# Application of Freight Identification Technologies to Marine Transportation

by

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B.S. Marine Transportation
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Submitted to the Department of Ocean Engineering
in Partial Fulfillment of the Requirements for the Degree of

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**Abstract**

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This study was carried out to investigate the use of freight identification technology for marine container tracking. This research was also intended to evaluate the different forms of the technology and enlighten ocean carriers on the strengths and weaknesses of each technology.

The various currently available products and the technologies they represent are identified along with their technical characteristics.

Three metrics are identified to assist in evaluating the technologies for this application. These are: Level of Service, Cost, and Institutional or Legal factors. The technologies are evaluated in relationship to these metrics and several implementation strategies are suggested.

Included are descriptions of some of the technical background and features of the technologies.

Thesis Supervisor: Professor Henry S. Marcus
Professor of Ocean Systems Management

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# CHAPTER I

## Introduction

This thesis is a study of the state of the art in freight tracking, and how freight tracking technology and practice could be adopted or improved upon for use tracking marine containers. Each major technology used today in freight tracking is analyzed from an ocean carrier point of view. Some suggestions on how marine container tracking may evolve are made, along with some projections of cost and implementation.

### Backround of Freight Tracking

Freight tracking has existed in much the same form since the Phoenicians first carried cargo for hire. All of the necessary documentation was recorded on paper, and forwarded either along with the cargo, or on a different vessel. The only advances for centuries were the arrival of airmails for expediting paperwork, and later the facsimile and other electronic means. All this really accomplished was to speed up (marginally) the flow of paper documents, it never really revolutionized the process. Trade carried on in much the same manner for centuries. It really didn't matter much, since the freight was manhandled at each transfer point, and the various modes were disconnected and organizationally fragmented. The intermodal through bill of lading had not been invented yet.

With the advent of the marine container, things eventually had to change. The container certainly revolutionized the handling of cargo, no one can dispute that. Now that cargo can be essentially packed in a bigger, more efficient box- it speeded up the through put of cargo tremendously. Today, it is the paper flow that is often the limiting factor on the door to door delivery time of a marine container. The container spends much of its time in a terminal, waiting for collection or the next intermodal connection to its destination. Research has shown that this is an information holdup, usually not an operational one. The other side of the problem is the error rate. Different sources give different estimates on this, but they all agree it is a serious problem particularly when a cargo must go through customs inspection and processing. If there is a discrepancy in the paperwork it often delays the customs clearance process until it is corrected. Then, there are two factors to document handling:

- Speed.
- Error rate.

Obviously, in this information age this cannot continue. There are examples of successful freight tracking such as the US rail system. Here is the first quandary. We usually do not track the freight exactly, but rather, we track the vehicle or container it is carried in. So, we must know what is in that vehicle. This example points out the system implications of this undertaking, it may be useless to track the containers unless they can be matched with the other necessary information in an easy to use, seamless manner. The US rail system mentioned above is a good example. Some railroads make excellent use of this information, and some do not. The first problem encountered is the fact that rail cars move on rails. A rail carrier knows that eventually all of his movable assets will be scanned and located in this manner. His tracking problem is much simpler.

**Obstacles to Introduction in marine container use:**

There are several obstacles to widespread introduction of this technology in the marine container transportation industry. Some of them are:

- This is a very traditional, slow to change industry.
- It is international in scope.
- The use of the information generated can be difficult to digest for a carrier.
- Difficulty in system integration on such a large scale.
- Cost.
- Low level of profitability in the industry today.
- Progression toward 'open systems architecture' and the security and other problems this represents.
- Tough decisions about integration into the Internet, and the existence of many 'legacy' systems.

This thesis will attempt to enlarge upon some of these difficulties and obstacles. Some of them are being solved, some solutions are in infancy. There is a great deal of work yet to be done.

The market place is bringing products into play at a very rapid rate. The technology is changing rapidly. What was state-of–the-art just a short time ago, can become obsolete (or at least, less than optimum) very quickly. The practice of integration is advancing rapidly as well. The driver for this is the growth of logistics in industry. Businesses are constantly looking for ways to shave costs from their supply chains. The weapon of choice is often better information, which will have to come from systems like 'freight tracking'.

### Ocean Carrier Solutions

The ocean carrier as mentioned before has unique problems compared to rail or even truck transportation. His assets are not necessarily contained within a system. Very often his internal problems seem to outweigh the customer's problems. These internal problems are:

- Where is my container?
- Who is using my assets, wearing out my tires and brakes, and how can I identify and bill them?
- Imbalance of container assets at various locations.

This thesis attempts to point out these problems and offer potential paths toward solutions.

### Push vs. Pull

Marketing of transportation services has always been quite traditional as well. Transportation of containers by sea is mostly a commodity business. Now, with the increasing focus on supply chain management by an ocean carriers customers, this has been changed to a 'pull' scenario, where the customers are driving the advances in freight tracking by their desire to reduce transit times, and utilize more transit information for their own planning. They want to know where their cargo is, and more importantly, what is happening to it?

This is driving carriers' desire to bring more information management capability on-line. This is really a specialized information technology (IT) problem.

To sum up, this is an examination of some of the problems, and many of the potential solutions combined with some guidance on how they compare.

# CHAPTER II

## Technology Scan

This chapter describes the identification technologies relevant to the maritime and land freight transportation fields. Key elements of ID Technologies are identified. A Technology Scan Matrix is presented with data on these key elements for the ID products found. The Scan was developed by means of many research methods including:

- Researching exhibits at Trade Conventions
- Research of industry journals and publications
- Searching electronic journals, publications, and Internet
- Searching existing databases
- Interviewing industry executives

The Scan contains information from 37 vendors and 45 products. A brief overall assessment shows:

- There is a large and growing number of ID Technology products.
- The rate of change in ID Technologies is large.
- Given the above two factors, there will probably be a shakeout of many of the existing products.

