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### Authors

Gillen, David  
Haynes, Matt

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**Public and Private Benefits in Intelligent  
Transportation Systems/Commercial Vehicle  
Operations: Electronic Clearance and Supply  
Chain Management**

**David Gillen, Matt Haynes**  
*University of California, Berkeley*

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# Public and Private Benefits in Intelligent Transportation Systems / Commercial Vehicle Operations: Electronic Clearance and Supply Chain Management

**David Gillen and Matt Haynes\***

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## ***INTRODUCTION***

Technological innovations have recently changed many of the ways the private trucking industry operates. These changes have enabled trucking firms to monitor more closely the distribution of goods and services, improve productivity, and develop higher levels of customer satisfaction. Of these innovations, ITS related applications play an important role in creating benefits for the private sector. ITS technologies are also increasingly offering the potential to bring about change to state and national agencies charged with overseeing goods movement in trucking. Recent research has shown that public agencies may be able to significantly reduce costs through the adoption of certain ITS applications.

Given the facts that the private sector has been experiencing the benefits brought about by innovations in transportation and ITS, experience in the private sector may offer guidance to public agencies wishing to adopt a given ITS technology. Despite the fact that the public and private sectors often use technologies in different ways, categories of benefits may be similar, and lessons from implementation may be transferable between the two. This report gives a brief overview of the studied benefits of ITS to private firms and the experienced and expected benefits to the public sector.

As specific examples of the ways in which technology has changed the way private trucking firms operate, Electronic clearance and supply chain management are looked at. Electronic clearance is an ITS application that allows trucks to use transponders to move through vehicle inspections stations and border crossing with minimal delay. Supply chain management is a concept increasingly employed by private firms to increase productivity. Though not directly associated with ITS applications, supply chain management relies largely on technology-based process monitoring to realize its benefits. Public agencies may be able to extract some valuable lessons from supply chain management in the potential to apply its principles to vehicle operations and regulatory oversight.

This paper first describes the ways in which ITS applications are classified in the area of commercial vehicle operations, and looks at electronic clearance applications as a type of case study. It then looks at supply chain management, its development, definitions, and potential applications to public sector operations. Finally, several important conclusions and recommendations are presented.

## ***ITS AND COMMERCIAL VEHICLE OPERATIONS***

In the Commercial Vehicle Operations (CVO) sector of the National ITS Program Plan and the National Transportation Infrastructure Initiative (NTII), several types of ITS applications are mentioned. These ITS applications are described as User Services, and are divided into six categories as follows:

- Commercial Vehicle Administrative Processes
- Commercial Vehicle Electronic Clearance
- Automated Roadside Safety Inspection
- On-Board Safety Monitoring
- Hazardous Materials Incident Response
- Commercial Fleet Administration and Management

The main goal of the six User Services is to apply existing and developing technologies to better streamline the enforcement process and safety issues of the state and federal regulatory structure. The program described the goal of electronic transactions between motor carriers and government regulatory agencies to provide what is described as “transparent borders” – the ability to move freely across the continent of North America without stops or safety compliance verifications (National ITS Architecture, 2001).<sup>1</sup>

## **Description of ITS/CVO Program Areas**

### *Safety Assurance*

The two elements of Safety Assurance are Safety Information Exchange and Automated Inspections. Safety Assurance enables inspectors to have access to better safety information so that the number of unsafe vehicles and drivers may be reduced. Most benefits data related to Safety Assurance have been in the form of opinion surveys of various stakeholders. For example, a comprehensive survey of truck and motorcoach operators found that truck drivers were more opposed to Automated Inspections than were motorcoach drivers. However, truck drivers carrying hazardous materials were found to be largely in favor of Hazardous Materials Incident Response programs (FHWA Report, 1997).

### *Credentials Administration*

Credentials administration services have the potential to provide significant cost savings to public administrative agencies. By enabling truck operators to obtain permits (these would include Hazmat trip permits, oversize/overweight permits, for example) and exchange data electronically, time and paperwork needs are lessened for the enforcing agency. Additionally, private operators stand to benefit from electronic credentialing, as paperwork requirements can be reduced as well. By expediting the issue of permits and accelerating information, vehicles can be used more efficiently and customer service can increase. Furthermore, it provides a ready database for tracing loads and a history of firms, routes and materials moved.

