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THESIS

**SMART TRANSPORT-A SURVEY OF TRACKING
TECHNOLOGIES FOR CARGO CONTAINERS AND
THEIR TRANSPORT PLATFORMS**

by

Jeffrey L. Williams

September 2003

Thesis Advisor:

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**SMART TRANSPORT
A SURVEY OF TRACKING TECHNOLOGIES FOR CARGO CONTAINERS
AND THEIR TRANSPORT PLATFORMS**

by

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Submitted in partial fulfillment of the
requirement for the degree of

MASTER OF SCIENCE IN SYSTEMS ENGINEERING

from the

**NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

As the threat of terrorism rises, nations seek solutions to secure their ports and lanes of commerce upon the world's oceans and skies. The transport industry has taken the lead in developing new technologies to track cargo containers and the transport platforms, for billions of dollars are at stake. This thesis examines the present and future communication and tracking systems used by the transport industry. Furthermore, an investigation into the tracking methods for high-value items such as diamonds will be disclosed. By analyzing the communication and tracking systems used by the transport industry, elements of the Homeland Security organization can mitigate terrorism on the lanes of commerce and ultimately prevent weapons of mass destruction from entering the United States.

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I. INTRODUCTION

A. STRATEGIC CONTEXT

In the wake of September 11, 2001 (9-11) the internal security of the United States has again been thrust onto the national conscience. Like the infamous day of December 7, 1941, the Japanese attack on Pearl Harbor, 9-11 has reminded us how truly vulnerable the country is to the evil of the world.

The nation's response to prevent another attack such as Pearl Harbor was to develop long-range radars that would provide plenty of warning of an attack from a squadron of aircraft or missiles, which were headed for our shores. In addition, the country developed an intelligence system that scours the world for information that would determine which countries were hostile to the United States (US). These systems enable us to find diplomatic solutions before tensions escalate to the level that another country would attack and also provide us the lead time and knowledge to carry the war to an aggressor state's front door.

However, 9-11 has cast light on a new aggressor, the terrorist. Terrorist groups are not nation states and do not possess the means of carrying out conventional warfare. They study our weaknesses within the US borders. They look at the transportation industry as a vehicle for terror to deliver a crushing blow to the US economy and national psyche.

September 11th proved that the country's airline industry was susceptible to terrorism and measures have been taken to mitigate any weaknesses within the airline system. In addition, 9-11 has brought about deep concerns for the security of the nation's ports. The most prevalent concern has been that a terrorist would attempt to smuggle a Weapon of Mass Destruction (WMD) into the country through a cargo container shipped from overseas. Knowing that drugs and illegal aliens are routinely smuggled into the country amongst other legitimate cargo on large commercial ships, this concern becomes very realistic and a potential nightmare for the nation.

Furthermore the General Accounting Office reports,

More than 95 percent of our non-North American foreign trade arrives by ship. In 2001, approximately 5400 ships carrying multinational crews and cargoes from around the globe made more than 60000 US port calls. More than 6 million containers enter the country annually [Ref 1].

These numbers indicate that terrorists have ample opportunity to deliver a WMD to one of the nation's ports.

If a WMD were detonated in one of the nation's major ports, the economic effect would be devastating. The nation got an early glimpse of the economic woes associated with the closure of a port during the labor conflict at West Coast ports in early October 2002. During the 10-day strife between management and dockworkers, it was estimated that the economy might have lost \$19.4 billion. Furthermore, not only was the US economy affected, but Asian manufacturers considered stopping production because their products were stacking up on the docks in Asian ports [Ref 2]. Thus, due to the interdependence of world trade, the longtime closure of American ports can have grave effects upon the global economy.

Due to the potential grave economic losses, the United States government and the maritime industry have taken significant steps to improve security of ports and cargo containers. Programs such as the Smart & Secure Tradelanes Initiatives, US Customs Service's Container Security Initiative, and Operation Safe Commerce are government and industry partnerships aimed at enhancing cargo security and efficiency along the global supply chain. The emphasis of these programs is to use or develop technologies to ensure that the cargo container is tamper proof and can be tracked from its place of origin to its final destination.

B. SUMMARY OF RESEARCH

The maritime and container industries worldwide have developed a number of technologies to track intermodal cargo containers from the time the container enters a terminal or dock to which transport platform it is loaded on and to its final destination. Many of the tracking technologies have been developed in North America and Europe. The tracking technologies being developed are broadly divided into two categories, satellite-based and infrastructure-based. Satellite tracking systems use Global Positioning Satellites (GPS), communications satellites, Global Standard for Mobile

telephony (GSM) and the Internet to relay information from containers, ships, or aircraft to the shipper and the carrier. Infrastructure-based systems use radio tags, tag readers, 802.11b wireless technology, Bluetooth Lite, GSM and the Internet to relay data from a service provider to the shipper and the carrier. Note that there are different combinations for the makeup of a satellite or infrastructure-based system, thus all elements listed above for the respective tracking system may not be present.

These technologies are implemented to improve efficiency, customer service, and security. The technologies allow transport companies to identify containers that are in a low use area and transfer them to a high use area. Idle containers or the transport of empty containers cost the transport companies money. The transport company can communicate directly with customers to relay the status of refrigerated or hazardous containers or indicate whether the shipment will be delivered on time. Customers can be alerted if the containers are damaged or compromised. The physical appearance of the tracking devices mounted on the containers deters unauthorized entries that result in theft, smuggling, and illegal immigration. As governments recognize the security benefits of tracking technologies and as their cost to be implemented become less for transport companies, the equipment will permeate throughout the market.

This thesis examines existing and future tracking and communication systems used to track cargo platforms and the cargo containers. The methodology involves a survey of the existing tracking systems and those planned for the future. In addition, the thesis will attempt to report on the tracking schemes used in unique/high value shipments, such as raw diamonds and international bank checks for clearance. Investigating the tracking and communication systems used to trace cargo and transport platforms may give elements of Homeland Security the ability to mitigate terrorism and prevent the transport of WMD into the United States.

Chapter II is a presentation of tracking systems for shipboard and airborne cargo. The technologies covered are satellite systems, radio identification systems, web-based systems, and the administrative trail created by the elements of the bill of lading and letter of credit. In addition, methods of how to defeat tracking systems, e-seals, and RFID tags are discussed.

Chapter III details the tracking systems for ships and aircraft. Satellite systems, radio systems, and human agent organizations are covered in this section.

Chapter IV depicts the methods for tracking unique or high value items. Tracking technologies for these items will concentrate on methods and processes used to trace items such as diamonds and international bank checks.

Chapter V covers areas in which the information within this thesis can be applied and proposes areas in which further study should be explored.

II. TRACKING SYSTEMS FOR CARGO

A. SATELLITE SYSTEMS

Satellite tracking systems are made up of two separate satellite networks used for determining positions and communicating data. Thus, the systems are respectively called Positioning and Communication Satellites.

1. NAVSTAR GPS and GLONASS

There are currently two positioning satellite systems that are operating today, the Navigation Signaling and Timing Global Positioning System (NAVSTAR GPS) operated by the United States Air Force and the Global Orbiting Navigation Satellite System (GLONASS) operated by the Russian Space Forces. Both of these systems have a 24-satellite network broken into 6 clusters (4 satellites per cluster) orbiting in a Medium Earth Orbit (MEO) and each transmits in the L band. GPS transmits the Standard Positioning Service (SPS) signal at 1572.4 MHz and GLONASS transmits the Standard Precision signal (SP) at 1602 MHz. Both of the satellite navigation systems are capable of transmitting signals which provide greater accuracy than SPS and SP. However, the SPS and the SP signals are available to all GPS users on a continuous, worldwide basis as were the GPS Precise Positioning Service (PPS) and the GLONASS High Precision (HP) signals are limited to military use. To calculate position, commercial GPS receivers capture the SPS or SP signals; the receiver multiplies the time it took for the signal to reach the receiver by the speed of light to determine how far the signal traveled. This calculation is completed four times for each satellite in a respective cluster and through a process called trilateration in which the receiver uses to deduce its position [Refs 3 and 4].

2. European Geostationary Navigation Overlay Service

The position determined by the receiver is usually within 20 meters of the actual position. To obtain a more accurate position an individual or entity may use a receiver capable of receiving Differential GPS Signals (DGPS). A DGPS signal contains the true position and measured position. The difference between these two measurements is designated as the differential corrected distance. This corrected distance can be stored in

the base station or sent to the receiver. When the receiver obtains the SPS or SP signal from each of the satellites, the receiver subtracts the differential correction from the estimated distance to each satellite to improve position accuracy.

DGPS can be derived by a combination of satellite and land-based systems or two different satellite constellations. Currently, DGPS is derived by using land-based and systems. The GPS signal is received at a land station that knows its exact location. The known location is compared with the received GPS signal, the corrected distance is calculated and the corrected signal is forwarded from the land station to everyone within the land station's region. Nonetheless, the European Space Agency, European Commission, and EUROCONTROL, the European Organization for the Safety of Air Navigation, are developing a system called the European Geostationary Navigation Overlay Service (EGNOS), which is based on a separate satellite system calculating DGPS. EGNOS will be fully functional by 2004.

EGNOS is being developed to ensure better accuracy and service. The premise of EGNOS is to provide uninterrupted reliable and accurate positioning data to safety critical applications such as aviation navigation. The accuracy of positions will improve from 20 meters to 5 meters. In addition, the signal from this system will carry the accuracy of the position of each GPS and GLONASS satellite, the accuracy of atomic clocks onboard the satellites, and information on disturbances within the ionosphere that might affect the accuracy of positioning measurement. Thus, the EGNOS system provides not only position data, but also a sense of reliability.

The EGNOS system is made up of three geostationary satellites and a network of ground stations. The constellation will send out ranging signals worldwide like those transmitted by GPS and GLONASS constellations via two Inmarsat-3 satellites, one over the eastern part of the Atlantic, the other over the Indian Ocean, and ESA Artemis satellite, which is above Africa. These birds do not have signal generators on board, thus the system will depend on a ground processing station to up-link the finished signal.

Currently the EGNOS system depends on the positioning signals received from GPS and GLONASS satellites. Through thirty Ranging and Integrity Monitoring Stations (RIMS), the measured positions of EGNOS, GPS, and GLONASS satellite are

processed and sent to four master control centers that determine the accuracy of GPS and GLONASS signals received at each station and determines position inaccuracies due to disturbances in the ionosphere. After all the deviations are calculated and integrated into the signal, the signal is sent via secure communications to six uplink stations throughout Europe. The uplink stations send the signal to EGNOS satellites, which then transmits the signal to users with EGNOS receivers [Ref 5].

3. Galileo

In the future EGNOS will get positioning data from a European owned global navigation satellite system called Galileo. Galileo will be very similar to GPS and GLONASS constellations. Thus, there will be 30 satellites in a MEO, in which three are spares. The first launch is scheduled for 2004 and full operational capability is scheduled for 2008 [Ref 6].

Currently, the aviation community does not sanction existing positioning satellites for use in aviation navigation because both GPS and GLONASS is owned and operated by the countries' respective militaries. Because the militaries have control there is no guarantee that the two systems will always be available to provide service. Thus, Europe has set out to develop a civilian owned system. In addition, Galileo's technology will provide accuracies up to one meter and cover the latitudes up to 75 degrees North. Having the capability of producing one meter accuracy and assuring the service is always available makes the system suitable for aviation navigation, running trains, and guiding cars on future automated highways [Ref 7].

4. ORBCOMM

As mentioned at the beginning of this chapter, a satellite tracking system consists of a GPS satellite system and a communication satellite system. For the remainder of this chapter the focus will be on communication satellite systems. One of the most popular communication satellite systems used for tracing containers is the ORBCOMM system which is based in Dulles, VA.

ORBCOMM is made up of 30 Low Earth Orbit (LEO) satellites and terrestrial gateways deployed around the world. Using a Subscriber Communicator (SC), GPS

signals are read from positioning satellites and relayed along with other data such as temperature, pressure, tank levels, alarms and flow rate into the ORBCOMM communication network via its satellites. The data are then down linked to a Gateway Earth Station (GES) if originated in the United States or through an international Gateway Control Center (GCC) if the data originated outside of the US. The GES or GCC then relays the message via satellite link or dedicated terrestrial line to a Network Control Center (NCC). The NCC routes the message to the final addressee via e-mail, dedicated telephone line or facsimile. Depending on the type of SC and location, the unit may be able to talk to GSM, radio and satellite communication systems. Because the system works in two directions it is possible to send data to the container via the Internet and ORBCOMM constellation. Note data sent via the ORBCOMM system are not for large data files or real-time interactive sessions. Figure 1 illustrates a possible ORBCOMM network configuration [Ref 8].

ORBCOMM's operations in Europe are spear headed by MCS Europe, based in the Netherlands. MCS Europe is responsible for encouraging the use of ORBCOMM services, managing terrestrial infrastructure, and assisting Value-Added Resellers (VAR). There are 31 VARs listed on the ORBCOMM website that are the middlemen between customers and ORBCOMM. The VARs provide industries with tailored expertise, solutions, and customer support to end-users. VARs' solutions have targeted customers that have reefer trailers, reefer containers, tank containers, road tanks, rail wagons, vessels, box containers and private cars. See a list of value added resellers and service providers in Appendix B for ORBCOMM and other communication satellites. In addition, Appendix A provides a listing of the characteristics for all of the communication satellites discussed in this thesis [Ref 8].