ID Technologies are divided into three major categories. Optical Character Readers, RFID tag, and satellite transponder Tags. With an Optical Character Reader (OCR) there are no tags or other additional devices attached to the movable asset to be identified. The OCR using video cameras reads the existing identification number stenciled on each container or movable asset. With RFID Technology a tag is placed on the movable asset to be identified. Independent of the tag, an electronic reader is necessary to complete the transaction of reading the tag (and typically relating this information to a central database). With Satellite Transponder Tag Technologies, the tag is placed on the movable asset and can be interrogated (or tracked) in real time from a distant location.

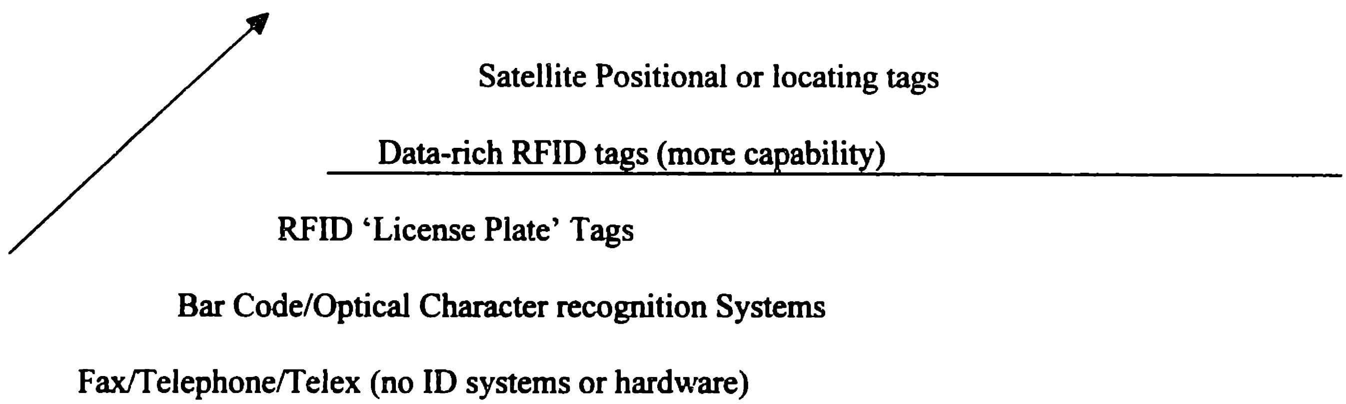
## FUNCTIONAL ELEMENTS OF SMART DATA CARRIERS IN LOGISTICS APPLICATIONS

Smart Data Carriers are a subset of Automatic Identification Technologies (AIT). Smart Data Carriers are often referred to as 'tags' in common industry usage. AIT includes process control hardware, application software, and hybrids (i.e. devices that combine more than one function such as combining License Plate data with position) that provide automatic data acquisition and transfer. In logistics applications, these technologies facilitate the capture of supply, maintenance, and transportation information related to inventory control, movement management, and shipment diversion.

The functional elements of a smart data carrier (tag) are data storage capacity, a license plate identifier, input/output communications capability, intelligence[1], a power

[1] Intelligence is defined here as the ability of the tag to make limited processing decisions based on user(e.g. Transportation Carrier) inputted parameters.

source, and its form factor or structure. Expect continuing progress in packaging these elements together more elegantly in smaller, more robust forms, with greater capability and at lower prices. Remarkable progress is being made continuously in improving the capability of tags, lowering the cost of tags, and incorporating the technology in increasingly more useful systems.




*FigureII-1 Hierarchy of Tags and ID Technologies*

*Horizontal line shows cutoff of 'Smart Data Carriers'*

The key elements for the Technology Scan Matrix are listed in Table II-1 below, followed by a description of each element.

| Element | Description |
|---|---|
| Data Storage Capacity | memory type and capacity |
| License Plate ID | media employed |
| Input/output Communications | frequency<br>protocol<br>capability<br>range |
| Intelligence | processor |
| Power Source | battery characteristics |
| Structure | physical size<br>temperature and humidity limitations<br>antenna requirements |

*Table II-1 Key Elements of Technology Scan Matrix*

## DATA STORAGE CAPACITY

Data storage may permit a wide range of fixed and variable information to be handled by the Smart Data Carrier. Some inexpensive Radio Frequency Identification (RFID) tags carry no more than their permanent identification number. More expensive tags can accommodate substantial variable data. For example, some tags can carry detailed information on the complete container contents. Smart data carriers are the most likely to have meaningful flexible data carrying capacity.

## LICENSE PLATE CAPABILITY

Central to almost all automated data carrier systems is a subset of data storage: a unique and permanent data carrier identifier that acts as a license plate[2]. This characteristic holds true for bar codes, RFID, and sophisticated satellite tracking transponders. The license plate is simply a unique identification number that can be cross-referenced to more detailed information about the shipment. The detailed information may reside in proprietary or distributed databases within a single business firm or, more likely, in several firms. Such a license plate is useful as a header even on AIT media that contain much more data, such as the more expensive RFID tags. Thus, in simple transactions such as the arrival of a loaded container at a terminal, only the tag identification number needs to be captured and transferred. The tag identification number can be correlated with information in the terminal operations database, and it can be passed on to managers and customers at remote locations.

[2]Formal License plates have a regulatory function and are usually issued by a governing body. 'License plate' is used here as a metaphor when referring to Smart Data Carriers and it refers to the uniqueness of the individual identification number.

