (cargo specific) • Periodic insp. data	• VIN • Sensors • EOBR • License Plate #	• 3rd party screening system • CDL# (Driver) • Isotope reader

Source: Belella, P., et al. (2012). Concept of Operations (ConOps) for Smart Roadside Initiative. Report No.: Not Provided (page 37). United States Department of Transportation, Federal Highway Administration.

*Other designation indicates that a host for the identified data source is either a known third party, or has not been identified.

Table 2-3. Motor Carrier User Information Needs

Users	Accomplishments Sought	Decisions Needed	Information Requirements	Data Sources: Federal	Data Sources: State	Data Sources: Carrier	Data Sources: Vehicle	Data Sources: Other*
Motor Carrier	• Minimization of travel delay • Avoidance of crashes • On-time delivery • Compliance with safety regulations	• Route optimization • Route selection • Rest stop location • Vehicle safety • Departure time • Dispatch/ Re-dispatch	• HOS status • Vehicle condition • Travel time • Parking availability • Road conditions • Environmental conditions • CDL endorsements • Credential and permit status • Roadside enforcement results • Driver reports • Change in driver status	• HAZMAT/ Restricted Cargo Rules/Regs • Query Central MCMIS	• Roadside sensors • TMCs • OS/OW Permit • Cargo Specific permits • DMV • PUC • Parking System	• Dispatch • OS/OW Permit • Cargo specific permits • Equip. pool • Driver pool • Delivery req'ts.	• Sensors • EOBR • Placards • License Plate #	• Parking System • Routing System • Nav. System • Driver

Source: Belella, P., et al. (2012). Concept of Operations (ConOps) for Smart Roadside Initiative. Report No.: Not Provided (page 39). United States Department of Transportation, Federal Highway Administration.

*Other designation indicates that a host for the identified data source is either a known third party, or has not been identified.

Table 2-4. CMV Enforcement Superior User Information Needs

Users	Accomplishments Sought	Decisions Needed	Information Requirements	Data Sources: Federal	Data Sources: State	Data Sources: Carrier	Data Sources: Vehicle	Data Sources: Other*
CMV Enforcement Supervisor	• Quality Control • Meeting performance requirements • Communication of results • Timeliness of reporting • Safety investigations and enforcement actions	• Manage & Allocate resources • Application of policy	• Trooper inspections • Monthly trooper performance data • Types and locations of violations • Types and locations of accidents • Policy guidance/updates • Trooper ID numbers • Reporting timeliness	• MCMIS • SAFER • A&I • SAFETYNET	• Law Enf./Criminal Info Sys • SAFETYNET • Crash reporting system • CMV info support system • Dispatch	• N/A	• N/A	• 3rd party screening system • Other States

Source: Belella, P., et al. (2012). Concept of Operations (ConOps) for Smart Roadside Initiative. Report No.: Not Provided (page 40). United States Department of Transportation, Federal Highway Administration.

*Other designation indicates that a host for the identified data source is either a known third party, or has not been identified.

Table 2-5. MCSAP Lead Agency Manager User Information Needs

Users	Accomplishments Sought	Decisions Needed	Information Requirements	Data Sources: Federal	Data Sources: State	Data Sources: Carrier	Data Sources: Vehicle	Data Sources: Other*
MCSAP Lead Agency Manager	• Quality Control • Meeting performance requirements • Communication of results • Timeliness of reporting • Safety investigations and enforcement actions	• Manage & Allocate resources • Application of policy	• Monthly trooper performance data • Types and locations of accidents • Policy guidance/updates • Reporting timeliness • Program reviews	• MCMIS • SAFER • A&I • SAFETYNET • DataQ • Query Central	• Law Enf./Criminal Info Sys • SAFETYNET • Crash reporting system • CMV info support system	• N/A	• N/A	• 3rd party screening system • Other States

Source: Belella, P., et al. (2012). Concept of Operations (ConOps) for Smart Roadside Initiative. Report No.: Not Provided (page 41). United States Department of Transportation, Federal Highway Administration.

*Other designation indicates that a host for the identified data source is either a known third party, or has not been identified

Table 2-6. FMCSA Personnel User Information Needs

Users	Accomplishments Sought	Decisions Needed	Information Requirements	Data Sources: Federal	Data Sources: State	Data Sources: Carrier	Data Sources: Vehicle	Data Sources: Other*
FMCSA Personnel	• Meeting performance requirements • Communication of results • Program funding & implementation • Safety investigations and enforcement actions	• Definition and application of policies • Establishment of priorities	• State performance data • State crash data • Policies • Available funding • Program reviews	• MCMIS • SAFER • A&I • SAFETYNET • L&I • UCR • DataQ	• N/A	• N/A	• N/A	• N/A

Source: Belella, P., et al. (2012). Concept of Operations (ConOps) for Smart Roadside Initiative. Report No.: Not Provided (page 41). United States Department of Transportation, Federal Highway Administration.

*Other designation indicates that a host for the identified data source is either a known third party, or has not been identified.

