U.S. Department of Transportation

Federal Motor Carrier Safety Administration

The 2006 Annual Motor Carrier Efficiency Study Report to Congress

A Report Pursuant to Section 5503(d) of the
Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users
(P.L. 109-59)

MC-R/RRT March 2008

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Executive Summary

Section 5503 of the Conference Report (H. Rpt. 109-203) accompanying the Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users (SAFETEA-LU, P.L. 109-59) set aside funding to examine the application of wireless technology to improve the safety and efficiency of trucking operations in the United States (U.S.). The intent is to enter into partnership with the motor carrier and wireless technology industries to cooperatively identify and test promising applications and devices in a "real-world" environment, and to promote the adoption and use of successful solutions by a broad array of motor carriers.

The specific objectives of the Motor Carrier Efficiency Study (MCES) include the following:

1. Identify inefficiencies in freight transportation.
2. Evaluate safety and productivity improvements made possible through wireless technologies.
3. Demonstrate wireless technologies in field tests.

The Federal Motor Carrier Safety Administration (FMCSA) was assigned responsibility for administering this program, and has completed specific actions pursuant to its provisions. In February 2006, FMCSA conducted an industry outreach and information gathering session to obtain input regarding the most effective means for addressing the objectives. During the session, representatives from trucking companies, wireless technology providers, and the consulting community offered recommendations regarding program structure and research approach.

Based on this input, FMCSA developed and issued a full and open solicitation for contractor teams to conduct Phase I of the program. This phase consists of the completion of activities pursuant to objectives 1 and 2 above, and the recommendation of field tests according to objective 3. The actual field tests will be conducted under Phase II of the program. The FMCSA has awarded a performance-based contract to a consulting team led by Delcan to perform the first phase, which was initiated on September 12, 2006.

Phase I consists of a series of tasks that will accomplish objectives 1 and 2 for four program elements. These elements include the following:

1. Fuel monitoring and operations management systems.
2. Electronic manifest systems.
3. Cargo theft prevention and security.
4. Roadside safety inspection systems.

The Phase I work plan, which concluded in January 2008, includes the following tasks:

- Gathering and analyzing existing literature regarding freight system inefficiencies, and the application of wireless technologies.

- Adapting and calibrating an analysis tool that will facilitate the comparative assessment of candidate technologies for benefits and costs.
- Stakeholder outreach sessions to capture information regarding baseline freight performance, user needs, performance measures, and feedback regarding technology options.
- A detailed analysis of current inefficiencies and opportunities for improvement in processes, methods, and tools.
- Identification and preliminary benefit cost analysis of specific wireless technology solution sets.
- Development of conclusions regarding the findings from Phase I, and for the conduct of Phase II.

Phase II of the program will consist of one or more pilot demonstrations wherein promising technologies will be deployed under realistic operating conditions. During this period, industry and government partners will assess the degree to which the solutions improve safety and operations consistent with the program objectives. The goal for these pilots is to provide sufficient evidence to support investment decisions for the government, and for the technology provider and user community.

Introduction

Genesis of the Program – SAFETEA-LU Legislation

A flexible, responsive, efficient, and cost effective trucking network is essential to the health of any freight system. With very few exceptions, the global supply chains that underpin the U.S. economy are heavily reliant upon a vital trucking industry to make the system perform. With overall freight volumes projected to continue to increase dramatically, the industry can expect pressures to enhance performance accordingly.

To some degree, advancements in operating methods, such as more tightly integrated supply chain management practices, and the injection of innovative technologies, have helped to improve efficiency. Electronic roadside screening and weigh station bypass initiatives provide cost savings for carriers, as do wireless radio-frequency identification devices (RFID) at international border crossings, satellite-based fleet management and communications systems, and more simple cellular telephone-based applications.

For a portion of the trucking industry—namely the larger common carriers and private fleets—these technologies have helped to streamline operations, leading to higher profitability. Although per-event gains remain modest, the volume of freight these carriers transport allows them to enjoy the benefits of economies of scale. As a result, for these carriers, and their supply chain partners, advanced wireless technologies provide real value.

In addition to offering improvements in efficiency, such technology investments often serve to enhance operational safety and security, both directly and indirectly. Electronic screening applications that incorporate biometric identification capabilities help to ensure that only authorized personnel are granted access to secure facilities and sensitive materials. The electronic screening applications also serve as key components of border crossing applications.