## INPUT/OUTPUT AND COMMUNICATIONS

Most smart data carriers contain some fixed data, such as their identification number entered at point of manufacture. More robust carriers permit the input of tailored data 'in the field' (i.e. during transportation or logistics operations) related to a specific logistics process, such as transportation of a shipment. This is an example of variable data. Local data entry may be 'write-once' or 'write-many'. A good example of write-once technology is the optical memory card or laser card. Write many technologies include Personal Computer (PC) cards and the higher capability RFID tags, which have repeatable (re-writable) memory media as part of the device. Smart data carriers will most likely use write-many technologies since inclusion of variable data requires the ability to 'write-many'. Table II-2 shows the relationship between different devices (tags) and data characteristics.

All data carriers offer some means to read their fixed and variable data. Some data carriers employ direct contact technologies such as magnetic stripes, PC card connections, or optical memory readers. Other carriers use non-contact methods such as optical recognition, infrared signals, or radio frequency transmission.

Radio frequency (RF) transmission is used in three different ways: short range, intermediate range, and long range. Short and intermediate range RF communications usually operate between tags and readers (or interrogator, a device for the retrieval of data or writing of data to/from the tag) within a terminal. The most common short-range tags are those based on a standard developed by Amtech. These tags usually require a direct line of sight, near perpendicular orientation of the tag to reader, and a distance within 5 to 7 meters. The Amtech tags are used by the railroads in North America and Europe and by a small number of U.S.- based ocean liner companies.

Intermediate range RF communications are usually omni-directional with a range of up to 100 meters. The most common example is produced by Savi Technology and is used by the U.S. Department of Defense.

Some high-end data carriers are capable of communicating at close proximity and great distances. Such carriers can receive and record data generated thousands of kilometers away, and they can provide or output data to recipients equally far away. Relevant technologies include cellular phones, AM radio signals, and satellite telemetry. Of course, data carriers that are not inherently capable of communicating at great distances can be linked together with other communications devices.

An important area for study will be the market importance of inherent long distance communications capabilities for smart data carriers. This area involves us in the interplay of technical and institutional questions about radio frequency spectrum controls and standards in different parts of the world.

| Type of Tag | Characteristic | Type of Data |
|---|---|---|
| Simple RFID (Usually passive, can be active) | License plate identifier | Fixed data |
| Data-rich RFID | License plate identifier plus User programmable data such as: Manifest Consignee Transit information | Fixed and Variable Data |
| Simple satellite GPS/GLS | Location determination plus License plate identifier | Fixed data plus (in some cases) internal location data |
| Sophisticated satellite GPS/GLS (Hybrids) | Location determination plus License plate Identifier plus variable data | Fixed and Variable Data |

*Table II-2 Data/Tag Information Relationship*

**INTELLIGENCE**

The defining feature of a smart data carrier (tag) is independent intelligence or data processing capability integrated in individual tags. The intelligence may be provided in a packaged set of components that moves with the freight-- such as networking together a close range RFID tag, a satellite transponder (a tag which responds to a satellite network rather than a terrestrial system of readers, usually for positional data), and a small computer. Alternatively, all of the requisite capabilities can also be integrated into a stand-alone tag.

Distributed intelligence can be used to interpret environmental conditions (such as temperature) or status (such as 'seal broken') and initiate action based on rules programmed into or received by the tag. Another type of 'intelligence' is real time positional information, which can be provided by the tag itself via internal Global Positioning System (GPS), or by merely passing a reader and reporting to an operations center.

One may have an intelligent distributed information system without having smart data carriers (smart tags). The most common approach today is to use simpler, cheaper, 'dumb' tags on containers or shipments. Information from these tags is collected by means of the interaction between readers and tags and then processed in one or more operations centers.

An important set of questions for the study will be to examine the tradeoffs between smart data carriers within smart(er) data systems. I expect the tradeoff relationships to change as the price/performance ratio improves for smart data carriers.

## POWER SOURCE

Data processing and transmission require energy. One class of tags is passive, with the energy for the data transmission or other on-board operations coming from external sources. The simplest example is a bar code or other optical scanning technology, where the power comes from the reader. Some RFID tags use passive backscatter technology, activated by and reflecting back energy from an interrogator. Other passive tags use inductive loops that draw power from the magnetic field of an interrogator.

Active tags draw power from an external source or an on-board battery. The external source may be the power systems of a tractor, a generator mounted on a refrigerated container, or a solar powered panel. Integrated replaceable batteries are another possibility.

Power options have significant impacts on the operational flexibility and value of data carriers. These impacts will be an important consideration for the study.

## FORM FACTOR

The physical structure of smart data carriers can vary widely. Tradeoffs include physical durability in intermodal and ocean borne container operations, space to accommodate antennas or transponders, and accessibility of batteries. A closely related issue is the location of the data carrier on the container, chassis, or tractor. Physical design, construction, and placement of the data carrier all influence the business prospects for smart data carrier applications.

## TAGGING VS. TRACKING

Some discussion of smart data carriers refers to tags, some discussion refers to tracking, and some discussion uses the terms interchangeably. It is important to clarify these terms since all smart data carriers (or 'tags') are used to 'track' and manage items in the distribution pipeline.

The critical difference is between two clusters of technologies:

- Those with short- or intermediate range communications and (usually) fixed locations for their 'readers' or individual communication sites. Many people refer to these as tagging or labeling technologies.
- Those with long-range communications and mobile reporting capability. People often refer to these as tracking technologies.

The first group usually 'tracks' shipment location by recording and reporting the event when an item with an Auto ID device (tag) passes close by a (fixed) reader. Examples include transactions at packing stations, loading docks, and terminal gates.

The second group usually records and reports its location at fixed time intervals, regardless of actual location. Examples are long-haul motor carriers, and urban fleets of trucks, delivery vans, or transit vehicles.

Both groups of technologies can include either simple license-plate-like capabilities or more complex data-rich capabilities.

The two groups are not mutually exclusive. They can complement each other depending on the overall concept of operations. For example, one might choose to apply simple license-plate media to pallets while tracking the trailer or container with a mobile GPS device.