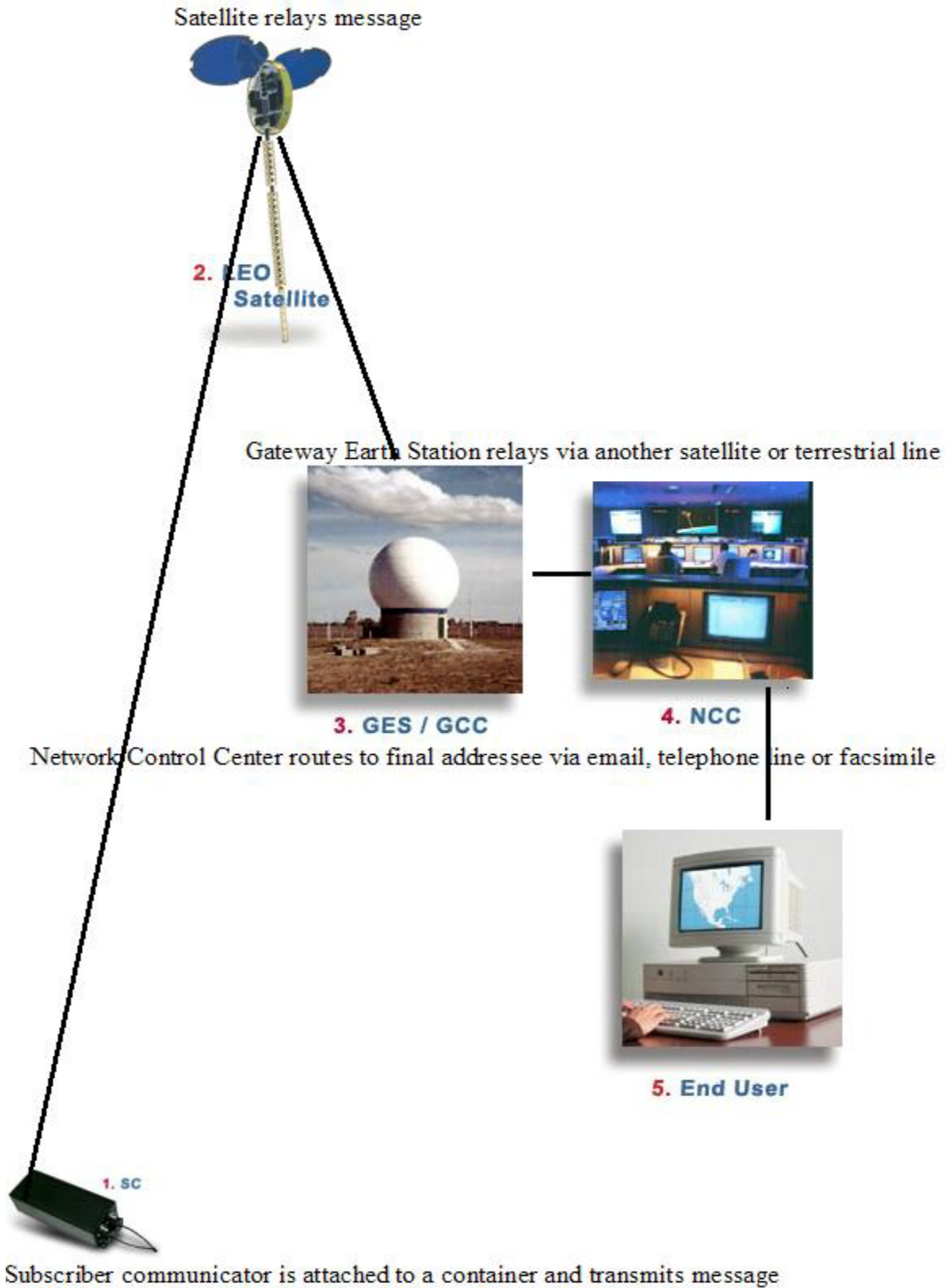


Figure 1. Possible ORBCOMM Network Configuration (After: Ref 8)

5. Argos

The Argos system was established in 1978 under a Memorandum of Understanding between the National Oceanic and Atmospheric Administration (NOAA), NASA, and the French Space Agency. Collecte, Localisation, Satellites (CLS) in Toulouse, France and Service Argos, Inc, a CLS subsidiary, in Largo, MD, manage the system. The primary purpose of the system is to monitor and protect the environment. To meet this goal the system has been employed to track and monitor hazardous cargo, barges carrying hazardous cargo, shipping, animals and fishing vessels [Ref 9].

Argos is a payload flown on board the NOAA Polar Orbiting Environmental Satellites (POES). There are currently two operational POES, NOAA-16, the morning satellite and NOAA-17, the afternoon satellite. In the future, Argos systems will be flown on satellites operated by the Japanese Space Agency and European Meteorological Satellite organization. The satellites fly in near-polar sun-synchronous orbit. The orbital period, 102 minutes, allows each satellite to view any point on the earth at least twice per day.

Customers in the hazardous shipping business mount Argos transmitters on their cargo units to maintain a trace of their hazardous material to ensure safe transit. These transmitters are sometimes called Platform Transmitter Terminals (PTT). PTT transmit to the Argos payload at 401.650 +/-4 KHz. Information transmitted by the PTT contains a preliminary synchronization sequence, statement of message length (32 to 256 bits), transmitter's ID number, and sensor data attached to the PTT or other message data (32 to 256 bits) [Ref 10].

The satellite then transmits to all three main ground stations located at Wallops Island, VA, Fairbanks, AL, and Lannion, France. There are regional receiving stations placed throughout the world, as well. See page 5 of Argos User's Manual for a list of regional receiving stations at www.cls.fr/manuel/. The regional ground stations can receive real-time data whenever a satellite is within station visibility. The information is either immediately relayed or stored and then dumped once passing over a ground station.

The ground stations then forward the data to Global and Regional Processing Centers (GPC and RPC). GPCs are located in Largo, MD and Toulouse, France. Both processing stations ensure quality control, location calculation, and archiving.

Unlike the ORBCOMM system, Argos can provide location data without GPS. Localization is calculated by measuring the Doppler shift from the platform transmissions.

Each time the Argos instrument receives a message from a transmitter, it measures the frequency and time-tags the arrival. Using this information the processing center computes the locus of possible positions for the transmitter. The processing center calculates an initial estimate of the transmitter's position from the first and last messages collected during the pass and the most recent calculated frequency. The intersection of the cones for these two messages with the terrestrial radius + the height declared for the transmitter gives two possible positions. For each position, least-squares analysis is used on the equations for refining the estimate of the transmitter's position and transmit frequency. The position with better frequency continuity is chosen [Ref 10].

This method provides accuracy of 300 meters. If the customer chooses, PTT units can be coupled with a GPS receiver and GPS data can be relayed, as well.

6. Inmarsat

In 1979 International Maritime Satellite system (Inmarsat) was launched to be the first maritime tracking system. In addition to providing service for ships, Inmarsat also provides service for the aviation community and the land mobile units. Inmarsat service supports phone, fax, and data communications up to 64 kbits/s. The service is enabled by four Inmarsat-3s, second generation satellites, in a geostationary orbit. These satellites are backed up by a fifth Inmarsat-3 and four Inmarsat-2s that are all in geostationary orbit. In 2005 Inmarsat expects to offer broadband service via Inmarsat-4 satellites. According to Inmarsat, these satellites will be able to deliver Internet and intranet content solutions, video on-demand, videoconferencing, fax, email, phone and LAN access at speeds up to 432kbits/s [Ref 11].

Depending on the customers needs they have a choice amongst a number of terminals, which can communicate with a satellite. For this chapter, focus is placed on Inmarsat-D+ terminals. These terminals are about the "size of a personal cd-player" and

are able to provide two-way data communications. Thus, these features have enabled Inmarsat to enter the container tracking and monitoring market. These terminals can be placed between the grooves on containers which make them unobtrusive. Currently these terminals are aimed at refrigerated containers, refrigerated and high-value road trailers and rail wagons [Ref 12].

Inmarsat D+ terminals can store and display up to 40 messages of up to 128 characters each. Customers can receive tone, numeric and alphanumeric messages and clear data. These terminals are integrated with GPS receivers, thus position data are provided as well [Ref 12].

The ground segment of the Inmarsat system consists of 40 Land Earth Stations (LES). Communications from the terminals placed on containers are relayed from the satellites to the LESs. The LES is an entryway into the telecommunication networks throughout the globe in which messages are routed to their respective customers. LES provide support to service providers, which provide the direct interface with Inmarsat customers [Ref 11]. See Appendix B for a list of Inmarsat service providers.

B. RADIO FREQUENCY IDENTIFICATION (RFID) SYSTEMS

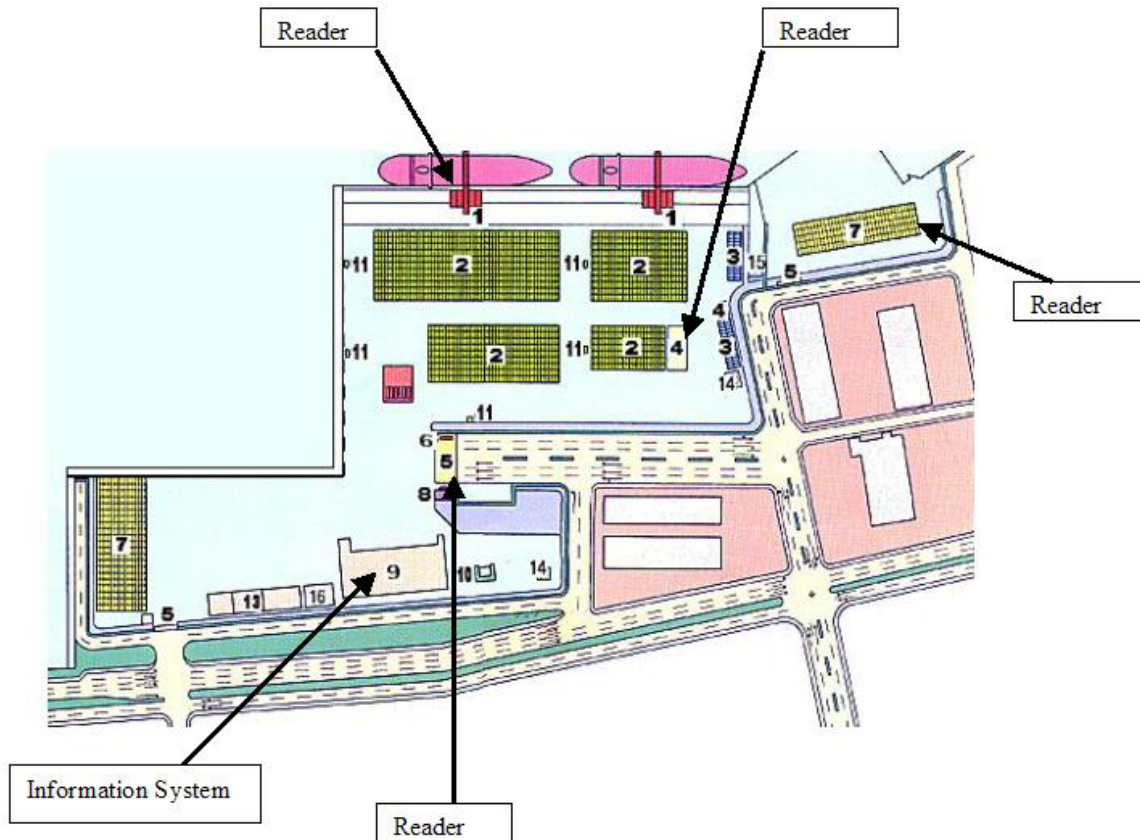
1. RFID Tags for Intermodal Containers

Radio frequency identification technology has been around since World War II. The British made the first major use of the technology by developing the earliest version of an Identification Friend or Foe (IFF) system. The IFF system was developed whereby a transponder was placed on Allied aircraft so that by giving the appropriate response to an interrogating signal, a friendly aircraft could automatically be distinguished from a foe. Not until the 1970s and 1980s were there other applications to utilize the technology, which mostly included identification systems for animals. During the 1990s RFID systems became apart of everyone's life. If you were a commuter in metropolitan area you may have placed a small device on your windshield called EZ Pass, E-Pass, or Smart Pass to get you through a tollbooth. Or you may have walked through the security terminals at the exit of a store or boutique after a purchase and have the alarm trigger because the security tag was not removed [Ref 13].

RFID technology is becoming more and more prevalent in many aspects of our daily lives and even more so in commercial and industrial arenas. Since 9-11, RFID has become a hot topic for tracking cargo in container terminals and across oceans. The above section discussed how satellite systems alone could track containers on ships across oceans. This section will concentrate on container tracking within terminals with RFID technology.

RFID technology in the container industry generally has five components: an active or passive tag (transponder), an antenna, a transceiver, a reader, and an information system to maintain and transport the data. Tags are programmed with data that identifies the container to which the tag is attached. Other information within the tag may be where the container originated, destination, goods within the container, and owner of the goods. Active tags use a battery to run the microchip circuitry and broadcast a signal to a reader. Passive tags are designed so that they reflect modulated RF energy back to the transceiver. In addition, tags can be designed so they can be read only or read and overwrite stored information. A reader retrieves and sometimes writes data to a tag. The reader then relays the data to a database.