### *Electronic Screening / Electronic Clearance*

Electronic Screening, or Electronic Clearance, offers the ability to reduce congestion at inspection stations, improve travel times, and reduce enforcement costs by regulatory agencies. Electronic Clearance allows vehicles deemed safe and legal to bypass inspection stations without being required to stop. Four main categories of Electronic Screening are listed by the FHWA: Safety Screening, Credential Checking, Border Clearance, and Weight Screening. A detailed summary of the studies and literature pertaining to Electronic Clearance is described in the following section.

### *Carrier Operations*

Carrier Operations are a final area in which the benefits of ITS/CVO implementation have been analyzed. With advanced technologies, motor carriers are able to schedule vehicles more efficiently and thus reduce the number of empty loads carried. Elements of Carrier Operations include Fleet Management, Traveler Information, and Onboard Monitoring. Various types of

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<sup>1</sup> Similar to the National ITS Program Plan, the Federal Highway Administration’s ITS Joint Program Office provides four major program areas of ITS/CVO for assessing their benefits. These program areas include: Safety Assurance, Credentials Administration, Electronic Screening, And Carrier Operations.

studies of the benefits of Carrier Operations have been carried out, ranging from opinion surveys of motor carriers to more advanced studies of the effect of such technologies on the resource allocation abilities of trucking firms.

***ELECTRONIC CLEARANCE***

Of particular interest in this research are the potential benefits of Electronic Clearance (EC) systems to private and public interests. EC is an integral part of the ITS/CVO program in that it offers significant cost savings to motor carriers and enforcement agencies. Taken together, the elements of electronic clearance offer a clear way to pursue the National ITS Program Plan’s goal of transparent borders and minimal restrictions on freight mobility. EC is taken as a case study for two main reasons. First, studies and testing of EC related applications have taken up a significant portion of ITS/CVO program funds since its inception. Additionally, EC provides a good example of the varying nature of public and private benefits that particular ITS/CVO applications may offer. The following section summarizes the functions that are contained in EC and performs a review of the literature that has been produced with regards to the benefits and costs of EC technologies.

**Functions of Electronic Clearance Applications**

Traditionally, motor carriers have had to stop periodically during their route to undergo safety checks and weight assessments. Also, when borders crossings are involved, be they state or national borders, checkpoint for credential compliance also occur. This has commonly been done at a fixed location along the side of a route, where trucks exit the roadway, wait for their vehicle to be cleared, and then proceed on to their destination. Occasionally, inspections are also done at variable points along the roadway, using portable or semi-portable scales.

<b>Table 1: Electronic Clearance Elements</b>	
<b><i>Element</i></b>	<b><i>Description</i></b>
<b>Safety Screening</b>	Automated safety inspections and better access to safety information
<b>Credential Checking</b>	Electronic permit approval, data warehouses for exchange of credentials data
<b>Border Clearance</b>	Transponder based border crossings
<b>Weight Screening</b>	Weigh-in-motion devices

These types of traditional weight and safety enforcement strategies have been criticized as adversely affecting highway safety as well as being redundant and ineffective (Titus, 1996). Though portable inspection facilities are viewed as being more effective than fixed facilities, they still retain the time consuming element and safety hazards that fixed facilities have (Kavalaris, 1994). If inspections are done unnecessarily, the result is a waste of productive time, increased delays for shippers and, an inefficient use of labor and assets. Furthermore, having portability means the facility can be moved to locations where need and compliance issues are greater.

Electronic clearance systems have the potential to alleviate some of the shortcomings of traditional roadside truck inspections and improve trucking productivity. While not eliminating the need for roadside inspection points altogether, they can allow safe and legal trucks to pass the checkpoint without needing to stop. Non-compliant vehicles and vehicles not equipped with electronic clearance capabilities are still required to stop at the inspection station.