Figure II-2 illustrates different types of Auto ID technologies used in transportation applications. Only one example, GPS devices on conveyances, is a mobile tracking device. All others are primarily fixed location or short range tagging methods.

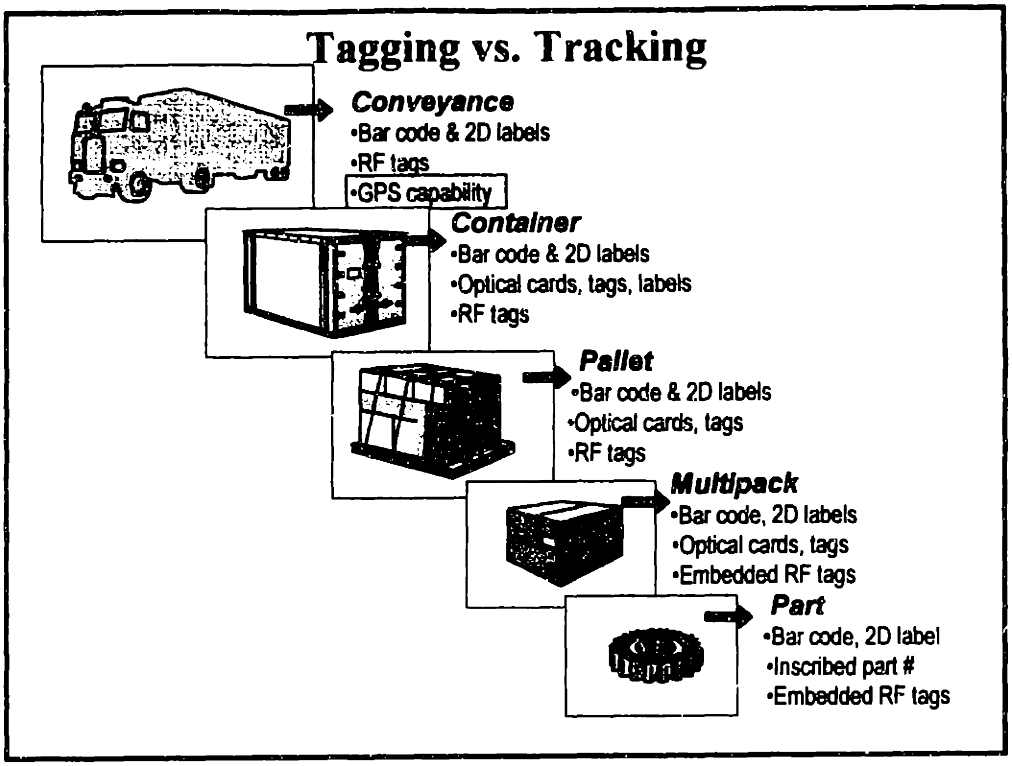



*Figure II-2 Tagging vs. Tracking*[3]

Automatic identification is a rapidly changing technology. During the course of this undertaking many changed and improved products have been introduced. The importance of correctly matching technology with application cannot be over emphasized.

The next chapter will deal with the operating scenarios that are relevant for ID Technology opportunities.

[3] Drawing from North River Consulting Group

## HOW TO READ THE MATRIX

The Technology Scan Matrix contains information gathered from 37 equipment vendors, and 45 products identified and categorized by 36 elements. These elements or product characteristics were chosen based on criteria resulting from the research, and I regard them as the most critical in choosing between products and in describing the best uses of these products.

A map is attached to assist in laying the matrix out on a flat surface. The matrix is best studied when spread out entirely on a flat surface according to the page numbering and attached map. Product name is included on the left leading column of each page for ease of reading. The products are listed according to vendor, alphabetically.

Most of the products in the Matrix are RFID tags, although many different types of products are shown here in the finished matrix. Most of the product characteristics apply directly to RFID, while many product characteristics apply to other products as well, such as satellite-based tags. Some products however, for instance, 'Maher Marine Terminals CCR' (optical character recognition system) are based on entirely different technologies and the major common link is the application served. These products are listed in the matrix, but written across the rows with a brief description of the technology rather than technical entries in the element columns. The matrix is intended to contrast various products and provide a useful comparison.

There are many gaps in the element columns, due to several factors:

- Products not on market yet, and/or design characteristics not fixed
- Information not forthcoming from vendor
- Element not applicable to that particular product

## MAP FOR LAYOUT OF COMPLETE TECHNOLOGY SCAN MATRIX

| | | | | |
|---|---|---|---|---|
| Page 26 | Page 29 | Page 32 | Page 36 | Page 39 |
| Page 27 | Page 30 | Page 34 | Page 37 | Page 40 |
| Page 28 | Page 31 | Page 35 | Page 38 | |

