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Commercial Vehicle Fleet Management and Information Systems

Technical Memorandum 3

ITS Fleet Management Technology
Resource Guide

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Acronyms

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AVL	Automatic Vehicle Location	1
AVM	Automatic Vehicle Monitoring	4
CDPD	Cellular Digital Packet Data	13
CMRS	Commercial Mobile Radio Service	12
DGPS	Differential Global Positioning System	8
DSRC	Dedicated Short-Range Communication	9
ESMR	Enhanced Specialized Mobile Radio	19
ETA	Estimated Time of Arrival	15
GPS	Global Positioning System	15
ITS	Intelligent Transportation Systems	1
LEO	Lower-Earth Orbit	4
LMS	Location and Monitoring Service	4
LORAN-C	Long Range Navigation	9
LTL	Less Than Truckload	2
MEO	Mid-Earth Orbit	4
MSS	Mobile Satellite Services	1
NVNG	Non-Voice Non-Geosynchronous	5
OBCs	Onboard Computers	1
PCS	Personal Communication Service	20
SMR	Specialized Mobile Radio	1
TDOA	Time-Difference-of-Arrival	5
VHF	Very High Frequency	6

1.0 Overview of ITS Technologies for Fleet Management

1.1 INTRODUCTION

In today's increasingly competitive economic environment, effective management of commercial vehicle fleets is important for all types of carriers and for the trucking industry as a whole. To meet fleet management needs, carriers increasingly are turning to intelligent transportation systems (ITS) technologies. ITS technologies can enhance the competitive advantage of the industry and of individual trucking companies by improving the efficiency of goods movements through real-time information exchange and communications, and by providing customers with up-to-the-minute information regarding the location and timing of shipments and deliveries.

This resource guide provides a summary of the technologies currently used for fleet management. Four broad categories of technology, along with their benefits and drawbacks, and current vendors and costs, are described in this introduction. In the body of the report, more detailed fact sheets are provided, which include information about each technology.

1.2 FLEET MANAGEMENT TECHNOLOGIES

ITS technologies for fleet management can be grouped into four major categories: automatic vehicle location (AVL) systems, mobile communications systems, on-board computers (OBCs), and routing and dispatching software.

- **Automatic Vehicle Location (AVL) Systems.** AVL systems make it possible to pinpoint the location of a vehicle using radio navigation systems. There are two basic types of AVL systems: satellite and ground-based infrastructure. When combined with on-board computers, routing and dispatching software, and communication systems, AVL systems allow drivers, dispatchers, shippers and receivers to track a truck from pickup to delivery, to facilitate "just-in-time" deliveries, to coordinate intermodal shipments, and to provide improved customer services.1 AVL systems are used most often by carriers, such as truckload carriers, that give a high priority to continuously tracking shipments and projecting accurate delivery times.2

- **Mobile Communications Systems.** Mobile communication systems provide two-way data or voice communication between drivers and dispatchers, and communication between carriers and other parties such as intermodal facility operators, regulatory institutions, clients, and intermodal carriers. Four technologies provide two-way mobile communications: mobile satellite services (MSS), specialized mobile radio (SMR) systems, cellular systems, and paging systems. These technologies can be integrated with a company's computer operations and vehicle location systems to allow for the exchange of real-time routing, dispatching, and pick-up and delivery information. The current primary

markets for mobile communications systems are less-than-truckload fleets, just-in-time delivery operations, and quick-response retail ordering companies.[3]

- **On-Board Computers.** OBCs are used to record business transactions, driver logs, vehicle location information, and mechanic's logs. This information is download from the OBC to the dispatch center using mobile communication systems. OBCS often are used in conjunction with routing and dispatching systems as well as wit maintenance scheduling software. Long haul truckload carriers, just-in-time delivery services, and couriers, who use OBCs to improve data entry, optimize routing, and provide shipment monitoring services to clients represent the primary markets for these technologies.[4]

- **Routing and Dispatching Software.** Routing and dispatching software helps carriers to select routes that minimize the time and cost of scheduling trucks, and helps assign freight and drivers to trucks. More sophisticated systems also make routing decisions based on real-time truck locations, generate route maps, estimate delivery times and distances, and help improve cost estimates. To realize their full potential, these systems must be integrated with OBCs, mobile communication systems, and AVL systems. The primary users of routing and dispatching software are carriers such as package delivery fleets and less-than-truckload (LTL) operators that assign a high priority to maximizing equipment utilization and improving overall cost-effectiveness.[5]

The ITS technologies included within each category are listed in Table 1.

1.3 RESOURCE GUIDE ORGANIZATION

The sections that follow provide a fact sheet on each of the currently available ITS fleet management technologies. For each technology, the following information is provided:

. Definition;

. How It Works;

. Market;

. Cost

. Vendors; and

. Outlook.

Section 2.0 discusses AVL systems. Mobile communication systems are covered in Section 3.0. Sections 4.0 and 5.0 discuss OBCs and routing and dispatching, respectively. The benefits, drawbacks, costs, and outlook of the technologies covered in this resource guide are summarized in Section 6.0.

Table 1. Fleet Management Technologies.

Automatic Vehicle Location (AVL) Systems

- Satellite AVL Systems
  - Global Positioning System (GPS) Satellites
  - Geostationary Satellites
  - Little Lower-Earth Orbit (LEO) Satellites (Also provides communication capabilities)
- Ground-Based Infrastructure Systems
  - Location and Monitoring Service, formerly known as the Automatic Vehicle Monitoring (AVM) Band (Also provides communication capabilities)
  - Dead Reckoning
  - LORAN-C
  - Signpost
  - Dedicated Short Range Communication (DSRC)

Mobile Communication Systems

- Mobile Satellite Services (MSS)
- Specialized Mobile Radio (SMR)
- Cellular
- Paging

On-Board Computers (OBCs)

Routing and Dispatching Software

2.0 Automatic Vehicle Location

2.1 OVERVIEW

Definition

Automatic Vehicle Location (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 allow drivers, dispatchers, shippers and receivers to track a truck from pickup to delivery, to perform "just-in-time" deliveries, to coordinate intermodal shipments, and to provide improved customer service. Law enforcement can use AVL technologies to track lost or stolen fleet vehicles and for emergency notification.[6]

How It Works

There are two basic types of AVL systems:

- Satellite AVL systems – These include global positioning systems, geostationary 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 signposts.

An AVL system calculates vehicle location with accuracies ranging from 100 feet to 3,000 feet. Basic systems also interface with software, with two-way communication between drivers and dispatchers, and with on-board computers that decipher AVL transmissions. More sophisticated AVL systems work in conjunction with other ITS technologies to provide services that include stolen vehicle recovery, road assistance, real-time routing and dispatching, and logs of truck routes that help improve routing and dispatching.[7,8]

The various satellite AVL and ground-based systems are described below in detail. (See Tables 2 and 3 for summaries of satellite and ground-based infrastructure AVL technologies.)