A typical RFID setup places an active or passive tag on a container. A reader is placed in a strategic point such as an entranceway. When the tag passes the reader, information on the tag is transmitted to the reader. That information along with the position of the reader is then transmitted to the information system, which maintains the information in a database. Depending on the service provider, that information is accessible to the customer by the Internet with a web browser or emailed upon query or sent at predetermined times. Figure 2 depicts a possible RFID setup at a container terminal [Ref 14]. This figure assumes that tags are already on the containers coming off the ship. The readers are placed at strategic positions throughout the yard to determine the position of the container. In addition, this RFID system would be complemented by 802.11b technology to relay data from the readers to the information system maintaining the database.



- 1. Container Crane
- 2. Container Yard
- 4. Inspection Range
- 5. Gate
- 7. Empty Van Pool
- 9. Office Building

Figure 2. **Possible RFID Setup in a Container Terminal (After: Ref 15)**

Most tags and readers communicate at frequencies ranging from 50 KHz to 2.5 GHz. The system described above, a typical product of Intermec, communicates at 915 MHz and 2450 MHz [Ref 14]. OTranscore, a global leader in supply chain management, works with the same setup, however, most of their asset tracking solutions are applied in rail yards for tracking rail cars or intelligent transportation systems, electronic toll ways or Smart Pass, for toll collection. Transcore does provide service for container tracking. The company’s products use the same frequency as Intermec [Refs 14 and 16].

Savi Technology, another global leader in asset management based in Sunnyvale, CA, offers a slightly different architecture from that mentioned above. In addition to the

tag and reader architecture, Savi includes another element that they call a signpost. This three-element architecture allows Savi to use multiple frequencies to communicate at short ranges, four meters or less, and long ranges, 100 meters. The system works by placing the signpost at strategic points within a container yard. The signpost transmits location data to the tag at 132KHz and the tag transmits at 433.92 MHz or 868 MHz to a reader, maybe at 100 meters away, the location data it received from the signpost. From the reader the data are relayed to information system [Ref 17].

One of the information system products that Savi sells to international shipping customers is the Asset Management System (AMS) for intermodal containers. As described by Savi, “AMS is a web-based application that provides online tracking, security monitoring, and management of cargo containers.” The system configuration consists of a MS Windows 2000, Sun Solaris 8, HP 11, or RedHat Linux 7.2 web server. An application server runs BEA WebLogic 6.1 SP2 and the database is run on Oracle 8I [Ref 18].

WhereNet Corp. and SkyBitz have teamed up to provide tracking not only upon the container’s arrival in a terminal but while in transit as well. WhereNet uses 802.11b technology throughout its Constant Visibility Solution (CVS) in terminal yards. Teaming with Skybitz allows WhereNet to take advantage of Skybitz’s Global Locating System which uses existing satellites to track assets. Together the companies have produced terminals, which contain two transmitters that take advantage of both solutions. The transmitter provided by Skybitz is unique because it does not calculate location from GPS. Instead, the GPS position data are forwarded to a service operation center to be calculated. Not having the calculations done organically increases the life of the battery used to power the unit [Ref 19].

2. E-Seals

Electronic seals (e-seals) are intelligent cargo seals that can automatically alert terminal personnel or concerned customers via wireless communications in the event of tampering. Alerts provide date, time, and position of the container when a seal is breached. The primary purpose of e-seals is to provide physical security. The seals may act as a sensor that provides an immediate alert upon a breach or behave as an indicator

that tells an official the seal was tampered with at a specified time. However, they can also take on the secondary role of tracking if the transmitter within the seal is designed with satellite GPS capability. Furthermore, e-seals have unique identification numbers that are recorded on the bill of lading and kept in databases. Thus, the container can be indirectly tracked by tracking the e-seal used to secure the container.

E-seals are made up of a two-element architecture, e-seal and a reader. The e-seals communicate with the reader via RFID, infrared, direct contact, or long range cellular or satellite. This paper will focus on e-seals that communicate via RFID, cellular or satellite. E-seals consist of a type of housing for electronics, a cable or bolt seal, which fastens the container doors, identification number, and for most, a power source.

Like the RFID tags described previously, e-seals are designed to be passive or active. The range for an active seal is up to 100 meters. E-seals operate in five frequency bands, which are determined by their geographical area. The International Standard Organization is working with industry to determine standard frequencies. Table 1 lists the frequencies used for e-seals in geographical regions around the world.

Frequency (MHz)	Geographical Area
315	Much of Asia
433	Europe and North America; parts of Asia
915	North and South America
862-928	Awaiting Global Approval
2450	Japan

Table 1. **Electronic Seals & RFID Frequencies (Ref 20)**

Readers are very much like the readers mentioned above when in the architectural environment. For instance, the readers are placed at entrances or key zones within a container terminal yard. However, some readers may be handheld which forces personnel to visually check the seal due to the short range. Thus, these readers could be personal digital assistants or laptop computers. In addition to the data mentioned earlier, seals may contain contents of the container, shipper’s contact information, other manifest details and destination.

An e-seal that lends itself to global tracking is a hybrid of an e-seal and a radio tag. This combination allows the unit to communicate via satellite, GSM and the Internet. All Set, a Swedish based company, manufactures a product like this in which the data passed to the reader are relayed to a global server via a satellite, GSM and the Internet. Communication between the tag and readers is accomplished via Bluetooth Lite technology, which operates at 2.45 GHz. Bluetooth Lite is a derivative of the personal area wireless network protocol Bluetooth. Bluetooth is used to connect personal digital assistants to cell phones, computers and other mobile devices wirelessly. All Set says the difference is that Bluetooth Lite allows for even more efficient radio protocol and ultra low power consumption. The readers are placed in strategic positions in ports so that they can report the position of the containers as they pass. Customers' computers are integrated with All Set's server so that they may receive updates without query. Furthermore, All Set's e-seals or tags can be integrated with sensors to monitor temperature, humidity, pressure, shocks, and lights. More importantly, unlike other e-seals, All Set's unit can alert personnel if the container is being breached from the sidewalls by detecting a change in the container's pressure or the introduction of light. The design of the seal aids in providing this capability. Note the placement of the seal as illustrated in Figure 3. Most seals are placed on the door locks of the container and alert personnel to when the door has been open [Refs 21 and 22]. All Set's unique placement provides partial concealment of the seal and the ability to incorporate sensory information which overcomes some of the vulnerabilities associated with e-seals. Further discussion of the vulnerabilities of e-seals can be found at the end of this chapter.



Figure 3. **Unique Placement of All Set E-Seal (From: Ref 21)**

NaviTag, a company based in North Quincy, MA, has designed e-seals that can be tracked via satellite, as well. This technology allows the tracking of the container's integrity while in transit. The e-seal contains a low power, simplex (communicates one way) satellite modem that allows it to communicate with existing satellites. The modem is integrated with door and light sensors to provide alerts of when the doors of the container open. Thus, this technology is similar to All Set except the unit is placed on the front of the container doors where it is susceptible to manipulation or damage. The data are relayed via satellite every one and half-hours to NaviTag's Datacentre. At the Datacentre the information is processed, stored, and sent to customers as required [Ref 23].

C. TRACKING SYSTEMS FOR AIR CARGO

1. Web-Based Systems

Information Builders, a software company based in New York, NY, developed a software solution called WebFOCUS that is used to track Unit Load Devices (ULD) for the airline industry. ULD is the name for a cargo container used in the airline industry. Under the management and operation of the International Airline Transport Association (IATA), sixty airlines funded the development of the WebFOCUS system. Essentially, Information Builders took the legacy error-prone ULD Control system and upgraded it to a web-based system. The web-based system works by having airlines enter ULD transfer information in a form at a Website maintained by IATA. The software verifies data as it is entered and prompts users to be accurate in their data entry. The data are stored in an

Oracle database running on a Windows server. The information is presented in HTML, XML, PDF, or Excel format that can be downloaded. This is by no means a real-time system; however, Information Builders foresees barcode or RFID technology being coupled with its WebFOCUS architecture to provide a real-time system [Ref 24].

2. RFID Tags on ULDs

Envirotainer, based in Knivsat, Sweden, is the world's largest provider of temperature-controlled air cargo containers. These containers are used to ship perishable pharmaceuticals, meat, seafood, produce, and semiconductors. The containers can maintain temperatures between 20 degrees and minus 20 degrees Celsius. Recently, Envirotainer teamed up with Savi Technology to develop a real time location system for tracking their ULDs.

The system is currently under development and may include a tag device that uses a global positioning system receiver attached to a cell phone modem. The tag would transmit the location and temperature of the ULD via satellite. The data are processed and stored using Savi's Asset Management System. In addition, the system allows Envirotainer to do online booking with clientele in order to track and better utilize their containers [Ref 25].

D. PAPER TRAIL



1. Bill of Lading

There are two important documents which are used to establish contract terms when moving containerized goods across international borders. These documents are the bill of lading and letter of credit. These documents can be used to determine the owner of the contained goods, destination of a cargo container, and what goods are in the container. For this section, focus will be on the Bill of Lading (B/L).

The B/L is a contract for transportation and receipt for cargo that a carrier gives to a seller when a carrier transports goods on behalf of a seller. The B/L certifies that the carrier has received the goods mentioned in the B/L and it proves ownership of the goods declared in the B/L.

A B/L can be bought, sold, or traded while the goods are in transport. In order for such a transaction to take place there must be a negotiable B/L or “to order” B/L. If a negotiable B/L is used then the carrier will not turn over the goods to the buyer until the seller endorses the original bill of lading and the carrier receives it. Getting the original bill of lading with seller’s endorsement keeps the carrier from being liable after releasing the shipment. There is also a straight B/L or a waybill, which cannot be bartered. Upon arrival at the destination the carrier will turn over the goods to the buyer when the buyer presents identification [Ref 26].

Information that should be included in a B/L is as follows: the name and address of the carrier (transport company); the shipper (the seller, sender, or his agent); the consignee (the buyer or his agent); the name and nationality of the ship; the port of departure and port of destination; description of goods; instructions of freight; place and date B/L was issued; and the number of original B/Ls. Figure 4 illustrates how a B/L would appear.

Shipper ALL SET MARINE LASHING AB				B/L No. HY205006	
Consignee TO THE ORDER OF KOREA EXCHANGE BANK, SEOUL, KOREA		KEIHIN MULTI-TRANS TAIWAN CO., LTD. 台灣京濱股份有限公司 台北市南京東路二段111號12樓 海樓(基)字第650號 MULTIMODAL TRANSPORT BILL OF LADING			
Notify Party HYUNDAI HEAVY INDUSTRIES CO., LTD. KYE-DONG 140-2, JONGR-KU SEOUL, KOREA		<small>Received by the Carrier from the shipper in apparent good order and condition unless otherwise indicated herein, the Goods, or the container(s) or package(s) said to contain the cargo herein mentioned, to be carried subject to all the terms and conditions appearing on the face and back of the Bill of Lading by the vessel named herein or any substitute at the Carrier's option and/or other means of transport, from the place of receipt or the port of loading to the port of discharge or the place of delivery shown herein and there to be delivered unto order or assigns. This Bill of Lading duly endorsed must be surrendered in exchange for the Goods or delivery order. In accepting this Bill of Lading, the Merchant agrees to be bound by all the stipulations, exceptions, terms and conditions on the face and back hereof, whether written, typed, stamped or printed, as fully as if signed by the Merchant, any local custom or privilege to the contrary notwithstanding, and agrees that all agreements, or freight engagements for and in connection with the carriage of the Goods are superseded by this Bill of Lading.</small>			
Pre-carriage by		Place of Receipt TAICHUNG, TAIWAN		Party to contact for cargo release HYUNDAI LOGISTICS CO., LTD. / SEL TEL: (822) 2170-3114 FAX: (822) 733-4237/4238	
Vessel MED KEELUNG V.60N		Voy.No.		Port of Loading TAICHUNG, TAIWAN	
Port of Discharge PUSAN, KOREA		Place of Delivery PUSAN, KOREA		Final Destination (Merchant's reference only)	
Container No. Seal No. Marks and Numbers HHI, ULSAN/PUSAN KOREA (IN DIA.) HHI HNO. CONTRACT NO: TYPE: W/NO. 1-75 Q'TY: PCS MADE IN TAIWAN R.O.C.		No. of Containers or pkgs. SHIPPER'S LOAD & COUNT S.T.C.: 75WDCS IN 3X20' CY -CY 3CNRS vvvvv		Kind of Packages; Description of Goods ORIGIN:TAIWAN CONTAINER FIXED FITTINGS 1.00 LOT CONTRACT NO.:CE366E204 HULL NO.1366 PRICE TERM:FOB TAIWAN PORT CREDIT NO.W0696204BS80061	
				Gross Weight 48354.00KGS	
				Measurement 75.00CBM	
Total number of Containers or other Packages or Units (in words)		"FREIGHT COLLECT" SHIPPED ON BOARD DATE: MAY.18.2002 VESSEL & VOY. NO.: MED KEELUNG V.60N PORT OF LOADING: TAICHUNG, TAIWAN SAY TOTAL: THREE (3) CONTAINERS ONLY. CNTR#YMLU2477228/YML2468529/23WDCS/14995KGS/CY-CY/20 CNTR#YMLU2518815/YML2468521/26WDCS/17714KGS/CY-CY/20 CNTR#YMLU2979041/YML2468554/26WDCS/15645KGS/CY-CY/20			
Merchant's Declared Value (See Clauses 18 & 23):		<small>Note: The Merchant's attention is called to the fact that according to Clauses 18 & 23 of this Bill of Lading the liability of the Carrier is, in most cases, limited in respect of loss of or damage to the Goods.</small>			
Freight and Charges		Revenue Tons		Rate Per	
Prepaid		Collect			
FREIGHT AS ARRANGED					
Exchange rate		Prepaid at PUSAN, KOREA		Place and Date of Issue TAIPEI, TAIWAN MAY.18.2002	
Total Prepaid in Local Currency		No. of Original Bill/L THREE/3		In witness whereof, the undersigned has signed the number of Bill(s) of Lading stated herein all of this tenor and date, one of which being accomplished, the others to stand void.	
Vessel		Laden on Board the Vessel Date MAY.18.2002		KEIHIN MULTI-TRANS TAIWAN CO., LTD.  AS CARRIER.	
Port of Loading		By			
<small>An enlarged copy of back clauses is available from the Carrier upon request.</small>					

Particulars furnished by Merchant. All descriptions contained herein considered unknown to the Carrier.

