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Motor Carrier Technologies—
Fleet Operational Impacts and Implications for Intelligent Transportation Systems/ Commercial Vehicle Operations

Report No. FHWA-MC-00-0005

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Prepared for
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400 Seventh Street, S.W.
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Foreword

This report describes the current level of information technology use by motor carriers and estimated benefits and costs of several widely used fleet technologies. Also described, is how these technologies can enable motor carrier participation in the U.S. Department of Transportation Office of Motor Carrier Safety-led National Intelligent Transportation Systems/Commercial Vehicle Operations (ITS/CVO) Program; how motor carriers perceive the value of ITS/CVO services to their businesses; and, based on current and projected technology use and value perceptions, estimates of potential motor carrier participation in ITS/CVO services.

This study was led by the ATA Foundation and supported by the National Private Truck Council. The study relied on extensive data collection via review of literature, published motor carrier financial and operating statistics, and survey and interviews with motor carriers, technology vendors, and other knowledgeable parties. The data were collected between September 1996 and March 1999.

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Contracting Officer's Technical Representative (COTR): J. Loftus-U.S. Department of Transportation Office of Motor Carrier Safety (202) 366-4516. The study team was comprised of the ATA Foundation (lead) and the National Private Truck Council. The effort was also assisted by Professor Mark Kazarosian of Stone Hill College and Professor Atreya Chakraborty of Brandeis University.

16. Abstract

This report documents the findings of a three-year research effort, led by the ATA Foundation to explore what information technologies are used by motor carriers and assess their impact on differing types of fleet operations; exam how these fleet technologies can enable participation in Intelligent Transportation Systems/Commercial Vehicle Operati (ITS/CVO) services; examine how motor carriers perceive the value of ITS/CVO services; and, estimate potential moto carrier participation in Intelligent Transportation Systems/Commercial Vehicle Operations (ITS/CVO) services.

Findings are documented for: (1) the specific technologies that are being most widely adopted by motor carriers to enhance operational efficiencies; (2) estimated motor carrier benefit/cost ratios for fleet technologies; and, (3) potential motor carrier participation in ITS/CVO services.

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Table of Contents

Executive Summary		i
I.	Introduction	1
II.	Motor Carrier Technologies	4
III.	Survey of Motor Carrier Technology Use	12
IV.	Use of Motor Carrier Technologies	16
V.	Technology Impacts on Motor Carrier Operations	25
VI.	Intelligent Transportation Systems/Commercial Vehicle Operations Services	35
VII.	Conclusions and Recommendations for Continued Research	51

Appendix A—Motor Carrier Surveys

List of Figures:

Figure 1
Factors Influencing Motor Carrier Adoption of Technologies and Participation in Government-Sponsored Technology Programs 2

Figure 2
Overview of Motor Carrier Technologies 4

Figure 3
Number of Survey Respondents by Fleet Size 13

Figure 4
Number of Survey Respondents by Average Length of Haul 13

Figure 5
Number of Survey Respondents by Commodities Hauled 14

Table of Contents (Continued)

Figure 6
Number of Survey Respondents by Variability of Routing 14

Figure 7
Number of Survey Respondents by Percent of Time Sensitive Hauls 15

Figure 8
Percent of Motor Carriers Using Fleet Technologies
and Annual Adoption Rates By Fleet Size 19

Figure 9
Percent of Motor Carriers Using Fleet Technologies
and Annual Adoption Rates By Average Haul Length 21

Figure 10
Percent of Motor Carriers Using Fleet Technologies
and Annual Adoption Rates By Carrier Type 23

Figure 11
Operational Impacts of Motor Carrier Technologies
Reported by Private Fleets Using the Technologies 26

Figure 12
Estimated Annual Cost Savings Per Power Unit; Percent Savings;
and Benefit/Cost Ratios Attributable to Computer-Aided
Routing and Dispatching 30

Figure 13
Estimated Annual Cost Savings Per Power Unit; Percent Savings;
and Benefit/Cost Ratios Attributed to Mobile
Communications Systems 31

Figure 14
Estimated Annual Cost Savings Per Power Unit; Percent Savings;
and Benefit/Cost Ratios Attributed to On-Board/Handheld
Computer Systems 32

Figure 15
Estimated Annual Cost Savings Per Power Unit; Percent Savings;
and Benefit/Cost Ratios Attributed to Maintenance Support Systems 33

Table of Contents (Continued)

Figure 16
Estimated Annual Cost Savings Per Power Unit; Percent Savings; and Benefit/Cost Ratios Attributed to Electronic Data Interchange/ Internet Access 34

Figure 17
Motor Carrier Technologies and Possible Applications for ITS/CVO Services 38

Figure 18
Significant Factors Relative to Value Perceptions for ITS/CVO Services 43

Figure 19
Percent of Surveyed Motor Carriers Perceiving Value for ITS/CVO Services 45

Figure 20
Estimated Motor Carrier Participation in ITS/CVO Services (Commercial Vehicles and Percent Participation) 50

Executive Summary

Executive Summary

Trucking companies are increasingly in the business of information management to stay competitive. Their use of information technologies (IT) in fleet operations is increasing dramatically both in terms of number of users and in intensity of use. The reasons for this include:

- For many segments of the industry, the carriers' customers are rapidly becoming technologically highly integrated organizations requiring seamless information exchange between all parties involved with the business (including transportation services, whether in-house or hired). To successfully compete for freight, trucking companies make significant investments in information technologies to meet the information demands of their customers.

- Motor carrier operating ratios are very low, generally two percent or less for for-hire carriers. Subtle productivity improvements across a carrier's operation can make the difference between profit and loss. Timely collection, processing, and use of information can enhance the management of all areas of fleet operations.

- Overall technology trends—increasing power and storage capabilities of computing platforms, development of increasingly robust and scalable software applications, increasing bandwidth availability, a general decline in technology costs, and increasing user acceptance of technology solutions.

The diversity of the trucking industry and its customers results in a wide range of technologies used in myriad combinations to meet their goals. This has implications for government-sponsored, technology-based motor carrier services. To solicit motor carrier participation and function effectively, the services must meet the same criteria that carriers apply to their selection of fleet technologies—1) is it cost-effective; and, 2) will it integrate seamlessly with existing or planned information technology infrastructure?

Intelligent Transportation Systems/Commercial Vehicle Operations

The Intelligent Transportation Systems/Commercial Vehicle Operations (ITS/CVO) Program is a cooperative effort between the U.S. Department of Transportation Office of Motor Carrier Safety, motor carriers, state government agencies, technology vendors, and other transportation stakeholders to define, pilot test, and deploy IT solutions to enhance roadway safety, and improve operational and regulatory efficiencies. Participation in the ITS/CVO program is voluntary for both states and motor carriers.

ITS/CVO Services focus on developing the technical infrastructure and institutional relationships that enable seamless information exchange between motor carriers, regulators, enforcement, and other authorized stakeholders. This information exchange could enable electronic regulatory transactions (i.e., electronic credentialing), focusing of

enforcement resources on unsafe motor carriers, and providing motor carriers real-time access to fleet safety and operations enhancing information.

The National ITS/CVO Program is comprised of four program areas: Safety Assurance, Credentials Administration, Electronic Screening, and Carrier Operations. The functions of the four program areas are described in the following:

Safety Assurance—improve targeting of high-risk operators for inspection rather than the entire motor carrier population through roadside access to real-time safety information; automate safety inspection activities to reduce inspection time and improve consistency; and, support in-vehicle safety monitoring.

Credential Administration—automate regulatory functions and enhance data communications capabilities of state agencies to enable paperless transactions between motor carriers and agencies.

Electronic Screening—screen commercial vehicles for size/weight, safety, and credential compliance at mainline speeds.

Carrier Operations—enhance motor carrier safety and efficiencies through technical/programmatic support for: delivery of timely and accurate information to fleet managers; outreach regarding benefits of technology-enhanced fleet operations; bringing emerging technologies to market; and, providing responders to hazardous materials incidents rapid access to information concerning the shipment.

Critical to the success of the ITS/CVO Program is motor carrier acceptance and participation in deployed services. That participation will be driven by the same criteria carriers use in deciding whether to adopt specific technologies to support their fleet operations.

In other words, the ITS/CVO services need to be an effective extension of carriers' IT solutions to successfully solicit motor carrier participation (i.e., the technologies enabling participation are widespread in use with strong adoption rates by motor carriers; the technologies provide strong benefit/cost ratios for motor carriers; and, they can be used in multiple applications in ITS/CVO services).

To assess the potential motor carrier participation in the ITS/CVO services, this effort examined how motor carriers use technology, which segments of the industry are using specific technologies, the benefits and costs of the technologies in fleet operations, and how the technologies could be used to support participation in the services.

Current Use and Potential ITS/CVO Applications of Fleet Technologies

Computer Aided Routing & Dispatch

Routing and Dispatch software, also known as Computer Aided Dispatch (CAD), generates pickup and delivery schedules and determines optimal routing based on the company's routing criteria (i.e. fastest route, toll averse, predominately interstate highway, etc.).

Many firms have integrated their order entry systems with CAD software to automatically match available loads with driver and equipment availability, improve asset utilization, decrease turn-around time on load acceptance, and enhance on-time performance. CAD is often integrated with a firm's other decision support software modules to track vehicle and driver utilization (hours-of-service), vehicle maintenance, calculate driver settlements, track loads, or automate the capture of mileage data for fleet credentialing and tax administration information.

CAD is used extensively in the trucking industry—53% of surveyed carriers. This is due, in part, to broad ranges in pricing and functionality making CAD a cost effective management tool for many sizes and types of trucking operations. The adoption of CAD has been strong between 1996 and 1998, an 8.5 percent annual increase.

The use of CAD can yield significant benefits to many types of motor carriers. These benefits are derived through improved coordination and utilization of personnel and assets. Benefit/cost ratios for CAD were estimated to range from 3.1:1 to 9.4:1.

Applications of CAD supporting participation in ITS/CVO services could include:

- Automated carrier collection of mileage data from dispatches for apportionment calculations or documentation for audits.

- Integration of exception-based travel information to trigger re-routing, scheduling, and load assignments.

Mobile Communication Technologies

Mobile communications provide voice and/or data communications between the drivers, dispatchers, and authorized third parties. Mobile communications technologies are used to notify drivers of new loads or changes in scheduling and routing. Additionally, dispatchers can be notified of en-route conditions such as vehicle location, traffic and weather delays, and vehicle breakdowns. Mobile Communications can also allow drivers to stay in-touch with their families while on the road, thus supporting driver retention.

Mobile communications technologies are the most widely used technologies in the trucking industry—72 percent of the surveyed motor carriers. Cellular phones and pagers are the most used mobile communications technologies, 62 and 55 percent, respectively.

These technologies are highly complimentary and are often used together. Strong annual growth is observed in the use of cellular phones (seven percent) and pagers (five percent) between 1996 and 1998. In 1998, approximately 30 percent of surveyed motor carriers used mobile radio, up modestly from 27 percent in 1996. Cellular phones, pagers, and mobile radio are used primarily by motor carriers whose average haul length is less than 500 miles. The level of use of these technologies is about the same across fleet sizes.

Satellite communication was used by 28 percent of survey respondents, up from 17 percent in 1996. The primary users are larger truckload fleets with haul lengths of greater than 500 miles. This technology is very often used with automatic vehicle location tracking and on-board computers. The greatest growth in satellite communications adoption came from firms that felt on time performance was their most important operating objective.

Many segments of the motor carrier industry realize benefits of mobile communications. These benefits accrue through rapid relay of new load information, travel conditions, or vehicle or driver availability thus improving personnel and asset utilization and potentially customer service. Benefit/cost ratios calculated for mobile communications range from 4.4:1 to 6.3:1.

Supporting participation in ITS/CVO services, mobile communications could be used to:

- Enable drivers access to real-time traffic/travel information via cellular phone.
- Enable dispatchers to communicate incident/ and re-routing information to drivers following exception alert from real-time traffic/travel information system.
- Remote monitoring of driver available hour-of-service or of vehicle systems.

Electronic Data Interchange and Internet/World Wide Web

Electronic Data Interchange (EDI) allows for inter-company computer-to-computer communication of data using standardized electronic message formats or "transaction sets." EDI enables companies to exchange information fast and efficiently, reducing the amount of paperwork and manual input, thereby improving data accuracy and processing speed. Strongly driven by customer requirements for conducting business electronically, EDI has become an integral part of many segments of the trucking industry.

Increasingly, motor carriers are using the Internet and web-based solutions to improve market reach, identify available loads and bidding, invoice, and communicate via e-mail. A basic application is a simple web page providing company information, such as contact names, phone numbers, area of operation, and hours of operation. More advanced systems can include on-line access to load postings, bidding, load acceptance, shipping document generation, etc. In a fully integrated system, the on-line information can be

integrated with an order entry module to start internal planning, routing, and distribution processes.

In 1998, EDI was used by 41 percent of surveyed carriers. Approximately 33 percent of small to mid-sized firms and 60 percent of large fleets were EDI capable in 1998. The number of surveyed companies using EDI increased 6.5 percent per year between 1996 and 1998, with the strongest adoption rates among large and short haul carriers (9.2 and 8.1 percent, respectively).

In 1998, 48 percent of surveyed firms reported using the Internet, up from ten percent in 1996. Adoption rates among firms using the Internet is very strong (19 percent per year) and generally consistent across haul types. Reflecting expected continued strong growth in overall Internet use, strong adoption rates for motor carriers can also be expected to continue for several years.

The benefit of EDI/Internet Access estimated in this analysis is limited to reductions in overall clerical labor costs. These reductions are assumed to be derived through improved administrative efficiencies. Estimated Benefit/cost ratios ranged from 2.7:1 to 11.7:1.

ITS/CVO uses of EDI/Internet could include:

- Electronic transmittal of carrier data, forms, supporting documentation to agencies.
- Electronic reception of credentials and payment of fees/taxes.
- Provide carriers electronic access to fleet safety inspection reports to enhance safety monitoring functions.
- Provide carriers electronic access to regulatory safety rules and regulations.
- Provide carriers access to real-time traffic/travel information.
- Posting of load information for access by emergency responders to incidents involving hazardous materials.

Automatic Vehicle Location

Automatic Vehicle Location systems (AVL) make it possible to pinpoint the location of a vehicle using satellite or ground-based technologies. When combined with on-board computers and routing and dispatching software, these systems can track and document detailed truck or load information from pickup to delivery.

AVL systems can be integrated with other carrier systems such as CAD, accounting software, and maintenance and safety support systems to provide customers with current shipment status information, enable dynamic re-routing, automate settlements and mileage and tax calculations, enhance driver log auditing, and track vehicle use for preventative maintenance purposes.

In 1998, 21 percent of survey respondents reported using AVL, up from 12 percent in 1996. AVL is primarily used by larger, time-sensitive, variable-route fleets requiring increased asset coordination. Long-haul users are primarily truckload fleets using satellite communications. The short haul users are generally larger pickup and delivery fleets using radio-based AVL.

Too few survey respondents reported using AVL to quantify benefits in this analysis.

Applications of AVL in ITS/CVO services could include:

- Carriers monitor vehicle speeds/location in real-time supporting driver monitoring or scheduling/routing based on available hours-of-service.
- Automated carrier data collection for apportionment calculations.
- Vehicle position reports supporting CAD response to roadway incident reports.
- Vehicle position reports support identification of loads by hazardous materials incident responders

On-Board or Hand-Held Computers

On-Board or Hand-Held Computers (OBCs) are data processing units that take information from sensors and other devices, process and present it to the truck driver or carrier in a convenient and easily accessible manner. These units can also keep records of sensor readings (such as engine and refrigeration unit data) for vehicle diagnostic and preventative maintenance purposes. Many fleet managers also use this data to analyze fleet performance statistics such as driver performance and fuel consumption.

OBCs can also control additional communication devices and interface with transponders installed on the tractor/trailer. They might also be connected to a hand-held device for data collection outside the vehicle, such as bar code reading, sensors, electronic signature readings, or keypads for direct driver data entry. An emerging application of OBCs is their use as electronic logbooks.

Ten percent of surveyed carriers reported using OBCs in 1998, up from six percent in 1996. Mostly larger fleets; firms with time-sensitive hauls, less-than-truckload and private carriers, and firms with safety performance as their prime objective use OBCs.

Six percent of surveyed carriers used electronic logbooks in 1998, compared to three percent in 1996. Approximately three to four percent of for-hire carriers reported using electronic logbooks, while 18 percent of the surveyed private carriers used the devices.

Benefit/cost ratios for OBCs are estimated to range from 0.3:1 to 6.6:1.

Within the context of ITS/CVO services, OBC/electronic logbooks can enable the following functions:

- Monitor driver/vehicle performance either in real-time or historically.
- Automate the recording/demonstration of drivers' hours-of-service.
- Enable presentation of vehicle systems performance data to inspectors.