| VENDOR | PRODUCT | Normal Rang | Max Range | Memory Type | Memory Capacity | Transaction Lif | Availab | Comm Method |
|---|---|---|---|---|---|---|---|---|
| Allen-Bradley | IntelliTrack Tags (Rockwell Automation) | 2- 19 inches | | RAM | 32 bytes | 1.5 million + | yes | |
| Amtech | AT5510 Trans Tag | 70 ft | 240 ft | EEPROM | 128 bits | 10000 | Yes | Reflective |
| Amtech | AT5704 Rail Tag | 50 ft | 180 ft | EEPROM/RAM | 32 K bits | 10000 | Yes | Reflective |
| Amtech | Universal Tag | 70 ft | 240 ft | EEPROM/RAM | 1 M bits | 10000 | Aug-93 | Reflective |
| AT/Comm | Smart Transponder | avail | 1.5 Miles | EEPROM/RAM | 128 K bits | 1000000 | Apr-93 | Single Freq. |
| AT&T | Contactless Smart Card | N/A | N/A | EEPROM | 24 K bits | 100000 | Yes | Ind,Cap Coup. |
| AT&T/MARK IV | Communicator | | | N/A | N/A | | Yes | Single Freq. |
| Avonwood | RF Tags | | | | | | yes | |
| Brady USA | sub $1 tag | 1.5 meter | | | | | Yes | |
| BTG USA Inc. | Supertag | | 4 meters | | counting | multiple id user choice coding | | |
| CheckPoint Systems | sub $1 tag | 1.5 Meter | | | | | yes | |
| CISR (South Africa) | Supertag | Mining applications | | | | | yes | |
| Combitech | Trans Tag TS 3100 | 21 ft | 38 ft | SRAM | 8 K - 256 K bits | Unlimited | Yes | Reflective |
| Combitech | Modem Tag TS 3110 | 21 ft | 38 ft | SRAM | 256 K bits | Unlimited | Yes | Reflective |
| Eagle-Eye | Satellite Tracking Device | global | OrbComm | | | 1+ year | | UHF |
| Gemplus | sub $1 tag smartcards | 1.5 meter | | | | | | |
| Hughes Electronics | (used by NATAP) | | | | | | yes | |
| IDTag | IDTag | prox | fixed code | 64 bit | | unlim | Yes | reflective |
| Integrated Silicon Design | sub $1 tag | 1.5+meter | | | | | yes | |

| VENDOR | PRODUCT | Normal Rang | Max Range | Memory Type | Memory Capacit | Transaction Lif | Availab | Comm Method |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| JRC | JUE-610DT Inmarsat D T/R unit | global | | | | | yes | satellite link |
| Lan Link | Transponder | 5 ft | 5 ft | | | | yes | passive |
| Magellan | GSC 100 | global | | OrbComm reseller | | GLS LEO | | |
| Maher Marine Terminals | Computer Character Recognition (CCR) | Similar to OCR technology | | 90% accuracy | Manned terminal station for error correction | | | |
| MARK IV | Exterior Transponder | 15 ft | 20 ft | EEPROM/RAM | 128 bits | 10000 | Yes | Single Freq. |
| Micro Design A-S | MD 5800.2 R/W Tag | 15 ft | 38 ft | | | | Yes | SAW |
| Micron | Postage Stamp | 10 M | 300 ft | SRAM | 2 K bits | Unlimited | avail | |
| Motorola (Indala) | IB 44 EX or AVT 159 | 90 mm | 2.74 M | 25 MPH reads | | | avail | |
| OrbComm | EL-2000 data communicator | global | | | | GLS -LEO | yes | |
| Philips Semicondictors | HITAG IC | sub$1 tag | | | | | yes | |
| PinPoint | 3D-iD LPS | RFLS system | | | | | no | |
| Pole-Star | FreightFinder Vesselfinder | similar to Eagle-Eye | | LEO satellite tracking system test underway | | GLS System reseller | OrbComm systems | |
| RFID,Inc. | sub$1 tag | 2 meter | | | | | ? | |
| Savi | Seal-Tag | 50 ft | 60 ft | EEPROM | 64 K bits | 10000 | Yes | |
| Savi | Ty-Tag | 50 ft | 60 ft | EEPROM | 64 K bits | 10000 | Yes | |
| Savi | SaviTag 410 | 0-30 ft | 600 ft | RAM | 128K byte | unlim | Yes | 433.92 |
| Siemens | Moby F Tag | | | | | | yes | |
| Sokymat | WorldTag | 800 mm | 2-3 M | 64- 8000 bit | 2-106 Kbaud | unlim | Yes | 125MHz |
| Symbol Technologies | | | | | | | | |

| VENDOR | PRODUCT | Normal Rang | Max Range | Memory Type | Memory Capacit | Transaction Life | Availab | Comm Method |
|---|---|---|---|---|---|---|---|---|
| Telxon Corporation | RF Tags | Supply chain solutions | | | | | | |
| TIRIS (Texas Instr) | Tag-it | 1.5 meter | | 256 bits | | unlim | Yes | 13.56 MHz |
| Torrey | LEOLink 2000 | global | | used by Eagle-Eye | | | yes | 140Mhz |
| | LEOLink 3000 | global | | used by Eagle-Eye | | 1 yr | yes | 140 MHz |
| WiData | Firefly tag (RFLS tag) | 200 ft | 400 ft | RAM | 4 K bits | unlim | Yes | 2.4 GHz |
| X-cyte | IDR002 Transponder | 15 ft | 20 ft | EPROM | 64 bits | Unlimited | Yes | SAW |

| PRODUCT | Modulation | Protocc | Frequency | R Data Rate | W Data Rate | Directionality | Multiple Read | Reader Power | Tag Power |
|---|---|---|---|---|---|---|---|---|---|
| IntelliTrack Tags |  |  |  | 3,000 bps | 3,000 bps |  | yes |  |  |
| (Rockwell Automation) |  |  |  |  |  |  |  |  |  |
| AT5510 Trans Tag | FSK/Man |  | 915, 2450 MHz | 76 Kbps |  | Focused | No | 30 mw, 1.6w max | None |
| AT5704 Rail Tag | FSK/Man |  | 915, 2450 MHz | 192 Kbps |  | Focused | No | 30 mw, 1.6w max | None |
| Universal Tag | FSK/Man |  | 915, 2450 MHz | 1.2 Mbps |  | Focused | No | 30 mw, 1.6w max | None |
| Smart Transponder | AM/FM |  | 915/49 Mhz | 9.6 Kbps |  | Focused/Omni | Yes | 10 mw | 5 mw |
| Contactless Smart Card | unavail |  |  | 2.4-19.2Kbps |  | N/A | N/A |  | None |
| Communicator | AM/AM |  | 910 Mhz | 500 Kbps |  | Focused | Yes | 100 uw (avg) | N/A |
| RF Tags |  |  |  |  |  |  |  |  |  |
| sub $1 tag |  |  |  |  |  |  |  |  |  |
| Supertag |  |  |  |  |  |  |  |  |  |
| sub $1 tag |  |  |  |  |  |  |  |  |  |
| Supertag |  |  |  |  |  |  |  |  |  |
| Trans Tag TS 3100 |  | HDLC | 2450 MHz | 267 Kbps | 167 Kbps | Focused-Circ | Yes | 150 mw | None |
| Modem Tag TS 3110 |  | HDLC | 2450 MHz | 267 Kbps | 167 Kbps | Focused-Circ | Yes | 150 mw | None |
| Satellite Tracking Device |  |  | 140 MHz |  |  | omni |  | n/a | n/a |
| sub $1 tag |  |  |  |  |  |  |  |  |  |
| smartcards |  |  |  |  |  |  |  |  |  |
| (used by NATAP) |  |  |  |  |  |  |  |  |  |
| IDTag |  |  | 125 KHz |  |  | focused | Yes |  |  |
| sub $1 tag |  |  |  |  |  |  |  |  |  |