Figure 4. Bill of Lading (From: Ref 27)

2. Letter of Credit

A letter of credit is a document that guarantees financial terms between a seller and buyer. On behalf of the buyer a bank will issue a letter of credit to pay a seller upon presentation of specified documents representing the goods in question. The letter of credit may stipulate the required documents to be the bill of lading, invoice, insurance or a combination thereof. In addition, the letter of credit will denote a time expiration clause. Thus, the seller is given so many days to acquire the documentation needed to deliver to the bank for which payment will be surrendered before the letter of credit expires. There can be more than one bank involved in this process especially in the realm of international trade. Typically, the buyer will obtain the letter of credit from a bank in which he or she is already a customer. The buyer's bank is called the advising bank which arranges transactions with the seller's bank, the issuing bank. The following details how a letter of credit is obtained:

- The buyer and seller agree to the terms and conditions of the transaction, including means of transport, period of credit offered, latest date of shipment and relevant international set of trade terms (Incoterm) to be used. These terms identify the exact responsibilities and liabilities of both the buyer and seller while the merchandise is in transit.
- The buyer submits a request to the bank for the letter of credit
- The bank evaluates the buyer's credit rating, and may require a cash cover and/or reduction of other lending limits.
- The buyer's bank issues the letter of credit and notifies the advising bank (seller's bank) by airmail, teleprinter exchange (telex), Society for Worldwide Interbank Financial Telecommunications (SWIFT) or Financial Information Network (FIN).
- The advising bank establishes the authenticity of the letter of credit using signature books or test codes, then informs seller (beneficiary) and confirms the letter of credit.
- The letter of credit becomes the legal agreement between the issuing bank and the designated beneficiary (seller).
- The seller confirms that the letter of credit matches the commercial agreement, and that the terms and conditions can be satisfied in the allotted time period. If there is anything that may cause a problem, an amendment should be requested.

- The seller ships the goods and gathers all the documents requested in the letter of credit, such as the invoice, transport document, bill of lading, insurance, etc.
- The documents are presented to a bank, often the advising bank. The advising bank checks the documents against the letter of credit.
- If the documents comply with requirements, the bank pays the seller and forwards the documents to the issuing bank.
- The issuing bank also checks the documents. If they are in order, the issuing bank will reimburse the seller's bank immediately.
- The issuing bank debits the buyer and releases the documents (including transport document), so that the buyer can claim the goods from the carrier [Ref 28].

Figure 5 is an example of a letter of credit.

INTERNATIONAL BANKING GROUP
Megabank Corporation
P.O. BOX 1000, ATLANTA, GEORGIA 30302-1000
CABLE ADDRESS: MegaB
TELEX NO. 1234567
SWIFT NO. MBBABC 72

ORIGINAL

OUR ADVICE NUMBER: EA00000091
ADVICE DATE: 08MAR97
ISSUE BANK REF: 3312/HBI/22341
EXPIRY DATE: 23JUN97

****AMOUNT****
USD****25,000.00

BENEFICIARY:
THE WALTON SUPPLY CO.
2356 SOUTH N.W. STREET
ATLANTA, GEORGIA 30345

APPLICANT:
HHB HONG KONG
34 INDUSTRIAL DRIVE
CENTRAL, HONG KONG

WE HAVE BEEN REQUESTED TO ADVISE TO YOU THE FOLLOWING LETTER OF CREDIT AS
ISSUED BY:
THIRD HONG KONG BANK
1 CENTRAL TOWER
HONG KONG

PLEASE BE GUIDED BY ITS TERMS AND CONDITIONS AND BY THE FOLLOWING:
CREDIT IS AVAILABLE BY NEGOTIATION OF YOUR DRAFT(S) IN DUPLICATE AT
SIGHT FOR 100 PERCENT OF INVOICE VALUE DRAWN ON US ACCOMPANIED BY THE
FOLLOWING DOCUMENTS:

1. SIGNED COMMERCIAL INVOICE IN 1 ORIGINAL AND 3 COPIES.
2. FULL SET 3/3 OCEAN BILLS OF LADING CONSIGNED TO THE ORDER OF THIRD HONG KONG BANK, HONG KONG NOTIFY APPLICANT AND MARKED FREIGHT COLLECT.
3. PACKING LIST IN 2 COPIES.

EVIDENCING SHIPMENT OF: 5000 PINE LOGS – WHOLE – 8 TO 12 FEET
FOB SAVANNAH, GEORGIA

SHIPMENT FROM: SAVANNAH, GEORGIA TO: HONG KONG
LATEST SHIPPING DATE: 02JUN97

PARTIAL SHIPMENTS NOT ALLOWED TRANSHIPMENT NOT ALLOWED

ALL BANKING CHARGES OUTSIDE HONG KONG ARE FOR BENEFICIARYS ACCOUNT.
DOCUMENTS MUST BE PRESENTED WITHIN 21 DAYS FROM B/L DATE.

AT THE REQUEST OF OUR CORRESPONDENT, WE CONFIRM THIS CREDIT AND ALSO ENGAGE
WITH YOU THAT ALL DRAFTS DRAWN UNDER AND IN COMPLIANCE WITH THE TERMS OF THIS
CREDIT WILL BE DULY HONORED BY US.

PLEASE EXAMINE THIS INSTRUMENT CAREFULLY. IF YOU ARE UNABLE TO COMPLY WITH
THE TERMS OR CONDITIONS, PLEASE COMMUNICATE WITH YOUR BUYER TO ARRANGE FOR
AN AMENDMENT.

Figure 5. Letter of Credit (From: Ref 29)

E. DEFEATING TRACKING SYSTEMS AND E-SEALS

1. GPS

At the heart of the tracking system lays the positional data provided by GPS. Without GPS the tracking system cannot perform its function. GPS has been found to be very susceptible to jamming and spoofing. Spoofing is the ability of intercepting data and sending false data to a recipient to produce misleading information. The John A. Volpe National Transportation Systems Center published a report stating, “A 1 Watt GPS-Like signal can prevent C/A code acquisition to more than 620 miles” [Ref 30]. C/A, course acquisition code, is the signal used by the civilian sector.

A spoofing experiment run by John S. Warner and Roger G. Johnston at the Los Alamos National Laboratory demonstrated how easy it would be to spoof the GPS signal. By using a modified GPS simulator, breaking the original signal to the GPS receiver with a GPS jammer, and inserting the GPS signal from the simulator, the scientists were able to submit false data to the receiver, which would be passed on to an unsuspecting service provider or customer. The benefit of spoofing the GPS signal makes it easy for criminal or terrorist organizations to “highjack” a container, truck, or railcar without bringing any attention to the new course in which the vessel or container would be directed by its new owner.

During the experiment, the scientists used two stationary trucks with one mounted with a GPS receiver and the other acting as the attacker with the GPS simulator. After the original GPS signal from the satellites was broken, a signal from the GPS simulator was introduced to the receiver. The scientists noted that the spoofing signal could be maintained up to 30 feet from the receiver, however, initial introduction of the simulated signal had to be done within close range for 15 seconds to 3 minutes. After establishing contact with the receiver the attacker could then move out to a maximum distance of 30 feet.

The GPS receivers attacked during the experiment were the handheld receivers Delorme Earthmate and Magellan Meridian. These receivers may or may not contain the same circuitry as the receivers used on cargo containers. Also, the scientists noted that obtaining a GPS simulator was relatively easy. The units could be bought or rented at reasonable prices. In addition, the units could be homemade using data from the Internet.

Lastly, the scientists believe that GPS spoofing could be countered by improving the accuracy of the clocks within the GPS receivers. The scientists suggest improved accuracy would not allow the clock error and drift to be exploited. Furthermore, the scientists believe that if a timestamp was added to the transmission of the signal from the GPS receiver that spoofing could be detected.

To obtain a copy of this report entitled, “A Simple Demonstration that Global Positioning System (GPS) is Vulnerable to Spoofing”, the interested reader may contact Dr. Warner via email at jwarner@lanl.gov [Ref 31].

2. Circumventing or Defeating E-Seals or Tracking Tags

Los Alamos National Labs Vulnerability Assessment Team (VAT) has declared, “All of these seals, at least in the way they are conventionally used, can be defeated quickly using only low-tech methods, tools, and supplies available to almost anyone at low cost” [Ref 32]. This national lab has tested “tamper-indicating seals” for the last 12 years. This section of the paper will discuss the methods which may be used to circumvent or defeat the security of an e-seal.

One of the problems that may exist for containers equipped with e-seals or tags placed on container ships is the placement of the container itself on the ship. Containers can be buried deep beneath the upper decks of a container ship. The burying of the container may mean that the signal from the e-seal or tag is buried and unable to communicate with a satellite. This may be overcome by developing an antenna system to be coupled with the ship’s existing communication system so that the e-seal or tag signal can be routed above decks and transmitted to the satellite.

A more intentional method of circumventing the function of an e-seal is to cut a hole in the container or remove the doors of the container from the hinges without disturbing the seal. Since most e-seals focus on deterring an individual from opening the doors by sounding an alarm if tampered with, the thief might find a way to go around the e-seals. Most e-seals are not capable of detecting other points of entry into a container other than the door entrance.

Furthermore, if a thief does not care about his or her intrusion being detected after the fact, the thief may defeat the seal by destroying it or using electronic jamming to eliminate the alarm and/or keeping the seal to prevent an investigation from determining

when the break-in occurred. E-seals are often designed to indicate when and where they were tampered with especially if they do not possess an alarm mechanism. Also, the perpetrator may remove a tag and place it on another container depending on how secure the tag is to the original host [Ref 31].

The VAT indicates education of e-seal use and vulnerabilities associated with particular e-seals and tags is badly needed. Normally e-seal installers and inspectors are not well trained on the vulnerabilities of e-seals and tags. In addition, vendors and manufacturers make unreasonable claims about the products they provide. The lack of education and overstatement of product capability aid sophisticated criminal and terrorist organizations in exploiting the e-seal and tracking tags [Ref 31].

3. Automated Information Systems

All of the information provided by a tracking system is usually delivered from the provider via the Internet to the customer. Since the provider is connected to the Internet the data provided are susceptible to all of the computer and network security vulnerabilities associated with the Internet. If a provider does not have information assurance for the company's network then the provider may be providing false data injected by hackers working on behalf of a criminal or terrorist organization. Even though a company has an outstanding information assurance program, if the program is not extended to the customer an attacker could spoof the customer. Although the company is sending good data the customer is getting altered data from an attacker, which is intercepting the good data and resending bad without the company or customer knowing.

F. SUMMARY

Orbcomm, Argos, and Inmarsat satellite communication systems have been evolving their services over the years and may find that demand for their tracking services will increase as prices drop and the shipping and manufacturing industries try to secure the global supply chain from manufacturer to retail. RFID and e-seal technology will play a significant role in local tracking within a terminal yard and provide security throughout the cargo containers transit. All of these technologies together, along with the paper work exchanged to establish payment and a description of the goods being shipped create an environment that can be examined by organizations of Homeland Security for

wrong doing or possible intelligence gathering. In addition, one should not be pulled in by a false sense of security because there are vulnerabilities which limit the tracking and security functions provided by GPS, e-seals, and RFID tags.

III. TRACKING SYSTEMS FOR SHIPS AND AIRCRAFT

A. SATELLITE SYSTEMS

1. Inmarsat

Inmarsat's satellite capabilities were developed for ship management and distress and safety applications. To provide these services Inmarsat has produced the Inmarsat-C terminal, a two-way data communications device, which is used on road vehicles, trains, fishing and merchant vessels and in aviation platforms. Once the Inmarsat-C is operational it transmits to the satellites at frequencies between 1626.5-1645.5 MHz and receives between 1530-1545 MHz.