The way that a truck is pre-cleared to pass a station without stopping is usually through a truck-mounted transponder that identifies the truck to the regulatory agency. Information is passed from the transponder to the agency on the carrier, driver, and vehicle characteristics. Additionally, a high-speed weigh-in-motion scale and vehicle classification and measuring devices send information to the agency computer. All of this information is transmitted to the agency which then analyzes it and sends back to the vehicle on a real-time basis necessary summary information, permit numbers and certification of inspection. Based on the information that is gathered and assessed, the vehicle is then instructed to proceed without stopping or to pull over for additional inspection.

## **Literature of Benefits and Costs**

The benefits and costs of EC systems have been assessed in several ways. Some studies have focused on the benefits to the private trucking sector, while others have concentrated on the public return on investment that EC may produce. Additionally, there have been some operational tests and computer simulation studies conducted as a further way of assessing benefits. Each of these types of studies is described below.

There have been several operational tests of EC systems since the ITS Program Plan was introduced in 1994, and, as mentioned above, EC testing has taken up a large part of the USDOT ITS/CVO funds. Pritchard (1996) provides a general overview of EC and its potential benefits and implementation issues. Through a review of the results of a survey of 700 motor carriers done by the American Trucking Association (ATA) Foundation, Inc., the merits of EC were studied. What was found is that the benefits that can be obtained through EC implementation vary largely depending on the size of the motor carrier and the existence of time-based driver compensation. The benefits of EC are only present when the motor carrier pays drivers on a time-based system, since drivers not paid by time did not impose a monetary penalty on the firm when stopping at an inspection station. This is an important point, as Pritchard notes that a majority of firms do not pay drivers based on time, so they do not derive any benefit from an EC system.

Pritchard found that the calculated benefit-cost ratios for trucking firms that pay drivers based on time to range from 3.3:1 to 6.5:1 for small firms (less than 10 trucks), from 3.7:1 to 7.4:1 for medium firms (11 to 99 trucks), and from 1.8:1 to 3.8:1 for large carriers (over 100 trucks).<sup>2</sup> It is also important to note the assumptions that were made in arriving at these numbers. It was assumed 1) that each ITS/CVO User Service is considered independently and not as part of an integrated system, 2) that the current regulatory environment is held constant, 3) that benefits are solely the result of labor costs of regulatory compliance and not the result of changes in safety or operational efficiency, and 4) that motor carriers will not participate in the financing of the ITS infrastructure. Based on the study results, it was found that the market potential for EC was from 256,000 to 1.4 million EC system units for installation in trucks (7 to 38 percent of the US medium and heavy truck population).

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<sup>2</sup> This conclusion must be interpreted carefully as it is not generalizable. Drivers not paid by time can impose negative monetary impact on the firm when stopping at/being tied up at inspection stations. Revenue opportunity costs, equipment delay costs, potential customer service failures at congested inspection stations can each create a negative business impact on a trucking company. In cases where drivers are paid on miles driven vs. time, delays at inspection stations can create morale-related service quality and related cost impacts.

Titus (1996), using time savings for the cost of labor and estimates of the distances that could have been traveled without inspection stops, estimated motor carrier costs of unnecessary stops of legal vehicles from roadside inspections. Titus assumed that if all trucks were equipped with EC technology, then the costs of all unnecessary stops would be eliminated. According to the results, the total cost savings of unnecessary stop elimination ranged from \$7.8 to \$13.2 million annually for safety inspections and from \$166 to \$282 million for weight inspections. Such cost savings would reduce industry costs for weight inspections by 99% and costs for safety inspections by 44-48%.