Table 2-7. FHWA Personnel User Information Needs

Users	Accomplishments Sought	Decisions Needed	Information Requirements	Data Sources: Federal	Data Sources: State	Data Sources: Carrier	Data Sources: Vehicle	Data Sources: Other*
FHWA Size & Weight Personnel	• Meeting performance requirements • Communication of result • Program funding & implementation • Compliance with Federal requirements	• Definition and application of policies • Establishment of priorities • Allocation of resources	• State performance data • Policies • Available funding • Program reviews	• SAFETY NET	• DOT permitting systems • State annual size and weight annual certification • WIM • Sensors	• N/A	• N/A	• N/A

Source: Belella, P., et al. (2012). Concept of Operations (ConOps) for Smart Roadside Initiative. Report No.: Not Provided (page 42). United States Department of Transportation, Federal Highway Administration.

*Other designation indicates that a host for the identified data source is either a known third party, or has not been identified.

Technologies Addressed: Backroom systems, vehicle-based systems, asset management, technology-based programs.

Bell, K.E., and Figliozzi, M.A. (2013). The Application of Smart Phone, Weight-Mile Truck Data to Support Freight-Modeling, Performance Measures and Planning. Report No.: OTREC-RR-13-10, Oregon Transportation Research and Education Consortium (OTREC).

Available On-line: http://otrec.us/project/504/

The Oregon Department of Transportation (ODOT) previously used global positioning system (GPS) devices to collect commercial weight-mile tax (WMT) data. To increase the efficiency and accuracy of WMT data collection, ODOT developed a WMT smartphone application – Truck Road Use Electronics (TRUE) that could be compatible with various smartphone devices. The TRUE application provides more accurate GPS coordinate readings, as well as truck weight, truck type, and commodities when integrated with weigh-in-motion data.

Technologies Addressed: Vehicle-based systems.

Black, C., Cassady, J., Le, S., Veile, A., and Schaefer, R. (2013). System Design Document (SDD) for Smart Roadside Initiative – Draft. Report No.: Not Provided. United States Department of Transportation, Federal Highway Administration.

This report documents the methods of information exchange between the driver, vehicle, enforcement personnel, and SRI technology applications. The SRI system prototype will facilitate communications through vehicle systems, roadside systems, back-office systems (utilized by enforcement agencies, motor carriers and service providers), and communication networks (e.g., local and wide area networks). The researchers presented a list of user needs/requirements for SRI technology applications and communications to be successful.

Among the key points are:

- The system must be able to identify CMV power units uniquely.
- The system must support the exchange of data between the CMV and the roadside without requiring the vehicle to stop.
- The system able must provide the ability to pass data collected from CMV to external systems.
- The system must provide the ability to receive data from external systems.
- The system must provide the ability to efficiently and effectively exchange data between external systems and local users at the roadside or in the CMV.
- The system must provide protection against unauthorized access to and use of data.
- The system must allow a vehicle operator to interact with it in a safe manner during vehicle operation.
- The system must be consistent with the ITS National Architecture and associated standards.

- The system must facilitate the integration of data from multiple sources into one or more cohesive, reusable datasets.
- The system must include information capture and processing functionality that meets specific CMV operation needs (e.g., truck parking and enforcement screening applications).
- The system must provide applications data in sufficient time to support decision-making at the roadside.
- The system must be able to identify, uniquely and reliably, which CMV driver is actually operating a CMV.
- The system must be able to support the identification of trailing equipment pulled by uniquely identifiable CMV power units.
- The system must operate in a V2X cooperative systems environment.

Technologies Addressed: Backroom systems, routing and dispatch, vehicle-based systems, technology-based programs.

Cherry, C., Bordley, L., Kelfer, J., Bryant, C., Ji, S., and Alexander, D. (2011). Wireless Roadside Inspection Phase II Evaluation Final Report. Report No.: NTRCI-50-2011-021, United States Department of Transportation, Research and Innovative Technology Administration.

Available On-line: http://www.ntrci.org/Uploads/Files/ResearchReports/U11-Wireless%20Roadside %20Inspection%20Evaluation%20Report.pdf

Researchers conducted a pilot study on the feasibility of three different communication systems obtaining information from on-board vehicle technology (e.g., electronic on-board recorders) and transmitting this information for wireless roadside inspections (WRI). The communication systems evaluated included 5.9 GHz dedicated short-range communications (DSRC), commercial mobile radio services (CMRS), and universal identification. Despite very limited data for the DSRC pilot test, results suggest that this would a feasible platform for data information exchange, a more robust data sample would be necessary for any formal conclusions. The results of the CMRS pilot suggest this would also be a feasible platform for WRI, however data accuracy and latency issues for automated enforcement would need to be corrected prior to full implementation. The results of the universal identification pilot suggest this is a feasible platform, however data latency and accuracy, as well as system automation are issues with this method.

Technologies Addressed: Vehicle-based systems, backroom systems.

Clough Harbour & Associates, LLP. (2012). Commercial Vehicle Information Exchange Window (CVIEW) Roadside Enforcement/Compliance Project: Comprehensive and Detailed Final Project Report. Report No.: C-01-66C, New York State Department of Transportation.

Available On-line: http://ntl.bts.gov/lib/46000/46000/46028/C-01-66c_-_Task_19_Final_Report_-_FINAL_-_9-4-12.pdf

This comprehensive report details the development of a CVISN electronic screening (e-screening) inspection site in Schodack, New York. The Schodack inspection site is fully operational with the following e-screening tools: permanent weigh-in-motion technologies, automatic vehicle identification sensors, and license plate recognition camera system. In addition, a local wireless network configuration is included in the e-screening system supporting on-site communications between equipment and providing enforcement personnel with 24-hour remote access to the system. Furthermore, the Schodack site is capable of collecting and monitoring bidirectional data and providing a data feed to the regional transportation management center. The results and operational benefits associated with the deployed of ITS at the Schodack site are documented in the next study.