Diagnostic and Maintenance Support Systems

Diagnostic and Maintenance Support systems (MSS) are used to collect information and track a variety of operational statistics and asset performance/wear data to allow timely maintenance activities. These systems can be used to analyze error codes from electronic engines and on-board computers, track the total number of hours and miles logged on the vehicle, service intervals, and flag a vehicle due for preventive maintenance work.

MSS were used by 30 percent of the surveyed carriers in 1998, an increase of six percent per year from 1996. The strong rate of adoption is due to the vendor community offering a range of MSS to meet the functional and price needs of many diverse fleet types. The benefits to firms using maintenance support systems examined in this analysis include reductions in maintenance and insurance costs derived through enhanced preventative maintenance programs. Benefit/cost ratios calculated for maintenance support systems range from 0.7:1 to 1.8:1.

Supporting ITS/CVO Safety Assurance functions, MSS can be used to enable automated maintenance records/reports possibly stored via on-board/handheld computers or RF-tags for electronic access by enforcement.

Automatic Vehicle/Equipment Identification

Automatic Vehicle/Equipment Identification (AVI/AEI) systems are generally based on dedicated short-range radio communication between a transponder or RF tag on the equipment and a stationary reader system. The transponders are typically programmed with identification, authorization and any other types of information unique to the user, equipment or the application.

AVI/AEI can be utilized to identify: equipment entering or exiting a yard (yard access control); equipment within a yard (equipment availability); trucks passing through toll collection lanes (electronic toll collection); or, fuel use and authorization.

Three percent of surveyed carriers reported using RF tags in 1998, compared to two percent in 1996—primarily by larger fleets to track assets and to coordinate load consolidation; smaller fleets operating in metropolitan areas supporting electronic toll collection; and fleets participating in electronic clearance programs. Too few survey respondents reported using AVI/AVE to quantify benefits in this analysis.

Regulatory uses of AVI/AEI include electronic identification and screening of vehicles for bypassing roadside inspections at mainline speeds and enable transmittal of information between roadside enforcement and vehicle. For the purpose of identifying vehicles, optical recognition technologies (license plate readers) are currently being tested as a "passive" alternative to RF tags.

Collision Warning Systems/Driver Impairment Detectors

Collision warning systems (CWS) alert the driver of possible collisions based on proximity to, and rates of closure, on obstacles. Obstacle detection can use closed-circuit television, infrared, or low frequency radar detection. Alerting signals can be audible or visual. These data can be downloaded or relayed via mobile communications and used for driver performance evaluation or accident reconstruction.

CWS was used by only three percent of the surveyed carriers in 1998. Annual growth between 1996 and 1998 was about one percent per year. Too few survey respondents reported using CWS to quantify benefits for the technology.

Emerging technologies include drowsy driver detection/warning systems to monitor a driver's physical state and performance behind the wheel and alert the driver and/or the carrier if a serious fatigue condition is detected. Systems under development could monitor driver posture changes, eye blinking and degree of eyelid closure, erratic steering, etc. to assess alertness. These sophisticated, non-intrusive detection/warning systems are not expected to reach the marketplace for several years.

There are near-market-ready devices that monitor the tractor's placement within the driving lane. If the placement/location changes, such as if a commercial vehicle begins to drift out of the lane, the driver receives an audible or tactile warning signal.

Supporting ITS/CVO safety assurance functions, CWS provide warnings to drivers of closure rates on obstacles (especially useful in limited visibility conditions). Other CWS features include the capture and storage of alert documentation for driver performance monitoring/review.

Motor Carrier Value Perceptions and Potential Participation in ITS/CVO Services

How motor carriers perceive value for ITS/CVO services/functions can provide a benchmark from which potential participation levels can be estimated. To this end, the surveyed motor carriers were asked to rank their perceived value for ITS/CVO services.

The results show that the highest values are placed on services in which requirements for participation involve the use of technologies currently widespread in use (proven, cost-effective, and interoperable technologies requiring little or no modifications for participation). It is also seen that the perceived value for ITS/CVO services is sensitive to fleet operating characteristics such as fleet size, range of operations, time sensitivity of hauls, and route variability.

Based on current and projected use of fleet technologies and the surveyed motor carriers' value perceptions by fleet characteristics, estimates of potential motor carrier participation in ITS/CVO services were developed. Participation estimates assume a sufficient time frame following implementation of ITS/CVO services to allow carriers to realistically assess service functionality, costs and possible benefits, and resolution to the many intricate barriers identified in states' ITS/CVO Institutional Issues studies and other related literature. These estimates are presented in Figure E1 and summarized in the following:

- The ITS/CVO services/functions estimated to have the highest initial and potential participation are those that are informational in function: electronic access to information about travel conditions, fleet safety performance, and motor carrier rules and regulations. It is expected that motor carriers would adopt these services rapidly due to the relatively low cost and expected adoption rates of enabling technologies, and potential medium to high benefits in terms of enhanced fleet operations and safety management.

- Participation in the electronic credentialing services for fleet registration, fuel tax administration, and oversize/overweight permitting can be expected to be modest at first, then developing rapidly towards strong participation levels. Similar to informational ITS/CVO services/functions, technology costs are expected to be relatively low. Low to medium benefits in terms of reduced administrative costs can be expected.

- Participation in electronic screening and automated safety inspection activities is expected to be low at first and slowly developing towards modest participation levels. Participation is expected to be constrained due to uncertain benefits, exposure levels, and institutional and technical issues.

- As a reasonably well-developed service in the more metropolitan areas, moderate growth is expected in the number of motor carriers participating in electronic toll

collection programs. This growth would be driven primarily by the benefits of toll discounts and administrative cost savings.

Figure E1
Estimated Motor Carrier Participation in ITS/CVO Services
(Commercial Vehicles and Percent Participation)

ITS/CVO Service	Conservative Participation Estimate (Commercial Vehicles & Percent)	Optimistic Participation Estimate (Commercial Vehicles & Percent)
Electronic Registration Credentialing	1.2 Million 33%	2.5 Million 63%
Electronic Fuel Tax Credentialing	0.7 Million 33%	1.4 Million 62%
Electronic Fuel Tax Filings/Payments	0.7 Million 33%	1.4 Million 62%
Electronic Oversize/Overweight Permitting	1.0 Million 26%	1.4 Million 39%
Demonstration of Hours-of-Service Compliance via Electronic Logs	0.2 Million 5%	0.3 Million 8%
Real-Time Access to Fleet Safety Inspection Reports	1.3 Million 33%	2.8 Million 71%
Electronic Access to Motor Carrier Rules and Regulations	1.2 Million 29%	2.7 Million 67%
Electronic Safety/Weight Screening	0.3 Million 7%	0.5 Million 9%
Access to Real-Time Traffic and Travel Information	1.7 Million 44%	2.9 Million 72%
Electronic Toll Collection	0.3 Million 7%	0.8 Million 20%
Hazardous Materials Incident Response	0.6 Million 16%	1.4 Million 35%

Section I

Introduction

I. Introduction

Trucking is the dominant mode of freight transportation in the United States, and projections are that this trend will continue well into the next century. According to a report prepared by Standard & Poor's DRI for the American Trucking Associations, trucking will account for 80.3% of freight revenues in 2007.[1]

Beyond moving freight, trucking companies are increasingly getting into the business of information management in order to stay competitive. The use of information technologies (IT) in fleet operations is increasing both in terms of number of users and in intensity of use. There are a number of factors driving this.

To begin with, more and more businesses are becoming technologically integrated organizations requiring seamless information exchange between their business and their service providers. This includes those who provide transportation services. To successfully compete for freight, many trucking companies have made significant investments in information technologies to meet the informational demands of their customers.

Furthermore, motor carrier operating ratios are very low, generally two percent or less for for-hire carriers. Subtle productivity improvements across a carrier's operation can make the difference between profit and loss. Timely collection, processing, and use of information can enhance the management of all areas of fleet operations.

Adding to this are overall technology trends—increasing power and storage capabilities of computing platforms, development of increasingly robust and scalable software applications, increasing bandwidth availability, and a general decline in technology costs—which lead more and more trucking companies to technology solutions for their business.

To meet the challenges of providing cost-effective transportation services, numerous technologies are available to motor carriers. When considering adoption of a particular technology solution, motor carriers consider two important criteria: 1) is it cost-effective; and, 2) will it integrate seamlessly with existing or planned information technology infrastructure?

The diversity of the trucking industry and its customers results in a wide range of technologies used in myriad combinations to meet these criteria. For example, many smaller fleets with customers not requiring a great deal of information from them have little use for sophisticated tracking, monitoring, decision support systems, etc. to effectively manage their business. On the other hand, large, widely dispersed fleets and/or fleets supporting extremely time-sensitive shipments, may require sophisticated IT to meet their business goals. This has implications for government-sponsored, technology-based motor carrier services. The services to be effective must meet these same criteria.

The Intelligent Transportation Systems/Commercial Vehicle Operations (ITS/CVO) Program is a cooperative effort between the U.S. Department of Transportation-Office of Motor Carrier Safety (OMCS), motor carriers, state government agencies, technology vendors, and other transportation stakeholders to define, pilot test, and deploy IT solutions to enhance roadway safety, and improve operational and regulatory efficiencies.

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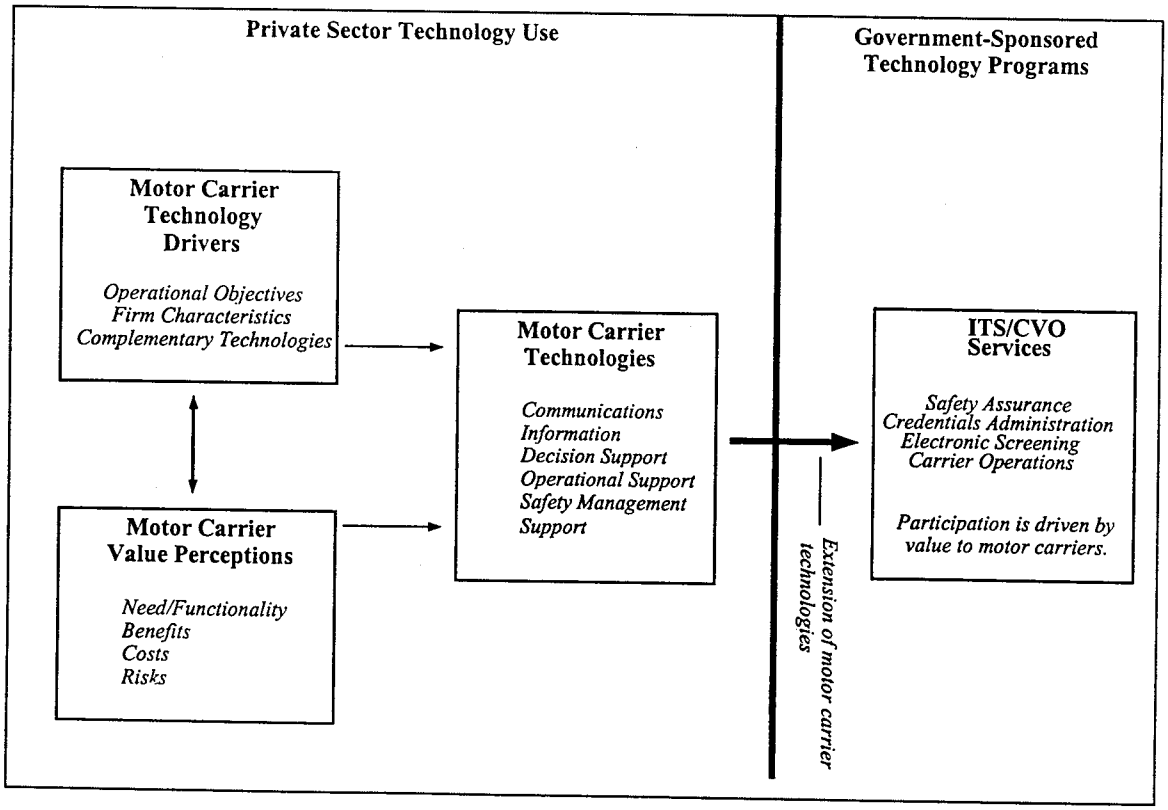
[1] *US Freight Forecast...to 2007*, Standard & Poor's DRI for the American Trucking Associations, 1999
ATA Foundation—*Motor Carrier Technologies-Fleet Operational Impacts and Implications for Intelligent Transportation Systems/Commercial Vehicle Operation, October 1999*

The National ITS/CVO Program is developing the technical infrastructure and institutional relationships that enable seamless information exchange between motor carriers, regulators, enforcement, and other authorized stakeholders. This information exchange could enable electronic regulatory transactions (i.e., electronic credentialing), focusing of enforcement resources on unsafe motor carriers, and providing motor carriers real-time access to fleet safety and operations enhancing information. Participation in ITS/CVO services is voluntary for both states and motor carriers.

Critical to the success of the ITS/CVO Program is motor carrier acceptance and participation in deployed services. As illustrated in Figure 1, that participation will be driven by the same criteria carriers use in deciding whether to adopt specific technologies to support their fleet operations. In other words, the ITS/CVO services need to be an effective extension of carriers' IT solutions to successfully solicit motor carrier participation (i.e., the technologies enabling participation are widespread in use with strong adoption rates by motor carriers; the technologies provide strong benefit/cost ratios for motor carriers; and, they can be used in multiple applications in ITS/CVO services).

Figure 1
Factors Influencing Motor Carrier Adoption of Technologies and Participation in Government-Sponsored Technology Programs



To guide the development of effective ITS/CVO services, the ATA Foundation and National Private Truck Council conducted research for OMCS to examine IT use by motor carriers and explore the implications for ITS/CVO services. This report presents the findings of that research.

Specifically, this document examines:

- what technologies are used by motor carriers;
- how extensively the technologies are used by different types of carrier operations;
- how the technologies impact motor carrier operating costs;
- how motor carriers perceive the value of ITS/CVO services to their businesses;
- how motor carrier technologies can be used to participate in ITS/CVO services; and,
- what the potential motor carrier participation rates are for ITS/CVO services.

This report is intended as a benchmark by which OMCS can direct its ITS/CVO program. There is no question that motor carriers will increasingly turn to technology solutions to meet customer demands and enhance operating efficiencies. Where benefit/cost ratios are strong for current uses of fleet technologies and synergies exist with the functions of the ITS/CVO services, it is appropriate that motor carriers would look for ways to utilize the services to improve safety, and advance operational and regulatory efficiencies.

Section II

Motor Carrier Technologies

II. Motor Carrier Technologies

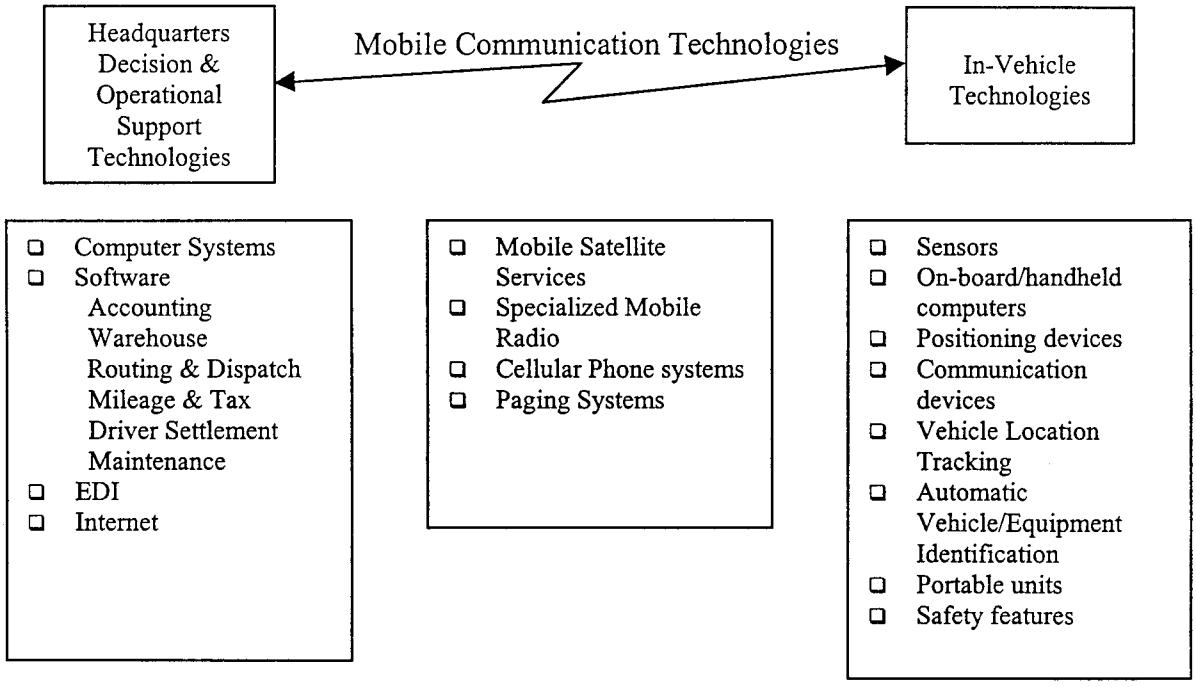
Technology applications have the potential to enhance nearly every aspect of a motor carrier's operation. From billing to preventive maintenance, technology now plays a role throughout the industry. This section presents an overview of motor carrier technologies and their applications in fleet operations.