The indirect benefits, particularly to the public, are equally significant. Wireless technologies already play an important role in motor carrier safety enforcement activities, size and weight enforcement activities, as well as for State infrastructure and transportation planning purposes. The result is safer trucks, safer roadways, increased freight mobility, and improvements in the environment, economy, and transportation efficiency. Further, carriers that are making a healthy profit are less inclined to cut corners on safety or security measures. The result is safer trucks and safer roadways.

There are, however, a number of opportunities to improve dramatically the health of the industry as a whole. For instance, a significant fraction of the domestic trucking "fleet" rests in the hands of owner-operators. These small business owners, many of whom are tasked with managing all aspects of their businesses *and* driving their trucks, historically have not had the resources to invest in sophisticated technologies. As a result, they struggle to remain competitive.

The challenge is to identify and exploit these opportunities to ensure that all segments of the carrier industry can benefit. Larger carriers would then be able to continue to reduce operating costs and smaller carriers—who perform critically important services—could share in the

promise of these advancements. This can only happen if they can afford to invest in technologies that allow them to mitigate the negative effects of the challenges they face, and to extract an extra measure of profitability from their operations.

Congress sought to address these needs by incorporating language into SAFETEA-LU that both promotes the application of innovative wireless technologies to trucking operations, and provides seed money to fund pilot demonstrations. Section 5503 of SAFETEA-LU stipulates that funding totaling $1,250,000 per year from Fiscal Year 2006 through Fiscal Year 2009 be utilized to conduct a study to identify these opportunities, and to conduct field tests in cooperation with the motor carrier industry and the wireless technology industry.

Assignment of Responsibility to FMCSA

The primary mission of FMCSA is to reduce crashes, injuries, and fatalities involving large trucks and buses.[1] In carrying out its safety mandate to reduce crashes, injuries, and fatalities involving large trucks and buses, FMCSA:

- Develops and enforces data-driven regulations that balance motor carrier (truck and bus companies) safety with industry efficiency.
- Harnesses safety information systems to focus on higher risk carriers in enforcing the safety regulations.
- Targets educational messages to carriers, commercial drivers, and the public.
- Partners with stakeholders including Federal, State, and local enforcement agencies, the motor carrier industry, safety groups, and organized labor on efforts to reduce bus and truck-related crashes.[2]

In pursuit of its mission, FMCSA regularly engages in cooperative technology research and development with the motor carrier community. Though care is exercised to maintain the integrity of the Agency's regulatory responsibilities, the administration routinely collaborates with industry leaders and technology vendors to define and examine innovative solutions to challenges facing the industry.

Since its formation by the Motor Carrier Safety Act of 1999, FMCSA has sought to reduce the number and severity of commercial motor vehicle (CMV) crashes and enhance the efficiency of CMV operations by:

- Conducting systematic studies directed toward more thorough scientific discovery, knowledge, or understanding.
- Adopting, testing, and deploying innovative driver, carrier, vehicle, and roadside best practices and technologies.

By expanding the knowledge and portfolio of deployable technology, the research and technology program helps FMCSA reduce crashes, injuries, and fatalities and deliver a program

[1] FMCSA Web site: http://www.fmcsa.dot.gov/about/what-we-do/mission/mission.htm
[2] FMCSA Web site: http://www.fmcsa.dot.gov/about/what-we-do/strategy/strategy.htm

that contributes to a safe and secure commercial transportation system.[3] In pursuit of these goals, the Office of Research and Analysis developed a set of strategic objectives that it relies upon to guide its work. These objectives include the following:

- **Produce Safer Drivers:** Research techniques that help to ensure commercial drivers are physically qualified, trained to perform safely, and mentally alert.
- **Improve Safety of CMVs:** Improve truck and motorcoach performance through vehicle-based safety technologies.
- **Produce Safer Carriers:** Support efforts to improve carrier safety by applying safety management principles, compiling best management practices, communicating best practices, and supporting the Agency's enforcement of carrier-related regulations.
- **Advance Safety Through Information-Based Initiatives:** Improve the safety and productivity of CMV operations through the application of information systems and technologies.
- **Improve Security Through Safety Initiatives:** Develop and implement safety initiatives that also have security benefits for truck and motorcoach operations.
- **Enable and Motivate Internal Excellence:** Improve performance to serve the customers and stakeholders of the Research and Analysis Divisions more effectively and economically.

Consistent with its stated mission, goals, and objectives, and in acknowledgement of its comprehensive knowledge of the motor carrier industry, FMCSA's Office of Research and Analysis was assigned the responsibility to administer the requirements set forth in Section 5503.