The HELP/Crescent Project (1994) evaluated the applicability of four separate technologies for screening transponder-equipped vehicles. These technologies would be discrete or stand-alone rather than as an integrated package. The technologies included automatic vehicle identification, weigh-in-motion, automatic vehicle classification, and integrated communications systems and databases. The benefits of such technologies were developed from a collection of databases, and showed that overweight loads could be reduced by 5% leading to a savings of \$5.6 million annually.<sup>3</sup> Also, weigh-station operating costs could be reduced by \$169,000 annually. Accident reductions due to credentials checking could save \$4.3–\$8.6 million and automated safety inspections could save \$156,000–\$781,000.<sup>4</sup> A full implementation of services examined in the Crescent project would yield a benefit/cost ratio of 4.8:1 for a typical state government over a 20-year period. Less complete implementations were found to range in benefit/cost ratio from no benefit up to 12:1. Less complete includes limits on the range of technologies applied, the geographic range of the applications and the information included.

#### *Electronic Clearance Simulation Studies*

Several computer simulation studies of hypothetical EC systems have also been conducted. Glassco (1997), in a simulation study, demonstrated ITS capabilities that could be used to improve the effectiveness of a hypothetical advanced truck weigh station. The study examined the delay reduction effects of increased transponder usage of trucks as arrival rates to the station varied. Trucks equipped with transponders were permitted to bypass the station thereby reducing delay by 100% compared with non-equipped trucks. As transponder usage increased, queue lengths behind the scales decreased, thus also decreasing the delay experienced for non-equipped trucks. Savings for non-equipped trucks varied as a function of average inter-arrival time, time required at the scale, and percent of trucks equipped with transponders. For an average inter-arrival time of 20 seconds and a weigh time of 25 seconds, non-equipped vehicles saved approximately 30 seconds for a 20% transponder equipage, and an average of 8 minutes was saved at the station for a 60% transponder equipage.

A simulation study of the Peace Bridge border crossing between the US and Canada evaluated the impacts of electronic border customs clearance implementation. The results for the US side, comparing 0% to 50% transponder usage, showed that truck timesaving averaged 66% and that

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<sup>3</sup> This value is based on the application of any one of the technologies in the particular setting that was analyzed and aggregating over all projects assessed.

<sup>4</sup> As in footnote 3, these values are an aggregate of the values obtained from assessments of the application of several of the technologies available in this area.



auto timesaving was 35%. Most of the truck timesaving was due to a 64% reduction in the number of trucks sent to secondary inspection. Benefits for the Canadian side were similar, showing a 40% reduction in system time for trucks (Nozick, 1999). It should be noted that electronic border clearance benefits rest on quite different data and process flows than electronic vehicle safety and weight inspections.

Another simulation study on US-Canada border crossings, done at the Ambassador Bridge crossing, was conducted at about the same time. The Ambassador Bridge Border Crossing System (ABBCS) study, conducted by Booz-Allen Hamilton (2000), was developed with the goal of allowing pre-processed vehicles, trade goods, and commuters to pass through the border checkpoints with expedited processing. The simulation showed that the time required for a truck equipped with electronic clearance information processing to enter the lane heading to the customs station to exiting the station could be reduced by 50%.

### **SUPPLY CHAIN MANAGEMENT**

The way in which firms manage and control their supply chains, or their links to suppliers, manufacturers, and customers, has changed greatly as a result of information technology-based processes. Supply chain management is the term that has been used to describe the way in which companies monitor in a real-time fashion their supply needs and distribution operations. More specifically, supply chain management (SCM) refers to the integration of these varied activities through improved supply chain relationships so that a firm may achieve a sustainable competitive advantage (Handfield and Nichols, 1999). It was not until the late 1980's that firms began to realize the potential productivity gains of managing their supply chain relationships more effectively. Since then, however, there has been a dramatic increase in firm's attempts to gain effective control over their supply chains.

In the past, various elements of the supply chain, including marketing, distribution, manufacturing, and purchasing, operated independently of one another. Organizations involved in the supply chain usually developed goals and objectives to maximize their productivity levels without regard to the other members of the supply chain. What ensued was that goals were often at cross-purposes with one another, and this led to less than optimal efficiency. For example, a manufacturing firm's objectives are usually to maximize throughput with minimal costs. These objectives can conflict with those of a marketing organization, which seeks to have high levels of customer service and maximum sales dollars (Ganeshan and Harrison, 1995). These processes in turn can have little concern for inventory levels and purchasing patterns, and it is easy to see how efficiency was lost in the organization of the supply chain. Supply chain management has allowed firms to move towards integration of the goals of the supply chain unit (marketing, distribution, manufacturing, and purchasing) as a whole and has improved coordination among its members.