For discussion purposes, motor carrier technologies can be divided into the following three categories:

1. Decision and Operational Support Technologies;
2. Communication Technologies; and,
3. In-Vehicle Technologies.

Figure 2 illustrates several of the technologies available in each category. A motor carrier's terminal/headquarters uses Decision and Operational Support Technologies to manage the entire fleet. The Communication Technologies provide the link to the vehicle. The company's vehicles, meanwhile, are equipped with a multitude of devices providing information about drivers, vehicles, and loads. This section describes these technologies and how they are used in fleet operations.

Figure 2 – Overview of Motor Carrier Technologies



Decision and Operational Support Technologies

A motor carrier's terminal/headquarters is its nerve center. Depending on the type of carrier, the terminal personnel can be responsible for a variety of tasks including:

- receiving orders;
- scheduling and routing;
- maintaining warehouse stocks;
- accounting;
- fleet credentialing and tax filings/payments;
- maintenance;
- safety management;
- driver settlements;
- providing information to other carrier locations; and,
- providing information to customers.

Many motor carriers have made significant investments in hardware and "in-house" developed or commercially available software products to automate these myriad functions. While the computing solutions vary depending on the specific needs of the carriers, functionally they can be very similar.

The decision and operational support technologies examined in this analysis include routing and dispatch systems, maintenance and safety management support systems, Electronic Data Interchange, and Internet.

Routing & Dispatch

Routing and Dispatch software, also known as Computer Aided Dispatch (CAD), generates pickup and delivery schedules and determines optimal routing based on the company's routing criteria (i.e. fastest route, toll averse, predominately interstate highway, etc.). Many firms have integrated their order entry systems with CAD software to automatically match available loads with driver and equipment availability, improve asset utilization, decrease turn-around time on load acceptance, and enhance on-time performance.

CAD is often integrated with a firm's other decision support software modules to track vehicle and driver utilization (hours-of-service), vehicle maintenance, calculate driver settlements, and track loads. As the routing system assigns vehicles and drivers to loads, other decision support modules can be automatically updated creating an up-to-the minute log of the fleet's assets. The information developed in the routing and dispatching process is also often integrated with mileage and tax calculation modules to automate fleet credentialing and tax administration functions.

Advanced CAD systems can include real-time tracking of assets via integration with automatic vehicle location systems, enabling up-to-date estimated arrival times and can trigger re-routing instructions to meet delivery demands.

Diagnostic and Maintenance Support

Diagnostic and Maintenance Support systems are used to collect information and track a variety of operational statistics and asset performance/wear data to allow timely maintenance activities. These systems can be used to analyze error codes from electronic engines and on-board computers, track the total number of hours and miles logged on the vehicle, service intervals, and flag a vehicle due for preventive maintenance work.

They can also be used to track a firm's inventory of spare parts, contacts for ordering specific parts, and the cost associated with each part. This feature ensures that the necessary equipment is on site when the preventive maintenance routines are initiated. The system will also allow the firm to track the usage of a particular part by individual truck.

Safety Management Support

Safety Management Support systems can include technologies for collecting, storing, and processing information such as personnel records, drivers' vehicle inspection reports, trip reports, accident reports, driver logbooks, mileage reports, etc.

A widely used technology application is logbook scanners used with log-auditing software. This application allows the digitization and electronic storage of paper driver logs. Auditing software reads the digitized logbook and compares the entries to hours-of-service restrictions. Logbook violations can trigger the generation of exception reports and disciplinary notice letters. These systems can also be integrated with vehicle tracking and dispatch systems providing additional information with which to validate logbook entries.

Another technology used for recording driver information is the on-board computer/electronic logbook. This technology allows the driver to input duty status and other trip information directly to a terminal, thus reducing driver administrative burdens. The electronic log also can reduce desk-side processing costs and facilitate internal auditing and safety compliance reviews.

Electronic Data Interchange

Electronic Data Interchange (EDI) allows for inter-company computer-to-computer communication of data using standardized electronic message formats or "transaction sets." EDI enables companies to exchange information fast and efficiently, reducing the amount of paperwork and manual input, thereby improving data accuracy and processing speed. Strongly driven by customer requirements for conducting business electronically, EDI has become an integral part of many segments of the trucking industry.

A typical motor carrier EDI transaction may involve the following steps:

1. Customer enters shipment information into their computer and electronically transmits information to the carrier's computer. Alternatively, customer posts load information for bidding by carriers.
2. Carriers receive load information and bid for shipment.

3. Customer accepts bid, load is scheduled and confirmed, and bill of lading is generated.
4. Carrier collects status data and sends a shipment information status message to the shipper and consignee on a regularly scheduled basis. Information contained therein includes the most recent status of the shipment as well as reference numbers. Customer updates their database automatically.
5. Once delivery is confirmed, carrier electronically transmits freight bill to customer.
6. Payer of freight charges electronically transmits payment to carrier's bank via Electronic Funds Transfer (EFT) and remittance advice to the carrier.

EDI is also used intra-company, particularly in private fleets to assure that all business units have current information.

Larger, better-capitalized motor carriers—the predominant users of EDI—have indicated that EDI is their preferred method for conducting the regulatory compliance transactions of credentialing and tax administration with state agencies. Currently several states either require or provide the option for EFT for sizable tax payments.

Internet/World Wide Web

Increasingly, motor carriers are using the Internet and web-based solutions to improve market reach, identify available loads and bidding, invoice, and communicate via e-mail. A basic application is a simple web page providing company information, such as contact names, phone numbers, area of operation, and hours of operation. More advanced systems can include on-line access to load postings, bidding, load acceptance, shipping document generation, etc. In a fully integrated system, the on-line information can be integrated with an order entry module to start the internal planning, routing, and distribution process.

The rapid increase in the use of the Internet and web-based solutions, especially among small- to mid-sized motor carriers, would indicate that this technology could be a cost-effective way to conduct electronic regulatory transactions with states or access fleet safety and operations-enhancing information.

Mobile Communication Technologies

Mobile communications provide voice and/or data communications between the drivers, dispatchers, and authorized third parties. Mobile communications technologies are often used to notify drivers of new loads, changes in scheduling and routing, and "drop and swap" opportunities. Additionally, dispatchers can be notified of en-route conditions such as vehicle location, traffic and weather delays, and vehicle breakdowns. Mobile communication technologies are also used to notify customers of estimated arrival times. Lastly, they can provide an opportunity for drivers to communicate with their families while on the road.

A mobile communications system can be integrated with a motor carrier's information systems, allowing for real-time exchange of information such as driver hours-of-service, vehicle position and performance, load status etc., with many functional departments.

These technology applications are strongly tied to the type of motor carrier operation. Some carriers have little need for their drivers to call-in "on-the-fly" and therefore require no direct communication link to their vehicles.

The most widely used mobile communications technologies are described below.

Mobile Satellite Services (MSS)

MSS uses a network of orbiting satellites to provide wide communication coverage between a carrier and its assets. Vehicles are outfitted with a satellite dish, which relays information to an earth station. From the earth station the information is sent along landlines or retransmitted via satellite to the carrier's operation center. Reversing the sequence allows the dispatcher to send messages to the truck driver. A variety of information, including voice, personal e-mail, and vehicle/driver performance, can be sent along this system. Automatic vehicle positioning is a common feature associated with MSS.

Specialized Mobile Radio (SMR) Systems

SMR Systems are two-way radio systems that use land-based radio towers across the country to transmit and receive information to/from a vehicle. The radio towers are connected through a network of telephone lines that can transmit the messages directly to the dispatcher. While generally less expensive than the MSS, some SMR systems suffer from blackout areas, particularly in rural areas, limiting their utility.

Cellular Phone Systems

Cellular phones are one of the most widely used technologies in the motor carrier industry. Messages are transmitted between the user's cellular phone and a ground-based transceiver. The transceiver's effective radius of about 16 miles denotes a cell. However, transceivers in urban areas may have an effective radius of less than five miles. Multiple cells are connected through a central switching station that automatically reroutes calls as trucks move from cell to cell within the system.

The primary use of cellular phones by motor carriers is to relay important rerouting instructions and new load information to their drivers. Some carriers have expressed safety concerns about drivers using cellular phones while in-motion, and therefore require their drivers to call-in at pre-determined times or will page a driver to tell them to call-in at their next stop.

Paging Systems

Pagers are also widely used by the motor carrier industry, often in conjunction with cellular phones. Dispatchers can send text messages to their drivers via the alphanumeric pagers signaling the need to call the terminal, add a stop to their route, or reroute around a particular area. Dispatchers using numeric pagers relay information about emergencies, routing revisions, special permit pick-ups, and the location of back-haul freight using a preset coding system.

In-Vehicle Technologies

In-vehicle technologies monitor the vehicle and the load and can deliver the information to the driver and/or motor carrier in real-time. Some of the uses of in-vehicle technologies include:

- providing vehicle diagnostic information to shop personnel to improve equipment maintenance;
- monitoring fuel consumption;
- evaluating driving performance;
- automating data collection to reduce driver and clerical administrative burdens;
- alerting dispatchers to conditions which could potentially result in delays; and,
- alerting the driver of potentially unsafe situations that may be developing in time to avoid accidents.

On-Board Computers (OBC)

OBCs are data processing units that take information from sensors and other devices, process and present it to the truck driver in a convenient and easily accessible manner. These units can also keep records of sensor readings (such as engine and refrigeration unit data) for vehicle diagnostic and preventative maintenance purposes. Many fleet managers also use this data to analyze fleet performance statistics such as driver performance and fuel consumption.

OBCs can also control additional communication devices and interface with transponders installed on the tractor/trailer. They might also be connected to a hand-held device for data collection outside the vehicle, such as bar code reading, sensors, electronic signature readings, or keypads for direct driver data entry. Some versions of OBCs use electronic transfer mechanisms such as digital radio, cellular, or satellite communications to relay real-time information from the vehicle to the motor carrier's dispatch office.

Automatic Vehicle Location (AVL)

AVL systems make it possible to pinpoint the location of a vehicle using satellite or ground-based technologies. When combined with on-board computers and routing and dispatching software, these systems can track and document detailed truck or load information from pickup to delivery. Real-time location information can be relayed to shippers and receivers to update arrival times.

There are two basic types of AVL systems:

- Satellite AVL systems – these include Global Positioning Systems (GPS), geo-stationary satellites, and lower-earth orbit satellites; and,

- Ground-based infrastructure AVL systems—these include automatic vehicle monitoring band systems, dead reckoning, long-range navigational systems, and electronic signposts to determine vehicle position.

An AVL system calculates vehicle location with accuracy ranging from 100 feet to 3000 feet. AVL systems can be integrated with other carrier systems such as CAD, accounting software, and maintenance and safety support systems to provide customers with current shipment status information, enable dynamic re-routing, automate settlements and mileage and tax calculations, enhance driver log auditing, and track vehicle use for preventative maintenance purposes. AVL is also used to facilitate stolen vehicle recovery, and can be a requirement for hauling specialized loads—munitions, for example.

Automatic Vehicle/Equipment Identification

Automatic Vehicle/Equipment Identification (AVI/AEI) systems are generally based on dedicated short-range radio communication between a transponder and a reader system. The transponders are typically programmed with identification, authorization and any other types of information unique to the user, equipment or the application.

The reader system includes a radio frequency (RF) receiver/reader, radio RF module, and antenna. The transponders, also called RF tags, are placed on motor carrier equipment to be identified, and the readers, antennas, and RF modules are installed at designated points to record the passing of tagged equipment.

AVI/AEI can be utilized to identify[2]:

- equipment entering or exiting a yard (yard access control);
- equipment within a yard (equipment availability);
- trucks passing through toll collection lanes (electronic toll collection);
- fuel use and authorization.

Regulatory uses of AVI/AEI include electronic identification and screening of vehicles for bypassing roadside inspections. For this purpose, optical recognition technologies (license plate readers) are being tested as a "passive" vehicle identification alternative to RF tags.

Collision Warning Systems

Collision warning systems alert the driver of possible collisions based on proximity to, and rates of closure, on obstacles. Obstacle detection can use closed-circuit television, infrared, or low frequency radar detection. Alerting signals can be audible or visual. These data can be downloaded or relayed via mobile communications and used for driver performance evaluation or accident reconstruction.

Driver Impairment Detectors

Drowsy driver detection/warning systems monitor a driver's physical state and performance behind the wheel and will alert a driver and/or the carrier if a serious fatigue condition is

[2] ATA Information Technology Council – Automatic Vehicle/Equipment Identification
ATA Foundation—*Motor Carrier Technologies-Fleet Operational Impacts and Implications for Intelligent Transportation Systems/Commercial Vehicle Operation, October 1999*

detected. Systems under development could monitor driver posture changes, eye blinking and degree of eyelid closure, erratic steering, etc. to assess alertness.

These sophisticated, non-intrusive detection/warning systems are not expected to reach the marketplace for several years. Currently though, simpler devices are on the market. One is an electronic device that monitors movements of the steering wheel with a magnetic sensor. When normal movements cease, within a driver or carrier preset time frame, the driver is alerted by an alarm. The alarm is automatically reset as soon as normal steering is restored.

There are near-market-ready devices that monitor the tractor's placement within the driving lane. If the placement/location changes, such as if a commercial vehicle begins to drift out of the lane, the driver receives an audible or tactile warning signal.

Section III

Survey of Motor Carrier Technology Use

III. Survey of Motor Carrier Technology Use

In 1998, the ATA Foundation and the National Private Truck Council (NPTC) conducted two surveys, one of 760 for-hire motor carriers and one of 172 private fleets. The purpose of the surveys was to examine how extensively various technologies are used in fleet operations; the rates of technology adoption among the fleets; provide information to estimate the potential operational benefits of the technologies; and, assess how motor carriers perceive the value of technology-based government services. The two surveys are presented in appendix A.

As presented in figures 3 through 7, the surveys captured information across a wide range of trucking operations. The surveys provided information on the operational characteristics of the individual motor carriers including fleet size, geographic range of operation, variability of routing, time sensitivity of pickups and deliveries, and special considerations due to cargo type.

Both surveys queried what technologies the companies used in 1996 and 1998. The technologies included:

- mobile communications;
- computer-aided routing and dispatching systems;
- automatic vehicle tracking;
- automatic vehicle identification;
- on-board computers;
- collision warning systems;
- Electronic Data Interchange;
- Internet access; and,
- other operational support systems.

The surveys also asked the motor carriers to rank how they perceive the potential value of ITS/CVO services to their companies. Additionally, the NPTC survey asked carriers to identify specific impacts of technologies on operations. The survey information and subsequent analyses were validated/augmented by follow-up discussions with motor carriers and reference to previous and ongoing research.[3]

Section IV of this report describes the extent of technology use and rates of technology adoption among trucking fleets. Section V assesses the impacts of the technologies on fleet operating costs. Section VI describes the OMCS ITS/CVO user services; how motor carrier technologies can enable participation in the services; and, in conclusion, based on how motor carriers perceive the value of the services, what the likely motor carrier participation rates are for the services.

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[3] Assessment of Intelligent Transportation Services/Commercial Vehicle Operations User Services: ITS/CVO Qualitative Benefit/Cost Analysis—ATA Foundation—1996 (ATA-96); Commercial Fleet Management and Information Systems—Cambridge Systematics/ATA Foundation—1997; *FleetForward* ATIS/CVO Operational Test—ATA Foundation (ongoing).