[3] FMCSA Web site: http://www.fmcsa.dot.gov/facts-research/research-technology/mission/ra.htm

SAFETEA-LU Section 5503 Directives

Specific Language

On August 10, 2005, the President signed the SAFETEA-LU legislation designed to improve the Nation's highway safety, modernize roads, reduce traffic congestion, and create jobs. Title V of the legislation specifies the various research initiatives that are to be undertaken, with a total budget authorization of $196,400,000 for each fiscal year from 2005 through 2009 set aside for the "surface transportation research, development, and deployment program." In authorizing the provisions of Title V, Congress issued the following findings:[4]

> (1) Research and development are critical to developing and maintaining a transportation system that meets the goals of safety, mobility, economic vitality, efficiency, equity, and environmental protection.
>
> (2) Federally sponsored surface transportation research and development has produced many successes. The development of rumble strips has increased safety; research on materials has increased the lifespan of pavements, saving money and reducing the disruption caused by construction; and Geographic Information Systems have improved the management and efficiency of transit fleets.
>
> (3) Despite these important successes, the Federal surface transportation research and development investment represents less than 1 percent of overall Government spending on surface transportation.
>
> (4) While Congress increased funding for overall transportation programs by about 40 percent in the Transportation Equity Act for the 21st Century, funding for transportation research and development remained relatively flat.
>
> (5) The Federal investment in research and development should be balanced between short-term applied and long-term fundamental research and development. The investment should also cover a wide range of research areas, including research on materials and construction, research on operations, research on transportation trends and human factors, and research addressing the institutional barriers to deployment of new technologies.
>
> (6) That it is in the United States interest to increase the Federal investment in transportation research and development, and to conduct research in critical research gaps, in order to

[4] Excerpted from Section 5103, "Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users," August 2005

ensure that the transportation system meets the goals of safety, mobility, economic vitality, efficiency, equity, and environmental protection.

This language clearly articulates congressional direction regarding the value of and need for research to improve the safety and efficiency of the transportation system. Among the priorities delineated in SAFETEA-LU is the need for a significant effort towards applying technology to improve freight transportation operations. Section 5503 of the law specifically addresses this need, and directs the efforts of the Executive Branch (and by extension, the U.S. Department of Transportation) in carrying out its provisions. The specific text of Section 5503 is provided herein for reference:

"SEC. 5503. MOTOR CARRIER EFFICIENCY STUDY.

(a) In General.--The Secretary, in coordination with the motor carrier and wireless technology industry, shall conduct a study to--

(1) identify inefficiencies in the transportation of freight;

(2) evaluate the safety, productivity, and reduced cost improvements that may be achieved through the use of wireless technologies to address the inefficiencies identified in paragraph (1); and

(3) conduct, as appropriate, field tests demonstrating the technologies identified in paragraph (2).

(b) Program Elements.--The program shall include, at a minimum, the following:

(1) Fuel monitoring and management systems.

(2) Radio frequency identification technology.

(3) Electronic manifest systems.

(4) Cargo theft prevention.

(c) Federal Share.--The Federal share of the cost of the study under this section shall be 100 percent.

(d) Annual Report.--The Secretary shall prepare and submit to Congress an annual report on the programs and activities carried out under this section.

(e) Funding.--Of the amounts made available under section 5101(a)(1) of this Act, the Secretary shall make available $1,250,000 to the Federal Motor Carrier Safety Administration for each of fiscal years 2006 through 2009 to carry out this section."

Interpretation for Purposes of Program Implementation

The FMCSA is primarily dedicated to the mission of enhancing the safety of motor carrier operations, and by extension, the overall safety of the motoring public. As such, the Administration's core research focus is on the application of technology to further this mission. However, it is important to note that because an efficient freight system that reduces delay and cuts operating costs ultimately delivers a safety benefit, there is a strong tie between the two, reinforcing the logic of assigning responsibility for the MCES to FMCSA.

Consistent with its safety mission, FMCSA evaluated the set of "minimum" program elements defined in the law, and determined that it would be both appropriate and advantageous to include an additional element. With an ever-growing population of trucks and a relatively constant level of roadside inspection resources, this element, "Roadside Safety Inspection Systems," focuses on new automated approaches to roadside inspections that would target unsafe motor carriers while not hindering the operations of safe and legal operators. Such an approach could allow public safety agencies and carriers to improve both safety and efficiency. Motor carrier enforcement agencies currently conduct approximately three million safety inspections per year, each taking between 30 and 60 minutes.

Additionally, FMCSA has expanded the scope of the "Fuel Monitoring and Management Systems" program element to include fleet management practices that promote safe operations, which can also contribute to more efficient operations. The new program element, entitled "Fuel Monitoring and Operations Management," encompasses opportunities for applying wireless technologies that leverage safety innovations to improve efficiency.