Information technology has played a critical facilitating role in the development of supply chain management. It has been described as the linkage that connects the members of the supply chain into an integrated whole (Quinn, 2000). Commonly accomplished through computers connected to the internet, firms can use technology-based applications to view up to the minute information on product orders, deliveries, and shipments. A properly operating seamless network of suppliers can

enable companies to reduce costs and increase revenues while decreasing the unreliability that was inherent in the formerly static supply chain system.<sup>5</sup>

### *Value of SCM*

SCM can add value in several ways. By allowing firms to integrate the elements of the supply chain network, there are decreased costs, higher profits, and the ability to develop a competitive advantage over like firms. Nix (2000) also describes the concept of customer value, which relates to the customer's perception of how his or her various needs are met and what benefits are obtained based on the cost paid. SCM enables the customer to experience an increase in perceived product value reflected as a higher level of satisfaction, and thus additional benefit is created. "The degree to which customers are satisfied by the value created in dimensions important to them influences purchase choices and behaviors that improve the financial performance of the supply chain and the firms within it" (Nix, 2001, p. 63).

SCM also adds value through reducing the time and money costs of transportation. Since transportation makes use of various financial, temporal, and environmental resources, it wastes resources to move products more than necessary (Bowersox and Closs, 1996). SCM enables products to be moved only when it is necessary, so it can therefore enhance the value of the product. Transportation in the context of supply chains is not a cost that need be minimized but an "interdependent cost component in the mix of trade-offs to be considered in managing a logistics system or a supply chain" (Min and Keebler, 2001, p. 254). Better managed transportation functions also mean that inventory levels are reduced and that products are produced closer to the actual time when they are needed, creating additional value (Nagarajan, et al, 1999).

### **Transportation and Supply Chain Management**

Before describing in greater detail the relationship between transportation and SCM, it is useful to briefly trace the historical role of transportation in commerce. Before deregulation occurred in the US, transport rates and charges were largely fixed and the high level of regulation made transportation service development and expansion relatively inflexible.<sup>6</sup> Transportation and logistics were primarily viewed as a necessary evil that could not be well adapted or integrated with other supply chain functions (Min and Keebler, 2001).

Since deregulation of all land transport modes occurred in the late 1970's and early 1980's, there has been an ever increasing interest on integration of transportation with other components within the supply chain.<sup>7</sup> In the period soon after deregulation, transportation tended to be driven by price, as managers began to search for new ways to survive with the new regulatory structure. This eventually led to an increase in pricing flexibility for carriers and the availability of new types of

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<sup>5</sup> Static in that it did not have real-time information and decisions were made on historical average data. For example, re-stocking would rely on the average order volume from the previous month.

<sup>6</sup> The inflexibility came about because any changes had to be approved by the regulatory board and were in most cases challenged by other firms operating in the market. This led to a protracted and litigious process.

<sup>7</sup> Marine transport was liberalized under the Ocean Shipping Reform Act of 1998. The Shipping Act of 1984 only provided partial regulatory relief, allowing (among several provisions) shipping lines to enter into volume shipping contracts with customers, and take independent pricing action based on set prior announcement deadlines to other conference members.

transportation services. As supply chain management has come into greater focus in the last decade, transportation has also become even more integrated with other supply chain functions (Min and Keebler, 2001).

Transportation is today increasingly being seen as a resource to be used by the supply chain as a way to increase profits and provide added value to the customer: “Successful carrier firms have recognized that transportation is more than just moving goods from one point to another – it involves the delivery of transportation/logistics services that meet the needs of customers” (Stock, 1988, p. 27). Because customer needs are placed at the forefront, firms must make concentrated efforts to maintain existing customers to remain viable. The need for maintaining existing customers is critical: it is five times as expensive to attract a new customer than it is to keep an existing customer (Slater and Narver, 1994).