Benefits and Drawbacks

According to a 1992 survey by the American Trucking Association (ATA) Foundation, which interviewed approximately 500 carriers, AVL users generally are pleased with the capabilities and performance of AVL systems.[9] A second ATA survey conducted in 1996, which interviewed approximately 700 carriers, indicated that the use of AVL systems is most prevalent among motor carriers with nationwide operations, and among large carriers (e.g., 100 power units or more).[10] In comparing the two basic types of AVL systems, however, satellite systems are less effective in urban areas, because their radio-navigation signals are reflected and distorted by buildings, bridges, power lines, and other structures. The greater

reliability of ground-based systems in urban areas may make this technology more attractive to short-haul motor carriers. In contrast to satellite systems, ground-based systems require a network of antennas to determine vehicle locations. Because sufficient antenna coverage does not exist throughout the United States, these systems fall short as a vehicle location determination system for long-haul trucking. Satellite systems, which have global coverage, can be used more effectively by long-haul carriers.

Market

About eight percent of the carriers interviewed in the 1996 ATA Foundation survey reported using AVL systems.[11] Large, national, and for-hire truckload fleets were the major users of this technology. The largest market for AVL services among metropolitan area fleets are transit, ambulance, and courier companies.[12] In general, carriers that are most concerned with tracking shipments and making accurate estimates of delivery times are more apt to employ AVL systems.[13]

Cost

Capital costs for AVL systems range from $100 to $3,000 per vehicle.

Vendors

Listings of vendors for satellite and ground-infrastructure AVL are included in Sections 2.2 and 2.3, respectively.

Outlook

AVL systems are expected to become more widespread as a result of the following developments:

- An expected decline in AVL system prices;
- The establishment of a complete global positioning system (GPS) constellation of 24 satellites, which has provided a more reliable and comprehensive coverage;
- The issuance by the Federal Communication Commission (FCC) of the final rules concerning the automatic vehicle monitoring (AVM) band, which has encouraged the entrance of more risk-averse firms into the AVM band market (now referred to as the location and monitoring service (LMS));
- The emergence of companies that provide lower-earth orbit (LEO) and mid-earth orbit (MEO) satellite systems, which are new digital communication systems that have the ability to track trailers, not just tractors, because powerful transmitters are not required;14 and
- The development of digital enhanced specialized mobile radio (ESMR) networks that now provide AVL capabilities.[15]

2.2 SATELLITE AVL SYSTEMS

Definition

Satellite AVL systems offer global coverage and work best when a vehicle is stationary and far from tunnels, tall buildings, and mountains. The three primary satellite AVL systems are as follows:

- Navstar Global Positioning System (GPS);
- Geostationary Satellite Systems; and
- Little Lower-Earth Orbit (LEO) Satellite Systems.

How It Works

Navstar Global Positioning System (GPS)

Navstar GPS is a one-way communication and vehicle location system developed and maintained by the United States Department of Defense. This system uses a technique called time-difference-of-arrival (TDOA). TDOA for Navstar measures the time delays of consecutive transmissions from at least three satellites (of a total of 24) located 10,900 miles above the earth to an in-vehicle receiver. In addition to an in-vehicle receiver, a GPS system requires an antenna and an on-board computer (OBC) connected to a mobile communications system. For an OBC to interpret the direction, speed, and other identification information of a vehicle, a receiver must capture a minimum of three satellite transmission signals. An OBC processes the vehicle information, which then may be sent via two-way radio or cellular telephone to the dispatch center. The GPS system will locate a vehicle within approximately 100 feet, but location determination may not be possible if high buildings block the transmission signal.16

Geostationa y Satellite Systems

Geostationary satellites orbit at the same rotational speed as the earth at a height of 22,238 miles; as a result, these satellites appear stationary from the earth's surface. These satellites operate in the KU band (14- to 16-MHz) and use TDOA techniques to determine vehicle location. TDOA for geostationary satellites deciphers the vehicle's position by measuring the time delay of consecutive transmissions from two satellites to a vehicle's antenna and in-vehicle processor. The location information is transmitted from an in-vehicle processor to the satellites and then to a dispatch center, which displays the vehicle's latitude and longitude on a map in relation to major landmarks. AVL companies that use geostationary satellites must rent transponders located on the geostationary satellites from commercial satellite owners such as General Electric or television companies. Geostationary satellites can locate a vehicle to within about 3,000 feet. However, terrain shadowing remains as a major problem with geostationary satellite systems, due to their limited number and their fixed-point in orbit.

Little Lower-Earth Orbit (LEO) Satellite Systems

Little LEO satellites plan to offer a two-way communication and a vehicle location service called non-voice non-geosynchronous (NVNG). This system transmits only data, and the

satellites do not move with the earth's orbit like geostationary satellites. Currently, two of the 36 satellite developed by Orbital Communications (Orbcomm) of Dulles, VA orbit the earth at a height of 400 to 500 miles, which is much lower than GPS and geostationary satellites. These satellites operate in the very high-frequency (VHF) band (137-140 MHz). With an incomplete system of only two satellites, Orbcomm can provide only vehicle location services; two-way communication is not yet possible. To determine vehicle location, the two satellites use a Doppler phase shift technique, which measures changes in receiver frequencies. The satellites transmit continuous synchronized signals which are received by on-board control devices; an in-vehicle processor calculates the vehicle's location. Little LEOs can locate a vehicle accurately within 3,000 feet. However, location accuracies frequently approach 100 feet.

Benefits and Drawbacks

GPS-based systems:

- **Benefits.** Global coverage. Greater accuracy of speed, location, and direction information than other existing satellite AVL systems. Can be small, hand-held, and portable, enabling trailer tracking. Free service (managed jointly by the U.S. Department of Defense (U.S. DOD) and the U.S. Department of Transportation (U.S. DOT)).

- **Drawbacks.** Does not work indoors. Terrain interference may occur in dense urban areas. A separate communications device is needed to send location information to a dispatch center.

Geostationary systems:

- **Benefits.** Global coverage. Does not require a mobile communication system such as a two-way radio to transmit location information back to a dispatching center.

- **Drawbacks.** Requires powerful transmitters, which prohibits the use of hand-held devices, makes the hardware more costly, and prohibits trailer tracking due to power requirements. High buildings can block transmission signals.

Little LEO systems:

- **Benefits.** Global coverage. Will offer two-way data communications. Little LEOs do not need powerful transmitters, due to close earth orbit. Thus, the hardware is cheaper, and hand-held devices and trailer tracking are possible. The effects of terrain interference are not significant.

- **Drawbacks.** Less accurate than GPS, especially when the vehicle is in motion. Little LEO communication systems cost about three times more than geostationary communication systems, however, prices are expected to drop significantly.

Table 2 compares the benefits and drawbacks of satellite AVL systems.

Table 2. Summary of Satellite AVL Technologies.