Figure 3
Number of Survey Respondents by Fleet Size

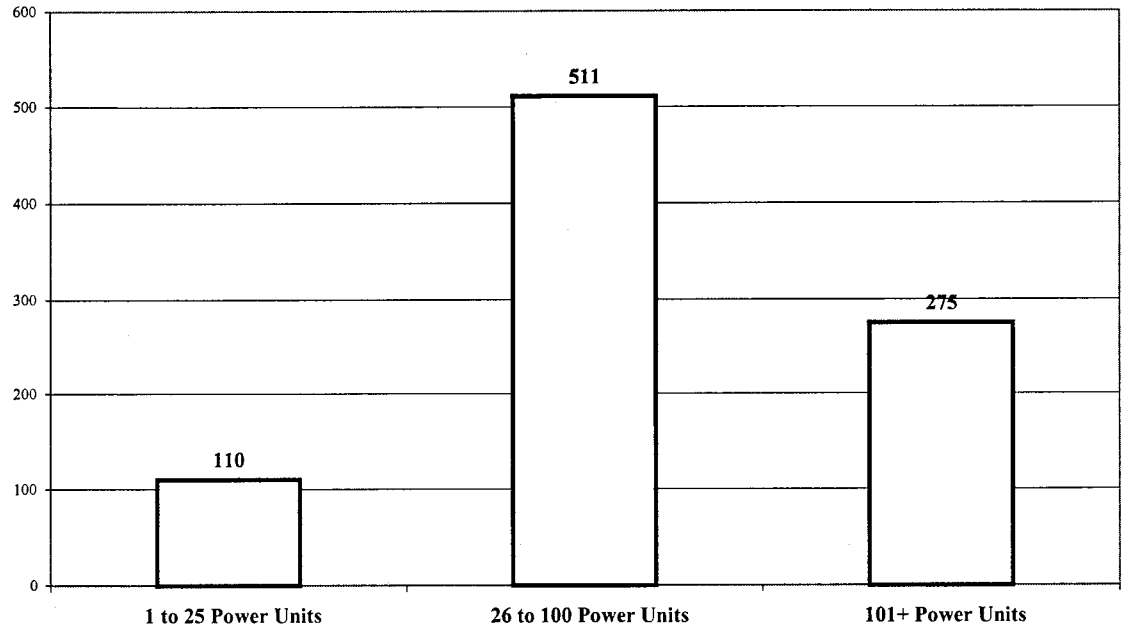


Figure 4
Number of Survey Respondents by Average Length of Haul

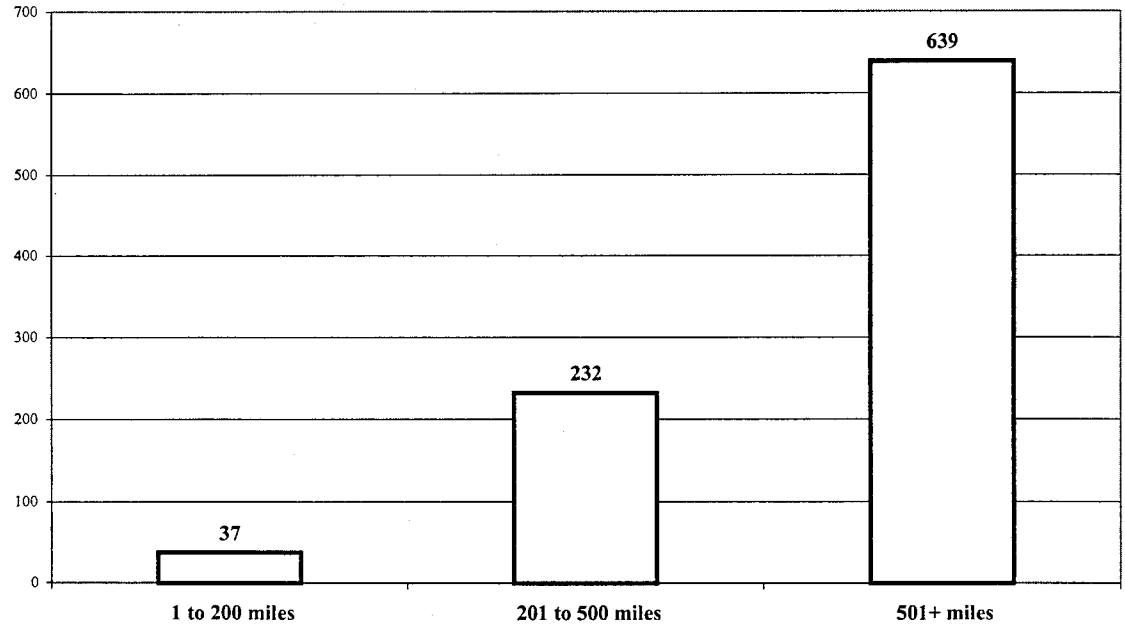


Figure 5
Number of Survey Respondents by Commodities Hauled
(Totals Exceed Number of Respondents Due to Multiple Types of Commodities Hauled by Carriers)

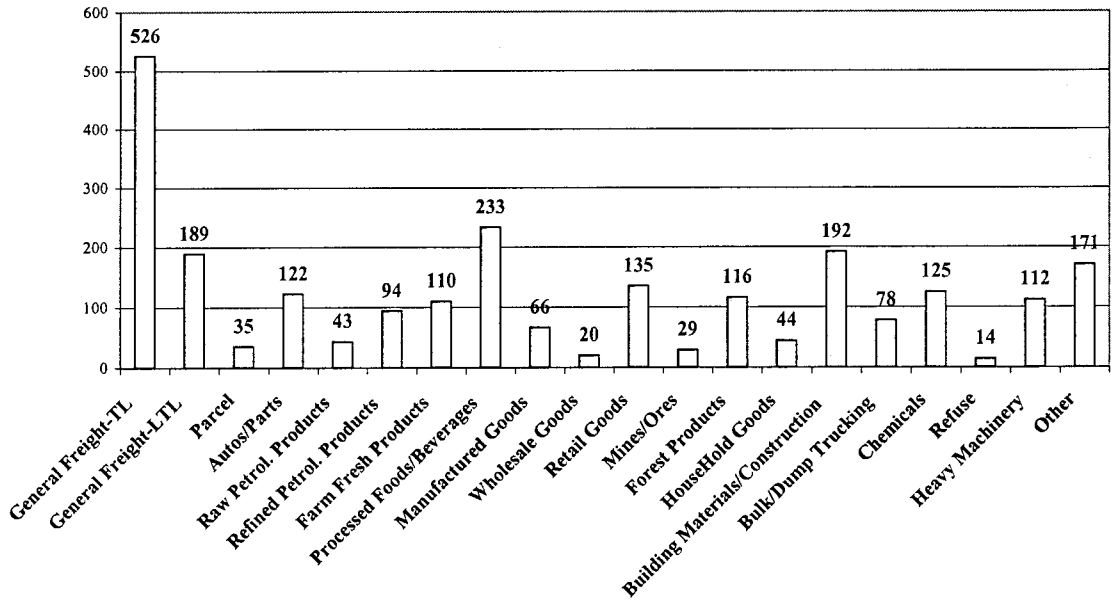


Figure 6
Number of Survey Respondents by Variability of Routing

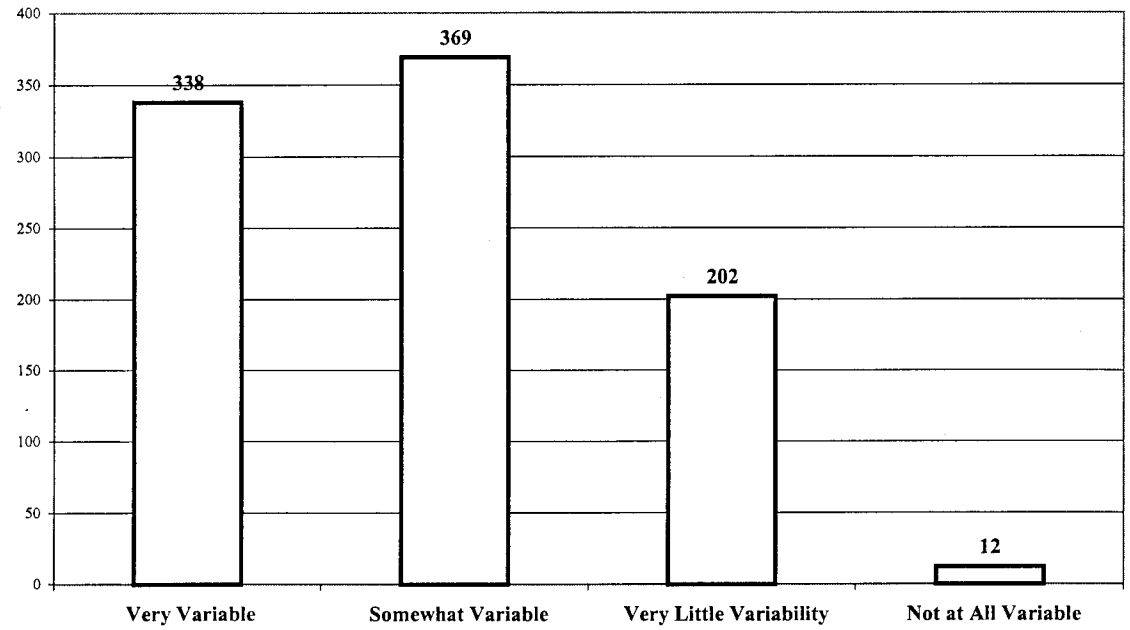
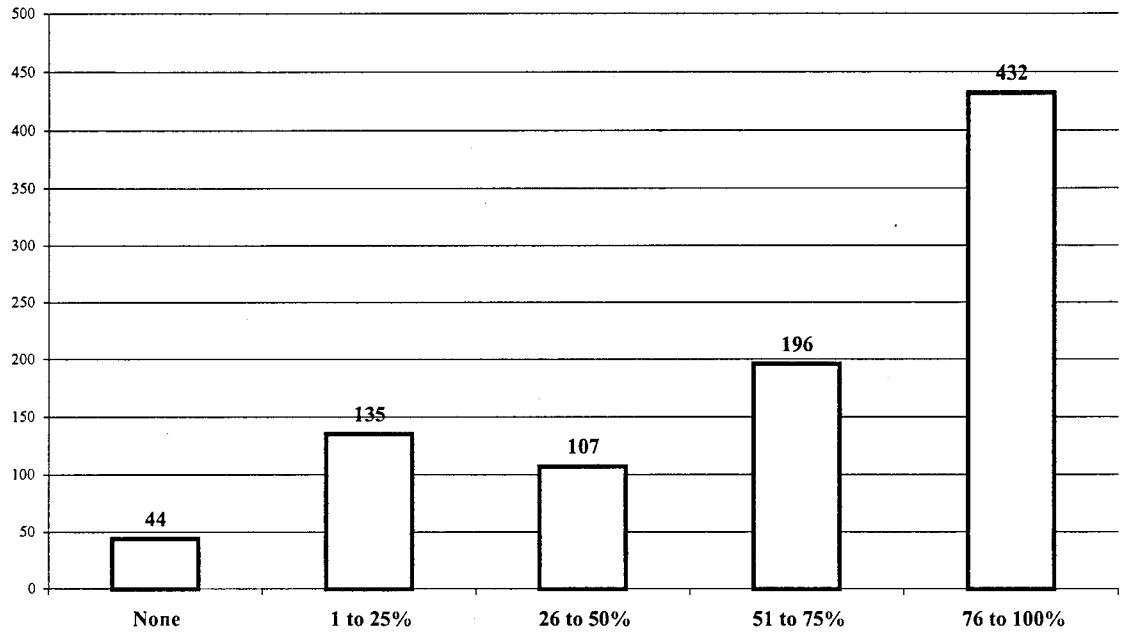


Figure 7
Number of Survey Respondents by Percent of Time Sensitive Hauls



Section IV

Use of Motor Carrier Technologies

IV Use of Motor Carrier Technologies

The two motor carrier surveys reveal that the characteristics of individual motor carriers (size of fleet, type of haul, time-sensitivity of hauls, routing variability, etc.), and their primary operational objectives (on-time performance, safety assurance, cost avoidance, etc.), directly influence the firms' choice of technologies and their perceived value for ITS/CVO services.

The survey findings are summarized in the following text, and presented in Figures 8 through 10 for commonly referenced fleet descriptors—fleet size, length of haul, and carrier type.

Decision/Operations Support Technologies— Computer-Aided Routing/Dispatching, Maintenance Support, Electronic Data Interchange, Internet

- Computer-aided routing and dispatching systems (CAD) are widely used in the trucking industry (53% of surveyed carriers). This is due, in part, to broad ranges in pricing and functionality making CAD a cost effective management tool for many different size and types of trucking operations.

- Adoption of CAD has been strong between 1996 and 1998, an 8.5 percent annual increase. This is seen particularly among private carriers, large fleets, and fleets with average haul lengths of less than 200 miles.

- The extent and intensity in the use of CAD is sensitive to haul type, level of priority for on-time performance, degree of route variability and time-sensitivity of hauls. The extent of CAD use is less sensitive to fleet size and average length of haul, though these factors do increase the intensity of use and degree of integration with other technologies (mobile communications, automatic vehicle location tracking, on-board computers).

- CAD use increases with the degree of routing variability and percent of time-sensitive hauls for firms with on-time performance as their primary operational objective. This is observed particularly in less-than-truckload operations.

- Maintenance support systems (MSS) are used by 30 percent of the surveyed carriers, increasing at six percent per year between 1996 and 1998. Similar to CAD, the strong rate of adoption is due to the vendor community offering a range of MSS to meet the functional and price needs of many diverse fleet types. The strongest adoption rates are observed among short haul carriers.

- In larger or longer haul fleets, MSS is often integrated with CAD to assure timely maintenance with minimal down time.

- In 1998, 58 percent of surveyed fleets were either EDI capable or use the Internet.

- Electronic Data Interchange (EDI) was used by 41 percent of surveyed carriers in 1998. Approximately 33 percent of small to mid-sized firms and 60 percent of large fleets were EDI capable in 1998. Though not captured by this survey,

intensity of EDI use (number of transaction sets sent) is greater among the larger fleets.

- The number of companies using EDI increased 6.5 percent per year between 1996 and 1998, with the strongest adoption rates among large and short haul carriers (9.2 and 8.1 percent, respectively).

- In 1998, 48 percent of surveyed firms reported using the Internet, up from ten percent in 1996. Adoption rates among firms using the Internet is very strong (19 percent per year) and generally consistent across haul types (higher for less-than-truckload carriers), fleet size, haul lengths (lower for short haul carriers), route variability, and time-sensitivity of hauls. Reflecting expected continued strong growth in overall Internet use, strong adoption rates for motor carriers can also be expected to continue for several years.

Communications Technologies—
Mobile Radio, Cellular Phone, Pagers, Mobile Satellite Communications

- Mobile communications technologies are the most widely used technologies in the trucking industry. Of the surveyed motor carriers, 72 percent report using one or more of these technologies.

- Choice of mobile communications technology is sensitive to operational objectives, length of haul, and haul type (truckload versus less-than-truckload).

- Cellular phones and pagers are the most used mobile communications technologies, 62 and 55 percent, respectively. These technologies are highly complimentary and are often used together.

- Strong annual growth is observed in the use of cellular phones (seven percent) and pagers (five percent) between 1996 and 1998. For mobile radio, the adoption rates are significantly lower (1.5 percent). This suggests that improved area coverage, declining service costs, and greater service plan choices make cellular phone and pager services economical to use for smaller, short- to- medium haul length fleets.

- Less-than-truckload carriers use cellular phones, pagers, and mobile radio more extensively than other carrier types. Shorter response time on customer orders, greater time sensitivity of shipments, and the need for tracking/coordinating greater numbers shipments drive this need for improved communications.

- Firms with short turn around time on dispatches as their primary objective are the biggest users of two-way radios and pagers in 1996. By 1998 they are also the biggest users of satellite communications.

- Cellular phones, pagers, and mobile radio are used primarily by motor carriers whose average haul length is less than 500 miles. By fleet size, the level of use of

these technologies is about the same across fleet sizes.

- Satellite communication is primarily used by larger truckload fleets with haul lengths of greater than 500 miles. This technology is very often used with automatic vehicle location tracking and on-board computers.

- The biggest change in satellite communications adoption came from firms that felt on time performance was their most important operating objective.

In-Vehicle Technologies—
On-Board Computers, Electronic Logbooks, Automatic Vehicle Location Tracking, Automatic Vehicle/Equipment Identification, Collision Warning Systems

- Ten percent of surveyed carriers reported using on-board computers (OBC) in 1998, up from six percent in 1996.

- OBCs are used mostly by larger fleets; firms with a greater percent of time-sensitive hauls, less-than-truckload and private carriers, and firms with safety performance as their prime objective.

- Six percent of surveyed carriers used electronic logbooks in 1998, compared to three percent in 1996. Approximately three to four percent of for-hire carriers reported using electronic logbooks, while 18 percent of the surveyed private carriers used the devices.

- Automatic Vehicle Location Tracking (AVL) is primarily used by larger, time-sensitive, variable-route fleets requiring increased asset coordination. Long-haul users are primarily truckload fleets using satellite communications. The short haul users are generally larger pickup and delivery fleets using radio-based AVL.

- Automatic Vehicle/Equipment Identification (AVI) is not widely used in the trucking industry. Three percent of surveyed carriers reported using RF tags in 1998, compared to two percent in 1996. This technology is used primarily by larger fleets to track assets and to coordinate load consolidation; smaller fleets operating in metropolitan areas for electronic toll collection; and fleets participating in electronic clearance programs.

- Collision Warning Systems (CWS) were used by only three percent of the surveyed carriers in 1998. Annual growth between 1996 and 1998 was about one percent per year. The low percent of carriers using CWS can be attributed to the limited number of product offerings; the relative newness of the technology on the market; system costs; carrier perceptions of efficacy; and, carrier reliance on simpler solutions such as oversized mirrors. Carriers also often rely on driver selection, training, and management as a non-technical approach to accident reduction.