The FMCSA is acutely aware of the challenges that face the commercial trucking community and is a strong partner with its members in the pursuit of operational, institutional, and technical enhancements that will promote a safe, efficient freight delivery system. With that in mind, FMCSA has defined a program to address the Section 5503 language that relies upon a collaborative partnership among government, trucking industry, and the vendor community.

Using rigorous research and technical assessment tools, FMCSA seeks to work with private industry partners to mitigate the risks associated with operational research and development of wireless technology. Conversely, FMCSA recognizes that the purpose of this legislation is not to replace what is typically privately funded research and development of technologies and applications, nor to serve as a promotional platform for specific products or devices. Throughout the program, measures will be taken to ensure that all activities are transparent and open, and that every effort is made to support the identification and evaluation of vendor-independent solutions.

Overview of the Program

Upon assignment of program responsibilities, FMCSA immediately began the task of planning its implementation. Because of the broad mandate to evaluate the impact of wireless technologies on safety and productivity in motor carrier freight transportation, FMCSA assembled a program management team. The team includes representatives from the Department's Office of the Secretary (OST) freight and policy office, the Federal Highway Administration (FHWA) offices of freight management and policy, and the Research and Innovative Technology Administration (RITA) Bureau of Transportation Statistics (BTS). This joint program management team led by FMCSA meets regularly with the charge to monitor and guide the program.

The FMCSA also engaged external stakeholders consistent with the congressional direction to engage the trucking and wireless industries in the execution of this program.

Program Planning

Program Planning was accomplished in phases. The FMCSA defined the fundamental structure of the program with input and consensus from the joint management team. This included the analysis of the Section 5503 language, and the extrapolation of program specifics based on the FMCSA mission. During this initial planning process, it was determined that the overall program methodology would be enhanced through collaborative discussions with representatives from the motor carrier community, and the wireless technology industry. Collaboration with these interests was accomplished through a 1-day forum, hosted by FMCSA, that followed a joint trucking and wireless industry conference sponsored by Eyefortransport,[5] an industry provider of technology information and research.

During the forum, FMCSA managers and staff received input regarding a number of key program planning elements. The conference was held in Miami, Florida, in February of 2006, and brought together technology experts from across the country; it also served as an invaluable tool for refining the program plan. The results of the workshop were used to refine the Phase I statement of work, and the technical feedback has been incorporated into FMCSA guidance for the program. A copy of the summary report is available on FMCSA's Web site, www.fmcsa.dot.gov.

[5] http://www.eyefortransport.com/

Phase I

Phase I of the MCES is primarily intended to identify inefficiencies in motor carrier freight transportation, including intermodal operations, cross-border movements, and points of freight interchange. The study shall also include the analysis of safety, productivity, and cost saving benefits that may be achieved through the application of wireless technologies. The FMCSA developed a comprehensive work plan to accomplish this.

The work plan contains the following six major components:

- *A Literature Review* – This effort consists of gathering and analyzing existing literature regarding the degree to which wireless technologies have been applied to address freight transportation needs, to examine the feasibility of expanding the level of application, and to identify additional promising technologies that offer new efficiency and safety improvement opportunities.

- *Cost Benefit Methodology Development* – The FMCSA directed the consultant to utilize a tool developed under the leadership of FHWA to conduct benefit cost analysis of various candidate technology solutions. This effort consists of adapting and calibrating the analysis tool that will facilitate the comparative assessment of candidate technologies for benefits and costs.

- *Stakeholder Consultation* – This effort consists of the execution of stakeholder outreach sessions to capture information regarding baseline freight performance, user needs, performance measures, and feedback regarding technology options.

- *Study of Freight System Inefficiencies* – This effort consists of a detailed analysis of current inefficiencies and opportunities for improvement in processes, methods, and tools employed within the freight community, centered on the various types of trucking operations (e.g., long-haul, local, expedited, intermodal, etc.).

- *Application of the Cost Benefit Methodology* – This portion of the program consists of the identification and preliminary benefit cost analysis of specific wireless technology solution sets. Based on the process-level inefficiencies identified above, the MCES team will select specific technology components and applications to examine for potential benefits and costs.

- *Analysis and Reporting* – At the conclusion of the Phase I effort, the MCES team will develop conclusions regarding the findings from Phase I.

The results of the Phase I effort will be detailed in a final report, which will be made available through the FMCSA Web site. Two separate reports to Congress will be prepared for Phase I – this report and one that will be prepared at the conclusion of Phase I activities. Phase I was completed in January 2008.