Technologies Addressed: Backroom systems, vehicle-based systems, asset management.

Intelligent Imaging Systems, Inc. (2013). Report No.: C-10-19, Schodack Smart Roadside Inspection System. New York State Department of Transportation.

Available On-line: http://ntl.bts.gov/lib/47000/47100/47101/C-10-19_Schodack_Smart_Roadside_Inspection_System_Enhancement_Final_Report.pdf

In an effort to improve the detection of noncompliant commercial drivers and vehicles, researchers updated the e-screening system at the Schodack inspection site in New York. The inspection site already was equipped with 5.9 GHz dedicated short-range communications (DSRC) to transmit automatic vehicle identification (AVI) information, automated license plate readers (ALPR), automated U.S. Department of Transportation (AUT) readers, and an overview camera. The following additional e-screening systems were tested across 240 vehicles: trailer/rear ALPR, vehicle over height detection sensors, and hazardous materials (HazMat) placard readers. The researchers validated the e-screening systems by extracting vehicle data recorded by the rear ALPR and the HazMat placard readers for the last 10 minutes of every hour during a 24-hour period. The researchers analyzed both the rear ALPR and HazMat placard data for “read accuracy” (correct, incorrect, did not read). The researchers suggest that the rear ALPR and HazMat placard reader further increase the automation of roadside inspections, resulting in benefits such as reduced congestion, improved out-of-service rates, increased inspector productivity and efficiency, increased fuel savings, and reduced greenhouse emissions.

Technologies Addressed: Backroom systems, vehicle-based systems.

LeBlanc, D., and Belzowski, B. (2012). Interoperability Issues for Commercial Vehicle Safety Applications. Report No.: DOT HS 811 674, United States Department of Transportation, National Highway Traffic Safety Administration.

Available On-line:
http://www.nhtsa.gov/DOT/NHTSA/NVS/Crash%20Avoidance/Technical%20Publications/2012/811674.pdf

To elucidate potential issues relating to the implementation of 5.9 GHz dedicated short-range communications (DSRC) in commercial trucks, researchers interviewed 16 individuals who were subject matters experts (SME) on the trucking industry and safety systems, vehicle-to-vehicle technologies, and DSRC. Among the issues identified were interrupted or false messages, equipping trailers with DSRC devices, accuracy of position estimates between two vehicles, broadcast security, certification of aftermarket devices, effects of large vehicles on DSRC, lack of technical experts, effect of CB radios on DSRC and lack of industry enthusiasm and engagement for DSRC. The figures on the following pages present the proposed recommendations for the aforementioned issues.

Table 2-8. Summary of Prioritized Issues and Recommendations

Issue Category	Issue Priority Level	Issue	Potential Impact	Recomm. Priority Level	Recommendation	
SAE J2735 basic safety message	2	Articulated vehicles are not yet incorporated into the SAE J2735 basic safety message standard.	The occupied space and path for articulated vehicles cannot be accurately broadcast when turning.	2	Revise the SAE J2735 basic safety message to accommodate articulated and heavy vehicles.	
	3	The SAE J2735 scaling for vehicle weight does not allow for broadcasting the actual weight of medium and heavy commercial vehicles.	With an incorrect weight estimate, other vehicles may make inappropriate choices.			
Trailer parameters	1	Trailer size parameters are not known by most power units, e.g., tractors in a semi-trailer configuration. While trailers are not unique to commercial vehicles, this is a critical issue for commercial vehicles.	Vehicles pulling trailers do not currently know length or weight. Safety application performance can be affected on both the host and remote vehicles.	1 (left), 1 (right)	Determine requirements for trailer parameter signals in the basic safety message. (Is weight really needed? How accurate must trailer length be?)	Investigate ways for a power unit to know trailer parameters, e.g., trailer electronics, power unit-based estimates, use of remote vehicle data, etc.
	3	To broadcast trailer size parameters, these are choices about whether to equip trailers with hardware or to estimate trailer parameters using a tractor-only solution. Determining whether there is a best solution would likely enable faster resolution of the issue.	Ability of remote vehicles to know trailer length. Equipping trailers will meet resistance from the carrier industry, and estimating trailer parameters on the tractor would be difficult to do reliably. Thus an issue is to find a feasible way to obtain and broadcast the trailer length..			

Issue Category	Issue Priority Level	Issue	Potential Impact	Recomm. Priority Level	Recommendation
DSRC Blockage	1	Blockage of DSRC may occur when the line of sight between two DSRC antennas is obstructed. Large vehicles can affect their own communications as well as that of neighboring vehicle pairs.	Safety application performance may degrade due to the latency of lost messages.	1	Estimate the impact on safety applications of the latencies that result from common blockage scenarios due to large vehicles.
DSRC multipath	2	DSRC multipath effects occur due to the large surfaces of commercial vehicles reflecting the DSRC.	Safety application performance may degrade due to latency or nulls and/or may lead to more complicated receivers.	1	Facilitate tests to understand blockage conditions, multipath issues, ground null locations, and their influence on packet receipt. Involve radio suppliers with diverse antenna/receiver setups.
DSRC ground nulls	2	Antenna height changes the location of ground reflection nulls.	Dead spot at a fixed range that depends on two antenna heights. Is this at a "critical" range?	1	Determine the location and the potential negative impact of ground nulls for high-mounted DSRC antennas.
DSRC dual-antenna	3	Secondary issue: If two or more antennas are on the same vehicle. There may be implementation issues.	Two antennas broadcasting the same information simultaneously may create self-blocking nulls and unnecessarily flood the area with redundant DSRC waveforms.	n/a	No recommendations are provided for secondary contingency issues.
Scalability	3	Will large vehicles complicate the issues of scalability, i.e., operation in an active DSRC area?	Obstruction & multipath could worsen the problem of communication in DSRC-congested areas.	2	Include large vehicles as part of scalability testing.