| PRODUCT | Modulation | Protocc | Frequency | R Data Rate | W Data Rate | Directionality | Multiple Read | Reader Power | Tag Power |
|---|---|---|---|---|---|---|---|---|---|
| JUE-610 DT | | | 1600 MHz | | | | yes | | |
| Transponder | | | 125 or 134.2 KHz | | | FOCUSED | NO | | |
| GSC 100 | | | | | | | | | |
| Computer Character Recognition (CCR) | | | | | | | | | |
| Exterior Transponder | AM/AM | | 915 MHz | 500 Kbps | | Focused | Yes | 100 uw (avg) | 1 mw |
| MD 5800.2 R/W Tag | ASK/BPSK | HDLC | 915, 2450 MHz | 300 Kbps | | Focused | No | | None |
| Postage Stamp | DSSS/DPSK | | 2450 MHz | | | Omnidirectional | | | |
| IB 44 EX or AVT 159 | | | | | | | | | |
| EL-2000 | | | 140 MHz | | | omni | | | |
| HITAG IC | | | | | | | | | |
| 3D-iD LPS | | | | | | | | | |
| FreightFinder Vesselfinder | | | | | | | | | |
| sub$1 tag | | | | | | | | | |
| Seal-Tag | | | 433 Mhz | 8 Kbps | | Omnidirectional | Yes | 2 mw | |
| Ty-Tag | | | 433 Mhz | 8 Kbps | | Omnidirectional | Yes | | |
| SaviTag 410 | FSK | Batch | 433 MHz | 28.8K | 28.8K | Omnidirectional | Yes | .003Mw | >003Mw |
| Moby F Tag | | | | | | | | | |
| WorldTag | ASK | Biphase | 215 MHz | 2-106K baud | | omni | Yes | | |

| PRODUCT | Modulation | Protocc | Frequency | R Data Rate | W Data Rate | Directionality | Multiple Read | Reader Power | Tag Power |
|---|---|---|---|---|---|---|---|---|---|
| RF Tags | | | | | | | | | |
| Tag-it | | | | 13.56 MHz | | Omni | Yes | | |
| LeoLink 2000 | | 50 meter tracking accuracy | | | | omni VHF antenna | | | |
| LeoLink 3000 | | | 140 MHz | 2400-4800 bps | | omni | | | |
| Firefly tag (RFLS tag) | | | 2.4 GHz | 4 K bits | | Omni | Yes | | |
| IDR002 Transponder | | | | | | Focused | Yes | | None |

| PRODUCT | Tag Cost | Fixed Reader Cost | Hand-Held Cost | Mobile ID Speed | Tag Type | Chip Power | Battery Type | Battery Life |
|---|---|---|---|---|---|---|---|---|
| IntelliTrack Tags |  |  |  |  |  |  | Lithium |  |
| (Rockwell Automation) |  |  |  |  |  |  |  |  |
| AT5510 Trans Tag | $50 | $8000-12000 | $8,000 | 180 mph | Active | 1.1 volts | Lithium | 10 years |
| AT5704 Rail Tag | $50 | $8000-12000 | $8,000 |  | Active | 1.1 volts | Lithium | 10 years |
| Universal Tag | $30-250 | $8000-12000 | $8,000 |  | Active | 1.1 volts | Lithium | 10 years |
| Smart Transponder | $38 | $7,000 | unavail | 80 mph | Active | 3 volts | Alkaline | 2 years |
| Contactless Smart Card | Lease |  |  | N/A | Passive | N/A | N/A | N/A |
| Communicator | Lease |  |  | 100 mph |  |  | 9v |  |
| RF Tags |  |  |  |  |  |  |  |  |
| sub $1 tag |  |  |  |  |  |  |  |  |
| Supertag |  |  |  |  |  |  |  |  |
| sub $1 tag |  |  |  |  |  |  |  |  |
| Supertag |  |  |  |  |  |  |  |  |
| Trans Tag TS 3100 | $75 | $10,000 | end of 93 |  | Active | <3 volts | Lithium-CM | 8 years |
| Modem Tag TS 3110 | $100-150 | $10,000 | end of 93 |  | Active | <3 volts | Lithium-CM | 8 years |
| Satellite Tracking Device | sub $200 ?? | n/a | n/a |  |  |  | lithium | 1 year + |
| sub $1 tag |  |  |  |  |  |  |  |  |
| smartcards |  |  |  |  |  |  |  |  |
| (used by NATAP) |  |  |  |  |  |  |  |  |
| IDTag |  |  | avail |  | passive |  |  |  |
| sub $1 tag |  |  |  |  |  |  |  |  |