Phase II

The results of the Phase I study will drive the efforts undertaken in Phase II. The principal result will be the conduct of pilot demonstrations in which promising technologies will be deployed in an operational environment. This will be done on a limited basis as a means to provide a real world perspective regarding functional capabilities and practical benefits and costs.

The FMCSA will manage these demonstrations, and will oversee technical and operational evaluations of the deployed solutions. The results of these evaluations will, to the extent possible, provide potential system developers and users with the evidence necessary to make informed decisions about long-term fielding and use of the systems.

As is always the case with publicly funded studies, the results will be made available to all interested parties, and every reasonable effort will be made to provide a fair opportunity for any qualified vendor to participate in the pilots.

Progress to Date

Motor Carrier Efficiency Study Phase I Procurement

Based on the information obtained during the industry day session in February 2006 and further discussions within the organization, FMCSA developed and issued a request for proposals to obtain consultant support services to execute Phase I of the program. The solicitation was issued March 30, 2006.

After a detailed evaluation process, a team led by Delcan was selected to perform the work. Delcan is a transportation management and technology consulting firm that has been in existence since 1953. Delcan supplemented its own capabilities by adding team members from ICF International, Productivity Apex Inc., Cheval Research (an 8(a) business) and the Commercial Vehicle Safety Alliance.

The firm, fixed-price contract was executed on September 12, 2006, and concluded in January 2008.

Phase I Work Progress

Since the September 12, 2006 award, the consultant team has begun work on three of the tasks contained in the contract. Input to this report represents the first work product completed by the contractor. More significantly, the contractor team has conducted work on the following contract tasks:

- *Task 1 – Literature Review.* The contractor team compiled more than 200 reference documents containing relevant information regarding industry inefficiencies and wireless technology applications, and extracted important findings from them. This will allow for a more complete assessment of the capabilities of the various wireless technologies, and the potential that exists for their application to new uses. The final report for this task has been completed.

- *Task 2 – Cost Benefit Methodology Development.* The contractor team has completed refining a previously developed tool for the specific needs of this program. Modest adjustments to the Freight Technology Assessment Tool, which was developed as part of an earlier effort by FHWA, were necessary to prepare it for use in estimating the potential benefits and costs of various technology implementations. This work includes the development of candidate supply chain scenarios, industry cost drivers, and prospective performance measures. The final report for this task has been completed.

- *Task 3 – Stakeholder Consultation.* The contract team identified opportunities for stakeholder consultation sessions similar to the February 2006 Industry Day event, and completed seven sessions. These sessions took place at locations around the country, where the contract team focused on obtaining input from motor carriers, federal and state agency motor carrier safety representatives regarding inefficiencies and potential solutions. Table 1 includes information regarding session dates and locations. The final report for this task has been completed.

Table 1: Stakeholder Consultation Session Schedule

Date	Event	Location
January 12, 2007	Private Fleet Session at National Private Truck Council "Fleet Management Institute" Event	Jacksonville, FL
February 20, 2007	Technology and General Trucking Session at eyefortransport "Wireless Truck 2007" Event	Miami, FL
March 1, 2007	Pacific Northwest Special Session on Intermodal and International Borders	Seattle, WA
March 26-28, 2007	Safety and General Trucking Session at Commercial Vehicle Safety Alliance Annual Conference	Atlanta, GA
April 3, 2007	Intermodal Session at the Port of Long Beach	Long Beach, CA
April 5, 2007	International Border Session at the Otay Mesa Border Crossing	San Diego, CA
April 19, 2007	Less-Than-Truckload and local Pick-up and Delivery Session in New Jersey	East Brunswick, NJ

- *Task 4 – Study of Freight System Inefficiencies.* Based upon a combination of input from motor carriers and other industry experts, and from the findings developed during the literature review, the contract team completed a detailed analysis of the implications of high-priority inefficiencies within the trucking industry. The findings included estimated costs associated with these inefficiencies, and potential wireless technology-based capabilities that may improve efficiency, safety, or both. A draft final report for this task has been completed. Information from this report will be included in the next annual report.

- *Task 5 – Application of the Cost Benefit Methodology.* This phase of the project is currently underway as of the completion of this report. The contractor team has begun analysis of the potential benefits and costs of wireless technology solutions to identify inefficiencies. This analysis will be completed and a final report prepared in the fourth quarter of 2007.