Messages can be sent either to or from the terminal. Messages can be no bigger than 32 kbytes. Messages are packetized upon transmission and reassembled at the Land Earth Station, where they are sent to the customer via the respective countries telecommunication system, telex, Internet, or telephone. Furthermore, Inmarsat-C possesses the capability to be polled. Polling allows the customer base station to query the Inmarsat-C terminal which causes information to be automatically transmitted back to the customer. For instance, if a shipping company wanted to know where its vessel was the company would send a signal from its base station to interrogate the Inmarsat-C terminal for position data.

The Inmarsat-C terminal can be incorporated with the vessel's existing navigation systems, such as GPS or Loran-C receivers, to provide position reporting. In addition, the terminal is integrated with the Global Maritime Distress and Safety System (GMDSS). With the touch of a button on a Digital Selective Calling (DSC) radio, a distress signal containing the name of the ship, the position, and nature of the distress is sent to other ships, shore stations, and rescue organizations every four and a half minutes. The signal travels via satellite, Inmarsat, VHF radio channel 70, HF and MF radio terminals. The International Maritime Organization requires ships over 300 gross tons to install Inmarsat-C terminals with the GMDSS [Ref 32].

GMDSS is composed of the Digital Selective Calling (DSC) radio, Navigational Telex (Navtex) weather and navigation information dissemination system, and Inmarsat.

See Section D of this chapter for detail on DSC. Navtex is a digital broadcast of weather forecasts, severe weather warnings, and navigational hazards. The broadcast is transmitted at 424 and 518 KHz by coastal stations [Ref 33].

Also, Inmarsat-C terminals are capable of sending and receiving e-mail. This capability largely depends on whether the service provider offers the service. Inmarsat-C terminals are assigned with a nine-digit identifier called the terminal ID or Inmarsat Mobile Number (IMN). The IMN allows the terminal to have a “virtual email address” when coupled with the domain name of the service provider. The format would be IMN@domain name. Example of a domain name would be Comsat.com, thus, 123456789@Comsat.com would be the e-mail address for an Inmarsat-C terminal. The vessel’s email address and destination address are put in the body of the message. The addresses are later extracted from the body and forwarded to the recipient via the Internet. Because data are transmitted over the satellites Inmarsat charges a fee which is paid via the vessel or terrestrial sender. The charges only apply when data are sent over the satellites. Service providers that provide e-mail via Inmarsat-C are Comsat, EIK Global Communications, France Telecom, Station 12, Stratos, T-Mobil, Telstra, and Telia Mobile [Ref 33].

2. Iridium

Iridium, an Arlington, VA, based company, is composed of 66 low-earth orbiting satellites which provide coverage over the entire world with the exceptions of Hungary, Poland, N. Korea, and N. Sri Lanka. Iridium phone calls are not allowed to connect over these countries’ local telephone systems. The satellites have the capability to cross-link or relay information amongst them. Crossing-linking also means that the satellite which received the initial data does not need a gateway to be in the satellite’s footprint which contributes to fewer outages and relies less on landline networks. Satellite-to-satellite communications are transmitted at 23.18 – 23.38 GHz [Ref 34].

Services provided by Iridium include data, short burst data, short message service, voice and paging. Iridium provides services to the marine industry through a two way voice and data terminal called SkyConnect Marine. Service partner SkyConnect LLC from Takoma Park, MD, markets the unit and the unit is produced by Icarus Instruments,

a Herndon, VA, based company. The terminal can be a dedicated handset for use on the bridge or multiple phones can share the dial tone. In addition, computers can be connected to the terminal to access the Internet and send email.

SkyConnect Marine provides communication services only; however, NAL Research Corporation based in Manassas, VA, provides a product called the 9522 L-Band Transceiver with GPS. This unit provides position, velocity, and time in addition to the other services previously mentioned. The terminals transmit and receive communications at 1616 – 1626.5 MHz [Ref 35].

Iridium's service partners also provide communication devices for aircraft. Icarus Instruments also produces the SkyConnect Executive cordless handset. This device is a satellite phone, which can be used in the cabin of a turbine or turbo-prop aircraft. The unit is not compatible with GPS because GPS has not been approved for air navigation purposes. This holds true for other Iridium compatible aircraft communication devices produced by Iridium service partners Honeywell, Intcomgrp, and BlueSkyNetwork [Ref 35].

3. Eutelsat

Eutelsat is a Paris, France, based company, providing service fleet management and communication services for the maritime community. The solutions for these services are titled EutelTRACS and Emsat.

Emsat is predominantly a communication suite for vessels to communicate at sea. The system provides mobile telephony and data services, SMS and positioning data. The system is composed of a small central unit with fax, computer, and sensor ports. There is a mobile handset with screen and an antenna. A GPS card is integrated into the system to provide positioning data. Emsat transmissions are relayed via an Inmarsat satellite located at 25.15 degrees East. The gateway for this system is located in Lario, Italy, and managed by Telespazio. Through this gateway customer's information is routed to Public Switched Telephone Network. See Appendix A for communication frequencies associated with Inmarsat satellites, and see Appendix B for a list of Eutelsat service providers that offer Emsat or similar solutions.

EutelTRACS is a joint project between EutelSat and Qualcomm Incorporated to bring efficient fleet management solution to maritime industry. EutelTRACS is supported by two Eutelsat satellites. These satellites are called SESAT and W3, which are located at 36 degrees East and 7 degrees West. Coverage is provided over Europe, the Atlantic Islands, North Africa, Middle East and Central Asia, and steerable coverage exists over the Aegean region and India. The gateway for this system is located near Paris. The uplink and downlink for the terminals are described in Appendix A.

The EutelTRACS terminal consists of a keyboard, liquid crystal display and base station. The unit can be connected to temperature sensors, leak and impact detectors via a RS232 interface connection. Thus, this system could be used for monitoring cargo containers as well. Software used to manage the link between the customer's information system and EutelTRACS Network Management Center is called QTRACS. This software manages the dispatching, messaging, positioning and mapping capabilities. The software can be run on personal computers, IBM AS/400 and System/36 midrange systems, mainframes, and UNIX systems [Ref 36].

4. Globalstar

Globalstar, a San Jose, CA, based company, provides 48 LEO satellites covering the earth from 70 degrees North to 70 degrees South for satellite phone communications. The ground segment of the system is made up of gateways, a Ground Operations Control Center (GOCC), Satellite Operations Control Center (SOCC), and Globalstar Data Network (GDN).

Through the gateways, transmissions are sent from satellites to the customer. The gateways are connected to local PSTN or public land mobile networks (PLMN) via T1 lines. Gateways are owned and managed by Globalstar service providers and are responsible for servicing their countries and other nations depending on the geographical location. The GOCC plans and controls the gateway terminals use of the satellites and coordinates with the SOCC. The SOCC tracks satellites, controls their orbits, and provides telemetry and command services. The GDN provides the connectivity amongst all of the elements previously mentioned [Refs 37 and 38].

The company’s original mandate is to provide handheld satellite phone service around the world. However, in recent years the company started to provide Internet and private data network connectivity, position location, SMS, and call forwarding. Globalstar does not advertise any of its services as being vessel-monitoring solutions or asset management tracking services; however, they do provide the solutions needed for aircraft and commercial and cargo ships to communicate position and other data while deployed.

Communication devices made for ships and aircraft uplink to the satellites at 1610 – 1625.5 MHz and downlinks at 2483.5 – 2500 MHz. The coverage only extends a little beyond 200 miles from the coastal areas around the world. This means that entire oceans are not covered, causing dropped calls in those areas. Figure 6 depicts the coverage provided by Globalstar. Within Figure 6 note that the orange color denotes the primary service area, the yellow color indicates extended service area low signal strength and the purple color represents areas with intermittent signal strength [Ref 34].

Although, Globalstar does not offer complete global coverage, the system assures connectivity in the primary service areas through a process called “path diversity”. This process enables two or more satellites that cast a footprint on the user to capture and transmit the call simultaneously. If a user moves out of the satellite footprint, the call is able to continue through another satellite without loss or disruption of the call [Ref 39].

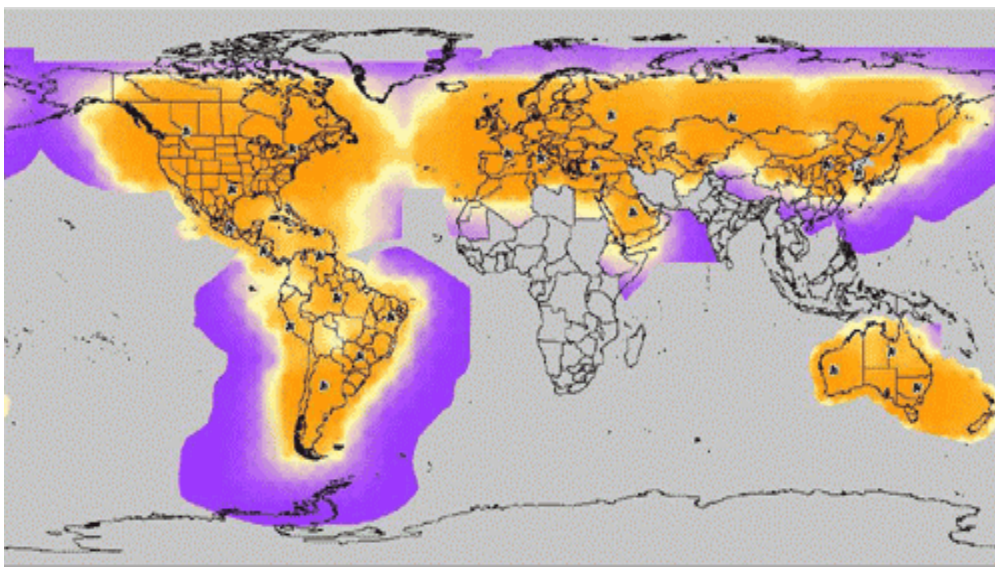


Figure 6. **Globalstar Coverage (From: Ref 39)**

Position location is provided by the Globalstar constellation rather via the GPS satellite system. The satellites calculate position using radio frequency (RF) time difference of arrival (TDOA), frequency difference of arrival, angle of arrival or a combination of the geolocation methodologies. Accuracy of the positions is up to 10 km.

Incidentally, this type of positional technology is similar to Radio Determination Satellite Service (RDSS) created by GEOSTAR in the 1980s and currently owned by Comtech Mobile Data Corporation (CMDC). RDSS establishes geolocation by radio frequency TDOA using two or more satellites in geosynchronous orbit. CMDC currently uses GPS along with the two-way communication capability of RDSS to provide location data in its movement tracking system service, which is enabled by Inmarsat constellation. Although GPS technology seems to be the favorite for geolocation, RDSS is worth investigating. Major Darius M. White, class of 2002 from the Naval Postgraduate School conducted thesis research on RDSS systems; thus, exploring his thesis would be an excellent way to find a complete discussion on RDSS and the geolocation methodologies mentioned previously [Ref 40].

Unlike others in the satellite service industry, Globalstar offers encryption to secure the customers communications. The encryption algorithm used is either Harris Citadel CCX or Triple Data Encryption Standard (DES). The encryption key is 128 bits in length. There are three unit models produced by Qualcomm, Rainbow Mykotronix, and Copytele Inc. See www.globalstar.com/view_page.jsp?page=encryption for more information about the encryption units produced by the previously mentioned manufacturers [Ref 41].

5. Thuraya

Commercial service for the Thuraya system commenced during July 2001. Thuraya Satellite Telecommunications Company, based in United Arab Emirates, owns the system. The system is made up of three geostationary satellites located at 44 degrees East, 28.5 deg East, and 87 degrees East. These locations allow coverage for Western Europe, Northern Africa, the Middle East, Central Asia and India. Figure 7 provides an illustration of the Thuraya coverage map.

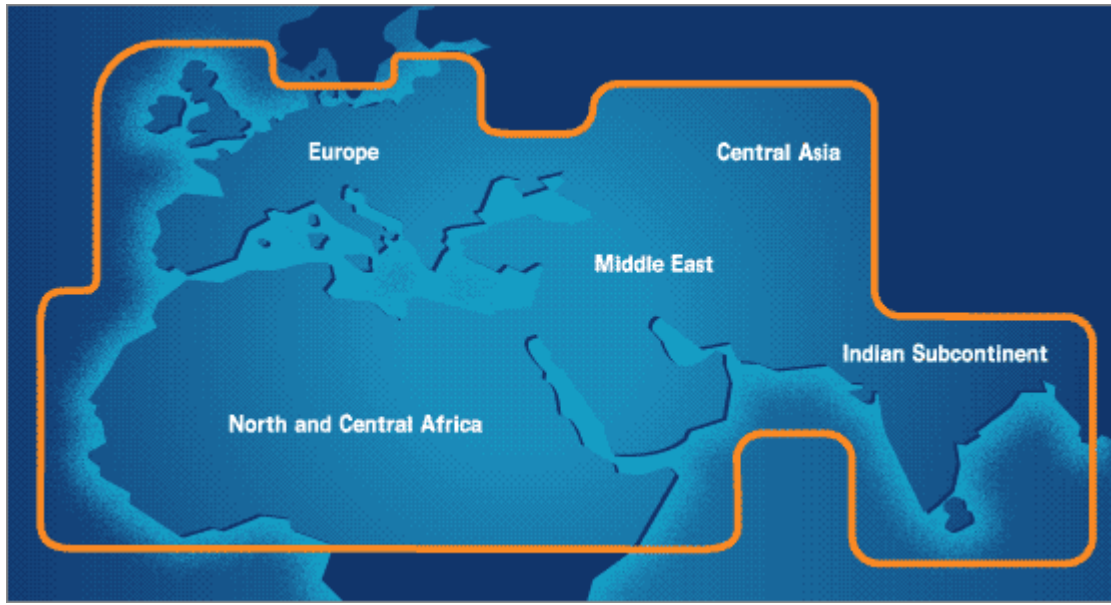


Figure 7. **Thuraya Coverage Map (From: Ref 42)**

Whether or not Thuraya offers location system solutions for cargo containers, ships, or aircraft is unclear since its primary purpose is to offer satellite phone capability throughout the coverage area. However, Thuraya's handsets contain satellite, GSM, and GPS technology. Thus, this system could provide customers with tracking capability but without the automation provided by other systems mentioned earlier. This is definitely a system that could cater to private individuals, small businesses, and criminal or terrorist syndicates. These phones transmit and receive at 1626.5 –1660.5 MHz and 1525 – 1559 MHz, respectively. The handsets are dual mode, thus they can switch from GSM to the Thuraya Satellite network when out of range of GSM cell towers [Refs 34 and 43].