Technology	Description	Benefits	Drawbacks
Global Positioning System (GPS) satellites	GPS satellites, located 10,900 miles above the earth, use TDOA to calculate a truck's position. TDOA measures the time delay of consecutive signals transmitted from a network of satellites. GPS has an AVL accuracy within 100 feet.	Global coverage. Greater accuracy of speed, locational, and directional information compared to other satellite systems. Users do not pay operational costs because the service is managed by the U.S. Department of Defense and the U.S. Department of Transportation. GPS does not require powerful transmitters, making hand-held devices and trailer tracking possible.	Provides only one-way communication from satellites. High buildings can block transmission signals, prohibiting vehicle location determination in urban areas. Does not work indoors.
Geostationary satellites	These satellites maintain geosynchronous earth orbits at a height of 22,500 miles. Using TDOA techniques, the AVL accuracy is about 3,000 feet.	Global coverage. Provides two-way data communication and vehicle location system.	These satellites require powerful transmitters, which prohibit the use of hand-held devices and trailer tracking, and make the hardware more costly. High buildings can block transmission signals.
Little Lower-Earth-Orbit (LEO) satellites	Little LEO satellites orbit the earth at a height of 400 to 500 miles. These satellites operate in a very-high-frequency bandwidth (137-140-MHz). They use Doppler phase shift techniques to locate vehicles, and have accuracies between 100 feet and 3,000 feet.	LEOs do not require powerful transmitters, making hand-held devices and trailer tracking possible. These satellites provide global coverage, two-way, real-time communication (future), and the equipment costs less than GPS.	Accuracy varies substantially when the vehicle is in motion. Little LEOs are not as accurate as GPS systems, and two-way communication is three times as expensive as geostationary.

Market

Satellite systems are the primary location/navigation technologies for fleet management marketed to the trucking industry because of their higher accuracy and lower costs when compared to ground-based infrastructure.

cost

GPS-based systems. Capital costs for vehicle units range from $300 to $3,000 per vehicle, depending on the unit's features.

Geostationary systems. Capital costs are $150 per month per vehicle for leased units or $3,500 to $4,500 to buy equipment.

Little LEO systems. Capital costs for vehicle units are less than $1,000 per vehicle.

None of the costs listed include maintenance and operation.

Vendors

GPS-based AVL manufacturers:17

- AUTO-TRAC, Dallas, TX;
- Fairchild Defense, Germantown, MD;
- HighwayMaster, Dallas, TX;
- Navigation Data Systems, Inc., New Orleans, LA;
- Rockwell International, Anaheim, CA; and
- Trimble Navigation, Sunnyvale, CA.

Geostationary satellite manufacturers:

- American Mobile Satellite Corporation (AMSC), Reston, VA;
- Qualcomm, Inc., San Diego, CA.

Little LEO satellites manufacturers:

- Orbcomm, Dulles, VA began operating its AVL system in 1995. By 1998, they plan to have a full constellation of 36 satellites.

Outlook

Prior to the development of GPS, geostationary systems dominated the satellite AVL market. However, GPS has seen tremendous growth that is expected to increase. LEO satellite systems will provide significant competition to GPS in a few years because of their ability to provide communications as well as AVL. The development of differential GPS (DGPS), which provides accurate AVL in dense urban areas through the use of supplemental ground-based transmitters, should provide GPS with a competitive edge for urban AVL applications.

Orbcomm plans to have all 36 little LEO satellites fully operational by 1998. VITAsat/Gemnet is a little LEO satellite system that is in development by Volunteers in Technical Assistance and CTA. Other companies that are requesting FCC licenses to operate little LEO satellites include Starsys Global Positioning, GE American Communications, Final Analysis, LEO One USA, and E-Sat.18

Now under development, big LEO satellites will relay positional data with only a slight time delay and will be able to transmit both data and voice. Big and little LEO satellite systems are both non-geostationary and orbit the earth at the same height, but little LEO satellites are limited to data transmissions. Big LEO satellites are expected to be in operation by 1998 or 1999. Big LEO systems will calculate vehicle location by measuring the time delay of transmissions between two or more satellites, and will be accurate to at least 300 feet. Competitors of big LEO satellite systems include Motorola's Iridium, Inc.; Qualcomm and Loral's Globalstar; TRW and Teleglobe of Canada's Odyssey (a MEO satellite system); and ICO Global Communications' Inmarsat P.[19]

2.3 GROUND-BASED INFRASTRUCTURE AVL SYSTEMS

Definition

Ground-based AVL systems differ from satellite systems in that they use ground transmitters or references instead of satellites to determine vehicle location. These systems can locate a vehicle more accurately than satellite AVL systems in dense urban areas, but their coverage tends to be less extensive. The four main types of ground-based AVL systems are as follows:

- Location and Monitoring Service (formerly the Automatic Vehicle Monitoring (AVM) Band);
- Dead Reckoning;
- LORAN-C;
- Signposts; and
- Dedicated Short-Range Communications (DSRC).

How It Works

Location and Monitoring Service

The LMS locates vehicles and provides two-way communication. The original AVM systems began to emerge after the FCC ruled in the 1970s that a portion of the 902-928 MHz band could be used for automatic vehicle monitoring.[20] However, commercial uses often were limited by interference with unlicensed "Part 15" users until a portion of this spectrum was reserved for LMS use by the FCC in 1995.

AVL is provided when a dispatcher uses a paging signal to activate a vehicle's transceiver, which responds by transmitting a signal to land-based antennas. A control system measures the response signal's time of arrival at several antennas and forwards the vehicle location information to the dispatcher. The accuracy of LMS systems ranges from 300 feet to 1,000 feet.

Dead Reckoning Systems

Dead reckoning AVL uses an on-board magnetic compass and wheel odometers to track a vehicle's distance and direction from a known starting point. An on-board computer calculates the vehicle location using the compass and odometer readings. Frequently, this location information is verified against a computerized map database through a technique known as "map-matching." Dead reckoning systems do not require receivers or external transmitters.[21]

Long Range Navigational (Loran-C) Systems

(LORAN-C, according to the 1996 Federal Radio-Navigation Plan, will be decommissioned by the year 2000. LORAN receivers will be obsolete after that date.)

To locate vehicles using LORAN-C, on-board receivers and processors measure the angles of synchronized radio pulses from two or more ground transmission towers of known position. The Federal government developed these ground towers in 1958 as a maritime navigation system and still operates and maintains the system; this eliminates operational costs for users. Even though the system now serves interior locations, it is most extensive and accurate (up to 1,000 feet) along coastal areas.[22]

Signpost Systems

Signpost technology is being used less frequently due to the sophistication of other AVL systems. Signposting involves placing beacons at roadside locations. As a vehicle equipped with a receiver passes a signpost, it receives encoded locational identifier information from the signpost. The vehicle transmits this information along with its own identifier information to a dispatch/control center. Signposts are installed on a case-by-case basis and are accurate to within 50 feet. They frequently are used to complement GPS in enclosed areas, such as covered roadways at airports.

Dedicated Short-Range Communications Systems

DSRC is a very basic technology that has existed for over 20 years. It is used over limited routes or to locate vehicles when they pass specific locations. Roadside transceivers read

vehicle identification information from a small electronic transponder "tag" located on a participating vehicle. This information is then transmitted electronically to a dispatch or other operations center. Traditionally, DSRC is used for electronic toll collection, traffic management, or electronic preclearance, but DSRC increasingly is being used to locate shipments or containers when they arrive at terminals or checkpoints. Some transponder tags can be reprogrammed with new information for each new trip or shipment.