### *Logistics*

The area of logistics originally belonged to the realm of manufacturing, but has since become increasingly incorporated into transport.<sup>8</sup> Transportation firms are making use of adding logistics functions into their value chains in order to make the best use of available information in moving products with maximum efficiency and effectiveness.<sup>9</sup> Logistics has also had an impact on the supply chains capabilities and profitability (Min and Keebler, 2001). Essentially, the goals of effective logistics management are to lower customer costs and improve service to the customer in the most efficient way. Nagarajan, et al, (1999) describes the logistics function as using the right information to move materials to the right place at the right time and at the right cost.

Logistics may be thought of as the organization, sequencing and timing of the movement component of SCM. Without knowing how to move materials in the best way, the potential benefits of managing the supply chain are much more difficult to arrive at, if at all. However, logistics alone cannot sustain or produce the benefits that SCM can. Logistics value-added includes efficient positioning of well-maintained transportation equipment, resulting in timely, serviceable product deliveries, efficient service reservation systems which minimize overbook problems, JIT inventory management principles result in lower warehousing requirements and more synchronous positioning of parts/components for assembly lines. These features speed product to market, improve customer perceptions and satisfaction, and yield better products/ outturns. “An understanding of the entire supply chain is critical in identifying and delivering value that improves the competitiveness of the chain as a whole” (Nix, 2001, p. 65). Thus, value may be created at many points along the supply chain, and logistics is simply one of those points.

Many transportation companies/carriers have branched out their service portfolios beyond transportation logistics, as transportation has become more of a commodity business. Product/service differentiation has driven many transport firms to horizontal integration across other supply chain sectors – i.e. warehousing, packing and labeling, inventory systems management, shipping and receiving, and even product inspection services. These service expansions have often been pursued as deliberate marketing strategies to extend customer loyalty

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<sup>8</sup> Logistics differs from transportation in that the latter focused exclusively on the carriage of goods (and people) whereas logistics includes the organization of information, products and processes to achieve some objective function and, it may include transportation.

<sup>9</sup> For a full description of value chains, see M. Porter, *Competitive Strategy* (1980)

across more segments of their supply chain logistics. They also drive private sector investments in ITS-related:

- web-based shipment tracking/ tracing systems;
- web-based reservation systems;
- web-based documentation/shipping instruction systems;
- automatic equipment identification (AEI) systems for warehouse and staging yard management activities;
- GPS-linked, line-haul vehicle tracking systems;

all of which are an array of labor-saving, service improvement technology innovations.

### *ITS and the Supply Chain*

As firms seek to emphasize and expand the role of transportation in their supply chains, ITS applications are facilitating these changes. As mentioned above, information technology plays a facilitating role in supply chain management. Within the transportation context, ITS applications occupy this enabling role. Such applications not only can optimize transportation operations, but they can have beneficial effects up and down the supply chain, adding value to the customer as well as providing for better integration of the organizations that make up the supply chain. This integration comes about because of the closer relationship required between firms and their suppliers, the need for high quality and reliability in service standards.

If ITS is said to play an enabling and facilitating role, then it must be stated what is enabled by or through ITS. ITS applications in the supply chain context may enable three things: better operations, integration, and the creation of customer value. Within operations, applications such as AVL and route guidance offer ways to reduce travel time and increase reliability. In terms of integration, ITS can facilitate better communication within firms and with other firms. Electronic Data Interchange (EDI), for example, allows paperless communication with other firms in the supply chain as well as with inspection stations and border crossings. The third way that ITS applications can enable is in the creation of customer value. In this area, ITS applications may allow the customer to track a shipment over the Internet and plan accordingly. Without AVL, or on-board monitoring ITS technologies, such creation of value would not occur because the information is not available on a timely basis..

### **SCM in the Trucking Sector**

The trucking industry has experienced several changes since deregulation. As mentioned above, deregulation of all modes of transport has led to new types of customer services being offered and to more flexible pricing options. Additionally, the trucking industry is characterized by intense competition, low profit margins, and a relative ease of entry into the market, making the need to acquire a competitive advantage even greater (Nagarajan, et al, 1999).