Preliminary Phase I Findings

Both the Literature Review and the stakeholder consultation sessions provided valuable insights regarding motor carrier industry inefficiencies, the direction of wireless technology research and development, and opportunities for the government to act as a catalyst for inducing positive change. Significant industry inefficiencies, as reported in the literature and examined during the stakeholder sessions, include:

- *Equipment/Asset Utilization, Underutilization*
  - *Detention/Demurrage Time* – Waiting at the shipper, waiting at the receiver; waiting at inspection facilities.
  - *Empty/Non-revenue Miles* – Empty trailer miles, empty straight truck miles; bobtail miles (for tractors); equipment misallocation.
  - *Lack of 24/7 Operations* – Shipper or receiver hours of operation, union rules, non-team driver operations, hours-of-service regulations.
  - *Lack of Optimized Routing* - Poor routing, scheduling, out-of-route miles.
  - *Unauthorized Equipment Use* – Use of truck or tractor-trailer by driver to haul cargo for payment outside of employment/lease/for-hire contract; use of trailers and containers for unauthorized cargo storage.

- *Fuel Economy, Fuel Waste*
  - *Excessive speed* – Driver behavior such as exceeding speed limits, tampering with governed throttle, tampering with other engine components.
  - *Idling* – Drivers leaving their truck idling when making brief stops rather than shutting the engine down (most often seen during very cold weather).
  - *Transmission management* - Poor shifting techniques.
  - *Preventive maintenance practices* – Excessive fuel consumption rates attributable to poor engine or drive train performance resulting from sub-optimal preventative or routine maintenance.
  - *Fuel purchase and mileage data recording* – Manual recording or data input that introduces errors, omissions, and is more vulnerable to falsification and reporting delays, from the driver to the motor carrier, or from the carrier to regulatory agencies. Fuel consumption rates are also indicators of vehicle engine and drive train performance, vehicle maintenance status, and driver behavior.

- *Loss and Theft*
  - *Stolen cargo/Pilferage* – Theft of part of the cargo at the shipper, receiver, or en route.
  - *Damage claims* – Damage to cargo due to mishandling during loading or unloading; due to improper load securing techniques, improper packaging or packing, or improper driving techniques.
  - *Stolen equipment* – Equipment stolen when bare (without cargo, not en route).
  - *Hijacked equipment* – Equipment stolen with cargo while en route, often by force.

- *Safety and Maintenance*
    - *Crashes* – Collisions, unintentional roadway departures.
    - *Preventive maintenance practices* – Break down due to lack of or improper routine maintenance of equipment.
    - *Driver equipment neglect* – Break down due to lack of or improper routine en-route inspection or maintenance of equipment by driver.
    - *Post-inspection Out of Service* – Detention of driver or equipment due to problems or defects with credentials (for motor carrier, driver, or equipment) or condition (driver or equipment).
    - *Tire failure* – Road hazards, improper inflation, excessive wear, tire defect.
    - *Other equipment failure* – Breakdowns, shut-down of equipment due to component defect.

- *Data/Information Entry and Exchange* – More than one-fourth of motor carriers surveyed by Eyefortransport in 2005 use only paper documents to account for their shipments and exchange shipment data with supply chain partners. Inefficiencies may be further introduced into the manifest, shipping and receiving, and billing processes by multiple data entry points for the same data, inaccurate initial data entry, and inaccurate, lost or delayed paper documentation.

The degree to which these inefficiencies represent systemic problems within the industry will be examined in subsequent study activities.

From the literature review the study team identified multiple classes of wireless technologies, and current applications within the motor carrier user community. The Wireless Technologies Summary Table (Table 2) reviews the primary attributes of the wireless technologies discussed. Each technology is briefly reviewed according to the following table columns:

- **Technology** – The name of the wireless technology or family of wireless technologies reviewed.
- **Description** – A brief description of the basis or primary purpose of the wireless technology.
- **Characteristics** – A snapshot of the technology performance characteristics including: data transfer rate (approximate documented speed (or range of speeds) within which data can be transferred to or from the subject technology), Range (approximate distance over which data can be transmitted to or from the subject technology).
- **Maturity** – A simple assessment of the level of maturity of the subject technology, taking into consideration the length of time that the technology standard has been in existence, and the deployment level (how widespread is this technology currently deployed). High = technology standards established and accepted for 5+ years, widely deployed; moderate = technology standards established 2-5 years, evolving to wide deployment; low = technology standards established less than 2 years, evolving deployment.

- **Motor Carrier Applications** – Examples of typical motor carrier, or potential motor carrier, applications.
- **Summary of Advantages and Disadvantages** – A brief summarization of the assessed advantages and disadvantages of the subject technology within the motor carrier operating environment.