Benefits and Drawbacks

LMS systems:

- **Benefits.** Provides two-way communication. Encounters no transmission interference in urban areas.
- **Drawbacks.** Requires a network of antennas, which are not yet in place nationwide and are unlikely to reach rural areas.

Dead Reckoning systems:

- **Benefits.** Provides accurate determination of location; often, it is coupled with GPS to ensure high accuracies in both urban and rural environments.
- **Drawbacks.** Accuracy varies outside urban areas, often requiring another complementary AVL Sys tern.

LORAN-C systems:

- **Benefits.** The infrastructure is in place throughout the United States and is maintained and operated by the Federal government.
- **Drawbacks.** Accuracy deteriorates away from the coastline, because ground tower coverage is less extensive. This technology will be obsolete by the year 2000.

Signpost systems:

- **Benefits.** Does not require sophisticated and expensive technologies.
- **Drawbacks.** Less advanced technology. Requires installation, tuning, maintenance and power supply for field-installed transmitters. Limited coverage of signposts restricts usefulness to specific routes and gateways.

DSRC **systems:**

- **Benefits.** Does not require sophisticated and expensive technologies.
- **Drawbacks.** Requires installation, tuning, maintenance and power supply for field-installed transmitters. Useful only at specific locations.

Table 3 compares the benefits and drawbacks of ground-based AVL systems.

Table 3. Summary of Ground-Based Infrastructure AVL Technologies.

Technology	Description	Benefits	Drawbacks
Location and Monitoring Service (LMS) Systems	LMS systems use radio frequencies and a network of antennas to locate vehicles. The dispatcher pages a vehicle's transceiver, which responds by transmitting a signal to land-based antennas. A control system calculates the vehicle's location by measuring the signal's time of arrival to various antennas.	LMS performs well in dense urban areas, where buildings may block transmission signals. Provides two-way communication.	LMS requires a network of antennas, which does not exist nationwide.
Dead Reckoning	Dead reckoning uses an on-board magnetic compass and wheel odometers to track a vehicle's distance and direction from a known starting point. An on-board computer calculates the vehicle location. This information then is used by the driver or transmitted to the dispatch/control center.	Dead reckoning can provide accurate vehicle locations in dense urban areas.	Accuracy varies outside urban areas.
LORAN-C	LORAN-C calculates a truck's latitude and longitude by measuring the time it takes synchronized radio pulses from two or more ground transmission towers to reach the truck.	The infrastructure is in place throughout the United States and is maintained and operated by the Federal government.	Accuracy deteriorates in interior territories because ground tower coverage is less extensive. LORAN-C will be phased out by the year 2000.
Signposts	Involves placement of transmitters at fixed locations, typically installed over the roadway on utility poles. As a vehicle passes the signpost, it receives the encoded locational identifier from the signpost, which the vehicle transmits along with its own identifier to a dispatch/control center.	Signposts are a simple and inexpensive technology, but are being phased out in favor of other, more advanced AVL technologies.	Useful only where beacons are installed.
DSRC	Roadside transceivers receive information from passing vehicles equipped with transponder tags.	DSRC is a simple and inexpensive technology.	Useful only at specific locations.

Market

LMS systems are holding their place in the market and remain competitive; LORAN-C is being phased out in favor of satellites. Dead reckoning is used by short-haul carriers, such as couriers, that need exact vehicle location information in dense urban areas. Fleet schedulers use dead reckoning for routing and dispatching, while drivers use it for navigation. Long-haul carriers may use GPS intermittently with map matching to update vehicle locations. Signposting continues to be used for localized areas, primarily for transit buses on fixed routes. DSRC is used primarily for toll road applications, to manage intermodal shipments, and to increase the efficiency of terminal operations.

Cost

LMS systems: Workstation software costs about $1,500. Vehicle transceivers are less than $500 per vehicle, and include communication capabilities.

Dead Reckoning systems: $1,000 to $2,000 per vehicle. Requires additional communication equipment.

Loran-C systems: The LORAN-C unit, which consists of an antenna, receiver, and microprocessor located in the truck cab, ranges from $500 to $2,000 per vehicle. Requires additional communication equipment.

Signpost systems: No data available.

DSRC systems: Varies on a case-by-case basis. Transponder tags generally cost less than $100 apiece with the transponders generally ranging from $25 to $50.

None of the costs listed include maintenance and operation costs such as monthly user fees.

Vendors

LMS system manufacturers:

- Teletrac, Inc., Leawood, Kansas.

Dead Reckoning manufacturers:

- Navigation Data Systems, Inc., New Orleans, LA (“FleetTrak” systems);
- Trimble Navigation, Sunnyvale, CA (“Starfinder” and “Placer” systems); and
- Westinghouse, Baltimore, MD (“SmartTrack Vehicle Management System”).

Loran-C manufacturers:

- Navigation Data Systems, Inc., New Orleans, LA ("FleetTrac" systems); and
- Teleride Sage, Ltd., Toronto, Ontario ("Teledispatch" system).

Signpost manufacturers:

- No manufacturers were identified.

DSRC transponder manufacturers:

- ASGI, Advanced Systems Group International, Inc., Dulles, VA; and
- Texas Instruments, Inc., Dallas, TX.

Outlook

Ground-based AVL systems are being adopted less frequently by motor carrier fleets. The decommissioning of LORAN-C will make LORAN receivers obsolete by the year 2000. Other ground-based AVL systems will begin to lose market share to satellite AVL systems as more satellites are launched during the next several years. Satellite systems are advantageous because they provide reliable global coverage, while remaining cost-competitive with ground-based systems.

Ground-based AVL systems also will be contending with strong competition from cellular AVL systems, which have the potential to gain a large market share of the AVL market within the next one to five years. This is because the FCC mandated that by 2001, commercial mobile radio service (CMRS) providers such as Cellular One must be able to locate 911 callers who are using cellular phones. In essence, this legislation is requiring vehicle location capabilities for many ITS communications systems.

A technology that monitors the location of cellular telephones is being developed by KSI, Inc., of Annandale, VA. This system uses two cell sites to triangulate a cellular telephone signal's angle of arrival. The vehicle location accuracy of the KSI system is expected to be at least 100 feet; the cost will vary depending on a case-by-case basis. The technique is undergoing field trials, and is not yet available commercially. When the infrastructure is in place, it will be able to monitor any vehicle that is equipped with a cellular phone. KSI expects the technology to facilitate fleet monitoring and incident management.