Issue Category	Issue Priority Level	Issue	Potential Impact	Recomm. Priority Level	Recommendation
Relative positioning	2	Errors in relative position estimates between two vehicles can occur due to differences in GPS satellite sets being used by a tall vehicle and a smaller vehicle traveling adjacent to the tall vehicle.	Safety application performance degradation	2	Test to measure the absolute and relative positioning errors for a small vehicle that is adjacent to a tall vehicle. (Is this distinct from the urban canyon problem?)
Aftermarket	3	Do enough vehicles have the SAE J1939 bus populated with basic safety message variables?	Would slow penetration of aftermarket devices	>3	Industry might consider standardizing a data bus gateway or other means to provide aftermarket systems access to the minimum BSM set.
Aftermarket	2	The public standard SAE J1939 makes it easier for nefarious broadcasts onto the bus. The OBE would pass along this false information.	Could compromise system safety by allowing hackers to create undesirable behavior on the road.	1	Determine whether rogue message broadcasts onto J1939 pose a risk to other vehicles. (Unconfirmed issue.)
Certification	1	Need a functional test to describe what communication performance should be.	Will allow radio vendors to focus development. May help define the remote vehicles for use in application-level track tests.	2	Consider developing a functional specification and test procedure set that defines expectations for performance around commercial vehicles. If viable for suppliers to replicate, it could accelerate industry readiness.
Certification	2	Since DSRC performance may depend on the physical configuration of vehicles, aftermarket device certification begs the question of how (and who) certifies these devices.	It is possible that OEMs may not want responsibility for certifying aftermarkets, and aftermarket manufacturers may not have the resources to certify with all makes and models.	2	Consider the certification process for aftermarket safety devices, using insights from testing (which may answer how many vehicle configurations need to be tested to have confidence in proper DSRC performance).

Issue Category	Issue Priority Level	Issue	Potential Impact	Recomm. Priority Level	Recommendation
Certification	3	Secondary issue: If transmission power is increased around large vehicles, then this attribute needs to be tested.	Certification and application-level testing may be necessary to explore modulating of transmission power.	n/a	No recommendations are provided for secondary contingency issues.
Application testing	2	Large vehicle effects on DSRC communication are not well documented. Will this uncertainty confound testing of safety application performance?	Real-world performance may be worse than the Application testing performance on a track.	3	Consider establishing standard large-vehicle antenna configurations for remote vehicles used in application-level testing.
Industry involvement	2	Not enough technical experts from the commercial vehicle industry are on standards committees.	Will miss opportunity for efficiency is research, or improved performance, if industry contributors are absent.	2	Consider ways in which to increase the number of commercials vehicle experts in the standards committees.
Industry involvement	1	Enthusiasm, understanding, and engagement of commercial vehicle industry in connected vehicles is not yet high.	Commercial vehicle issues may remain hidden, adding risk to deployment benefits and timing.	2	Continue outreach, particularly with fleets, possibly focusing on return-on-investment aspects of DSRC equipment.
Volunteered issues	2	Overpowered CB radios are common in class 8 freight vehicles. Can this affect DSRC communication?	Unknown potential for affecting the DSRC reception onboard these vehicles	2	Test DSRC performance with nearby overpowered CB radio antennas.

Source: LeBlanc, D., and Belzowski, B. (2012). Interoperability Issues for Commercial Vehicle Safety Applications. Report No.: DOT HS 811 674 (pages 27-30), United States Department of Transportation, National Highway Traffic Safety Administration.

Technologies Addressed: Vehicle-based systems.

Lee, J., and Cho, H. (2013). Commercial Vehicle Preclearance Program: Motor Carriers' Perceived Impacts and Attitudes Towards Potential Implementation. Proceedings of the Eastern Asia Society for Transportation Studies, Vol. 9.

Available On-line: http://easts.info/on-line/proceedings/vol9/PDF/P96.pdf

Researchers utilized a phone survey methodology to gather motor carrier perceptions on the utilization of preclearance programs in Queensland, Australia. Of the 122 carriers contacted for this study only 40 participated. Of these 40 carriers, 25 percent were small (1 to 10 employees), 48 percent were medium (11 to 50 employees) and 27 percent were large (50 or more employees).

Among the survey findings, 55 percent of carriers noted excessive delays at weigh stations, noting delays ranging between 10 minutes and 1 hour. Carrier awareness and knowledge of preclearance programs is lacking, with 75 percent of respondents noting a need for more information about the program. At the time of the phone survey only 35 percent of respondents had prior knowledge of preclearance programs. Willingness to pay for preclearance programs differed among participants such that 7.5 percent were willing to pay for the service, 15 percent noted willingness to pay would be dependent upon cost and government influence, finally all of the small carriers indicated they would not pay to use the preclearance system. The researchers conclude that successful implementation of preclearance systems in Australia are dependent upon cost-effective benefits to carriers, a balance between government and carrier influence, and the appropriate marketing and communication about the systems to trucking industry stakeholders.