Table 2: Summary of Wireless Technologies

Technology	Description	Characteristics	Maturity	Motor Carrier Applications	Summary Advantages/Disadvantages
Wireless technology type	*Brief description of technology*	*Operating range, data transfer tates, etc.*	*Level of maturity*	*Summary of motor carrier applications*	*Advantages or disadvantages of technologies within a motor carrier 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 1000 feet (effectively, depending on type of tag: active, passive; or power level)	High	Weight station by-pass programs, port operations, international border crossing 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 Mbps **Range** - Line of site 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**: Good 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

Technology	Description	Characteristics	Maturity	Motor Carrier Applications	Summary Advantages/Disadvantages
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 area network applications, yard/dock operations, service facility hot spots, fuel facility operations	**Advantages**: Mature technology, Strong wireless connections between devices and routers or gateways, suitable for full-scale network operation, fast connections, better local base station range than Bluetooth, IrDA **Disadvantages**: More complicated set up of network, peripherals, and connecting devices; not designed for long range communications
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	**Advantages**: Operates over greater distances than Wi-Fi, more bandwidth, broader range of frequencies, non-line of site 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 set up **Disadvantages**: Very short range operations dependent on power, no TCP IP support

Technology	Description	Characteristics	Maturity	Motor Carrier Applications	Summary Advantages/Disadvantages
Satellite	Global satellite-based telecommunications network and Global Positioning System (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 sensors, high speed wireless personal area network (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, similar disadvantages as 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-held device communications, high bandwidth access to fiber optic networks	**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 site operations

Technology	Description	Characteristics	Maturity	Motor Carrier Applications	Summary Advantages/Disadvantages
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 dependent 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**: Dedicated frequencies in non-trunked systems; 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.
Zigbee (IEEE 802.15.4)	Short range radio frequency standard for monitoring and control in mesh networks	**Data Transfer** – 20 to 250 kpbs **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

Also as part of the literature review, the study team examined the program element areas to gather information regarding what current and emerging systems are pertinent for addressing needs in these areas, what the supporting technologies are, and what data elements would be considered important for acquisition using such systems. The team also performed a brief analysis of the suitability of the identified technologies for delivery of the capabilities described within the program element areas. The results of this effort are discussed in detail in the Task 1 report.

Finally, the study team extracted from the literature a comprehensive listing of performance measures that are used currently by industry or by academic researchers to quantify improvements in safety, efficiency, and security (e.g., cargo theft). The study team will use a subset of these measures as part of benefit cost analyses to be conducted later in the project.

At the top level, there are five performance attribute categories: safety, security, productivity, efficiency, and cost. The study team formulated the initial performance measures and assigned each to an attribute. Table 3 presents these performance measures, as well as the attribute to which they are assigned. A brief description/interpretation of each measure is also provided.

Table 3: Proposed Performance Measures

No.	Performance Measure	Description/Interpretation	Performance Attribute
1	Annual fuel consumption	Gallons/liters of fuel per year	Cost
2	Annual miles driven	Total number of miles logged by drivers per year	Productivity
3	Average annual inspection time	Yearly average for the motor carrier	Efficiency
4	Chassis utilization rate	Applies to motor carrier, time available vs. time used	Productivity
5	Cost per mile	Applies to motor carrier	Cost
6	Crashes per vehicle mile	Applies to vehicle	Safety
7	Customs inspection compliance rate	Average motor carrier customs compliance rate	Efficiency
8	Damage rate per shipment	Applies to motor carrier	Cost
9	Deadhead miles as a percentage of total miles driven	Yearly rate of deadhead miles by motor carrier	Efficiency
10	Downtime for compliance checks	Applies to motor carrier, measured annually	Efficiency
11	Driver retention rates	Applies to motor carrier; components of this metric - average number of drivers employed per year, number of drivers leaving per year	Safety
12	Driver revenue efficiency	Applies to motor carrier	Efficiency
13	Driver utilization	Applies to motor carrier	Efficiency