| PRODUCT | Tag Cost | Fixed Reader Cost | Hand-Held Cost | Mobile ID Speed | Tag Type | Chip Power | Battery Type | Battery Life |
|---|---|---|---|---|---|---|---|---|
| JUE-610 DT | | | | | | | | |
| Transponder | | | | | PASSIVE | | | |
| GSC 100 | | | | | | | | |
| Computer Character Recognition (CCR) | | | | | | | | |
| Exterior Transponder | $61 | $12,000 | $5,700 | 100 mph | Active | 9 volts | Lithium | 5 years |
| MD 5800.2 R/W Tag | | | | 100 mph | Passive | N/A | N/A | N/A |
| Postage Stamp | | | | | passive | | Nickle-Cad | |
| IB 44 EX or AVT 159 | | | | | | | | 7 - 8 yr battery |
| EL-2000 | | | | | | rechargeable 12VDC | | |
| HITAG IC | | | | | | | | |
| 3D-iD LPS | | | | | | | | |
| FreightFinder | | | | | | | | |
| Vesselfinder | | | | | | | | |
| sub$1 tag | | | | | | | | |
| Seal-Tag | $115 | $2,000 | | | Active | | | 3-5 years |
| Ty-Tag | $50 | $2,000 | | | Active | | | 3-5 years |
| SaviTag 410 | | | avail | 100 mph | Active | 3.6V | lithium | 9 yrs |
| Moby F Tag | | | | | | | | |
| WorldTag | | | avail | | passive | | | |

| PRODUCT | Tag Cost | Fixed Reader Cost | Hand-Held Cost | Mobile ID Speed | Tag Type | Chip Power | Battery Type | Battery Life |
|---|---|---|---|---|---|---|---|---|
| RF Tags | | | | | | | | |
| Tag-it | $3 | | avail | | passive | | | |
| LeoLink 2000 | | | | | | needs power supply | | |
| LeoLink 3000 | | | | | | needs power supply | | |
| Firefly tag (RFLS tag) | $35 tag | | $3,000 | | | | | |
| IDR002 Transponder | | | | 300 mph | | | | |

| PRODUCT | Replaceable | Battery Life | R/W | Battery Low | Sleep Delay | Humidit | Shock | Storage Temp | Operating Temp |
|---|---|---|---|---|---|---|---|---|---|
| IntelliTrack Tags (Rockwell Automation) | | | | yes | | | | | |
| AT5510 Trans Tag<br>AT5704 Rail Tag<br>Universal Tag | Yes | | | | | | | | F -40 to +185 |
| Smart Transponder | | No effect | | | 10 msec | | | C -40 to +80 | C -40 to +60 |
| Contactless Smart Card Communicator | N/A | N/A | | N/A | N/A | 85% | | C -40 to +66 | C -20 to +65<br>C -40 to +70 |
| RF Tags | | | | | | | | | |
| sub $1 tag | | | | | | | | | |
| Supertag | | | | | | | | | |
| sub $1 tag | | | | | | | | | |
| Supertag | | | | | | | | | |
| Trans Tag TS 3100 | No | unavail | | unavail | unavail | | 500 G, 1ms | | C -30 to +80 |
| Modem Tag TS 3110 | No | unavail | | unavail | unavail | | | | C -40 to +70 |
| Satellite Tracking Device | yes | | | | | | | | |
| sub $1 tag<br>smartcards | | | | | | | | | |
| (used by NATAP) | | | | | | | | | |
| IDTag | no | | | | | | | | C -40 to +80 |
| sub $1 tag | | | | | | | | | |

| PRODUCT | Replaceable | Battery Life | R/W | Battery Low | Sleep Delay | Humidi | Shock | Storage Temp | Operating Temp |
|---|---|---|---|---|---|---|---|---|---|
| JUE-610 DT | | | | | | | | | |
| Transponder | | | | | | | | | |
| GSC 100 | | | | for personal use | | 12VDC rechargeable | | | |
| Computer Character Recognition (CCR) | | | | | | | | | |
| Exterior Transponder | | Reduction - 1yr | | None | unavail | | | | C -40 to +70 |
| MD 5800.2 R/W Tag | N/A | N/A | | N/A | N/A | | | | C -40 to +90 |
| Postage Stamp | | | | | | | | | C -20 to +60 |
| IB 44 EX or AVT 159 | | | | | | | | | |
| EL-2000 | | | | | | | | | |
| HITAG IC | | | | | | | | | |
| 3D-iD LPS | | | | | | | | | |
| FreightFinder | | | | | | | | | |
| Vesselfinder | | | | | | | | | |
| sub$1 tag | | | | | | | | | |
| Seal-Tag | No | | | Warning | 10 msec | | | | |
| Ty-Tag | Yes | | | Warning | 10 msec | | | | |
| SaviTag 410 | Yes | 9yrs | | | yes | 100% | MilStd 810E | C -50 to +85 | C-50 to +85 |
| Moby F Tag | | | | | | | | | |
| WorldTag | Yes | | | | | | IEC 68 2-49 | C-25 to +70 | |

| PRODUCT | Replaceable | Battery Life | R/W | Battery Low | Sleep Delay | Humidi | Shock | Storage Temp | Operating Temp |
|---|---|---|---|---|---|---|---|---|---|
| RF Tags | | | | | | | | | |
| Tag-it | No | | | | | | | | |
| LeoLink 2000 | | | | | | | | | |
| LeoLink 3000 | | | | | | | | | |
| Firefly tag (RFLS tag) | Yes | | | | | 95% | 6 ft drop | C-20 to +50 | |
| IDR002 Transponder | | | | | | | | | |