The researchers noted three primary areas and strategies to enhance trucking industry stakeholder support for preclearance systems in Australia:

- Awareness:
  - Advertise benefits to carriers;
  - Expand communication channels;
  - Sponsor CVO-related events.
- Financial Incentives:
  - Reduced registration fees;
  - Reduced monthly/annual fees;
  - Free trial periods.
- Nonfinancial Incentives:
  - Ensure confidentiality of data and prohibit data exchange between States or Federal officials;
  - Incorporate positive updates of carrier safety records;
  - Provide reliable and updated technologies;
  - Provide uniform and interoperable technologies;
  - Simplify enrollment/administrative processes.

Misener, J., Andrews, S., Cannistra, P, and Garcia, D. (2012). Communications Data Delivery System Analysis Public Workshop Read-Ahead Document. Report No.: FHWA-JPO-12-039, United States Department of Transportation, Research and Innovative Technology Administration.

Available On-line: http://ntl.bts.gov/lib/45000/45500/45597/FHWA-JPO-12-039_CDDS_Read_Ahead_40912_v3_2_Final.pdf.

This report documents the attributes and obstacles of cellular systems, dedicated short-range communications (DSRC), WiFi, and satellite digital audio radio service systems (SDARS) for supporting vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and infrastructure-to-vehicle (I2V) communications. It is based on work previously conducted and was designed to be a “read ahead” resource for participants in a Public Workshop. The report does not specify its methodology and does not specifically address commercial vehicles.

Conclusions of the technology capabilities include:

- Cellular systems and WiFi do not support basic safety messages because a vehicle’s on-board equipment cannot identify surrounding vehicles’ Internet Protocol addresses.
- WiFi systems encounter I2V and V2V communication issues due to the relationship between vehicle speed and message latency, limited amounts of data being captured, and the increased need for backend management of wireless networks.

- Cellular systems encounter I2V and V2V communication issues due to the range of data captured being too large, leading to irrelevant message transmittals.
- DSRC was designed to facilitate V2I, I2V, and V2V communications and can support basic safety message transmittal between two entities. However an implementation concern is that to support data exchange between two vehicles, both vehicles must be traveling at speeds ranging between 5 to 11 miles per hour.
- SDARS, though not designed for two-way communications, can be used to support other systems' communications.
  - A vehicle can receive a basic safety message via SDARS, but a vehicle cannot send a message via SDARS.

Technologies Addressed: Vehicle-based systems.

3.0 Safety Technology

Safety is a prominent concern shared among trucking industry stakeholders. Several commercial motor vehicle safety technology systems exist, each with unique design specifications intended to prevent safety incidents. The documents within this section provide background on the available safety technologies, deployment of the systems across fleets and technology cost/benefit analyses.

Bowman, D., Baker, S., Stone, S., Doerzaph, Z., and Hanowski, R. (2013). Development of Performance Requirements for Commercial Vehicle Safety Applications. Report No.: DOT HS 811 772, United States Department of Transportation, National Highway Traffic Safety Administration.

Available On-line:
http://www.nhtsa.gov/DOT/NHTSA/NVS/Crash%20Avoidance/Technical%20Publications/2013/811772.pdf

Researchers examined carrier perceptions on the use of commercial motor vehicle (CMV) safety systems and the adoption of vehicle-to-vehicle (V2V) communication technologies in their fleets. Carrier deployment of safety systems in their fleets was dependent upon a variety of factors, including return-on-investment (ROI), installation, maintenance, system reliability, driver acceptance, driver overreliance, and data accessibility. Carrier consideration of V2V technologies was dependent upon ROI, advanced capabilities provided by dedicated short-range communications (DSRC), integration, system reliability, data management, driver behavior management, and driver acceptance. Supplier and original equipment manufacturers (OEM) were surveyed on their perceptions of DSRC and V2V integration. Among the factors that would influence these stakeholders to integrate the systems on the back end were customer demand, regulatory policies, standardization, safety benefits, ROI, vehicle to infrastructure communication benefits and DSRC radio integration.

Technologies Addressed: Vehicle-based systems.

Corsi, T.M., Cantor, D.E., Grimm, C.M., Sienicki, D.M. (2007). Factors Underlying the Adoption of New Safety Technologies by U.S. Commercial Carriers. Report No.: FMCSA-RRA-07-007, United States Department of Transportation, Federal Motor Carrier Safety Administration.

This 2005 study surveyed 415 of the largest for-hire carriers within the United States on their adoption of vehicle and driver safety technologies. General implications suggest that carriers have adopted several safety technologies, however not fleetwide. For example, 94 percent of carriers had at least some of their drivers equipped with cellular phones, while 53 percent of carriers had deployed navigation systems in some of their vehicles, and 24 percent of carriers had partially adopted route and dispatching systems.

Technologies Addressed: Routing and dispatch, vehicle-based systems, asset management.

Houser, A., Murray, D., Shackelford, S., Kreeb, R., and Dunn, T. (2009). Analysis of Benefits and Costs of Lane Departure Warning Systems for the Trucking Industry. Report No.: FMCSA-RRT-09-022, United States Department of Transportation, Federal Motor Carrier Safety Administration.