Figure 8
Percent of Motor Carriers Using Fleet Technologies and Annual Adoption Rates By Fleet Size

Technology	1 to 25 Power Unit n=110	26 to 100 Power Units n=511	Greater than 100 Power Units n=275
Specialized Mobile Radio			
1996	29%	26%	30%
1998	32%	29%	31%
Annual Adoption Rate	1.4%	1.7%	0.8%
Cellular Phone			
1996	49%	46%	50%
1998	62%	62%	61%
Annual Adoption Rate	6.9%	8.4%	5.2%
Pagers			
1996	47%	43%	47%
1998	53%	54%	56%
Annual Adoption Rate	3.2%	5.4%	4.5%
Satellite Communications			
1996	21%	22%	7%
1998	35%	28%	13%
Annual Adoption Rate	7.0%	3.0%	3.0%
Automatic Vehicle Location			
1996	8%	10%	17%
1998	16%	19%	30%
Annual Adoption Rate	3.7%	4.3%	6.8%
Computer-Aided Routing and Dispatching			
1996	31%	34%	43%
1998	46%	49%	62%
Annual Adoption Rate	7.3%	7.7%	9.4%
On-Board Computers			
1996	8%	5%	10%
1998	12%	6%	18%
Annual Adoption Rate	1.8%	0.7%	4.1%

Figure 8 (Continued)
Percent of Motor Carriers Using Fleet Technologies and Annual Adoption Rates By Fleet Size

Technology	1 to 25 Power Unit n=110	26 to 100 Power Units n=511	Greater than 100 Power Units n=275
Electronic Logbooks			
1996	7%	3%	3%
1998	9%	5%	9%
Annual Adoption Rate	1.0%	0.9%	2.6%
Maintenance Support System			
1996	21%	15%	23%
1998	33%	27%	35%
Annual Adoption Rate	6.0%	5.6%	5.9%
Collision Warning System			
1996	1%	0%	2%
1998	3%	1%	5%
Annual Adoption Rate	1.0%	0.3%	1.8%
EDI			
1996	20%	22%	41%
1998	33%	32%	60%
Annual Adoption Rate	6.4%	5.1%	9.2%
Internet			
1996	11%	9%	12%
1998	52%	42%	57%
Annual Adoption Rate	20.7%	16.4%	22.8%
RF Tags			
1996	5%	2%	2%
1998	7%	2%	4%
Annual Adoption Rate	1.4%	0.2%	1.1%

Figure 9
Percent of Motor Carriers Using Fleet Technologies and Annual Adoption Rates By Average Haul Length

Technology	200 miles or Less n=37	201 to 500 miles n=232	Greater than 500 miles n=639
Specialized Mobile Radio			
1996	41%	46%	20%
1998	43%	49%	22%
Annual Adoption Rate	1.4%	1.7%	1.1%
Cellular Phone			
1996	51%	61%	44%
1998	62%	75%	58%
Annual Adoption Rate	5.4%	7.0%	7.0%
Pagers			
1996	62%	55%	40%
1998	62%	62%	52%
Annual Adoption Rate	0.0%	3.5%	5.9%
Satellite Communications			
1996	5%	4%	22%
1998	11%	11%	35%
Annual Adoption Rate	2.7%	3.5%	6.7%
Automatic Vehicle Location			
1996	14%	4%	14%
1998	27%	10%	26%
Annual Adoption Rate	6.8%	2.6%	5.9%
Computer-Aided Routing and Dispatching			
1996	24%	26%	42%
1998	46%	40%	58%
Annual Adoption Rate	10.8%	7.4%	8.3%
On-Board Computers			
1996	5%	6%	7%
1998	11%	11%	10%
Annual Adoption Rate	2.7%	2.6%	1.8%

Figure 9 (Continued)
Percent of Motor Carriers Using Fleet Technologies and Annual Adoption Rates By Average Haul Length

Technology	200 miles or Less n=37	201 to 500 miles n=232	Greater than 500 miles n=639
Electronic Logbooks			
1996	5%	5%	3%
1998	8%	10%	4%
Annual Adoption Rate	1.4%	2.4%	0.9%
Maintenance Support System			
1996	5%	20%	19%
1998	27%	30%	30%
Annual Adoption Rate	10.8%	4.8%	5.7%
Collision Warning System			
1996	0%	1%	1%
1998	0%	3%	3%
Annual Adoption Rate	0.0%	0.7%	1.0%
EDI			
1996	24%	26%	29%
1998	41%	39%	43%
Annual Adoption Rate	8.1%	6.5%	6.7%
Internet			
1996	8%	8%	12%
1998	32%	43%	51%
Annual Adoption Rate	12.2%	17.6%	19.8%
RF Tags			
1996	0%	2%	2%
1998	3%	3%	3%
Annual Adoption Rate	1.4%	0.7%	0.5%

Figure 10
Percent of Motor Carriers Using Fleet Technologies and Annual Adoption Rates By Carrier Type

Technology	Truckload n=285	Less-than-Truckload n=69	Private Carriers n=172	Specialized Haulers n=401
Specialized Mobile Radio				
1996	30%	59%	18%	24%
1998	33%	67%	23%	24%
Annual Adoption Rate	1.5%	4.0%	2.5%	0%
Cellular Phone				
1996	49%	59%	33%	53%
1998	58%	74%	61%	63%
Annual Adoption Rate	4.5%	7.5%	14.0%	5.0%
Pagers				
1996	45%	68%	38%	45%
1998	53%	80%	46%	57%
Annual Adoption Rate	4.0%	6.0%	4.0%	6.0%
Satellite Communications				
1996	21%	22%	7%	17%
1998	35%	28%	13%	30%
Annual Adoption Rate	7.0%	3.0%	3.0%	6.5%
Automatic Vehicle Location				
1996	14%	16%	8%	11%
1998	25%	22%	16%	21%
Annual Adoption Rate	5.5%	3.0%	4.0%	5.0%
Computer-Aided Routing and Dispatching				
1996	39%	43%	29%	37%
1998	54%	58%	48%	53%
Annual Adoption Rate	7.5%	7.5%	9.5%	8.0%
On-Board Computers				
1996	4%	12%	12%	4%
1998	6%	16%	19%	8%
Annual Adoption Rate	1.0%	2.0%	3.5%	2.0%

Figure 10 (Continued)
Percent of Motor Carriers Using Fleet Technologies and Annual Adoption Rates By Carrier Type

Technology	Truckload n=285	Less-than-Truckload n=69	Private Carriers n=172	Specialized Haulers n=401
Electronic Logbooks				
1996	1%	3%	11%	1%
1998	3%	4%	18%	2%
Annual Adoption Rate	1.0%	0.5%	3.5%	0.5%
Maintenance Support System				
1996	20%	29%	19%	15%
1998	31%	42%	32%	25%
Annual Adoption Rate	5.5%	6.5%	6.5%	5.0%
Collision Warning System				
1996	2%	0%	1%	0%
1998	3%	0%	2%	3%
Annual Adoption Rate	0.5%	0%	0.5%	1.5%
EDI				
1996	31%	52%	20%	25%
1998	47%	68%	31%	37%
Annual Adoption Rate	8.0%	8.0%	5.5%	6.0%
Internet				
1996	11%	14%	10%	9%
1998	51%	61%	51%	42%
Annual Adoption Rate	20.0%	23.5%	20.5%	16.5%
RF Tags				
1996	1%	3%	5%	0%
1998	2%	3%	8%	1%
Annual Adoption Rate	0.5%	0.0%	1.5%	0.5%

Section V

Technology Impacts on Motor Carrier Operations

V. Technology Impacts on Motor Carrier Operations

Motor carriers measure operational performance through many metrics. The specific metrics and the priorities assigned to them often vary from one motor carrier to the next, depending on the carriers' specific operational objectives and fleet configurations. Figure 11 presents often-used metrics and the technologies that can impact them based on the 172 responses to the NPTC Private Fleet survey. Through discussion with numerous for-hire motor carriers and review of earlier ATA Foundation survey results[4], it is believed that the private fleet responses reflect the operational impacts of technology experienced by many for-hire industry segments.

Many of these observed impacts can be attributed to:

- Improved driver/vehicle utilization with reduced costs per load through reduced out-of route miles or empty miles.
- Reduced fuel costs through improved routing, vehicle/driver monitoring, fuel price lookups, improved mechanical efficiency of vehicle through timely maintenance.
- Higher driver job satisfaction and personnel retention through improved earnings, reduced scheduling pressures, reduced paperwork burdens, increased time at home, ability to be reached by family while on the road, etc.
- Improved safety performance through enhanced scheduling, vehicle/driver performance monitoring, retention of safe drivers, timely maintenance, warning drivers of obstacles/unsafe conditions.
- Improved customer satisfaction through automated order entry/invoicing, load status reports, increased on-time performance.
- Increased desk-side productivity and reduced administrative costs through migration to a "paperless" organization and use of decision support systems.

Quantifying the Technology Impacts

To estimate the operational impacts of fleet technologies, the 760 ATA Foundation survey responses were combined with available published financial and operating statistics.[5] Financial and operating statistics for most of the respondents to the NPTC survey were not available, therefore these observations were not included in the quantitative analysis.

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[4] ATA-96

[5] ATA 1996 Motor Carrier Finance and Operating Statistics Annual Report; Transportation Technical Services Blue Book 1997-1998.

Figure 11
Operational Impacts of Motor Carrier Technologies
Reported by Private Fleets Using the Technologies

Fleet Operational/Safety Impacts	Mobile Communications (n=130)	Vehicle Location Tracking (n=27)	On-Board or Handheld Computers (n=37)	Electronic Logbooks (n=34)	Transponders (n=14)	Collision Avoidance System (n=4)	Electronic Data Interchange (n=51)	Internet Access (n=87)	Computer Aided Routing-Dispatching (n=75)	Maintenance Support Systems (n=59)
Improved on-time performance	57%	30%	32%	9%	36%		6%	8%	37%	12%
Increased pick-ups/deliveries	47%	33%	16%	3%	7%		4%	11%	23%	3%
Improved equipment utilization	49%	33%	30%	6%	7%		8%	11%	41%	25%
Improved load tracking/status	37%	44%	16%	3%			4%	7%	15%	
Reduced en-route delays	40%	22%	11%	6%	36%		4%	5%	17%	19%
Reduced empty miles	35%	22%	11%				6%	5%	35%	2%
Reduced fuel consumption	11%	19%	38%	15%	7%		4%		27%	19%
Reduced dispatcher/driver ratios	12%		8%	12%			4%	1%	15%	2%
Reduced administrative costs	19%	4%	24%	21%			12%	13%	16%	24%
Reduced maintenance costs	5%		16%	6%	7%		2%	1%		46%
Improved information flow	68%	37%	8%	3%			12%	23%	15%	7%
Improved driver utilization	48%	30%	27%	18%	29%		2%	5%	40%	2%
Improved driver retention	17%	4%	8%	15%	7%			5%	5%	3%
Improved hours-of-service monitoring	18%	7%	49%	53%			2%		13%	
Improved driver performance monitoring	26%	11%	49%	32%	7%		2%	1%	16%	10%
Improved roadside inspection performance	3%		19%	15%	21%	25%		1%		32%
Reduced accidents	3%	4%	24%	18%	14%	25%		1%	1%	12%
Improved compliance with regulations	8%	11%	38%	38%	14%		2%	13%	11%	29%
Reduced insurance costs	2%		19%	21%	7%	25%				10%

Many of the impacts described in Figure 11 can be captured as reductions in labor costs (drivers, dispatchers, and clerical staff); fuel costs; maintenance costs; and, insurance costs.

These items represent significant variable operating costs to motor carriers. As a percent of a motor carriers total operating expense these items average: drivers (23%); fuel (10%); maintenance (5%); dispatchers (4%); insurance (4%); and, clerical staff (4%). Even moderate performance improvements in these areas could significantly add to a motor carrier's profitability.

To account for different operating characteristics and cost structures, the survey sample was segmented based on ranges of fleet size and average length of haul, and haul type (truckload, less-than-truckload, specialized carriers). Analysis of Variance (ANOVA) techniques used to identify significant cost differences (at the 95% confidence level) for the segments between motor carriers using technologies and those who do not, holding constant:

- Scale of operations/output—number of power units operated and gross revenue.
- Equipment rents and transportation services purchased from other firms as measured in dollars and distribution of fleet miles between owned vehicles, leased without drivers and leased with drivers.
- Geographic range of operation (average haul).
- Time sensitivity of shipments.
- Degree of routing variability.
- Primary marketing objectives (lowest freight rates, on-time performance, short turn-around time on pickups, safety performance, and specialized equipment).
- Complimentary technologies.

For each segment, the estimated cost reductions were divided by the average number of power units operated by the motor carriers who do not use a particular technology to calculate a per power unit technology benefit. Technology costs per power unit were based on the likely cost of a system given the general fleet characteristics of each segment (i.e., small fleets would opt for lower cost, simpler technology solutions, while larger or more geographically distributed fleets may require more sophisticated integrated information gathering and decision support technologies). The benefit/cost ratios developed in this analysis represent the estimated per power unit benefit divided by the likely cost of the technology per power unit.

The fleet characteristics of the segments do overlap, which can allow some inferences to be drawn where the number of carriers in a specific segment using a technology may be too few to estimate impacts. The characteristics of the sample segments are as follows:

Truckload Carriers

- Primarily fleets of 26 to 100 power units (66%).
- Generally long haul.
- Majority of hauls are time sensitive.
- Routing is variable.

Less-than-Truckload Carriers

- Primarily fleets of 100 or more power units (58%).
- Haul lengths are generally less than 200 miles.
- Hauls are very time sensitive.
- Routes are evenly distributed between variable and fixed.

Specialized Carriers

- Primarily fleets of 26 to 100 power units (65%).
- Haul lengths are mostly 100 to 250 miles.
- Hauls are time sensitive.
- Most routing is variable.

Short Haul (1-200 miles)

- Mostly fleets of 26 to 100 power units.
- Hauls are generally not very time-sensitive.
- Routing is mostly fixed.

Medium Haul (201 to 500 miles)

- Mostly fleets of 26 to 100 power units.
- Hauls are generally not very time-sensitive.
- Routing is mostly variable.

Long Haul (Greater than 500 miles)

- Fleets are predominantly 26 power units or greater (evenly distributed between fleets of 26 to 100 power units and fleets of greater than 100 power units).
- Hauls are very time-sensitive.
- Routing is mostly variable.

Figures 12 through 16 present the estimated per power unit cost savings and calculated benefit/cost ratios for CAD, mobile communications, on-board computers, maintenance support systems, and EDI/Internet—technologies used by sufficient numbers of carriers to estimate impacts. Blank cells represent no statistically significant difference in costs—due to no significant impact or too few carriers represented for either the technology user or non-technology user groups for the segment. The following summarizes the findings:

Computer-Aided Routing and Dispatching

The use of CAD is observed to yield significant benefits to many types of motor carriers. These benefits are derived through improved coordination and utilization of personnel and assets. Cost reductions in the following ranges can be seen: driver labor costs—five to 10 percent; fuel costs—eight to 15 percent; maintenance costs—13 to 26 percent; dispatcher labor costs—11 to 25 percent; and, insurance costs—seven to 15 percent. A wide range of CAD products are available to motor carriers at relatively low cost per power unit result in strong benefit/cost ratios for the technology—ranging from 3.1:1 to 9.4:1.

Mobile Communications

Similar to CAD, many segments of the motor carrier industry could realize benefits of mobile communications. These benefits could accrue through rapid relay of new load information, travel conditions, or vehicle or driver availability thus improving personnel and asset utilization and potentially customer service. Mobile communications service offerings are numerous, with pricing that can make the technology economically feasible for many diverse types of motor carriers. Observed reductions in operating costs were: driver labor costs—five to 16 percent; fuel costs—eight to 20 percent; maintenance costs—eight to 24 percent; dispatcher labor costs—nine to 34 percent; and, insurance costs—six to 25 percent. Benefit/cost ratios calculated for mobile communications range from 4.4:1 to 6.3:1.

On-Board/Hand-Held Computers

The functions of OBCs—data collection, processing, and communications support—primarily support load tracking, fleet asset management, driver management, and general administrative tasks. OBCs can be an expensive technology to purchase and use relative to the need for data collection and tight tracking/monitoring of loads, assets, or personnel for many segments of the industry. Operating cost reductions fall into the ranges of: driver labor costs—three to 14 percent; fuel costs—12 to 24 percent; maintenance costs—five to nine percent; and, insurance costs—eight to 21 percent. Benefit/cost ratios for on-board computer systems range from 0.3:1 to 6.6:1.