TrackMobile of San Diego, CA also has developed a technology that monitors the location of cellular telephones. Chips inside cellular phones coupled with receivers near cell sites will allow fleet dispatchers to identify the location of a cellular phone. The company is in the final stages of testing, and plans to sell its product commercially by late 1997. The vehicle location accuracy is expected to be from 300 to 3,000 feet, depending on the coverage area.23

Galaxy Microsystems of Austin, TX has developed a ground-wave positioning system that uses four transmitting towers located on the periphery of a metropolitan area and radio waves

below the AM band (180-450 kHz). Galaxy has not begun to sell its product commercially because it is looking for a corporate partner. The current plan is to market this technology primarily as a personal locator. Nevertheless, the technology also could be used as a cellular telephone locator by integrating a chip into cellular telephones. The accuracy is 30 feet or better and will cost about $100 per unit.[24]

Another technology that can be used in assessing vehicle location is cellular digital packet data (CDPD). Small transmitter chips are placed in cellular handsets; these chips transmit cost-efficient packets of data at high speeds over unused cellular voice channels. This system soon will be widely available; however, this technology does not function indoors or in dense urban areas.

3.0 Mobile Communication Systems

3.1 OVERVIEW

Definition

Mobile communication systems provide data or voice communication between drivers and dispatchers, and communication between carriers and other parties such as intermodal facility operators, regulatory agencies, clients, and intermodal carriers. A mobile communication system can be integrated with a company's computer operations, on-board computers and vehicle location systems, allowing for the exchange of real-time routing, dispatching, driver, client, and vehicle information. There are four ways to provide mobile communications:

- Mobile satellite services (MSS);

- Specialized mobile radio (SMR);

- Cellular; and

- Paging.

Two-way radio systems were the most commonly used communication systems for drivers and dispatchers prior to the introduction of satellites, pagers and cellular phones. Originally, mobile satellite communications systems were limited to text transmissions, while specialized mobile radio and cellular systems were limited to voice communications. Currently, satellite systems still provide mostly data messaging services; SMR and cellular systems offer both voice and data transmissions.

How It Works

Satellite systems depend on earth-orbiting transmitters; SMR, cellular, and paging operations depend on ground-based transmitter facilities. More detailed explanations of the technologies are provided below in the descriptions of each mobile communication system.

Benefits and Drawbacks

The benefits of a mobile communication system are as follows:

- Increases the number of possible pickup and delivery stops during a given trip because dispatchers and drivers are able to communicate in real-time;

- Improves the accuracy and consistency of data collected from shippers, due to on-site data entries;[25]

- Transmits emergency signals / messages to drives (e.g., concerning family members) and to dispatchers (e.g., regarding a flat tire or breakdown); and
- Enables dispatchers to locate customer shipments and to calculate estimated time of arrival (ETA), delays, and costs for services. [26]

The drawbacks associated with mobile communication systems are:

- Costs;
- Complexity of the selection of a system;
- System maintenance; and
- System operation.

The strengths and weaknesses of each mobile communication system are discussed in the Sections 3.2, 3.3, 3.4, and 3.5 on mobile satellite systems, specialized mobile radio, cellular, and paging, respectively.

Market

The 1996 survey conducted by the ATA Foundation of approximately 7– motor carriers found that about one-half of the surveyed fleets were using mobile communication system.[27] Market shares were similar between for-hire carriers and private fleets. Less-than-truckload carriers, long-haul companies, and just-in-time delivery operations are the primary types of carriers using mobile communication systems.[28] Carriers tend to favor mobile satellite services because of lower costs and better overall coverage; cellular systems rank second and are especially popular with local and regional fleets because of these systems' good regional coverage.

Cost

The cost of mobile communication systems vary widely, depending on the systems' capabilities. Simple pager systems may cost as little as $50; very sophisticated MSS systems may cost up to $4,000. This cost range excludes maintenance and operation costs such as monthly user fees.

Vendors

Refer to the descriptions of individual mobile communication systems in Section 3.2 through Section 3.5.

Outlook

Mobile communication companies are offering a range of communication options (i.e., satellite, SMR, cellular, and paging services) to provide optimal communication services at the lowest cost. One option consists of integrated mobile communication systems that automatically switch from land-based to satellite networks depending on the location of the truck. Rockwell International developed the first integrated system; Norcom Networks has a competitive system.

The regional carrier segment of the market is beginning to expand. Regional carriers find terrestrial-based systems, such as cellular, more appealing because of their low initial costs. CDPD, which transmits data during pauses in cellular conversations, will make cellular systems more useful and cost-effective. Cellular providers are installing new CDPD hardware and are expected to market regional carriers because an integrated, national cellular network does not yet exist.29

3.2 MOBILE SATELLITE SERVICES

Definition

The standard Mobile Satellite Service (MSS) uses geostationary satellites to relay messages between drivers and dispatchers. Except for the AMSC satellites, which provide voice, data, and dispatching capabilities, MSS only offer text messages.

How It Works

Drivers transmit messages to satellites, which relay the messages to an earth station. To receive messages, dispatchers must use a modem to access their messages at the earth station. The reverse sequence is used when dispatchers send messages to drivers. (AMSC provides direct communications without an earth station.) Unlike GPS satellites, which are managed by the U.S. DOD and the U.S. DOT, most geostationary satellites are owned by private companies.30 To relay messages, satellite services such as Rockwell International must lease space on geostationary satellites. Some of the satellite systems include the following:

- AMSC satellite, which is owned by AMSC, but operated by a consortium of firms including AMSC, Hughes Communications, Inc., and AT&T;
- GTE's Spacenet 2; and
- Inmarsat's Marisat.

Benefits and Drawbacks

Major benefits include:

- Range of satellite coverage, which includes the continental United States, Canada, and Mexico, makes it superior to both SMR and cellular truck systems; and
- Companies can easily track and record communications using text messaging.

Drawbacks of a MSS include:

- Requires expensive hardware to relay messages to satellites;
- Lacks useful fax capabilities because of slow data transmission speeds to and from satellites;[31]
- Limited satellite capacity prevents MSS from providing real-time voice communication (AMSC can provide near real-time communication on demand); and
- During peak periods, the phone lines of the earth station may become congested, so small carriers without dedicated lines may be at a disadvantage.

Market

Mobile satellite services have captured the largest share of the mobile communication systems market. Of about 220,000 wireless communication systems in operation throughout the nation, over 200,000 are satellite systems and used primarily by long-haul operations.[32]

Cost

The hardware for a basic system costs between $3,000 and $4,000 per truck, and includes a transceiver, a dome-shaped antenna and a display terminal. The dispatcher software for a basic system costs between $2,500 and $4,000 per workstation, and must run on the equivalent of a DOS-based IBM 486. The basic monthly fee for transmission of a specified number of characters ranges from $30 to $60 per vehicle.[33] These estimates do not include maintenance costs.

Vendors

The following firms consolidate the various hardware, software, and integration tools into mobile satellite communication packages:

- American Mobile Satellite (AMSC), Reston, VA;
- Qualcomm, Inc., San Diego, CA;

- Norcom Networks, Bellevue, WA;
- Racotek Inc., Minneapolis, MN; and
- Rockwell International, Cedar Rapids, IA.

Outlook

Future satellite developments that promise both voice and data transmissions will present serious competition to MSS. These satellites include the little lower-earth orbit (LEO) satellites by Orbcomm; and big LEO satellites, with competing service providers, including Motorola's Iridium, Inc.; Qualcomm's and Loral's Globalstar; TRW's and Teleglobe of Canada's Odyssey; and ICO Global Communications' Inmarsat P.[34] (See Section 2.2 for details.) The Nationwide Wireless Network (NWN) by Mobile Telecommunication Technologies (Mtel) will provide a combined satellite and ground-based two-way communications system.