Available On-line: http://ntl.bts.gov/lib/51000/51200/51250/09-022-RP-Lane-Departure.pdf

This report provides an overview and cost/benefit analysis of commercial motor vehicle lane departure warning systems (LDWS). General findings indicate that carriers that invest in this technology will yield larger returns-on-investment than carriers that do not. On average, carriers can expect a return of $1.37 to $6.55 for every dollar spent on investment.

Technologies Addressed: Vehicle-based systems.

Murray, D., Shackelford, S., and Houser, A. (2009). Analysis of Benefits and Costs of Forward Collision Warning Systems for the Trucking Industry. Report No.: FMCSA-RRT-09-021, United States Department of Transportation, Federal Motor Carrier Safety Administration.

Available On-line: http://ntl.bts.gov/lib/51000/51200/51249/09-021-RP-Forward-Collision.pdf

This report provides an overview and cost/benefit analysis of commercial motor vehicle forward collision warning systems (FCWS). General findings indicate that carriers that invest in FCWS will experience greater returns-on-investment than carriers that do not. On average, carriers can expect a return of $1.33 to $7.22 for every dollar spent on investment.

Technologies Addressed: Vehicle-based systems.

Murray, D., Shackelford, S., and Houser, A. (2009). Analysis of Benefits and Costs of Roll Stability Control Systems for the Trucking Industry. Report No.: FMCSA-RRT-09-020, United States Department of Transportation, Federal Motor Carrier Safety Administration.

Available On-line: http://ntl.bts.gov/lib/51000/51200/51248/09-020-RP-Roll-Stability.pdf

This study provides an overview and cost/benefit analysis of commercial motor vehicle roll stability control systems (RSCS). Overall findings indicate that carriers that invest in RSCS will have greater, positive returns-on-investment than carriers that do not invest in these systems. On average, carriers can expect a return of $1.66 to $9.36 for every dollar spent on investment.

Technologies Addressed: Vehicle-based systems.

Pickett, R.L., Murray, D., and Flanigan, C. (2010). Onboard Safety System (OSS) Deployment Research: A Synthesis of Research on the Costs, Benefits and User Requirements Associated with Motor Carrier Safety Technologies. Transportation Research Board Annual Meeting, 2010. *(Peer Reviewed)*

Available On-line: http://www.atri-online.org/research/results/ATRITRBOSS.pdf

The research identified factors related to small carrier adoption of onboard safety systems (OSS).

The top five motivators for OSS adoption by small carriers were:

- Safety statistics;
- Purchase price;
- Overall cost;
- Insurance cost/savings;
- Product features.

The top five motivators for OSS adoption by small carriers were:

- Tax credits/breaks;
- Good warranty;
- Carrier/peer feedback;
- Reduced insurance;
- Return-on-investment.

Technologies Addressed: Vehicle-based systems.

4.0 Technology Utilization

The deployment of commercial motor vehicle technology systems varies across variables such as carrier needs, fleet demographics, industry sector, deployment feasibility and expected return-on-investment. The documents below provide industry-wide technology utilization trends and technology-specific cost/benefit analyses.

2005 Motor Carrier Technology Survey: A Survey of Information and Communications Technology Usage and Key Benchmarking Data for the Trucking Industry. (2005). Alexandria, VA: American Trucking Associations.

This research examines a 2005 Technology and Maintenance Council survey of carrier technology deployment (including wireless communications and onboard computing). Among the wireless communication technology findings, a majority of the respondents (47.6 percent) had purchased mobile communications prior to 2000 and expenditures for the technologies ranged from less than $100 to greater than $3,000 per driver or power unit.

Of the 68 carriers who noted the capabilities of their communication technologies, 42.6 percent of carriers indicated they deployed two-way voice with cellular phones, 36.7 percent deployed two-way satellite-based text messages with onboard or handheld computers, 23.5 percent deployed two-way voice with radios and 23.5 percent deployed one-way text message with pagers.

Of the 68 carriers to indicate future wireless technology needs, the plurality noted out-of-route monitoring systems (35.3 percent), electronic DOT logs (33.8 percent), and vehicle and driver performance data (33.8 percent; Table 4-1).

Table 4-1. Future Wireless Technology Needs

Technology	Percentage
Out-of-route monitoring	35.30%
Electronic DOT logs	33.80%
Vehicle and driver performance	33.80%
Safety and security	32.40%
Electronic Entry of Pickup and Delivery Information	30.90%
Trailer Tracking	29.40%
Onboard Navigation	29.40%
Delivery of in-cab faxes/images	25.00%
Automated Fuel Tax	23.50%
Accident Reconstruction	20.60%
Signature Capture	16.20%
Remote Disablement	8.80%
None	13.20%

Source: 2005 Motor Carrier Technology Survey: A Survey of Information and Communications Technology Usage and Key Benchmarking Data for the Trucking Industry (page 21). Alexandria, Virginia: American Trucking Associations.

Of the 47 carriers to respond to radio frequency identification tag (RFID) deployment, only 12.7 percent currently use RFID for asset or freight tracking, with 70.2 percent indicating they would not deploy the technology in the next five years.

Of the 81 carriers to respond to electronic log use, 87.6 percent did not use electronic logs. Of the 31 carriers to respond to future deployment of electronic logs, 22.5 percent indicated they would, 35.5 percent indicated they would not and 41.9 percent indicate they might.