Due to the conditions of the trucking industry, there have been a large number of innovations designed to allow firms to operate more productively. Similar to other modes, the movement of freight is no longer the only strategy of trucking firms. To succeed, manufacturing and service firms must integrate their supply chains to reduce costs and provide added value to customers. A number of technological innovations have been employed by trucking firms in attempts to accomplish this, several of which fall under the umbrella of ITS/CVO applications. A list of the innovations is given in Table 2 below.

<b>Table 2: Technological Innovations in Trucking Industry</b>	
<b><i>Innovation Category</i></b>	<b><i>Examples</i></b>
<b>Telecommunications</b>	Wireless, satellite communications
<b>Computer hardware and software</b>	Mainframe systems, electronic vehicle management
<b>Navigation and positioning</b>	AVL, route guidance, computer aided dispatch
<b>Sensing and tagging</b>	Electronic toll tags, transponders
<b>Data exchange and fusion</b>	Electronic Data Interchange (EDI) with outside agencies
<b>On board diagnostics</b>	Process monitoring, trip recorders
<b>Internet and bar codes</b>	Real time freight tracking for customers

Source: Nagarajan, et al, 1999

The ITS/CVO applications largely fall under the ITS Program Area of Carrier Operations mentioned above, and include AVL, on-board computers, real-time driver information, transponder based tolling and border clearance, and so on. Additionally, Electronic Data Interchange is an innovation that falls under the Credentials Administration ITS Program Area, as it can involve credential checking with the enforcement agency.<sup>10</sup>

#### *Benefits of ITS Applications in Trucking*

There have been several studies performed on how some of these applications benefit trucking firms, which are described below. On-board monitoring systems are one area that benefits firms by enabling real-time monitoring of a firm's vehicle fleet.<sup>11</sup> On-board monitoring is a type of process monitoring technology that enables better management of a firm's resources in the short term by recording trip characteristics and allowing dispatchers to use this information when scheduling subsequent runs. Problems with the delivery of a good can be quickly remedied, minimizing disruptions downstream on the supply chain.

Hubbard (1998) studied two types of on-board monitoring, and found that such information is more valuable for trucks that operate far from home, and less valuable for trucks that return home at the end of the day. Also, trucks that deliver to loading docks and that haul goods for which sales/inventory ratios are low are particularly advantaged by the use of on-board computers. Thus, it appears that where the effective logistics management is being employed to keep inventories low, the benefits of an ITS application are more pronounced. In a later study, Baker and Hubbard (2000) also found that the use of on-board computers tended to lead to less driver ownership of vehicles and suggested that this could lead to less independent contracting and larger firms.

Despite the evidence suggesting clear benefits to supply chain management facilitated by information technology and ITS application, there has not been such a clear benefit reflected by increases in firm productivity. Chakraborty and Kazarosian (1999) studied this lack of clear evidence that information technology necessarily increases productivity. Using the trucking industry as an example, they concluded that the ability of a firm to realize productivity benefits from

<sup>10</sup> EDI is critical in the arena of international freight movement conventions and is often an integral data exchange component in large-scale, inter-carrier operating alliances.

<sup>11</sup> We refer to generic on-board monitoring, not the ITS on-board safety monitoring nomenclature (cited in the National ITS Architecture as Market Package CVO 08).

spending on technology depends on marketing objectives. That is, a trucking firm wanting to increase productivity by implementing an AVL system must first decide a fitting marketing objective, such as whether it wants to market itself as always being on-time. Then, by including the impact of marketing objectives, the productivity impact of a particular ITS application can be better verified.

### **APPLICATION TO THE PUBLIC SECTOR**

While it is rather clear that ITS and SCM have dramatic benefits for the private sector, it is less certain if and how SCM can benefit the public sector. In the above section on EC, it is shown that ITS/CVO applications can save costs for government. However, an emphasis on SCM technology may also allow for public cost savings, better customer service, and benefits of integration. This section describes public private benefits and possible ways that SCM can affect public management and oversight activities.