No.	Performance Measure	Description/Interpretation	Performance Attribute
14	Empty moves per year	Total yearly empty moves for the motor carrier	Productivity
15	Fuel consumption per mile/per ton-mile	Applies to motor carrier	Efficiency
16	Idling time	Applies to motor carrier, annual measure	Productivity
17	Improved identification of compliance breaches at international borders	Macro-level, will be difficult to quantify due to lack of data	Security
18	Improved identification of compliance breaches at roadside inspection points	Macro-level, will be difficult to quantify due to lack of data	Security
19	Insurance costs per vehicle mile traveled	Applies to motor carrier	Cost
20	Loading/Unloading times	Applies to motor carrier	Efficiency
21	Loss/theft rate per shipment	Applies to motor carrier	Security
22	Number of moves per year	Applies to motor carrier	Productivity
23	Percentage of on-time arrivals	Applies to motor carrier	Efficiency
24	Roadside safety inspection compliance rate	Average motor carrier roadside safety compliance rate	Efficiency
25	Safety regulation compliance rate	Annual motor carrier number of safety violations	Safety
26	Savings from reduced border inspection time	Extrapolated macro-level savings resulting from process improvements/elimination	Cost
27	Savings from reduced safety inspection time	Extrapolated macro-level savings resulting from process improvement/elimination	Cost
28	Savings from reduced transloading time at intermodal facility	Extrapolated macro-level savings resulting from process improvements/elimination	Cost
29	Savings from reduced transloading time at seaports	Extrapolated macro-level savings resulting from process improvements/elimination	Cost
30	Savings from reduced transportation time	Extrapolated macro-level savings resulting from process improvements/elimination	Cost
31	Savings resulting from improved fuel efficiency	Extrapolated macro-level savings resulting from process improvements/elimination	Cost
32	Savings resulting from reduced insurance costs	Extrapolated macro-level savings resulting from process improvements/elimination	Cost

No.	Performance Measure	Description/Interpretation	Performance Attribute
33	Savings resulting from reduced theft/loss	Extrapolated macro-level savings resulting from process improvements/elimination	Cost
34	Total out of route miles	Applies to motor carrier, will be measured annually	Efficiency
35	Tractor utilization rate	Applies to motor carrier, time available vs. time used	Productivity
36	Traffic congestion delay	Applies to motor carrier, will be difficult to quantify due to generic nature of supply chains	Efficiency
37	Truck downtime due to unscheduled maintenance	Applies to motor carrier	Productivity
38	Truck dwell time in terminal or transloading facilities	Applies to motor carrier, measured annually as total or percent	Efficiency

It should be noted that actual user data for some of the listed performance measures may be difficult to obtain. In some cases, neither motor carriers nor their supply chain partners capture data with the frequency or precision necessary for technical analysis. Additionally, competition among carriers is significant, and some data, particularly related to costs of operations, is considered proprietary in nature. The study team intends to use industry averages where such concerns exist.

The stakeholder sessions also provided a means for the study team to use motor carrier input to prioritize inefficiencies and to begin to identify wireless technology-based capabilities that might offer improvements. As part of the study of inefficiencies undertaken in Task 4 of the project, the study team quantified the effects of these high-priority inefficiencies, and formulated analysis scenarios through which the benefits and costs of potential solutions will be estimated.

The output from Task 4 will include a summarization of the inefficiencies the team analyzed, along with the current effects they have on motor carrier operations and the potential benefits to be gained through the use of wireless technology solutions. These figures will be based upon a combination of published results from prior studies and interviews with motor carrier industry experts.

Throughout the stakeholder sessions, and during follow-up discussions with representatives from the motor carrier and technology vendor communities, the study team solicited suggestions regarding potential wireless technology solutions to the inefficiencies examined in Task 4. The study team specifically asked industry representatives for recommendations regarding capabilities that would allow for motor carriers to reduce inefficiencies and mitigate their adverse effects.

Conclusion

The FMCSA has instituted a rigorous process to ensure that the Section 5503 program objectives are accomplished, and is joined by representatives from OST, FHWA, and RITA/BTS in actively directing and monitoring the work being conducted by the contractor team. In addition to regular program status reviews, FMCSA has implemented performance-based contract terms that require the development and publication of interim reports. These measures will promote adherence to the technical and programmatic needs specified in SAFETEA-LU.

Early results compiled as of the completion of this report suggest that opportunities exist to apply wireless technologies to address significant inefficiencies within the motor carrier community. The results of the benefit and cost analysis that remains to be completed under this project will further illuminate the opportunities that exist to promote the development, adoption, and use of new applications that leverage wireless technology. It is expected that the analysis will also serve to pinpoint the most promising combinations of technology and motor carrier operations.

The remaining Phase I project activities concluded in January of 2008. The 2007 annual report will detail the actions taken to complete the project, and the appropriate findings, conclusions, and recommendations.

At the conclusion of the project, FMCSA will have at its disposal the information necessary to guide the investment of Phase II program funding based upon scientific analysis of the potential benefits and costs of technology implementations within commercial supply chains. Additionally, the contractor team is providing FMCSA with the knowledge necessary to use the tool for future efforts associated with supply chain benefit/cost analysis.