Technologies Addressed: Backroom systems, routing and dispatch, vehicle-based systems, asset management, technology-based programs.

Bunch, J., et al. (2011). Intelligent Transportation Systems Benefits, Costs, Deployment and Lessons Learned Desk Reference: 2011 Update. Report No.: FHWA-JPO-11-140, Washington, D.C.: Research and Innovative Technology Administration.

Available On-line:
http://www.itsknowledgeresources.its.dot.gov/its/benecost.nsf/files/bclldepl2011update/$file/ben_cost_less_depl_2011%20update.pdf

This research examined costs, benefits and user satisfaction related to motor carrier participation in electronic credentialing systems (e.g., IRP, IFTA, oversize/overweight). In a survey of 800 motor carriers, the top three factors influencing participation in electronic credentialing included the convenience of obtaining credentials, staff time savings, and reduced downtime among trucks. In a separate survey of 38 motor carriers participating in electronic credentialing, researchers calculated an annual net benefit of $360,500 per carrier due to reduced truck downtime and increased labor savings. The estimated average annual costs to maintain IRP and IFTA credential systems per State was approximately $250,000.

Technologies Addressed: Backroom systems, vehicle-based systems, asset management.

Garner, H. (2012). 2012 Truck IT Report: A Brief Analysis of eyefortransport's Recent Survey. *eyefortransport.*

Available On-line: http://events.eyefortransport.com/truckIT/pdf/TruckITReport12012.pdf

This report summarizes carrier technology trends and utilization. The top three drivers of carrier technology adoption are lowering costs, increased customer service and proven benefits. The top three technologies that carriers would like to see improvements to, but also consider having the greatest return-on-investment and the biggest planned investment include route optimization technology, mobile device applications, and driver monitoring technology. The researchers indicate that due to changing industry regulations and driver shortages, carriers have shifted their technology focus from company efficiency (e.g., transportation management software) to driver-centric approaches (e.g., route optimization).

Technologies Addressed: Backroom systems, routing and dispatch, vehicle-based systems.

Golob, T.F., and Regan, A.C. (2002). Trucking Industry Adoption of Information Technology: A Structural Multivariate Discrete Choice Model. *Transportation Research Part C: Emerging Technologies, 10,* 205-228. *(Peer Reviewed)*

Available On-line:
http://www.researchgate.net/publication/222701744_Trucking_industry_adoption_of_information_technology_a_multivariate_discrete_choice_model

This research study evaluated 1,136 California carriers on technology deployment in 1998. Of the fleets fully equipped with technological devices 52 percent utilize mobile communication devices, 16 percent use automatic vehicle location devices and 6 percent use PrePass transponders. In relation to the aforementioned technologies, for-hire carriers and large fleets are more likely to deploy these devices than private and small fleets. Furthermore, researchers statistically estimated the likelihood of carriers to adopt seven different technologies (e.g., satellite radio, automatic vehicle location, automatic vehicle identification, electronic data interchange, vehicle maintenance software, routing software and CB radio). Results from the analyses indicate that technology adoption is dependent upon carrier operational characteristics (e.g., size, for-hire, truckload, just-in-time, intermodal air, tanker) and the specific technological device.

Technologies Addressed: Backroom systems, routing and dispatch, vehicle-based systems, asset management.

Intelligent Transportation Systems Commercial Vehicle Operations (ITS CVO) Synthesis and Analysis Report. (2010). The American Transportation Research Institute. E2 Engineering.

This synthesis combined data from a multitude of sources (e.g., Federal Motor Carrier Safety Administration, State Departments of Transportation) on the deployment of several Intelligent Transportation Systems (ITS) both in the private and public sectors.

The ITS in this report are further defined by the following:

- Technology versus software;
- Use in private versus public sector;
- Relative cost to carrier (low, medium, high);
- Utilization by carrier size (small, medium, large);
- Voluntary versus mandatory deployment;
- Mainstream versus emerging;
- Federally sponsored;
- ITS operational across State boundaries;
- Relative cost to public entities (e.g., State agencies).

Table 4-2 details the specific technology systems from the synthesis, carrier deployment and the cost to the carrier.

Table 4-2. ITS Technology Deployment and Costs

Technology	Deployment	Cost
Management Systems	Mainstream	Low (Less than $500)
CB Radios	Mainstream	Low (Less than $500)
Onboard Satellite Communications	Mainstream	Medium ($501-$3,000) to High (Greater than $3,000)
Onboard Terrestrial/Cell Phone Systems	Mainstream	Medium ($501-$3,000)
Cell Phones/Smart Phones/PDAs/Push-to-talk phones	Mainstream	Low (Less than $500)
Automatic Vehicle Location	Mainstream	High (Greater than $3,000)
Tractor GPS/GLS	Mainstream	Medium ($501-$3,000)
Trailer Tracking	Mainstream	Low (Less than $500)
DSRC/Transponders	Mainstream	Low (Less than $500)
Radio Frequency Identification Tags	Mainstream	Low (Less than $500)
E-seals	Mainstream	Low (Less than $500)
Lane Departure Warning Systems	Emerging	Medium ($501-$3,000)
Vehicle Stability Systems	Emerging	Medium ($501-$3,000)
Collision Warning Systems	Emerging	Medium ($501-$3,000)
Collision Mitigation Systems	Emerging	Medium ($501-$3,000)
Tire Pressure Monitoring/Inflation Systems	Mainstream	Medium ($501-$3,000) to High (Greater than $3,000)
Electronic Onboard Recorder	Emerging	Medium ($501-$3,000)
Event Data Recorder	Mainstream	Low (Less than $500)
Preclearance Systems	Mainstream	Low (Less than $500) to High (Greater than $3,000)
Electronic Toll Collection	Mainstream	Low (Less than $500)

Source: Intelligent Transportation Systems Commercial Vehicle Operations (ITS CVO) Synthesis and Analysis Report. (2010). TIMTC Technology Spreadsheet. The American Transportation Research Institute. E2 Engineering.