All of these systems expect to have significantly lower costs than current MSS systems.

3.3 SPECIALIZED MOBILE RADIO (SMR) NETWORK

Definition

A specialized mobile radio (SMR) network is a two-way communication system similar to mobile satellite services except that messages are transmitted via land-based antennas instead of satellites.

How It Works

Data and voice messages are transmitted between users' handsets and a network of land-based antennas using radio bands over 800 kHz. The antennas are connected by a network of telephone lines. Unlike mobile satellite systems, there is no need to call a central network facility to retrieve messages. Messages are transmitted directly to the dispatcher via telephone and to the driver via radio.

Benefits and Drawbacks

The main advantage of SMRs over satellite is that SMR transmissions are somewhat faster, thereby providing more efficient fax and voice capabilities. The main disadvantage of SMRs is that the ground infrastructure used to relay messages does not cover the entire continental United States. Antennas are located in most metropolitan areas of the United States, but the coverage is sparse in rural regions and is difficult when buildings, mountains, or tunnels obstruct transmissions. A carrier's ability to use this technology would depend on the completeness of coverage in the carrier's operating range.

Market

SMR was authorized in 1974 by the Federal Communications Commission as a supplement to citizens band (CB) radio. Despite its maturity, SMR has failed to gain significant market penetration. Satellite systems are favored for commercial vehicle communications.

Cost

An in-vehicle SMR-based system costs between $1,000 and $2,000.[35] Dispatcher software totals between $2,000 and $3,000; and monthly user fees range from $50 to $100. Other fees include fleet connections to radio lines (up to $1,000 per month) and telephone rates that range from $0.40 to $0.80 per minute. These estimates do not include maintenance costs.

Vendors

The following manufacturers produce SMR systems:

- ARDIS, Lincolnshire, IL ("Transportation Express");
- Motorola Inc., Schaumburg, IL ("CoveragePLUS");
- Nextel Communications, McLean, VA ("NexNote");
- Racotek Inc., Minneapolis, MN ("RacoNet"); and
- RAM Mobile Data, New York, NY ("Mobitex").

Outlook

As the cellular phone/data industry expands, it will provide more competition for SMR. Nevertheless, enhanced specialized mobile radio (ESMR) networks are being developed that support more reliable and cost-effective voice and data services.[36] ESMR will also be able to provide AVL capabilities.

3.4 CELLULAR PHONE SYSTEMS

Definition

Cellular mobile communications systems are two-way communication systems similar to mobile satellite and SMR communication networks except that messages are transmitted using cellular phones.

How It Works

Voice conversations 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.

Benefits and Drawbacks

Historically, cellular systems offered to commercial vehicle operators charged long-distance telephone fees, as well as "roaming charges" (i.e., cellular usage fees ranging from three to five dollars per call). Furthermore, cellular systems traditionally offered only voice transmissions. New systems have eliminated "roaming charges" and also have lower start-up costs, but high long-distance telephone charges keep operating costs high.[37] Similar to SMR and satellite, signals can fade when obstructed by tunnels, mountains, or buildings. Because cells are sparse in some of the less populated areas of the United States, there are coverage limitations.

Market

Cellular systems attract smaller fleets such as local and regional companies because of their low initial costs. Commercial vehicle operators rank cellular systems as a distant second, compared to mobile satellite systems.

Cost

A cellular phone with an auxiliary transmitter, which significantly extends the phone's range, costs approximately $1,500 per truck for a five-year lease. Cellular phone systems without auxiliary transmitters have monthly fees between $30 and $40 per truck. All cellular voice transmissions average approximately $0.50 per minute. These estimates do not include maintenance costs or long-distance charges.

Vendors

The main distributors of cellular mobile communication systems to motor carriers are:

- HighwayMaster, Dallas, TX;
- Qualcomm, Inc., San Diego, CA; and
- PeopleNet Communications, Corp., Chaska, MN.

Outlook

The market for cellular mobile communication systems is growing dramatically, reducing its cost to consumers. The capacity of cellular telephone services will increase over the next

decade as service providers and users switch from analog to digital systems that transmit data messages. Two digital technologies will compete for this rapidly growing market segment: Personal Communication Service (PCS) systems and CDPD.

PCS systems are more efficient in the use of cellular channels than current analog cellular systems. PCS systems differ from cellular in that they operate at a higher frequency (1.8 to 2.0 GHz) compared to cellular phones (800 to 900 MHz). Sprint, Ameritech, Bell, and other long-distance telephone service providers are developing PCS systems, having purchased licenses from the FCC. Several systems are already in use in major metropolitan areas, providing strong competition to cellular service.

CDPD further improves existing analog cellular efficiency by transmitting data during pauses in phone conversations. This technology, like PCS, can be interfaced with onboard computers to quickly transmit AVL, vehicle status, and vehicle identification information to dispatchers. CDPD was developed by a consortium of McCaw Cellular, GTE, Contel, Ameritech, Bell Atlantic, NYNEX, PacTel, and Southwestern Bell. Fleet managers must purchase a CDPD digital modem to operate the system and pay approximately $0.05 per data message.[38]

Although CDPD provides digital service for existing analog cellular providers, many of these companies are installing PCS transmitters to preserve their mobile communications market. Many companies offer handsets that automatically switch between analog cellular and PCS systems. It is not known which, if either, of these technologies will become dominant.

3.5 PAGING SYSTEMS

Definition

Pagers are mobile communication devices used by dispatchers to send messages to drivers. Dispatchers use pre-coded messages to relay information such as emergencies, routing revisions, special permit pick-ups, and backhaul freight. Dispatchers also can alert resting drivers using a "sleeper beeper" option.

How It Works

Dispatchers transmit phone numbers, two-digit codes, and status or full-text messages to drivers. Messages can be transmitted over various radio frequencies. Pagers alert drivers of a message via blinking lights or beeps, and display a 12-number coded message showing first a customer's phone number and then a two-digit code which refers to one of up to 99 coded messages. Coded messages make the system ideal for transmitting pre-recorded correspondences, but it is not capable of transmitting detailed instructions. More sophisticated pagers can provide voice-mail; full-text messages; a message-retrieval system for the driver; a service that repeats urgent messages every 15 minutes for three hours; and group paging.[39]

Benefits and Drawbacks

The main advantage of a paging system is its low cost. The main disadvantages are the lack of extensive two-way communications, and the inability to convey detailed messages.

Market

The paging market is targeting mainly smaller fleets such as owner-operators, as well as long-haul and fixed-route operations.

Cost

Pagers cost less than $200 to purchase; monthly air time or service fees amount to about $20 per truck. These estimates do not include maintenance costs.

Vendors

The main manufacturers and distributors of paging systems for motor carriers are:

- Airtouch Paging, Dallas, TX;
- Cue Network, Irvine, CA;
- MobileMedia, Ridgefield Park, NJ; and
- Paging Network, Plano, TX.