#### **Public Benefits from ITS/CVO Applications**

Several studies have looked specifically at the benefits that can be realized by public agencies through the implementation of ITS/CVO. These studies have largely found there to be benefits to agencies from ITS/CVO introduction, but they have largely studied how agencies may save on regulation enforcement costs rather than how agencies may make use of the potential for productivity gains.

Booz-Allen-Hamilton (1994) found benefit/cost ratio to the government of 7.2 for electronic clearance, 7.9 for one-stop/no-stop shopping, and 5.4 for automated roadside inspections. Rubel (1998) set out to answer the questions pertaining to the savings and additional revenues that investment in ITS/CVO might bring about, as well as the required level of investment by the state in ITS/CVO deployment. Case study findings arrived at several conclusions:

- Because states vary in ways of administering and enforcing CVO operations, benefits of ITS/CVO deployment will vary.
- Electronic credentialing, the in-house administration function of ITS/CVO, produces significant net benefits to agencies because of its small start up costs.
- With respect to electronic clearance, costs of implementation are likely to be high and thus will make it more difficult for agencies to benefit from such technology.<sup>12</sup>
- Also, agency benefits are dependent on the extent of participation by the motor carrier industry.

These conclusions were the result of a model used to calculate agency benefits. The model, however, did not take into account economic benefits to motor carriers or societal benefits such as those which an increase in safety may produce.

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<sup>12</sup> The higher costs for public agencies relates to higher transactions cost of moving change through any public agency and the lack of incentives created by the opportunities in using EDI, for example. It does not imply that benefits would differ in kind between public and private sectors.

## SCM in the Public Sector

If ITS plays an enabling role within the private sector supply chain, it can also enable better management practices in the public area. Since the private trucking sector must communicate often with public agencies, there is an interest for private managers to integrate in some capacity to better manage the supply chain. Public agencies may also use several ideas of SCM to obtain similar benefits. Through integration and EDI, less paperwork is required, and costs are decreased. Within public fleet operations, the potential benefits of SCM practices may result in increased travel time reliability, route guidance, and better operational oversight.

Hall (1997) showed the ways ITS and integration of operations can be used to improve private vehicle operations and governmental services within intermodal traffic management centers. Despite finding that there is little market incentive towards this integration, there was also little opposition towards a move in this direction. Based on interviews and focus groups, trucking firms were found to be willing to invest and participate when there was only a modest investment required, when there were no new taxes involved, when efficiency, safety and customer service were promoted, and finally when such compliance was voluntary. Finally, the industry was more likely to favor CHP efforts towards integration rather than Caltrans or DMV efforts due to the perception of the CHP as more efficient and business-like.

## CONCLUSION

There are several important conclusions that can be extracted from the literature of electronic clearance and supply chain management. First, the benefits that the public and private sectors can expect from adopting ITS technologies can vary largely. For the trucking industry, benefits can vary depending on market objectives, the size of the firm, and nature of the regulatory environment. Public benefits can accrue due to cost savings in enforcement and safety improvements, and benefits can vary depending on the type of ITS/CVO technology and level of penetration into the motor carrier industry.

Because of the varying nature of benefits and since there are significant implementation costs to EC systems; the implementation of such a system in a particular case should be studied carefully. With proper implementation, studies suggest that EC will produce a net benefit to the implementation agency through cost savings. However, benefits are contingent on participation by the motor carrier industry. Because level of participation is critical for agencies to realize benefits, there should be a need for agreement from motor carriers before an EC system is introduced. Efforts toward integration might be guided by private experience with supply chain management. In effect, the business case for EC has been made in the private sector and this should inform the public sector. The difficulty is the public sector has different performance criterion than the private sector. Benefits are clear for private industry, and similar benefits can likely be experienced in the public sector.

Experience from the private industry should serve as a benchmark for any agency exploring an application that has been more widely deployed by trucking firms. Private firms have begun to experience productivity benefits, increased customer service levels, and a competitive advantage over other firms due in part to ITS/CVO applications such as on-board monitoring and AVL.

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