Technologies Addressed: Backroom systems, routing and dispatch, vehicle-based systems, asset management, technology-based programs.

In-Vehicle Commercial Vehicle Technology Use Survey Results. (2003). Alexandria, VA: American Transportation Research Institute.

Researchers surveyed 150 carriers on the current technology deployment in their fleets, anticipated technology adoption, drivers of technology adoption and return-on-investment.

Key findings of current carrier practices indicated that:

- Several carriers had not deployed technologies;
- Cellular and satellite communication technologies are widely accepted;
- Real-time position tracking systems are commonly deployed;

- Navigation systems are deployed equally across fleet sizes;
- Few safety technologies have been deployed.

Technologies Addressed: Backroom systems, routing and dispatch, vehicle-based systems, asset management.

Knipling, R.R., and Bergoffen, G. (2011). Potential Safety Benefits of Motor Carrier Operational Efficiencies. *Commercial Truck and Bus Safety Synthesis Program, 20.* Washington, D.C.: Transportation Research Board.

Available On-line: http://www.trb.org/Publications/Blurbs/166473.aspx

This study surveyed 79 motor carrier safety managers on company safety and operational practices. Results from the survey indicated that 55 percent utilized general navigation systems, 38 percent utilized truck-specific navigation systems, 85 percent provided E-ZPass transponders/toll reimbursement to drivers, 55 percent deployed onboard computers and 74 percent utilized mobile communications.

Technologies Addressed: Routing and dispatch, vehicle-based systems.

Koslowski, T. (2006). In-Vehicle Technologies Provide Differentiation Opportunities for U.S. Commercial Vehicle Manufacturers – Summary. Report No.: G00141361 Gartner.

Available On-line: https://www.gartner.com/doc/493288/invehicle-technologies-provide-differentiation-opportunities

This technical brief summarizes interview findings across 150 United States carriers on in-vehicle technologies. The results indicate that large and medium carriers are more likely to use technologies than small carriers. Furthermore, carriers are highly interested in devices such as vehicle tracking and client, cargo, and order information technologies. Expected benefits from in-vehicle technologies included: operational effectiveness improvements, safety and security improvements, enhanced logistics management, automated services, and infotainment services.

Technologies Addressed: Backroom systems, vehicle-based systems.

Maccubbin, R.P., et al. (2008). Intelligent Transportation Systems Benefits, Costs, Deployment, and Lessons Learned: 2008 Update. Report No.: FHWA-JPO-08-032, United States Department of Transportation, Research and Innovative Technology Administration.

Available On-line: http://ntl.bts.gov/lib/30000/30400/30466/14412.pdf

This research report provides an overview of electronic screening systems deployed in commercial vehicles. Drivers in Georgia, Kentucky, Tennessee, and North Carolina participated in a year-long program testing the effectiveness of an infrared brake screening system. The infrared screening system identified 84 percent of vehicles for further inspection, compared to traditional screening systems which only identified 34 percent of vehicles. Truck drivers indicated increased time efficiency, while vehicle inspectors indicated increased accuracy as benefits of electronic screening systems.

Technologies Addressed: Backroom systems, routing and dispatch, vehicle-based systems, asset management.

Marett, K., Otondo, R.F., and Taylor, G.S. (2013). Assessing the Effects of Benefits and Institutional Influences on the Continued Use of Environmentally Munificent Bypass Systems in Long-Haul Trucking. *MIS Quarterly, 37*(4), 1301-1312. *(Peer Reviewed)*

In this study a survey was conducted on factors influencing driver use of bypass systems across 212 drivers and 24 States. Statistically significant relationships were found between intentions to use bypass systems and competitive pressures, participation among other drivers, industry pressures, accessibility to the systems, and financial savings. The findings from the study suggest that drivers do view bypass systems favorably due to cost and time savings that would be forfeited at physical weigh stations.

Technologies Addressed: Vehicle-based systems.

Nagarajan, A., Canessa, E., Nowak, M., Mitchell, W., and White, C.C. (2005). Technology in Trucking. In D. Belman and C. White, *Trucking in the Age of Information*, 47-182. Burlington, VT: Ashgate Publishing Ltd.

Available On-line:
https://faculty.fuqua.duke.edu/~willm/bio/cv/papers/Technology_in_Trucking_2005.pdf

In this study, researchers surveyed carriers between 1999 and 2000 on technology adoption, perceived success, drivers of technology adoption, impact technology had on business operations, and the primary purpose of each specific technology. The results suggest that mobile communications (60 percent) were adopted the most, followed by electronic data interchange (43 percent), imaging systems (27 percent), bar coding (21 percent), decision support systems (18 percent) and automatic vehicle/equipment identification systems (15 percent).

Technologies Addressed: Backroom systems, vehicle-based systems.

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