Maintenance Support Systems

The benefits to firms using maintenance support systems examined in this analysis include reductions in maintenance and insurance costs derived through enhanced preventative maintenance programs. The observed benefits are: maintenance costs—seven to 21 percent and insurance costs—six to 19 percent. Benefit/cost ratios calculated for maintenance support systems range from 0.7:1 to 1.8:1.

Electronic Data Interchange/Internet Access

The benefit of EDI/Internet Access estimated in this analysis is limited to reductions in overall clerical labor costs. These reductions are assumed to be derived through improved administrative efficiencies. The cost reductions ranged from five percent for small firms to eleven percent for mid- to large carriers. Benefit/cost ratios ranged from 2.7:1 to 11.7:1.

Figure 12
Estimated Annual Cost Savings Per Power Unit; Percent Savings; and Benefit/Cost Ratios Attributable to Computer-Aided Routing and Dispatching*

Fleet Characteristic	Drivers	Fuel	Insurance	Maintenance	Dispatchers	Total
Haul Type						
Truckload	$1,740 7%	$1,718 13%	$373 7%	$1,128 17%	$807 24%	$5,767
Less-than- Truckload	$2,003 5%	$642 9%	$330 7%	$1,467 19%	$840 25%	$5,282
Other Specialized Carriers		$860 8%	$499 10%	$1,059 14%	$468 19%	$2,887
Average Haul Length						
200 miles or Less		$1,925 15%	$468 8%		$401 19%	$2,794
201 to 500 miles	$2,663 9%	$1,249 15%			$610 19%	$4,522
Greater than 500 miles	$2,288 9%		$813 15%	$883 13%	$158 9%	$4,142
Fleet Size						
1 to 100 Units	$2,915 10%		$494 9%	$1,337 26%	$1,335 17%	$6,081
Greater than 100 Units			$443 9%	$1,674 20%	$297 11%	$2,414

Fleet Characteristic	Drivers	Fuel	Insurance	Maintenance	Dispatchers	Total
Haul Type						
Truckload	2.3:1	2.3:1	0.5:1	1.5:1	1.1:1	7.7:1
Less-than- Truckload	2.7:1	0.9:1	0.4:1	2.0:1	1.2:1	7.1:1
Other Specialized Carriers		1.2:1	0.7:1	1.5:1	0.7:1	4.2:1
Average Haul Length						
200 miles or Less		2.2:1	0.5:1		0.4:1	3.1:1
201 to 500 miles	4.7:1	2.2:1			1.1:1	8.0:1
Greater than 500 miles	5.2:1		1.9:1	2.0:1	0.4:1	9.4:1
Fleet Size						
1 to 100 Units	2.9:1		0.5:1	1.3:1	1.3:1	6.0:1
Greater than 100 Units			0.6:1	2.2:1	0.4:1	3.3:1

*** Note: Impacts are not additive across fleet characteristics**

Figure 13
Estimated Annual Cost Savings Per Power Unit; Percent Savings; and Benefit/Cost Ratios Attributed to Mobile Communications Systems*

Fleet Characteristic	Drivers	Fuel	Insurance	Maintenance	Dispatchers	Total
Haul Type						
Truckload	$1,423 8%	$1,887 12%	$755 15%	$1,040 21%	$593 21%	$5,698
Less-than- Truckload	$2,724 6%	$830 15%	$601 12%	$781 9%		$4,936
Other Specialized Carriers	$3,202 16%	$1,015 9%	$681 13%	$1,163 18%		$6,061
Average Haul Length						
200 miles or Less	$2,940 10%	$1,335 14%	$1,145 24%		$444 16%	$5,863
201 to 500 miles	$3,119 11%	$1,629 16%	$571 11%	$1,091 16%	$435 16%	$6,852
Greater than 500 miles	$3,394 12%	$2,067 14%	$461 9%	$432 6%	$940 34%	$7,294
Fleet Size						
1 to 100 Units	$3,083 12%	$1,156 8%	$459 9%	$1,211 25%	$390 9%	$6,297
Greater than 100 Units	$1,667 5%	$2,507 20%	$402 8%	$1,214 15%	$667 23%	$6,456

Fleet Characteristic	Drivers	Fuel	Insurance	Maintenance	Dispatchers	Total
Haul Type						
Truckload	1.3:1	1.7:1	0.7:1	0.9:1	0.5:1	5.1:1
Less-than-Truckload	2.4:1	0.7:1	0.5:1	0.7:1		4.4:1
Other Specialized Carriers	2.9:1	0.9:1	0.6:1	1.1:1		5.6:1
Average Haul Length						
200 miles or Less	2.7:1	1.2:1	1.1:1		0.4:1	5.4:1
201 to 500 miles	2.9:1	1.5:1	0.5:1	1.0:1	0.4:1	6.3:1
Greater than 500 miles	3.1:1	1.9:1	0.4:1	0.4:1	0.8:1	4.6:1
Fleet Size						
1 to 100 Units	2.8:1	1.1:1	0.4:1	1.1:1	0.4:1	5.8:1
Greater than 100 Units	0.9:1	2.3:1	0.4:1	1.1:1	0.5:1	5.4:1

*** Note: Impacts are not additive across fleet characteristics**

Figure 14
Estimated Annual Cost Savings Per Power Unit; Percent Savings; and Benefit/Cost Ratios Attributed to On-Board/Handheld Computer Systems*

Fleet Characteristic	Drivers	Fuel	Insurance	Maintenance	Dispatchers	Total
Haul Type						
Truckload	$791 3%		$415 8%	$530 9%		$1,736
Less-than- Truckload	$3,657 8%	$937 12%		$430 5%		$5,024
Other Specialized Carriers	$2,672 12%	$1,578 15%	$494 8%			$4,743
Average Haul Length						
200 miles or Less			$315 8%			$315
201 to 500 miles	$3,067 14%		$332 20%			$3,339
Greater than 500 miles	$3,009 9%	$3,153 16%	$497 10%			$6,659
Fleet Size						
1 to 100 Units		$3,266 24%	$755 21%			$4,333
Greater than 100 Units						

Fleet Characteristic	Drivers	Fuel	Insurance	Maintenance	Dispatchers	Total
Haul Type						
Truckload	0.8:1		0.4:1	0.5:1		1.7:1
Less-than- Truckload	3.6:1	0.9:1		0.4:1		5.0:1
Other Specialized Carriers	2.6:1	1.5:1	0.5:1			4.6:1
Average Haul Length						
200 miles or Less			0.3:1			0.3:1
201 to 500 miles	3.0:1		0.3:1			3.3:1
Greater than 500 miles	3.0:1	3.1:1	0.5:1			6.6:1
Fleet Size						
1 to 100 Units		3.0:1	1.0:1			4.0:1
Greater than 100 Units						

*** Note: Impacts are not additive across fleet characteristics**

Figure 15
Estimated Annual Cost Savings Per Power Unit; Percent Savings; and Benefit/Cost Ratios Attributed to Maintenance Support Systems*

Fleet Characteristic	Drivers	Fuel	Insurance	Maintenance	Dispatchers	Total
Haul Type						
Truckload			$999 19%	$1,462 21%		$2,460
Less-than- Truckload			$332 6%	$569 7%		$902
Other Specialized Carriers			$637 13%	$995 14%		$3,416
Average Haul Length						
200 miles or Less						
201 to 500 miles			$970 20%			$3,349
Greater than 500 miles			$678 13%	$1,717 14%		$2,395
Fleet Size						
1 to 100 Units						
Greater than 100 Units			$860 8%			$860

Fleet Characteristic	Drivers	Fuel	Insurance	Maintenance	Dispatchers	Total
Haul Type						
Truckload			0.7:1	1.0:1		1.7:1
Less-than- Truckload			0.3:1	0.4:1		0.7:1
Other Specialized Carriers		1.2:1	0.4:1	0.7:1		2.3:1
Average Haul Length						
200 miles or Less						
201 to 500 miles		1.7:1	0.7:1			2.4:1
Greater than 500 miles			0.5:1	1.3:1		1.8:1
Fleet Size						
1 to 100 Units						
Greater than 100 Units			0.7:1			0.7:1

*** Note: Impacts are not additive across fleet characteristics**

Figure 16
Estimated Annual Cost Savings Per Power Unit; Percent Savings; and Benefit/Cost Ratios Attributed to Electronic Data Interchange/Internet Access*

Fleet Characteristic	Clerical Staff Labor Costs	Benefit/Cost Ratios
Haul Type		
Truckload	$1,291 11%	5.3:1
Less-than- Truckload	$1,923 11%	9.6:1
Other Specialized Carriers	$1,443 11%	8.1:1
Average Haul Length		
200 miles or Less	$561 5%	2.7:1
201 to 500 miles	$2,428 11%	11.7:1
Greater than 500 miles	$1,774 11%	9.6:1
Fleet Size		
1 to 100 Units	$907 5%	3.1:1
Greater than 100 Units	$1,140 11%	5.7:1

*** Note: Impacts are not additive across fleet characteristics**

Section VI

Intelligent Transportation Systems/ Commercial Vehicle Operations Services

VI. Intelligent Transportation Systems/Commercial Vehicle Operations Services

The OMCS-led National ITS/CVO program is envisioned to enhance roadway safety and operational efficiencies through development of institutional relationships and technology infrastructure allowing seamless CVO information exchange among authorized stakeholders. Participation in ITS/CVO is voluntary for all stakeholders.

This section describes the functions of the National Intelligent Transportation Systems/Commercial Vehicle Operations (ITS/CVO) Program; how technologies currently used to support fleet operations could enable motor carrier participation in ITS/CVO services; how motor carriers perceive the value of ITS/CVO services; and, based on the above, presents estimates of motor carrier participation in fully deployed ITS/CVO services.

ITS/CVO Program Areas

The National ITS/CVO Program is comprised of four program areas: Safety Assurance, Credentials Administration, Electronic Screening, and Carrier Operations. The functions of the four program areas are described in the following text. Figure 17 provides an overview of possible applications of motor carrier technologies in supporting the functions of ITS/CVO services.

Safety Assurance—improve targeting of high-risk operators for inspection rather than the entire motor carrier population through roadside access to real-time safety information; automate safety inspection activities to reduce inspection time and improve consistency; and, support in-vehicle safety monitoring.

Targeting and inspection functions currently being tested and deployed include:

- identify vehicle;
- electronically access vehicle and carrier safety history;
- review driver logbooks;
- inspect vehicle systems;
- issue citations;
- document/upload inspection results;
- conduct safety audits/compliance reviews;
- review/analyze areas of deficiency in safety management practices of "high-risk" carriers; develop and deliver remedial educational programs;
- provide on-line access to motor carrier safety rules and regulations;
- provide on-line access to fleet safety inspection information.

Safety monitoring functions under development or currently in limited use include:

- monitor performance of vehicle systems;
- monitor and evaluate driver fitness for duty/performance;
- monitor load for stability/leakage;
- monitor condition of road surface (i.e., black ice);
- monitor presence of and closure rate to other vehicles or roadway obstacles;
- notify driver or carrier of unsafe conditions or performance exceptions;

- record information for later retrieval and review by carrier maintenance and safety departments.

Motor carrier technologies that could support these functions include: EDI, Internet, OBCs, electronic logbooks, and AVI.

Credential Administration—automate regulatory functions and enhance data communications capabilities of state agencies to enable paperless transactions between motor carriers and agencies.

Credential Administration functions include:

- automate collection and calculation of mileage and fuel use by jurisdiction;
- electronically apply for and receive CVO credentials;
- calculate fees and taxes due;
- electronically file fuel tax reports and respond to audit inquiries;
- electronically pay fees and taxes;
- automate response to audit inquiries.

Motor carrier technologies that could support these functions include: EDI, Internet, CAD, OBCs, electronic logbooks, AVL, and CWS.

Electronic Screening—screen commercial vehicles for size/weight, safety, and credential compliance at mainline speeds.

Electronic screening functions include:

- identify vehicle and carrier;
- weigh vehicle in motion;
- electronically access vehicle and carrier safety history;
- electronically verify carrier credentials;
- approve clearance or conduct inspection.

The motor carrier technology most widely used to participate in electronic screening is AVI/AVE using RF Tags.

Carrier Operations—enhance motor carrier safety and efficiencies through technical/programmatic support for: delivery of timely and accurate information to fleet managers; outreach regarding benefits of technology-enhanced fleet operations; bringing emerging technologies to market; and, providing responders to hazardous materials incidents rapid access to information concerning the shipment.

A Carrier Operations service holding great promise for motor carriers is Advanced Traveler Information Services for Commercial Vehicle Operations (ATIS/CVO) to support enhanced fleet routing and dispatching. ATIS/CVO allows motor carriers to ascertain vehicle location, rate of travel, status of constraints (i.e., available hours-of-service); access CVO specific travel information; calculate impact of travel conditions on schedules/routes; reroute/re-deploy fleet assets; communicate information to driver; and, notify shippers/receivers of scheduling changes.

Hazardous Materials Incident Response functions could include:

- identify vehicle;
- responder/emergency response center access to carrier load information;
- load information and emergency procedures to responders;
- notification of incident to carrier, clean-up contractor, insurance company, etc.

Motor carrier technologies that could support Carrier Operations functions include: EDI, Internet, CAD, Mobile Communications, OBCs, AVL, and AVI.

A non-CVO specific service which could enhance fleet operations is electronic toll collection. Motor carrier technologies, which could support this service, include: RF tags, EDI, and Internet.

Figure 17—Motor Carrier Technologies and Possible Applications for ITS/CVO Services

Motor Carrier Technologies	Technology B/C Ratios in Fleet Operations	Number of Carriers Currently Using Technology	Expected Growth Rate in Number of Carriers Using Technology	Applicable to ITS/CVO Service/Program Area	Possible Application in ITS/CVO Service
EDI/Internet	2.7:1 to 11.7:1	High	High	Safety Assurance- Electronic Access to Fleet Safety Information and Motor Carrier Rules and Regulations	-Carrier access to fleet safety inspection reports to enhance monitoring. -Carrier access to regulatory safety requirements-federal and state-specific.
				Electronic Credentialing, Fuel Tax Administration, Permitting	-Transmittal of carrier data, forms, supporting documentation to agencies. -Reception of credentials. -Payment of fees/taxes.
				Real-Time Traffic Information	-Access ATIS/CVO Server for retrieval of information. -Notify shippers or receivers of scheduling changes.
				Hazardous Materials Incident Response	-Posting of load information for access by emergency responders.
Computer-aided Routing and Dispatching	3.3:1 to 9.4:1	High	Moderate	Electronic Credentialing, Fuel Tax Administration, Permitting	-Automated carrier collection of mileage data from dispatches for apportionment calculations.
				Real-Time Traffic Information	-Integration of exception-based travel information to trigger re-routing, scheduling, and load assignments.
				Hazardous Materials Incident Response	-Automated carrier collection of vehicle/load information from dispatches.
Mobile Communications	4.4:1 to 6.3:1	High	Moderate	Real-Time Traffic Information	-Driver access to ATIS/CVO information via cellular phone. -Dispatcher communicates incident/ routing information to drivers.
				Safety Assurance- On-board Monitoring	-Remote monitoring of driver available hour-of-service. -Remote monitoring of vehicle systems.

Figure 17 (Continued)—Motor Carrier Technologies and Possible Applications for ITS/CVO Services

Motor Carrier Technology	Technology B/C Ratios in Fleet Operations	Number of Carriers Currently Using Technology	Expected Growth Rate in Number of Carriers Using Technology	Applicable to ITS/CVO Service/Program Area	Possible Applications of Technology in ITS/CVO Services
On-Board Computers	0.3:1 to 6.6:1	Low	Low	Safety Assurance- On-board Monitoring	-Monitor driver/vehicle performance either in real-time or historically.
				Safety Assurance- Automated Roadside Inspections	-Automate recording/demonstration of drivers' hours-of-service. -Presentation of vehicle systems performance data to inspectors.
				Electronic Credentialing, Fuel Tax Administration, Permitting	-Automated carrier data collection for apportionment calculations.
Electronic Logbooks	1.3:1 to 1.4:1* **	Very Low	Low	Safety Assurance- Automated Roadside Inspections	-Automate recording/demonstration of drivers' hours-of-service.
				Electronic Credentialing, Fuel Tax Administration, Permitting	-Data capture for apportionment calculations.
Maintenance Support Systems	0.7:1 to 2.4:1	Moderate	Moderate	Safety Assurance- Automated Roadside Inspections	-Automated maintenance records/reports possibly stored via on-board/handheld computers or RF-tags for electronic access by enforcement.
				Safety Assurance- Electronic Access to Fleet Safety Information	-Carrier access to fleet safety inspection reports providing input to flag vehicles for maintenance and repairs.
AVI / RF-Tags	Not Estimated**	Very Low	Low	Electronic Screening	-Identify vehicle/carrier at mainline speeds. -Transmittal of information to/from roadside enforcement.
				Hazardous Materials Incident Response	-Identify carrier/load information to emergency responders.
				Electronic Toll Collection	-Identify carrier/vehicle for toll payment.