Outlook

Currently, one-way paging is used extensively by motor carriers. Two-way paging networks are available as of 1997 using the new PCS network which is available in selected metropolitan areas. Mobile Telecommunication Technologies (Mtel) is developing a nationwide, two-way PCS network that will enable users to send and receive messages that are more detailed than current two-way pagers.[40] (See Section 3.3 for more detail.) FlashComm of Melbourne, FL has plans to implement a nationwide, two-way messaging and vehicle-location service using high-frequency radio channels and subcarrier channels. FlashComm expects their service to be more economical than satellites, and more sophisticated than one-way pagers.[41]

4.0 On-Board Computers

Definition

On-board computers (OBCs), sometimes referred to as electronic trip recorders, monitor vehicle performance measures such as speed, fuel consumption, and hours of service. This information is downloaded from the vehicle's OBC to the dispatch center using mobile communication systems. OBCs often are used in conjunction with routing and dispatching systems as well as with maintenance-scheduling software. OBCs provide the following functions:

- **Business Transactions.** Registers delivery times, state line crossings, and customer signatures for proof-of-delivery; transmits delivery notifications.
- **Driver Log.** Enables drivers to input records of fuel consumption and hours of service using a keyboard and display screen.
- **Vehicle Location Information.** Deciphers automatic vehicle location system transmissions.
- **Mechanic's Log.** Tracks engine idling, braking, shifting, and acceleration patterns, as well as data from diagnostic systems for ancillary equipment such as refrigeration units. Allows drivers to collect vehicle operations data prior to a malfunction in order to improve safety performance of vehicles.[42]

How It Works

Trip information is recorded by bar code readers, sensors, electronic signature readings, or driver data entry. In older OBCs, a removable memory cartridge is used to transfer the recorded data to an office microcomputer for analysis. Newer 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. One type of on-board computer, called a palmtop computer, transmits stored trip information automatically to dispatchers when the driver places the computer in its cradle inside the truck cab.

Benefits and Drawbacks

The main benefits of OBCs are the savings that occur through lower maintenance costs, and extended vehicle replacement periods that are made possible by the OBC's monitoring functions. The data also can be used to improve fleet safety performance. For example, one company experienced a 56 percent reduction in accident costs and a 25 percent drop in accident frequency after installing OBCs.[43] The main disadvantages of OBCs are the high initial costs for technology and employee training, and the ongoing costs for system maintenance. In addition, rapidly changing technology may make OBCs a risky investment due to the potential for obsolescence.

Market

One-quarter of the approximately 700 motor carriers responding to the 1996 ATA Foundation survey reported using OBCs, primarily for monitoring fuel and engine use. The survey report calculated OBC usage to be approximately 10 percent industry-wide.[44] About six percent of respondents, mostly large and private fleets, reported using electronic driver logs.[45] Long-haul truckload carriers, just-in-time delivery services, and couriers are more apt to use OBCs to improve data entry, optimize routing, and provide shipment monitoring services to clients.[46]

Cost

OBCs range from $200 to $3,000 per unit. These estimates do not include maintenance and operation costs.

Vendors

OBC manufacturers include:

- Cadec Systems Inc., Londonderry, NH ("SensorPLUS");
- IBM, San Jose, CA ("Touchmobile");
- Norand, Cedar Rapids, IA ("RT/DT1700 Radio Data Terminal");
- Qualcomm Inc., San Diego, CA ("SensorTRACS," "JTRACS," "TrailerTRACS"; and
- Rockwell International, Troy, MI ("ProSeries Electronics" and "Tripmaster Data Max II").

Outlook

OBCs are likely to become a standard tool for commercial vehicle operations to obtain a real-time inventory of drivers' activities, business transactions, vehicle location, and mechanical operations. The recent development of the Microsoft Windows CE operating system will further enhance the capabilities of OBCs in the near future. This operating system is designed specifically for palm-top computers. An upcoming fuel tax reporting service developed by HighwayMaster of Dallas, TX will create fuel tax reports according to the number of miles traveled in each state as recorded by OBCs; service will be used to streamline the interstate tax filing process.[47]

5.0 Routing and Dispatching Software

Definition

Routing and dispatching software, also known as computer-aided dispatch, helps select routes that minimize the time and cost of scheduling trucks, and helps assign freight and drivers to trucks. More sophisticated systems also make routing decisions based on real-time truck locations, generate route maps, estimate delivery times and distances, and help improve cost estimates.

How It Works

The simplest routing programs plot the shortest highway path between a set of given points; more sophisticated programs pick the optimum route given instructions to minimize travel time and fuel costs within performance parameters such as driver hours, equipment, traffic, and warehouse constraints. These software programs historically have been custom-tailored to a carrier's operations. The standardization of database software and the use of point-and-click "windows" applications has reduced costs and improved user friendliness.

Benefits and Drawbacks

The 1996 ATA Foundation survey found that carriers using routing and dispatching software reported operating cost savings of three to ten percent in mileage, fuel, time, labor, and paperwork.[48] Other benefits include:

- **Improved dispatcher productivity.** Companies report that routing procedures, which used to take staff eight hours with a manual system, now can be finished in one hour.

- **Reduced client inventory costs.** With computerized routing and dispatching systems, more companies are using "just-in-time" delivery systems that no longer require firms to keep extensive inventories at manufacturing plants.

- **Improved communication efficiency.** One company reports that dispatchers must spend 15 minutes on the phone when relaying load information to drivers. With a computerized system, the data can be relayed instantaneously.[49]

- **Reduced labor costs.** A **company** does not need to employ logistics experts to operate these systems. Simple user interfaces make it possible for employees without specialized training to operate the system. Some shippers are beginning to make their routing and dispatching information available on the Internet so that receivers can track shipments in real-time thus reducing dispatchers' workloads.

The main drawback of routing and dispatching software is that it must be coupled with other technologies to be most effective. For example, OBCs are needed to calculate a vehicle's position, and mobile communication systems are needed to send the vehicle location

information to the dispatcher. Dispatchers use AVL information for real-time routing and dispatching.

Market

The 1996 ATA Foundation survey of calculated that approximately one-fifth of motor carrier fleets use routing and dispatching software.[50] Three-quarters of large and national fleets in the survey reported using the technology, as did one-half of the medium and regional fleets, and one-quarter of the small and local fleets.[51] The primary users of routing and dispatching software are carriers that are interested in maximizing equipment utilization and improving their overall fleet cost-effectiveness such as package delivery fleets and less-than-truckload operations.[52]

Cost

A basic software package for the dispatch office costs about $3,000. Other expenses to consider include hardware, training and system maintenance costs. Companies with automatic routing services have reported achieving savings equal to the start-up costs within the first year of the system's operations. The overall cost reductions for fleets average 30 percent.[53]

Vendors

The following companies manufacture mobile dispatch software:

- CAPS, Inc., Atlanta, GA;
- Dialog Systems Div., E. Lansing, MI;
- Dis-Patch, Neenah, WI;
- Easy Street Software, Inc., Raleigh, NC;
- Etak, Inc., Menlo Park, CA;
- Leaseway Technology, Beachwood, OH;
- Logistics Systems Engineering Inc., Annapolis, MD;
- MicroAnalytics, Inc., Arlington, VA;
- Qualcomm, San Diego, CA;
- Roadnet Technologies, Inc., Timonium, MD;
- RoadShow RTSI, Vienna, VA; and
- STSC, Inc., Rockville, MD.