6. **New ICO**

New ICO is a London, UK, based company that offers global coverage for messaging, data transfer, telephone and Internet connectivity via handheld devices. To launch this service the company will operate 10 satellites with 2 spares at MEO with inclinations at 45 and 135 degrees. There will be 5 active satellites per orbital plane. The ground segment of the system will consist of 12 earth stations or Satellite Access Nodes (SAN) located throughout the world. Using the company's high-bandwidth global Internet Protocol network called ICONET the satellites will be able to communicate with the SAN [Ref 44].

Like the Thuraya system, the handsets will be dual mode capable. The handsets will automatically switch from GSM network to the New ICO network depending on the signal strength with a GSM tower or users can manually switch between networks. The handsets will uplink at 2165 – 2200 MHz and downlink at 1990 – 2025 MHz. Furthermore, the National Rural Telecommunications Cooperative (NRTC) reports that New ICO proposed to the Federal Communication Commission to authorize the use of satellite frequencies on the ground for all Mobile Satellite Service (MSS) providers. By transmitting satellite frequencies on the ground amongst a MSS provider's earth stations, the user would not have to be in view of the satellite to connect to the MSS providers network. Whether the FCC has ruled on this proposal is uncertain [Ref 45].

7. Ellipso

Satellites communication providers will continue to grow in numbers and expand their services. New systems such as Ellipso, a Washington DC based company, which comes online in the next couple of years will expand their services from personal communications to asset management tracking to expand their market audience and profitability.

Ellipso's handsets and terminals are unique in the fact that they are capable of providing global positioning data and look very similar to mobile cell phones carried today. In addition, the handsets can act as modems for accessing the Internet. The phones are dual mode, which allows them to access cellular phone networks and the Ellipso network. Ellipso's terminals will operate using second generation (2G) and third generation (3G) technologies. The 2G terminals will transmit at 2165-2200 MHz and receive at 1990-2025 MHz. The 3G terminals will transmit at 1610-1621.5 MHz and receive at 2483.5-2500 MHz.

The difference between 2G and 3G technologies in the Ellipso network lies in the bandwidth. The 3G technology uses wideband Code Division Multiple Access (CDMA) and 2G is straight CDMA. Wideband indicates that the frequency band is four times larger than the 2 GHz band used in 2G. This wider frequency band will allow more users to carry on simultaneous conversations.

Ellipso's satellite constellation will consist of four orbital planes covering the world from 50 degrees South and upward. There will be two elliptical orbits consisting

of 5 birds each inclined at 116 degrees. The apogees are 7605 km and perigees are 633 km and the orbital period is 3 hours. There will be two circular orbits at 8050 km consisting of four and three birds inclined at 50 degrees South and 50 degrees North.

The Ellipso system will start with 12 gateways and be connected to the local telecommunication networks using an Internet protocol to talk on wireless or wireline networks. The gateways are also designed to be the workhorses of the system leaving the satellites to relay data only. The gateways will conduct hand-offs, signal modulation, multiplexing and satellite tracking [Ref 46].

B. HUMAN AGENTS

Lloyd's Marine Intelligence Unit (LMIU) a London, UK, based company has established a network of human agents throughout 2000 ports around the world to provide information on the movement of vessels. The network is comprised of 400 principal agents and supported by what the company calls subagents. The agents gather their intelligence from Port Authorities, coast guards, pilots, customs, insurers, news agencies, and other trusted sources.

Information provided by the agents includes owner, change of owner, flag changes, operator, casualty reports, types of communications systems aboard the vessel, Inmarsat communication identification number, origin and destination of the vessel, characteristics of vessels such as engine type, fuel type, position and size of cargo hold, type of lifting equipment on board and more. A complete list of items gathered by LMIU agents can be found at www.loydsmiu.com.

All the data are put into a database. LMIU boasts that the company has movement and ownership data since 1976 and casualty data available since 1990. LMIU allows customers to access the data via the Internet, CD-rom, or hard copy. For instance, LMIU's Vessel Tracker service provides arrived and sailed dates, expected sailing date, next port of call, and estimated time of arrival. For more money the service will provide name, flag and ownership changes. This service is fed directly by the agent network. This service may be provided to the customer via email or LMIU website [Ref 47].

C. AUTOMATIC IDENTIFICATION SYSTEM (AIS)

AIS is not a global tracking system, but serves more as a control and local tracking technology for ships approaching port. AIS is a broadcast communication

system mandated by the International Maritime Organization (IMO) for the safety of mariners. The purpose of the system is to provide collision avoidance while underway, notice of arrival to ports, and traffic management coming into ports. By using VHF transmitters, two VHF Time Division Multiple Access receivers, one VHF Digital Selective Calling (DSC) receiver, GPS and DGPS receivers and a link to shipboard display and sensor systems information such as the ship position, course and speed, rate of turn, angle of heel, pitch and roll, Maritime Mobile Service Identifier (MMSI), IMO number, radio call sign, name of ship, dimensions of ship, draught of ship and more are passed to other AIS equipped ships or shore stations. Using this information ships and shore stations can immediately identify an approaching ship and provide short messages containing warnings or navigational hazards via email or radio [Ref 48].

AIS will be fitted to all ships as mandated by IMO's Maritime Safety Committee in Chapter V, Regulation 19.2.4 which applies to all ships of 300 gross tons and upwards engaged on international waters voyages and cargo ships of 500 gross tons and upwards engaged on international voyages and passenger ships irrespective of size. Further details on this regulation concerning the dates in which the rules will apply to other vessels can be found at www.navcen.uscg.gov/enav/ais/AIS_carriage_reqmts.htm [Ref 48].

In addition, the Maritime Transportation Security Act (MTSA) orders AIS on all commercial vessels of at least 65 feet in length, certain passenger vessels (as determined by the Secretary), and towing vessels over 8 meters and 600 hp; on all navigable waters of the United States. The MTSA also grants the Secretary authority to expand carriage to any other vessel it deems necessary for safe navigation, to issue exemptions or waivers should it find that AIS or other navigation requirements are not necessary for the safe navigation of a vessel or on a waterway, and, directs the Secretary to prescribe regulations implementing these provisions. Secretary refers to the Secretary of the Department of Homeland Security in which the Coast Guard operates [Ref 48].

There are five AIS types; however, Class A and Class B models are only relevant for this discussion since the interest is in tracking ships. Class A is for the vessels mentioned above in IMO regulation. Class B is for vessels that do not meet the requirements for Class A. Class B systems do not transmit vessel's IMO number or call sign, estimated time of arrival or destination, rate of turn, static draught and navigational

status. Other AIS systems are located on search and rescue aircraft, shore stations providing location of navigational aids and shore stations providing text messages.

The system transmits in the VHF band thus range of the signal is nominally good out to 20 nautical miles. Frequencies used by the system are 161.975 and 162.025 MHz. If repeaters are used the signal can be extended farther. Also, there is movement afoot to have the signal relayed over Inmarsat satellites since ships of 300 gross tons and above are required to be fitted with Inmarsat-C for GMDSS, which was mentioned earlier in this document [Ref 48].

D. DIGITAL SELECTIVE SERVICE (DSC)

DSC is used with both AIS and GMDSS. DSC is digital technology incorporated in the latest VHF, MF, and HF marine radios. Using what some mariners call the “mayday button”, a preformatted distress message is transmitted in digital form. The message will contain the MMSI and geolocation if integrated with GPS. DSC also allows a vessel to selectively call a specific vessel without other vessels or stations in the area receiving the message. Thus, the call-up of a vessel on channel 16 and switching to a more private channel is not needed. DSC is set to channel 70 on VHF radios [Ref 49].

E. SUMMARY

All of the satellite systems mentioned above are communication systems that offer geolocation service; however, they target different audiences for their products. In general, Inmarsat, Iridium, Eutelsat, and Globalstar provide service for shipboard and aviation use. Thuraya, New ICO, and Ellipso provide personal communication for those in areas where conventional phone service is not available. In addition, the personal phones provided for each of these systems could be used on established cellular networks due to the dual modality designed into the handsets.

Because these units do offer global communication for personal use, terrorist and criminal organizations are probably taking full advantage of this capability to manage their enterprises. Elements of Homeland Security should explore these systems to glean any information that may provide indications and warnings of terrorist and criminal activity. In addition, if AIS is transmitted over Inmarsat, this information and that data produced by LMIU should be leveraged to diminish the threat against the sea lanes of commerce.

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IV. METHODS FOR TRACKING UNIQUE ITEMS

A. DIAMONDS

1. Illicit Trade of Diamonds

Diamonds are a form of currency that can be moved in a moment's notice and with little trouble. Imagine carrying ten million dollars in your pocket without any suspicion. Due to their ease of movement, they are very attractive to criminal and terrorist organizations. They are used to pay debts, pay bribes, and buy arms due to the ease of their liquidation. To thwart the illicit trade of diamonds often called "Blood Diamonds" or "Conflict Diamonds" the international community has sought a process, which depends on a chain of certificates to accompany the shipment of raw diamonds. The world will depend on these chains of certificates called the Kimberly process to enforce accountability and deterrence in the illegal trade of diamonds.

Before discussing the Kimberly process, take a look at the world diamond mining industry in Figure 8. Most of the world's diamond deposits are in Africa, Australia, Canada, and Russia. Major diamond trade takes place in Antwerp, Tel Aviv, New York and Mumbai. The hot spot for diamonds is in the African region due to civil wars taking place in countries such as Sierra Leone, Angola, and the Democratic Republic of the Congo. In these regions the sale of diamonds is used to finance the internal conflicts.



Figure 8. **Snap Shot of the World Diamond Industry (From: Ref 50)**

In addition, terrorists are able to cash in on the instability of the regions because their movements go largely unnoticed, and they are able to launder money via buying diamonds. Monrovia, Liberia, has reportedly become the place to launder money using diamonds. To make the transaction, one would find a willing Monrovia diamond salesman, offer to buy the diamonds a little over market value to make the transaction appealing to the salesman, travel to either Switzerland, the United States, or Antwerp, Belgium and sell the diamonds below market value to redeem the cash quickly [Ref 50].

2. Tracing Rough Diamonds

In illicit transactions such as this, rough diamonds are probably bartered. Rough diamonds are virtually untraceable. However, the BBC reported early this year that Belgian scientists have devised a way of determining the origin of individual diamonds. Scientists have developed a technique, which can provide a chemical fingerprint of a diamond that will reveal where the diamond was mined. The technique consists of drilling a microscopic hole into a diamond and extracting a sample. Using chemical analysis techniques the sample is compared to other samples to determine where the diamond originated. The technique is still being perfected and scientists will have to gather chemical composition fingerprints from diamond mines around the world to have a basis to compare rough diamonds [Ref 51].

3. Tracing Polished Diamonds

Polished diamonds that are made ready for retail sale are often engraved with a serial number using a laser or an ionic beam. The serial number is usually placed along the girdle of the diamond. These high-tech engravings make polished diamonds easier to track. Figure 9 reveals Canadian diamond companies fingerprinting techniques to allow their diamonds to be tracked.