Figure 17 (Continued)—Motor Carrier Technologies and Possible Applications for ITS/CVO Services

Motor Carrier Technology	Technology B/C Ratios in Fleet Operations	Number of Carriers Currently Using Technology	Expected Growth Rate in Number of Carriers Using Technology	ITS/CVO Service	Possible Applications of Technology in ITS/CVO Services
AVL	Not Estimated**	Low	Low	Safety Assurance- On-board Monitoring	-Carrier monitor vehicle speeds/location in real-time supporting review of driver performance or scheduling/routing based on available hours-of-service.
				Electronic Credentialing, Fuel Tax Administration	-Automated carrier data collection for apportionment calculations.
				Real-Time Traffic Information	-Vehicle position reports support CAD response to incident reports.
				Hazardous Materials Incident Response	-Vehicle position reports support identification of loads by responders
Collision Warning Systems	Not Estimated**	Very Low	Low	Safety Assurance- On-board Monitoring	-Provide warnings to drivers of closure rates on obstacles. Optional features could include alert documentation for driver performance review.

* Estimated benefit/cost ratio is based on previous ATA Foundation research—Assessment of Intelligent Transportation Services/Commercial Vehicle Operations User Services: ITS/CVO Qualitative Benefit/Cost Analysis.

** Too few carriers in sample used the technology to develop statistically significant benefit estimates.

Motor Carrier Value Perceptions for ITS/CVO Services

How motor carriers perceive value for ITS/CVO services/functions can provide a benchmark from which potential participation levels in the services can be estimated. Care should be used in interpreting value rankings, however, as they assume that carriers have full knowledge regarding the technical requirements, costs and benefits, and issues involved in participation. Value rankings also assume that a service will function as designed.

A high value ranking for a service by a large percent of carriers does not assure high participation rates. Such a value ranking would be better interpreted as existence of high interest in a service/function, but as more information is provided to carriers regarding operational parameters and business/regulatory risks, interest and willingness to participate may be affected either positively or negatively.

This notwithstanding, this analysis attempts to estimate potential motor carrier participation in fully deployed/mature ITS/CVO services using motor carrier value perceptions constrained by observed growth in the number of carriers using enabling technologies and institutional issues which could depress participation levels.

To gauge value levels, the surveyed motor carriers were asked to rate how they perceive the value of ITS/CVO services/functions to their business (1=no value, 5=high value). The results show that the highest values are placed on services in which:

- technology requirements for participation involve the use of technologies currently widespread in use (proven, cost-effective, and interoperable technologies requiring little or no modifications for participation);
- a service has the potential for reducing a perceived regulatory burden on the carriers;
- the services provide useful information to fleet/safety managers; and,
- use of the services is initiated by the carriers.

It is also seen that the perceived value for ITS/CVO services is sensitive to fleet operating characteristics such as fleet size, range of operations, time sensitivity of hauls, and route variability. Figure 18 presents the factors (technology use and fleet characteristics) that significantly correlate to perceived high value (a ranking of 4 & 5) for ITS/CVO services. Directly related factors are those in the use of a technology or a firm characteristic (i.e., fleet size, time sensitivity of hauls) would result in a higher perceived value for a service. An inversely related factor would show an opposite relationship (i.e., an increase in value perception for a decrease in the factor, or visa versa).

Figure 19 presents the percent of surveyed carriers by fleet size and average length of haul perceiving values of high (5), mid to high (4 and 5), and moderate to high (3, 4 and 5), respectively. These relationships and value perceptions are discussed in the following text.

Electronic credentialing/fuel tax administration services values are greater as fleet size and average length of haul increases. This is due to the higher number of credentialing transactions and a greater proportion of credentialing and tax administrative activities conducted in-house. These are

typically supported by better capitalized and more developed technology infrastructure as carrier size or haul length increases.

Value placed on informational services such as access to fleet safety performance or motor carrier rules and regulations lessens due to staff specialization in safety management, along with greater information gathering/processing/management infrastructure as fleet size increases. Smaller fleets, especially with longer haul lengths would likely see the greatest value added for these services as they could represent a relatively cost effective source of information.

Value for electronic screening and automated safety inspections is seen to generally decrease as fleet size increases. Larger motor carriers have cited that "down-time" for inspections either does not represent a significant cost to their businesses or that reduced inspections/inspection time does not represent a savings that can be practically captured. They also note that as carriers with well-developed safety programs, they are well known to enforcement officials and may not be as intensively targeted for inspections.

Not surprisingly, carriers with greater than 50 percent of hauls being time sensitive, place a higher value on roadside screening and automated safety inspection services than those with less than half of hauls being time sensitive. This would suggest likely participation by carriers servicing "just-in-time" or similar customers with tight delivery windows. It is also observed that value increases as length of haul (and therefore, exposure to numerous inspections per trip) increases.

Carrier value perceptions for real-time traffic and travel information and electronic toll collection relate to fleet factors in similar fashion and for many of the same reasons as electronic screening or automated safety inspections. Carriers whose majority of hauls are time-sensitive also give these services higher values. It should be mentioned that participation by fleets with exposure to areas of heavy congestion or numerous toll plazas would be expected to be significantly higher than among those carriers operating in areas of lower exposure.

Value for Hazardous Materials Incident Response posts increases as fleet sizes increase and haul lengths decrease. Obviously, the number of hazmat hauls and type of materials transported would strongly influence potential participation.

Figure 18
Significant Factors Relative to Value Perceptions for ITS/CVO Services

ITS/CVO Service	Directly Related Factors	Inversely Related Factors
Electronic Registration Credentialing	-EDI -Internet Access -Computer-Aided Routing and Dispatching -Average Length of Haul -Fleet Size	-Time Sensitivity of Hauls -Degree of Route Variability
Electronic Fuel Tax Credentialing	-EDI -Internet Access -Computer-Aided Routing and Dispatching -On-Board Computers -Average Length of Haul -Fleet Size	-Time Sensitivity of Hauls -Degree of Route Variability
Electronic Fuel Tax Filings/Payments	-EDI -Internet Access -Computer-Aided Routing and Dispatching -Time Sensitivity of Hauls -Average Length of Haul -Fleet Size	
Electronic Oversize/Overweight Permitting	-EDI -Internet -Average Load -Fleet Size	-Time Sensitivity of Hauls -Degree of Route Variability
Electronic Safety/Weight Screening	-Computer-Aided Routing and Dispatching -Internet Access -Maintenance Support Systems -Time Sensitivity of Hauls -Average Length of Haul	-Degree of Route Variability -Fleet Size
Automated Roadside Safety Inspections (Including Demonstration of Hours-of-Service Compliance via Electronic Logbooks)	-Electronic Log Books -EDI -Computer-Aided Routing and Dispatching -On-Board Computers -Maintenance Support Systems -Mobile Communications -Average Length of Haul	
Real-Time Access to Fleet Safety Inspection Reports	-Internet Access -Computer-Aided Routing and Dispatching -Maintenance Support Systems -Mobile Communications -On-Board Computers -Time Sensitivity of Hauls	-Degree of Route Variability -Fleet Size

Figure 18 (Continued)
Significant Factors Relative to Value Perceptions for ITS/CVO Services

ITS/CVO Service	Directly Related Factors	Inversely Related Factors
Electronic Access to Motor Carrier Rules and Regulations	-Internet Access -Maintenance Support Systems -Time Sensitivity of Hauls -Average Length of Haul	-EDI -On-Board Computers -Fleet Size
Access to Real-Time Traffic and Travel Information	-Computer-Aided Routing and Dispatching -Internet Access -Mobile Communications -Degree of Route Variability -Average Length of Haul	
Electronic Toll Collection	-Computer-Aided Routing and Dispatching -EDI -Internet Access -On-Board Computers -Average Length of Haul	-Fleet Size
Hazardous Materials Incident Response	-EDI - Computer-Aided Routing and Dispatching -Mobile Communications -On-Board Computers -Fleet Size	-Time Sensitivity of Hauls -Average Length of Haul

Figure 19
Percent of Surveyed Motor Carriers Perceiving Value for ITS/CVO Services As High (5) and Mid to High (4 & 5), and Moderate to High (3, 4, &5)

ITS/CVO Service/Function	Fleet Size								
	1 to 24 Power Units			25 to 100 Power Units			Greater than 100 Power Units		
Value=>	(5)	(4&5)	(3, 4, &5)	(5)	(4&5)	(3, 4, &5)	(5)	(4&5)	(3, 4, &5)
Electronic Registration Credentialing	15%	35%	61%	24%	51%	78%	34%	58%	81%
Electronic Fuel Tax Credentialing	14%	34%	61%	24%	52%	77%	32%	58%	81%
Electronic Fuel Tax Filings/Payments	15%	37%	55%	25%	51%	78%	31%	60%	81%
Electronic Oversize/Overweight Permitting	17%	28%	35%	18%	30%	40%	21%	31%	44%
Electronic Safety/Weight Screening	31%	56%	75%	34%	59%	82%	36%	63%	84%
Automated Roadside Safety Inspections	17%	42%	64%	15%	36%	70%	9%	32%	64%
Demonstration of Hours-of-Service Compliance via Electronic Logs	13%	29%	51%	11%	25%	51%	14%	30%	57%
Real-Time Access to Fleet Safety Inspection Reports	22%	50%	76%	28%	57%	83%	27%	55%	82%
Electronic Access to Motor Carrier Rules and Regulations	26%	48%	75%	22%	49%	77%	15%	43%	76%
Access to Real-Time Traffic and Travel Information	38%	61%	81%	40%	69%	88%	39%	67%	87%
Electronic Toll Collection	30%	53%	66%	32%	54%	72%	31%	56%	75%
Hazardous Materials Incident Response	8%	25%	36%	10%	22%	39%	9%	21%	45%

Figure 19 (continued)
Percent of Surveyed Motor Carriers Perceiving Value for ITS/CVO Services As High (5) and Mid to High (4 & 5), and Moderate to High (3, 4, &5)

ITS/CVO Service/Function	Average Haul Length								
	1 to 200 Miles			201 to 500 Miles			Greater than 500 Miles		
Value=>	(5)	(4&5)	(3, 4, &5)	(5)	(4&5)	(3, 4, &5)	(5)	(4&5)	(3, 4, &5)
Electronic Registration Credentialing	20%	49%	72%	22%	50%	77%	28%	53%	79%
Electronic Fuel Tax Credentialing	17%	50%	69%	22%	49%	73%	27%	53%	78%
Electronic Fuel Tax Filings/Payments	17%	50%	67%	23%	50%	76%	27%	54%	79%
Electronic Oversize/Overweight Permitting	14%	31%	40%	17%	30%	42%	19%	29%	40%
Electronic Safety/Weight Screening	37%	54%	88%	34%	60%	80%	34%	60%	83%
Automated Roadside Safety Inspections	18%	33%	69%	12%	38%	67%	15%	36%	69%
Demonstration of Hours-of-Service Compliance via Electronic Logs	9%	18%	36%	10%	28%	55%	13%	28%	54%
Real-Time Access to Fleet Safety Inspection Reports	42%	67%	81%	29%	56%	77%	26%	56%	75%
Electronic Access to Motor Carrier Rules and Regulations	28%	47%	80%	22%	48%	76%	19%	46%	76%
Access to Real-Time Traffic and Travel Information	49%	65%	83%	37%	68%	86%	39%	67%	87%
Electronic Toll Collection	34%	51%	65%	32%	56%	68%	31%	54%	75%
Hazardous Materials Incident Response	1%	20%	42%	3%	17%	34%	6%	18%	36%

Adoption of Primary Enabling and Supporting Technologies Affecting Potential ITS/CVO Service Participation

Computer-Aided Routing and Dispatching,
Maintenance Support Systems, Mobile Communications

Computer-Aided Routing and Dispatching, Maintenance Support Systems, and Mobile Communications systems are widely used in the industry and can enable or support the functions of several ITS/CVO services such as electronic credentialing, safety information services, Hazardous Materials Incident Response, or real-time traffic and travel information. The benefits/cost ratios for these technologies in fleet operations are generally strong, suggesting continued steady carrier adoption. The use of these technologies to support the ITS/CVO services is a minimal departure from current fleet uses.

Mobile communications use is high with moderate continued growth expected. The technology can enable driver access to roadway information such as travel reports or rest stop availability, timely response to changing conditions, and driver monitoring (fitness, available hour-of-service, etc.). As with CAD, business risks are considered minimal since use of mobile communications to participate in ITS/CVO services is a minimal departure from current fleet uses.

EDI/Internet

EDI/Internet-use by motor carriers is high. Adoption rates are also high, especially in the number of carriers using the Internet. A potential barrier to EDI for use in regulatory applications is the relatively high start up costs for non-EDI capable carriers. This is especially true among carriers with smaller fleets. For these carriers, web-based solutions may provide a cost-effective approach to participation. Participation estimates assume that at least three out of four carriers would have the minimum technology to participate.

Significant administrative costs savings associated with the technology infrastructure supporting EDI/Internet use in fleet operations could indicate similar cost savings in credentialing/tax administrative functions. Potential motor carrier benefits of informational services such as real-time traffic and travel information are currently being defined through operational tests, but hold promise for enhancing fleet management.

On-Board Computers/Electronic Logbooks

On-board data capture devices such as on-board computers or electronic logbooks are used to support several fleet and safety management applications. The relatively high costs for these devices and supporting systems generally limit their use in the industry, and adoption rates are low.

Regulatory applications could include the presentation of information to enforcement officials electronically to speed the inspection process. As discussed previously, time savings en-route may actually only benefit specific sub-segments of the industry and these alone may not justify purchase of the devices

Automatic Vehicle/Equipment Identification

Fleet applications of Automated Vehicle/Equipment Identification enabled by RF tags, are limited. The number of carriers equipping their vehicles with RF tags is low and observed rates of adoption are about one percent per

year or less. Developing applications for the technology include equipment identification in intermodal operations, supporting yard/cross-dock management, electronic toll collection, and electronic clearance programs—applications used by sub-segments of the industry and not the majority of motor carriers.

Automatic Vehicle Location Tracking

Vehicle position reports generated via Automatic Vehicle Location systems could be used to support IFTA and IRP audits or provide documentation for safety compliance reviews. The significant expense of these systems coupled with a limited need for fleet asset tracking by many types of operations would limit their use in regulatory applications.

Potential Participation in ITS/CVO Services

Estimates of participation levels in ITS/CVO services developed in this analysis are in terms of numbers of commercial vehicles. Numbers and distribution of vehicles by fleet characteristic were obtained from the 1997 U.S. Department of Commerce Vehicle Inventory and Use Survey. For all ITS/CVO services except fuel tax administration services, the universe of commercial vehicles is approximately four million (all commercial vehicles with a gross vehicle weight greater than 10,000 lbs.). For the fuel tax credentialing/administration services, the universe is approximately 2.2 million (commercial vehicles operated interstate with a gross vehicle weight of 26,001 lbs. or greater, per International Fuel Tax Agreement).

This analysis assumes that only motor carriers perceiving values of three or greater are potential participants in ITS/CVO services. Conservative and optimistic participation estimates were developed. Conservative estimates are based on the percent of carriers indicating a value perception of 4 or 5, constrained by technology adoption rates observed between 1996 and 1998. The optimistic estimates are based on the percent of carriers indicating a value of 3, 4, or 5, constrained by the technology adoption rates. The exception to this is electronic toll collection, in which the technology adoption rate is assumed to be twice the observed for 1996 to 1998. This is due to the economic carrier benefits of toll discounts (up to 15 percent) and reduced administrative costs.

Participation estimates assume a sufficient time frame following implementation of ITS/CVO services to allow carriers to realistically assess service functionality, costs and possible benefits, and resolution to the many intricate barriers identified in states' ITS/CVO Institutional Issues studies and other related literature. These estimates are presented in Figure 20 and summarized in the following text:

The ITS/CVO services/functions estimated to have the highest initial and potential participation are those that are informational in function: electronic access to information about travel conditions, fleet safety performance, and motor carrier rules and regulations. It is expected that motor carriers would potentially participate in these services more rapidly due to the relatively low cost, and expected adoption rates for enabling technologies, low business risks, and potential medium to high benefits in terms of enhanced fleet operations and safety management, and improved regulatory compliance.

Participation in the electronic credentialing services for fleet registration, fuel tax administration, and oversize/overweight permitting can be expected to be modest at first, then developing rapidly towards strong participation levels. Similar to informational ITS/CVO services, technology costs and business risks are expected to be relatively low. Low to medium benefits in terms of reduced administrative costs can be expected.

Participation in electronic screening and automated safety inspection activities is expected to be low at first and slowly developing towards modest participation levels. Participation is expected to be constrained due to uncertain benefits, exposure levels, and complex institutional and technical issues.