Outlook

Newer versions of computerized routing programs will give drivers an opportunity to provide input to routing and dispatching through improved on-board systems. On-board, colored, touchscreen-display computer-routing maps are expected to be available to drivers by 1998. Until this time, new routing systems will record page and grid numbers of common map books to facilitate location identification for drivers.[54]

6.0 Summary

6.1 SUMMARY OF BENEFITS, DRAWBACKS, AND COSTS

As summarized in Table 4, each of the four types of ITS technologies used for fleet management has benefits and drawbacks. For example, some technologies, such as satellite AVL systems, offer broad geographic coverage, but do not perform well in urban areas where structures interfere with signal transmissions. Other systems, such as mobile communications paging systems, are relatively inexpensive compared to some of the alternative communication technologies, but offer only limited two-way communications from dispatchers to drivers. It is important that carriers understand these benefits and drawbacks to ensure that they select the ITS fleet management system that can best meet their needs and goals.

Cost remains a major consideration for carriers interested in adopting fleet management technologies. Table 5 provides information on the range of costs associated with each category of ITS fleet management technologies, as well as a list of the vendors selling each technology. It is clear from the table that, even within each technology category, there is a wide range of equipment costs. In general, costs escalate as the power and flexibility of the technologies increases.

6.2 SUMMARY OUTLOOK

The most important challenge for the future of ITS fleet management technologies is to improve mechanisms for integrating AVL systems, OBCs, mobile communication systems, and routing and dispatching software. Service providers are beginning to market complete systems that incorporate these components to facilitate "one-stop shopping" for fleet management technologies. Technologies that incorporate real-time congestion and incident information also are expected to reach the market in the near future. As on-road and on-board ITS technologies improve, drivers or dispatchers also will be able to access automated traffic information. The market for these technologies is expected to continue to grow, as competitive pressures within the motor carrier industry push carriers to pursue fleet management technologies that will improve efficiencies and reduce costs.

Table 4. Summary of Fleet Management Technologies: Benefits and Drawbacks.

Technology	Benefits	Drawbacks
Automatic Vehicle Location (AVL) Systems	***Satellites Global coverage:*** Higher accuracy and lower cost compared to ground-based.	***Satellites:*** May not be effective in urban areas where signals are reflected or distorted by buildings, bridges and power lines.
	Ground-Based: Performs well in urban areas.	***Ground-Based:*** Incomplete antenna network across the United States, especially in rural areas.
Mobile Communication Systems	***Satellite:*** Comprehensive coverage of the United States, and populated areas of Canada.	***Satellite:*** Transmits only data messages; expensive hardware; Lacks fax capabilities; slower transmissions during peak periods.
	SMR: Transmits voice, data and fax messages. Data transmissions group messages and communication tracking.	***SMR:*** Limited coverage in many areas of the United States.
	Cellular: Low start-up costs. Transmits both data and voice messages.	***Cellular:*** High user fees. Limited coverage in rural areas.
	Paging: Low cost, easy-to-use service.	Paging: Allows only one-way communication (dispatchers to drivers). Unable to communicate detailed instructions.
On-Board Computers (OBCs)	Relatively low maintenance costs. Extends useful life of vehicle. Improves fleet safety performance.	Requires up-front costs for purchasing the software and hardware, and for training employees.
		Rapidly changing technology may result in quick obsolescence of equipment, and may make it difficult to remain competitive.
		Involves system maintenance costs.
Routing and Dispatching Software	Improves dispatcher productivity.	Requires up-front costs for purchasing the software and hardware, and for training employees.
	Increases inventory efficiencies.	Involves system maintenance costs.
	Improves communication productivity.	

Table 5. Fleet Management Technologies: Major Vendors and Costs.

Technology	Major Vendors	costs
Automatic Vehicle Location (AVL) Systems	GPS-based: AUTO-TRAC; Fairchild Defense; HighwayMaster; Navigation Data Systems, Inc.; Rockwell International; and Trimble Navigation.	***GPS-based:*** Capital costs are $300 to $3,000 / vehicle for vehicle units.
	Geostationary: American Mobile Satellite; Qualcomm, Inc.	***Geostationary:*** Capital costs are $100 to $200 / month per vehicle for leased units and for a messaging service.
	Little LEO: Orbital Communications.	***Little LEO:*** Capital costs for vehicle units are less than $1,000 / vehicle.
	AVM band: Teletrac, Inc. of Leawood, Kansas.	***AVM band:*** Capital costs for workstation software equals about $1,500. Vehicle transceivers cost less than $500.
	Dead reckoning: Etak, Inc.; Navigation Data Systems, Inc.; Trimble Navigation; and Westinghouse Transportation Systems.	***Dead reckoning:*** Capital costs are $1,000 to $2,000 / vehicle.
	LORAN-C: Navigation Data Systems, Inc.; and Teleride Sage, Ltd. (Units are no longer being produced.)	***LORAN-C:*** Capital costs are $1,500 / vehicle.
	Signposts: No manufacturers identified.	***Signposts:*** Case-by-case basis.
	DSRC: Case-by-case basis. Transponders cost less than $100.	
Mobile Communication Systems	***Satellite:*** American Mobile Satellite; Norcom Networks; Qualcomm, Inc.; and Rockwell International.	***Satellite:*** Hardware ranges from $3,000 to $5,000 / vehicle; Dispatcher software averages from $2,500 to $4,000; Monthly user fees range from $30 to $60 / vehicle.
	Radio: ARDIS; Motorola; RAM; and Racotek.	***Radio:*** Radios cost about $2,000 / vehicle; Dispatcher software totals between $2,000 and $3,000; and user fees range from $50 to $100 / month.

Table 5 ITS Fleet Management Technologies: Major Vendors and Costs. (continued)

Technology	Major Vendors	costs
Mobile Communication Systems	Cellular: HighwayMaster; Qualcomm, Inc.	***Cellular:*** A complete system totals about $1,500/vehicle for a 5-year lease; Monthly fees cost between $30 and $40/vehicle; and transmissions range from $0.30 to $0.50/minute.
	Paging: Airtouch Paging, Cue Network, MobileMedia, Paging Network.	***Paging:*** Hardware totals about $500/vehicle; Workstation software costs about $2,000; and service fees amount to about $20/month.
On-Board Computers (OBCs)	Cadet Systems Inc.; IBM; Norand; Qualcomm, Inc.; Rockwell International.	OBCs range from $200 to $3,000.
Routing and Dispatching Software	CAPS; Dialog Systems Division; Dis-Patch; Easy Street Software; Etak, Inc.; Leaseway Technology; Logistics Systems Engineering; MicroAnalytics; Qualcomm, Inc.; Roadnet Technologies; RoadShow RTSI; STSC.	A basic software package located at the dispatch office costs about $3,000.

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