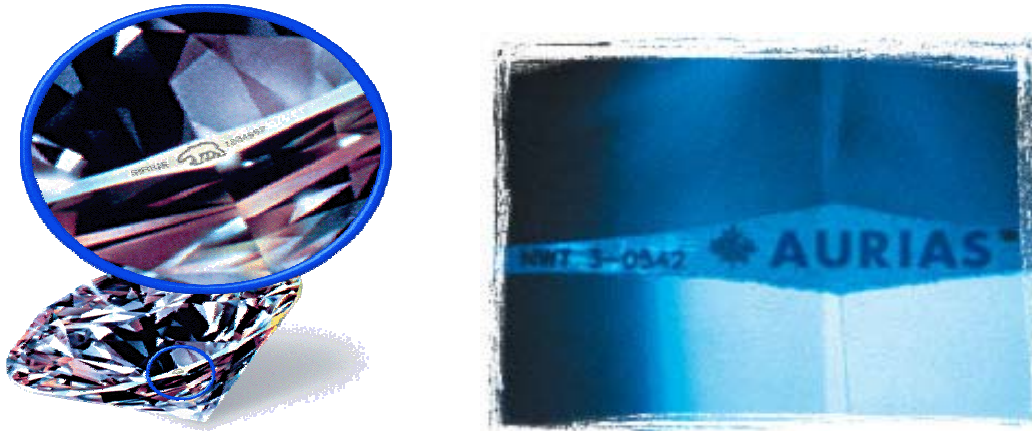


Figure 9. **Diamond Fingerprinting (From: Refs 52 and 53)**

4. Kimberly Process

The Kimberly Process also ensures that polished diamonds do not come from conflict diamonds due to the controlled process in which rough diamonds are handled. The Kimberly Process Certification Scheme (KPCS) was born May 2000 in Kimberly, South Africa in response to the threat of conflict diamonds illicit trade undermining the legitimate diamond market. The United Nations General Assembly Resolution 55/56 urged the international community to provide a solution to curb the trade of conflict diamonds and KPCS was the answer from over 50 nations, which attended the conference.

KPCS requires that a nation involved in the trade of rough diamonds provide a certificate to accompany the shipment of the rough diamonds and the container to be sealed. The certificate will travel with the diamonds all the way to the retail buyer. In addition, a confirmation receipt is sent to the originating exporting authority. The

country from whose territory a shipment of rough diamonds is leaving and possesses the authority to validate the Kimberly Process Certificate designates the exporting authority [Ref 54].

Nations participating in the KPCS are responsible for developing their certificates; however, they must contain specific elements to meet the minimum requirements set by the Kimberly Process. Those standards are as follows:

- Each Certificate should bear the title “Kimberley Process Certificate” and the following statement:

- “The rough diamonds in this shipment have been handled in accordance with the provisions of the Kimberley Process Certification Scheme for rough diamonds”.

- Certificates may be issued in any language, provided that an English translation is incorporated;

- Unique numbering with the Alpha 2 country code, according to ISO 3166-1

- Tamper and forgery resistant

- Date of issuance

- Date of expiry

- Issuing authority

- Identification of exporter and importer

- Carat weight/mass; Value in US\$

- Number of parcels in shipment

- Relevant Harmonised Commodity Description and Coding System

- Validation of Certificate by the Exporting Authority

Optional Elements

- A Certificate may include the following optional features:

- Characteristics of a Certificate (for example as to form, additional data or security elements);

- Quality characteristics of the rough diamonds in the shipment;

- A recommended import confirmation part should have the following elements:

- Country of destination;

- Identification of importer;

- Carat/weight and value in US\$;

- Relevant Harmonised Commodity Description and Coding System;

- Date of receipt by importing Authority;

- Authentication by Importing Authority [Ref 55].

Although the KPCS has the best intentions, it will only be as good as the earnestness and commitment forged by each of the nations participating in the process.

B. INTERNATIONAL BANK CHECKS

There is no standard process in which foreign checks are handled by financial institutions. The following is an email from a colleague describing how his institution handled foreign transactions. Mr. Turner worked in the banking industry for nine years and held the position for Regional Vice President before embarking on a new career.

Back when I used to negotiate checks drawn on foreign banks the procedure would be to provide our client a voucher for acceptance of the check drawn on the foreign bank. Then we would prepare an international draft requesting that the check be converted to one drawn on a US dollar account with a bank that uses the US Federal Reserve as a clearinghouse. We would then wait on a physical check to credit our client's account. In some cases the foreign bank would wire transfer the funds to our client's account. This scenario was especially true for banks in developing or third world countries, or those with unstable governments. Another scenario is that the check you were presented is actually drawn on a US dollar account with an American bank that the foreign bank uses for its dollar accounts. In this case your bank would simply take the check as deposit and credit your account as it would with any other check drawn on a US bank [Ref 56].

This process may be entirely different at other institutions, but they may use common conduits to communicate the transaction of a foreign check. Some of the communication systems used by banks are Telex and SWIFTnet.

1. Telex

Telex stands for teleprinter exchange. From the 1920's until the 1980's, a network of mechanical and electronic teleprinters and telephone switching centers made up the Telex system. The system operates with the international telegraph alphabet Nr. 2 and at a throughput speed of 50 baud. Telex allows real-time two-way text communication between two users. Terminals used by each user display what is being written by the sender and receiver. Industries that use the system are largely the financial and shipping sectors. In the shipping industry Inmarsat-B terminals deliver Telex from ships to Inmarsat LES via satellite. The LES has connectivity with the Telex network.

These industries use Telex because the system provides delivery receipt of a message and requires authentication between sender and recipient. Due to this capability, Telex was granted global document legal status. Documents sent via telex are considered legally binding. Major banks do not use the Telex system anymore, but the system is still used in developing countries [Refs 57 and 58].

Today, instead of using outdated teleprinter terminals Telex is accessed with Personal Computers (PC) running Telex software or through an internet/Telex gateway. Using Telex software such as TMDData Services' PCTelex on an IBM compatible PC equipped with a Hayes modem, a user can dial into the TM Telex Network through a PSTN. The software emulates the functionality of a Telex terminal to be able to send and receive telex messages [Ref 58].

Telex accessed via an internet/Telex gateway may or may not require the addition of software. A company called Plain Sailing based in the UK offers Telex services using existing email. Email is prepared as usual; however, the recipient's address is unique. For instance, TX_51290899@telexbynet.co.uk indicates that there is a telex message being sent (TX), to UK (country code is 51) and Telex number is 290899. The message is then delivered via the Internet to the TelexByNet router, passed to the Telex gateway where the message is entered on the Telex system and reports from the Telex gateway are sent to the Telex delivery reporting system, and reports are sent to the originator. Reports contain delivery confirmation, acknowledgement from the recipient that the message was received; duration of the transaction, and date and time Telex was received [Ref 59].

This method is not real-time; however, Plain Sailing does offer real-time service through a package called RealTelex. This package requires software that emulates a Telex terminal. Connecting through the Internet to the RealTelex router, messages are sent to the Telex gateway and directly to the recipient's Telex machine. The RealTelex software provides the functionality of Plain Sailing's Telex delivery reporting system. The software will log incoming and outgoing messages, as well [Ref 59].

Until 1973 banks, communicated with Telex. Since this time, Telex was automated by the banking industry through an industry-owned cooperative called the Society for Worldwide Interbank Financial Telecommunication (SWIFT). Today SWIFT

is composed of 7500 financial institutions from 199 countries that provides the communication network for secure transactions between the institutions. In 1977, the company introduced the Financial Information Network (FIN). FIN is a store and forward financial messaging service that runs on the X.25 protocol.

X.25 is a packet switching protocol designed for sending data over a wide area network. The protocol allows users to establish virtual paths between them. A subscriber of the network will call another subscriber. As the call is placed, switches and circuits are established to create the dedicated path. X.25 does not have Internet Protocol (IP) addressing. X.25 addresses are noted as called address and calling address. The source of the call must provide its address and the address of the subscriber being called to establish a virtual calling session [Ref 60].

2. SWIFTnet

In addition, X.25 provides error detection and correction due to slow throughput speeds. Coupled with encryption X.25 provided a suitable communication solution for banks considering the importance of their communication transactions. Although FIN is still being used today, the system is being replaced with SWIFTnet FIN. SWIFTnet FIN provides secure real-time and store-and-forward messaging file transfer and browsing capability. SWIFTnet FIN runs on the IP protocol and encrypts traffic with Public Key Infrastructure (PKI) technology and uses secure IP protocol between networks. Secure IP commonly called IPsec uses router gateways to provide an encrypted Virtual Private Network (VPN). SWIFT is the certificate authority, registration authority, and certificate directory for its PKI. Using proprietary software, SWIFTnet Link and SWIFTAlliance interface products, SWIFT projects to have its members connected to SWIFTnet by the end of 2004 [Ref 61].

C. SUMMARY

SWIFTnet handles large transactions such as foreign exchange payments, securities transaction and other large transactions between financial institutions. Thus, due to the continuing use of Telex in Third World countries and the ability of Inmarsat-B terminals to communicate Telex messages from sea to shore, the Telex system may be

used in communication efforts by terrorist or their financial transaction may be sent via Telex since this system is sometimes the premiere communication standard in a developing nation.

Furthermore, if the Belgian scientists are able to perfect a technique that can match a diamond to its origin this may give the Kimberly Process real influence in curtailing illegal diamond trading. Customs agents or other authorities would be able to determine if the Kimberly Certificate was valid by comparing the scientific origins of the diamonds to those origins alleged on the certificate. This type of validation process would eventually make diamond trading for terrorist and criminal organizations an uninviting venture.

V. CONCLUSION

A. APPLICATIONS

1. Maritime Tracking System

There have been discussions in the US government for creating a maritime tracking system for ships, which approach the coastal waters of the United States. The Chief of Naval Operations has exclaimed,

In conducting homeland defense, forward deployed naval forces will network with other assets of the Navy and the Coast Guard, as well as the intelligence agencies to identify, track and intercept threats long before they threaten this nation.

I said it before and I'll say it again today, I'm convinced we need a NORAD for maritime forces. The effect of these operations will extend the security of the United States far seaward, taking advantage of the time and space purchased by forward deployed assets to protect the U. S. from impending threats [Ref 62].

This thesis contributes to a possible national maritime tracking effort by providing information on tracking systems used by commercial sectors to track ships and aircraft that could be monitored by Homeland Security and Defense organizations for terrorist activity.

As described in Chapter III, the Automated Identification System (AIS) could be transmitted via Inmarsat satellites. Instead of having the AIS signal transmitted 96 hours before reaching US coastal waters, transmissions could be sent via Inmarsat and relayed to maritime watch centers around the world whenever vessels set sail. Foreign and US Coast Guards would be able to track vessels from port-to-port around the globe and share their data on suspicious ships. The Maritime Security Act supports this general concept.

However, Maritime Information Service of North America (MISNA) proposes to take advantage of the GMDSS and Inmarsat combination as opposed to AIS because GMDSS is a more established system. GMDSS is currently used for emergency situations, but MISNA recommends having authorized shore stations polling the system for positional data and having that information relayed to a central watch floor [Refs 62 and 63]. Even though each system currently provides a unique service both can be

adapted to broadcast geolocational data of ships around the world over a satellite network. Monitoring such a network will help to mitigate terrorist activity upon the lanes of commerce.

2. Telex Coverage

In addition, this thesis raises the concern that terrorists may be using the Telex system to communicate within their organizations due to the geographical locations in which they operate. Terrorists are often operating in developing countries or third world countries to keep a low profile. These countries may not have established cellular networks or access to the Internet. However, a Telex system may be operational. In addition to possible terrorists' communiqués passing over these networks, terrorist financial transactions may be passing over the Telex system. Telex was originally developed to support banking transactions, and some poor countries may still be using this system in their financial institutions. If the Telex system is not being monitored Homeland Security and Defense Organizations should investigate these systems.

3. Pushing E-Seals and RFID Development

Lastly, this thesis points out the weaknesses associated with e-seals and RFID tag systems. Knowing these weaknesses will give policy makers within the Homeland Security Organization the ability to continue a push for the development of better e-seals and RFID tags. In addition, education on the installation and inspection of these systems may be brought to the forefront to enhance security not only from the product end but from the user end, as well.

B. AREAS FOR FURTHER STUDY

1. Relatively New Satellite Systems

There are a number of new satellite systems that have recently come online or will be coming online in the near future. Globalstar, New ICO, and Ellipso systems meet the description of being new or relatively new, thus they require a more in-depth investigation, which may lead to better collection efforts against these communication systems. In addition, there needs to be a continuing lookout for existing satellite systems that may initiate the offering of location services in their solution or product line. Furthermore, satellite systems that provide digital television broadcasting should be

explored for tracking capability. In a report written November 2002 by EyeForTransport called “Cargo Security Overview”, the organization lists the use of digital television frequencies as an emerging technology for tracking mobile assets. Currently open sources do not provide any insight into this technology, but it may be on the horizon [Ref 64].

2. More Spoofing Required

The GPS spoofing experiment conducted by Los Alamos National Lab was an eye opener to the vulnerability of the GPS system. Similar experiments aimed at actual GPS receivers used in tags and e-seals presented in this paper and those in the near future should be conducted to provide an even more realistic environment. Further exploration should include the possibility of targeting GPS receivers on ships and planes. Targeting GPS for ships and planes may stimulate debate for adding protections to the civilian GPS signal. If success is found in spoofing or jamming the GPS receivers on ships and aircraft, one must also study the protective measures being taken by the Europeans to prevent spoofing and jamming against the Galileo project. The Galileo project is being built for the sole purpose of assuring continuous civilian use and for aviation navigation. For instance, if foreign aircraft entering European airspace are to use Galileo for air navigation, what protective measures are the Europeans taking so that the signal cannot be compromised which may cause an aviation accident?