As a reasonably well-developed service in the more metropolitan areas, moderate growth is expected in the number of motor carriers participating in electronic toll collection programs. This growth would be driven primarily by the benefits of toll discounts and administrative cost savings.

Figure 20
Estimated Motor Carrier Participation in ITS/CVO Services
(Commercial Vehicles and Percent Participation)

ITS/CVO Service	Primary Enabling (E) & Supporting (S) Technologies	Conservative Participation Estimate (Commercial Vehicles)	Optimistic Participation Estimate (Commercial Vehicles)
Electronic Registration Credentialing	EDI/Internet (E)	1.6 Million 40%	2.5 Million 63%
	CAD (S)	1.2 Million 32%	2.0 Million 50%
Electronic Fuel Tax Credentialing	EDI/Internet (E)	0.9 Million 42%	1.4 Million 62%
	CAD (S)	0.7 Million 33%	1.1 Million 50%
Electronic Fuel Tax Filings/Payments	EDI/Internet (E)	0.9 Million 42%	1.4 Million 62%
	CAD (S)	0.7 Million 33%	1.1 Million 49%
Electronic Oversize/ Overweight Permitting	EDI/Internet (E)	1.0 Million 26%	1.4 Million 39%
Demonstration of Hours-of-Service Compliance via Electronic Logs	Electronic Logbooks (E)	0.2 Million 5%	0.3 Million 8%
Real-Time Access to Fleet Safety Inspection Reports	EDI/Internet (E)	1.9 Million 47%	2.8 Million 71%
	MSS (S)	1.3 Million 33%	2.0 Million 49%
Electronic Access to Motor Carrier Rules and Regulations	EDI/Internet (E)	1.6 Million 40%	2.7 Million 67%
	MSS (S)	1.2 Million 29%	1.9 Million 47%
Electronic Safety/Weight Screening	RF Tags (E)	0.3 Million 7%	0.5 Million 9%
Access to Real-Time Traffic and Travel Information	EDI/Internet (E)	1.9 Million 48%	2.9 Million 72%
	CAD (S)	1.7 Million 44%	2.2 Million 56%
	Mobile Communications (E & S)	2.0 Million 50%	2.6 Million 67%
Electronic Toll Collection	RF Tags (E)	0.3 Million 7%	0.8 Million 20%
Hazardous Materials Incident Response	EDI/Internet (E)	0.8 Million 20%	1.4 Million 35%
	CAD (S)	0.6 Million 16%	1.1 Million 35%

Section VII

Conclusions and Recommendations for Continued Research

VII. Conclusions and Recommendations for Continued Research

It appears that, based on this research, the market does exist for some government-sponsored ITS/CVO services. As stated in the introduction, crucial to the success of the ITS/CVO program is motor carrier acceptance of and participation in the deployed services. To achieve this acceptance, it is important to focus on those services that become an effective extension of motor carriers' own IT solutions.

Beyond identifying those services which hold the most promise for motor carrier acceptance and participation, it is recommended that future research be conducted to examine ways to overcome barriers to acceptance of technologies which hold promise for increased roadway safety.

As a first step, it is recommended that research be conducted to examine ways to overcome driver resistance to in-vehicle performance monitoring, coupled with research on how to best use the performance information obtained to improve safety.

Safety monitoring via in-vehicle recorders or vehicle position tracking systems have the potential for enhancing the effectiveness of well-developed safety management programs. The practice, though, has been constrained, in part, to drivers viewing this as on the job surveillance carrying penalties for performance outside of guidelines.

Driver acceptance of monitoring technologies may be improved through management practices and settlement structures which emphasize awards or bonuses based on the performance information captured via monitoring technologies. It is recommended that case studies be developed for firms who have successfully used safety monitoring technologies. These case studies could form the basis for education and outreach on the benefits of in-vehicle monitoring and best management practices for the use of performance information.

Appendix A

Motor Carrier Surveys

ATA Foundation
Motor Carrier Safety, Operations and Technology Survey
All responses will be kept strictly confidential

1. How many power units does your company operate?

Long Haul	☐ 1 to 5	☐ 6 to 19	☐ 20 to 50	☐ 51 to 100	☐ 101 to 249	☐ 250 to 499	☐ 500+
Local	☐ 1 to 5	☐ 6 to 19	☐ 20 to 50	☐ 51 to 100	☐ 101 to 249	☐ 250 to 499	☐ 500+

2. Which best describes your company's average length of haul?
☐ 1 to 50 miles ☐ 51 to 100 miles ☐ 101 to 200 miles ☐ 201 to 499 miles ☐ 500+miles

3. How many terminal facilities does your company operate?
☐ 1-2 ☐ 2-5 ☐ 5-9 ☐ 10-15 ☐ 16-20 ☐ 21-25 ☐ Greater than 25, please specify:_____

4. What commodities does your company haul? **Please check all that apply.**

☐ General Freight-Truckload	☐ General Freight—Less-than-Truckload	☐ Household Goods-Movers
☐ Automotive Parts or Vehicles	☐ Heavy Machinery	☐ Bulk—Dump Trucking
☐ Raw Petroleum Products	☐ Refined Petroleum Products	☐ Building Materials
☐ Mine Ores	☐ Forest Products	☐ Hazardous Chemicals
☐ Processed Foods	☐ Farm Fresh Products	☐ Retail Store Delivery
☐ Parcel	☐ Refuse	☐ Other: _____

5. How variable are your company's routes?
☐ Very Much ☐ Somewhat ☐ Very Little ☐ Not at all

6. What percentage of your dispatches are time-sensitive or perishable?
☐ None ☐ 1-25% ☐ 26-50% ☐ 51-75% ☐ 76-100%

7. What percentage of your dispatched require permit for oversized/overweight loads?
☐ None ☐ 1-25% ☐ 26-50% ☐ 51-75% ☐ 76-100%

8. What Technologies did your company use in **1996** and **Now**? **Please check all that apply.**

1996	Now	1996	Now	1996	Now
☐	☐ None of the Listed				
☐	☐ Cellular Phone	☐	☐ On-board scales	☐	☐ Electronic Data Interchange
☐	☐ Two-way radio	☐	☐ Vehicle location tracking	☐	☐ Internet access
☐	☐ Pagers	☐	☐ Collision avoidance system	☐	☐ On-board/hand-held computers
☐	☐ Satellite communications	☐	☐ Electronic logbooks	☐	☐ Mayday Alert Device
☐	☐ RF Tags	☐	☐ Automated Diagnostics	☐	☐ Maintenance Tracking Software
		☐	☐ Computer-Aided Routing	☐	☐ Computer-Aided Dispatching

9. Please rank the following items in order of importance to marketing your company to customers:
(1=most important, 6=least important)

_____ Lowest freight rates
_____ On-time performance
_____ Short turn-around on customer requests
_____ Safety performance
_____ Specialized equipment/Dedicated equipment
_____ Other, please specify:_____

Motor Carrier Safety, Operations and Technology Survey—Page Two

10. Does your company conduct the following safety practices:	Yes	No
Award fuel savings bonuses to drivers?	☐	☐
Present safe driving awards or other incentives to drivers?	☐	☐
Road test new drivers?	☐	☐
Have a fleet speed limit?	☐	☐
Have a driver policy and procedures manual?	☐	☐
Hold regular safety awareness and training meetings?	☐	☐
Instruct drivers on federal safety regulations?	☐	☐
Instruct drivers on how to inspect vehicles?	☐	☐
Send drivers to performance training schools?	☐	☐
Have a driver apprenticeship program?	☐	☐
Monitor driver hours-of-service and discipline drivers for violations?	☐	☐
Have a company road patrol to monitor drivers or inspect vehicles?	☐	☐
Monitor drivers via on-board recorders or vehicle tracking?	☐	☐

10. There are many ongoing Federal and state initiatives to automate regulatory processes and improve roadway efficiency. These include motor carrier electronic/computer access to agencies to file applications, receive operating credentials, file tax reports and make payments; be electronically cleared to bypass weight and safety inspections; have electronic access to real-time traffic and fleet safety information; electronically post hazardous materials shipment information for rapid access by emergency response personnel; or, automated safety inspections.

Please rank the potential value of the following envisioned automated government services to your company:

	(1=no value; 5=very valuable)					Don't
	1	2	3	4	5	Know
Electronic application/reception for registrations	☐	☐	☐	☐	☐	☐
Electronic application/reception for fuel tax credentials	☐	☐	☐	☐	☐	☐
Electronic fuel tax filings	☐	☐	☐	☐	☐	☐
Electronic application/reception for oversize/overweight permits	☐	☐	☐	☐	☐	☐
Electronic clearance from roadside safety inspections	☐	☐	☐	☐	☐	☐
Electronic clearance from weight inspections	☐	☐	☐	☐	☐	☐
Automated toll lanes	☐	☐	☐	☐	☐	☐
Electronic access to motor carrier regulations	☐	☐	☐	☐	☐	☐
Real-time access to your fleet's safety inspection information	☐	☐	☐	☐	☐	☐
Real-time access to traffic and road conditions	☐	☐	☐	☐	☐	☐
Load posting of HazMat shipments for emergency responders	☐	☐	☐	☐	☐	☐
Roadside safety inspections using automated diagnostics	☐	☐	☐	☐	☐	☐
Electronic driver logs for inspection by MCSAP inspectors	☐	☐	☐	☐	☐	☐

Company Name: _____ Phone: _____

Contact Person: _____ Fax: _____

Please complete and return this survey in the enclosed self-addressed, postage-paid envelope or FAX to:
The ATA Foundation—660 Roosevelt Avenue, Pawtucket, RI 02860 Fax: (401) 722-0109

If you have any questions, please call us at (401) 722-7800. Thank you for your time.

National Private Truck Council
Motor Carrier Safety, Operations and Technology Survey
All responses will be kept confidential

1. How many power units does your company operate?
   Long haul _____
   Local (P&D) _____

2. Are you an: ☐ **Inter-state** ☐ **Intra-state** motor carrier? Which best describes your company's average length of haul? ☐ 1-49miles ☐ 50-100miles ☐ 101-200miles ☐ 201-499miles ☐ 500+miles

3. How many distribution/terminal facilities does your company operate?
   ☐ 1-2 ☐ 3-5 ☐ 6-9 ☐ 10-15 ☐ 16-20 ☐ 21-25 ☐ Greater than 25, please specify:_____

4. Do you have for-hire authority? ☐ Yes ☐N o
   If Yes, what percent of your hauls are for-hire? ☐ 1-25% ☐ 26-50% ☐ 51-75% ☐ 76-100%

5. What industry categories best describe your company? **Please check all that apply.**

☐ General Freight-Truckload	☐ General Freight—Less-than-Truckload	☐ Industrial Gases
☐ Construction	☐ Restaurants/Fast Foods	☐ Chemicals
☐ Farm Fresh Products	☐ Refined Petroleum Products	☐ Public Utilities
☐ Mine Ores	☐ Manufactured Goods	☐ Government or Schools
☐ Processed Foods	☐ Mining	☐ Retail/Grocery Stores
☐ Beverages	☐ Oil/Petroleum Products	☐ Sanitation/Refuse
☐ Services	☐ Wholesaler	

   ☐ Other, please specify: _____

6. What percent of your dispatches are time sensitive or perishable?
   ☐ None ☐1 -25% ☐ 26-50% ☐ 51-75% ☐ 76-100%

7. How variable are your company's routes?
   ☐ Not at all ☐ Very Little ☐ Somewhat ☐ Very Much

8. What percent of your dispatches require permit for oversize/overweight loads?
   ☐ None ☐1 -25% ☐ 26-50% ☐ 51-75% ☐ 76-100%

9. Please rate the following items in importance to your company: **(1=not important; 5=very important)**

	1	2	3	4	5
On-time performance	☐	☐	☐	☐	☐
Real-time shipment status	☐	☐	☐	☐	☐
Equipment utilization	☐	☐	☐	☐	☐
Equipment availability	☐	☐	☐	☐	☐
Preventative maintenance	☐	☐	☐	☐	☐
Driver safety awareness	☐	☐	☐	☐	☐
Driver retention	☐	☐	☐	☐	☐
Maintenance costs	☐	☐	☐	☐	☐
Accident/insurance costs	☐	☐	☐	☐	☐
Fuel costs	☐	☐	☐	☐	☐

10. What Technologies did your company use in **1996** and **Now**? **Please check all that apply.**

Mobile Communications			In-Vehicle Monitoring			Data/Decision Support		
1996	**Now**		**1996**	**Now**		**1996**	**Now**	
☐	☐	Cellular Phone	☐	☐	Vehicle location tracking	☐	☐	Electronic Data Interchange
☐	☐	Two-way radio	☐	☐	On-board/hand-held computers	☐	☐	Internet access
☐	☐	Pagers	☐	☐	Electronic logbooks	☐	☐	Computer-Aided Routing/Dispatching
☐	☐	Satellite Comm.	☐	☐	Transponders	☐	☐	Maintenance Tracking Software
☐	☐	Collision avoidance system				☐	☐	Bar-coding/Optical Recognition

Motor Carrier Safety, Operations and Technology Survey—Page Two

11. Please check off the boxes that describe how the following technologies impact your fleet's operations:

Fleet Operational Impacts	Mobile Communications	Vehicle Location Tracking	On-Board or Handheld Computers	Electronic Logbooks	Transponders	Collision Avoidance System	Electronic Data Interchange	Internet Access	Computer Aided Routing or Dispatching	Maintenance Tracking Software	Barcoding/Optical recognition
Improved on-time performance											
Increased pick-ups/deliveries											
Improved equipment utilization											
Improved load tracking/status											
Reduced en-route delays											
Reduced empty miles											
Reduce fuel consumption											
Reduced dispatcher/driver ratios											
Reduced administrative costs											
Reduced maintenance costs											
Improved communications											
Improved driver utilization											
Improved driver retention											
Improved hours-of-service monitoring											
Improved driver performance monitoring											
Improved roadside inspection performance											
Reduced accidents											
Improved compliance with regulations											
Reduced insurance costs											

Motor Carrier Safety, Operations and Technology Survey—Page Three

12. Does your company conduct the following safety practices:

	Yes	No
Award fuel savings bonuses to drivers?	☐	☐
Present safe driving awards or other incentives to drivers?	☐	☐
Road test new drivers?	☐	☐
Have a fleet speed limit?	☐	☐
Have a driver policy and procedures manual?	☐	☐
Hold regular safety awareness and training meetings?	☐	☐
Instruct drivers on federal safety regulations?	☐	☐
Instruct drivers on how to inspect vehicles?	☐	☐
Send drivers to performance training schools?	☐	☐
Have a driver apprenticeship program?	☐	☐
Monitor driver hours-of-service and discipline drivers for violations?	☐	☐
Have a company road patrol to monitor drivers or inspect vehicles?	☐	☐
Monitor drivers via on-board recorders or vehicle tracking?	☐	☐
Instruct drivers as to policies and procedures in event of accident?	☐	☐
Have accident investigation procedures?	☐	☐

13. There are many ongoing Federal and state initiatives to automate regulatory processes and improve roadway efficiency. These include motor carrier electronic/computer access to agencies to file applications, receive operating credentials, file tax reports and make payments; be electronically cleared to bypass weight and safety inspections; have electronic access to real-time traffic and fleet safety information; electronically post hazardous materials shipment information for rapid access by emergency response personnel; or, automated safety inspections.

Please rank the potential value of the following envisioned automated government services to your company:

	(1=no value; 5=very valuable)					Don't
	1	2	3	4	5	Know
Electronic application/reception for registrations	☐	☐	☐	☐	☐	☐
Electronic application/reception for fuel tax credentials	☐	☐	☐	☐	☐	☐
Electronic fuel tax filings	☐	☐	☐	☐	☐	☐
Electronic application/reception for oversize/overweight permits	☐	☐	☐	☐	☐	☐
Electronic clearance from roadside safety inspections	☐	☐	☐	☐	☐	☐
Electronic clearance from weight inspections	☐	☐	☐	☐	☐	☐
Automated toll lanes	☐	☐	☐	☐	☐	☐
Electronic access to motor carrier regulations	☐	☐	☐	☐	☐	☐
Real-time access to your fleet's safety inspection information	☐	☐	☐	☐	☐	☐
Real-time access to traffic and road conditions	☐	☐	☐	☐	☐	☐
Load posting of HazMat shipments for emergency responders	☐	☐	☐	☐	☐	☐
Roadside safety inspections using automated diagnostics	☐	☐	☐	☐	☐	☐
Electronic driver logs for inspection by MCSAP inspectors	☐	☐	☐	☐	☐	☐

Company Name: _____ Phone: _____

Contact Person: _____ Fax: _____

Please complete and return this survey in the enclosed self-addressed, postage-paid envelope or FAX to:
The National Private Truck Council—Fax: (703) 683-1217
If you have any questions, please call Jane McIntyre at (703) 683-1300 x 206.

Thank you for your time.