3. Combination of Satellite and RFID Tracking System

In the near future there may be the possibility of marrying RFID technology with satellite communication technology. This paper has already mentioned the relationship that exists between 802.11b, Bluetooth Lite, GSM and satellite technology, which is used to track containers. However, no company has presented a solution that uses RFID and satellite technology to provide full-time tracking of a cargo unit. Generally, RFID technology stops when the container unit is loaded on a vessel and picks up again when the unit gets to its destination. Thus, there is no tracking provided while the container is in transit except for maybe the tracking of the vessel.

NASA’s Jet Propulsion Laboratory in Pasadena, CA, proposes the development of a system that would use an infrared transceiver for local communication and a microwave

transceiver for communication over longer distances. To accomplish this proposal, a tag or transponder would work in unison with what the lab calls a retainer unit. The tag would have the basic functions of being able to store data, providing self-power and incorporating GPS. The tag would then be placed into the retainer. Through the retainer, communication could be done via a satellite, microwave repeaters, infrared, and possibly with RFID. This design allows for more information to be loaded on a tag and communicated in local and transient environments [Ref 65].

The problem with developing such a device as proposed by NASA or other systems like it is maintaining a power source and keeping the cost of the unit down. After manufacturers are able to manage the power issue more systems will be developed which are similar in concept proposed by NASA. Thus, the market needs to be monitored for these new developments.

C. SUMMARY OF WORK

The goal of this project was to explore the different tracking technologies used to trace cargo containers, ships, and aircraft. In addition, an investigation of tracking unique items such as diamonds and foreign bank checks was conducted to gain some insight on how the diamond and financial industries could be examined to mitigate criminal and terrorist exploitation in these areas. This study also alerts organizations in Homeland Security and Homeland Defense of new communication signals that will be associated with commercial shipping, which can be scrutinized for evidence of terrorist activity.

Lastly, the vulnerabilities associated with the deployment of GPS, e-seals and tags were reiterated from the findings conducted by the VAT at Los Alamos National Laboratories. Although e-seals and tags are developed with the intentions of improving security, improper use may be undermining their effectiveness. In addition, authorities should always be mindful that malicious computer attacks could be performed to spoof the contents of a cargo unit. In other words, what a user sees on the screen may be what the company intended to ship, but what was actually shipped in the designated cargo container was something entirely different. The stroke of a few computer keys can subvert state-of-the-art tracking technology unless a strong information assurance plan is implemented and executed in concert with the tracking systems.

APPENDIX A. SATELLITE CHARACTERISTICS

Satellite Systems

Description	ORBCOMM	ARGO	INMARSAT	GLOBALSTAR	IRIDIUM	EUTELSAT
Orbit Type	LEO	Polar Sun Synch, Circular	GEO	LEO	LEO	GEO
Orbit Height (Km)	900	850	36000	1400	900	36000
Number of Satellites	30	4 to 6	6 to 20	48 (8 spares)	66	3
Frequency Uplink (MHz)	G-S 148 - 149.9	PTT - S 401.65	T-S 1626.5 - 1646.5	G-S 5091 - 5250	G-S 29.1 - 29.3 GHz	13 - 14.5 GHz
Frequency Downlink (MHz)	G-S 137 - 138, 400.05 - 400.15	unknown	S-T 1530 - 1545	S-G 6875 - 7055	S-G 19.4 - 19.6 GHz	10.95 - 12.75 GHz
MAC Method	X.400	unknown	FDMA	CDMA	FDMA/TDMA	
Service	Data, GPS and messaging	Data, GPS	Voice, data, fax, telex	Voice, data, fax	Voice, Data, FAX, GPS	Voice, fax, data, sms, GPS
Coverage	Global	Global	Global	Global	Global	W & E Europe, Mediterranean, Middle East, and Atlantic Ocean
Inclination (degrees)	45 and 135	98.7	0 - 4.2	52	86.4	13.5
Website	orbcomm.com	argosinc.com	inmarsat.com	globalstar.com	iridium.com	eutelsat.com

Description	NEW ICO	THURAYA	ELLIPSO	EGNOS	Galileo
Orbit Type	MEO	GEO	Cir Equatorial & Elliptical	GEO	MEO
Orbit Height (Km)	10000	36000	633	36000	10000
Number of Satellites	10	3	17	3	30
Frequency Uplink (MHz)	S-H 2165-2200	G-S 6425 - 6725	G-S 15400 - 15700	1.6 GHz	C and L band
Frequency Downlink (MHz)	H-S 1990-2025	S-G 3400 - 3625	S-G 6775 - 7075	14 GHz	unknown
MAC Method	TDMA	FDMA	W-CDMA	CDMA	CDMA
Service	Voice, data, fax, GPS	Voice, data, fax, GPS	Voice, data, GPS, Internet	GPS	GPS
Coverage	Global	Western Europe, N. Africa, Middle East, Central Asia, & India	55 degrees South and up	Europe	Global
Inclination (degrees)	45	6	0 and 116	0	56
Website	ico.com	thuraya.com	ellipso.com	esa.int	esa.int

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APPENDIX B. VENDOR LIST

Satellite Resellers and Service Providers

1. ORBCOMM RESELLERS

Hanestar

OHB Teledata GmbH
Universitätsallee 29
28359 Bremen
Germany
Phone: +49/421/20 20-8
www.hanestar.com

ADSI

1031 Bay Blvd. Suite F
Chula Vista, CA, 91911
USA
Phone: (619) 585-0435
www.satguard.com

OMNITRONIC SA

Ing. Norberto Pesce, Director 5501 Godoy Cruz Avda. San Martin Sur 36
Mdza
Argentina
Phone: +(54) 261-422-0359
www.omnitronic-sa.com

SkyTracSystems Ltd.

Kathleen Wallace,
201-3590 Airport Road
Penticton, British Columbia, V2A 7J6
Canada
Phone (250) 492-5363
www.skytrac.ca

Telespazio S.p.A.

Guglielmo Mazzacano, Via Tiburtina, 965
Rome, 00156
Italy
Phone: +(39) 06 4079 3365
www.telespazio.com

VEERS Elektronik + Meerestechnik GmbH & Co. KG
Stephan Wenzke, Flugplatz Holtenau Sued Eekbrook 15 Kiel,
Germany, D-24159 Europe
Phone: +49 (0) 431 / 36 914 36
www.veers-kiel.de

XR Communications
Brian J Wilson, COO
404-12 High Street E Moose
Jaw, Saskatchewan, S6H 0B9
Canada
Phone: (306) 693-3442

VascoTrack Ltd.
Phil Vella, General Manager
No. 2 Royal Mews Gadbrook Park
Northwich, Cheshire, CW9 7UD
UK
Phone: +(44) (0) 1606-812-600
www.vascotrack.com

2. INMARSAT SUPPLIERS

Arcom Telecom Services & Applications
40 Agiou Konstantinou, Aethrio Centre
Maroussi
151 24 Athens
Greece
Phone: +30 (210) 6107379

DH-Intercom
Felix-Wankel-Str 16
Oldenburg
D-26125
Germany
Phone: +49 (441) 9350320

7E Communications
Swan House
203 Swan Road
Middlesex TW136LL
United Kingdom
Phone: +44 (0) 20 8744 8500
www.7E.com

Marlink Communications

Avenue Guillaume Herinckxlaan 80
Brussels
1180
Belgium
Phone: +32 (2) 3717111
www.marlink.com

VISTAR

2 Brewer Hunt Way
Kanata, ON K2K 2B5
Canada
Phone: 1-866-499-6199
www.vistardata.com

3. EUTELSAT SERVICE PROVIDERS**Markland Group, Inc**

108, Ivan Javakhishvili St
Tbilisi 380064
Georgia
Phone: +995 77 41 07 50

France Telecom Mobile Satellite Communications

16 Boulevard du Mont d'Est
93192 Noisy-le-Grand Cedex
France
Phone: +33 1 48 15 73 54

Telespazio

Via Tiburtina 965
00156 Rome
Italy
Phone: +39 06 4079 3778

CTC

31-33, Smolenska St.
Kiev 01680
Ukraine
Phone: +380 44 490 8128

Applied Satellite Technology

Burlingham House
Hewett Road
Gapton Hall Estate
Great Yarmouth

Norfolk NR31 ONN
United Kingdom
Phone: +44 1245 275 581

SATKO

Buyukere Cad. No: 121
Ercan Han II-Blok
Kat: 4-80300 Gayrettepe
Istanbul
Turkey
Phone: +90 212 212 8200

4. IRIDIUM SATELLITE SERVICE PARTNERS

Electronic & Electrical Maintenance Co

Shuwaikh-Industrial Area
Area 1, Street 12
Block 99
Kuwait
Phone: +965 482 0113
www.eemchkuwait.com

East Satcom Telecommunications

United Emirates
Phone: +97114 2211211

European Datacomm NV

Heidestraat 257
2070 Zwijndrecht
Belgium
Phone: +32 3 210 15 10
www.edchq.com

Global Plus Limited

Allied Building
Francis Rachel Street
P.O. Box 195
Mahe
Seychelles
Phone: +27 12 346 1444
www.global-plus.com

Xantic

P.O. Box 153
Caboolture Qld 4510
Australia
Phone: (71) 22432 Telesc AA
www.xantic.net

Jembas Assistencia Tecnica Lda

Rua Rainha Ginga 190
Luanda
Angola
Phone: +244 2 320629
www.jembas.com

Singapore Telecommunications Ltd.

Mobile Satellite Business
15 Hill Street #02-00
Telephone House 1
Singapore 179352
Phone +65 64169333
www.singtel.com

5. GLOBALSTAR REGIONAL PROVIDERS**Saudi Globalstar Operations**

P.O. Box 25916
Riyadh 11476
Saudi Arabia
Phone: 966 1 474-8848

Globalstar North Africa

4. Av d'Essaouira Rabat 1000
Tunisia
Phone: 037 76 79 37/09
www.globalstarna.ma

Mibo Trading d.o.o

Azize Sacirbegovic 9
Sarajevo-Bosnia and Herzegovina
Phone: +387 33 201333

Globalstar Egypt

1 Hassan Allam Street, Heliopolis
Cairo 11341
Egypt
Phone: +20 2 41878678

Apex Communications –Vancouver
Globalstar
1-525 Seymour St.
Vancouver, British Columbia V6B 3H7
Canada
Phone: 604-689-3300
www.teamapex.net

TE.SA.M. Venezuela
Av. Principal de la Castellama con
Av. San Felipe, Torre Centro Letonia,
PB Local G1. Caracas. Venezuela
Phone: +58 2121 286 9060

GloCall Satellite Telephones BV
Jacques Perkstraat 3A
2274 GP Voorburg
P.O. Box 95555, The Netherlands
Phone: +31 (0)70-3001818

6. THURAYA SERVICE PROVIDERS

7E Communications
Swan House
203 Swan Road
Middlesex TW136LL
United Kingdom
Phone: +44 (0) 20 8744 8500

Algerie Telecom Mobile
Centre de Gestion et de
Facturation Thuraya
07 Chemin du Paradou Chalet N
23 16045 Hydra
Alger
Tel +21321712652/601940

Alkan Communication
Thuraya Satellite Services
8 El Gazaaer St.
New Maadi 11435
Cairo, Egypt
Tel: +202 5169722
www.alkan.com/thuraya.htm

The Telecommunication Company of Iran

TCI Building
Dr. Shariati Ave
Tehran, Iran
Phone: +98 21 8780500

Danisat Ltd.

P.O. Box 472
50 Town Range
Gibraltar
Phone: +45 73 425601

Partners Company Ltd.

P O Box 4668
Sana'a Yemen
Phone: +967 1 420499

FARHAN COMMERCIAL COMPANY. LTD

P.O. Box 5887
Riyadh 11432, Saudi Arabia
Phone: +966 1 2192000

Syrian Telecommunications

Establishment
Austrad Al Mazza
P.O. Box 11774
Damascus Syria
Phone: +963 11 612 2226

Tunisie Telecom

Rue Asdrubal- 1002
Tunis
Tunisia
Phone: +216 1960414

IMTCL

216-Upper Mall
Bawa Park
Lahore, Pakistan
Phone: 92-42-5877921

E-seals and RFID Providers

All Set

Gustavslundsvagen 147, Box 14112
S-167 14 Bromma, Sweden
Phone: +46 (8) 801588
www.allset.se

Intermec Corporate Headquarters

6001 36th Avenue West
Everett, WA 98203-9280
Phone: (425) 348-2600
www.intermec.com

NaviTag

221 West Squantum St.
North Quincy, MA 02171
Phone: +01 781 210 0203
www.navitag.com

Savi Technology

615 Tasman Drive
Sunnyvale, CA 94089-1707
www.savi.com

Transcore Marketing Communications

19111 Dallas Parkway, Suite 300
Dallas, Texas 75287-3106
Phone: (972) 733-6010
www.transcore.com

Hi-G-Tek

16 Hacharoshet St
Or-Yehuda 60375, Israel
Phone: 972-3-5339359
www.higtek.com

E.J. Brooks Company

World Headquarters
8 Microlab Rd
Livingston, NJ 07039
www.ejbrooks.com

WhereNet

2858 De La Cruz Blvd.
Santa Clara, CA 95050
www.wherenet.com

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Fort George G. Meade, Maryland
5. Cryptologic Research Laboratory, Code EC
Department of Electrical and Computer Engineering
Naval Postgraduate School
Monterey, California
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Coeburn, Virginia
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