| PRODUCT | Dimensions | Weight |
|---|---|---|
| IntelliTrack Tags | | |
| (Rockwell Automation) | | |
| AT5510 Trans Tag | in 9.3 x 2.38 x 0.69 | 170 g |
| AT5704 Rail Tag | | |
| Universal Tag | | |
| Smart Transponder | unavail | unavail |
| Contactless Smart Card | in 3.37 x 2.12 x .03 | |
| Communicator | in 5.6 x 3.3 x .9 | |
| RF Tags | | |
| sub $1 tag | | |
| Supertag | | |
| sub $1 tag | | |
| Supertag | | |
| Trans Tag TS 3100 | mm 54.5x87x13 | 45g |
| Modem Tag TS 3110 | mm 35 x 60.8 x 87 | unavail |
| Satellite Tracking Device | 2.6 X 6 X 1.2 inches | |
| sub $1 tag | | |
| smartcards | | |
| (used by NATAP) | | |
| IDTag | micro | |
| sub $1 tag | | |

| PRODUCT | Dimensions | Weight |
|---|---|---|
| JUE-610DT | | |
| Transponder | | |
| GSC 100 | | |
| Computer Character Recognition (CCR) | | |
| Exterior Transponder | in 7.87 x 1.65 x 1 | 200 g |
| MD 5800.2 R/W Tag | unavail | unavail |
| Postage Stamp | 56 X 33 X 7 mm | 13 g |
| IB 44 EX or AVT 159 | | |
| EL-2000 | 205 x 124 x 61 mm | 960g |
| HITAG IC | | |
| 3D-iD LPS | | |
| FreightFinder | | |
| Vesselfinder | | |
| sub$1 tag | | |
| Seal-Tag | | |
| Ty-Tag | in 2.5 x 3.5 x 2 | |
| SaviTag 410 | 8.75 X 2.8 X 0.85 in | avail |
| Moby F Tag | | |
| WorldTag | round thin 20 to 50 mm dia | |

| PRODUCT | Dimensions | Weight |
|---|---|---|
| RF Tags | | |
| Tag-it | paper thin | avail |
| Leo Link 2000 | 10 X 6 X 1 inches | |
| Leo Link 3000 | 15.75 X 9.5 X 3.4 in | 8.2 lbs |
| Firefly tag (RFLS tag) | 2.25 X 2.57 X 0.9 in | avail |
| IDR002 Transponder | | |

# CHAPTER III

## Level of Service and Cost Factors

In Chapter II, the foundation was constructed for further investigation of Smart Data Carriers. In this Chapter, I will develop and use the three axis framework of Level of Service (LOS), Cost, and Institutional or Legal factors as a device to evaluate the technologies. These three areas were identified in research as the key elements to use in comparing freight identification technologies.

Institutional issues are key aspects of the environment for the application of multiple technologies. In today's transportation marketplace safety, cost, business questions, and other factors are frequently regulated. New technology is no exception, although sometimes it takes some time before a new technology is reflected in law.
(Institutional issues will be discussed further in Chapter IV)

In this report I will show how an assessment of the impact of various single applications of technology, and combinations of technologies can be accomplished using the three axes of the framework. This can happen along different planes along the same axis; in cost for instance, analysis can be done on a terminal's internal factor costs with the result being a cost reduction. On another plane, a carrier's equipment costs may rise with the introduction of new container tracking gear to be attached to existing equipment, but the target is increased revenue through premium service.

We will introduce scenarios in this Chapter to illustrate possible combinations and uses of the technologies identified.

1. A terminal owner, not a member of a carriers organization, who wishes to provide his customers with better information, reduce his labor, improve gate productivity and productivity in the yard. He uses OCR at his gate to capture entry and exit, and identify containers. This can be compared with the carriers' database and provide useful information.
2. A more advanced operation. This would probably be a segment of a carrier's organization of owned terminals and containers. RFID tags are placed on containers along with strategically placed readers. This can be as advanced as one wants, using passive, License plate tags, or more capable data-rich tags. The entire system can be integrated to provide extremely useful information.
3. A highly developed system using satellite tags on containers to provide real time positional information. These tags can be mated with data-rich RFID tags for a very sophisticated system. Information on container location, status, position and so on is readily available.

## LEVEL OF SERVICE

Under LOS we will discuss just what it is that these technologies can do for a customer/carrier relationship. All transportation has a level of service. In order to evaluate a service, LOS is a critical element to understand. LOS is perhaps the basic component of any transportation system. Price and other LOS variables are usually the only things that are considered by a customer when choosing an alternative. (Price is the amount paid for the service; by cost I mean the internal cost of providing that service. Price should equal cost plus some amount of profit and overhead, governed by the competitive factors in the marketplace)

Cost of course, is the other side of LOS. In basic terms increased LOS costs more to provide. There is a trade-off between them in a competitive market, establishing the price and LOS that is desired by the customers and/or provided by carriers. Innovation in hardware, software, and business process technologies is often the catalyst that changes the LOS/cost trade-off.

In simple terms, wise technology choices can enable carriers to offer increased LOS at lower cost. In this dynamic environment the availability of new technology may drive demand for increased LOS based on this new technology.

In a discussion of this subject, it may be advisable to first list the things known about LOS from research in other transportation areas. The providing entity, a carrier, terminal, or other transportation service, has a choice regarding the LOS to provide. The choice may be limited by customer requirements, but is always subject to a choice from several technologies or services to satisfy this requirement. This choice ultimately determines the cost of any freight tracking installation.

Elements of Level of Service (LOS):

1. Price

2. Convenience

3. Reliability

4. Time (savings or loss)

5. Loss or damage to cargo

6. Tracking ability

Number 6 gives us the possibility of two additional elements:

7. Ability to monitor cargo condition

8. Greater Flexibility/Ability to re-route cargo

Number 7 & 8 may be summarized by the ability to manage cargo in transit that provides improved ability to manage by exception. For example freight that is on time and in good condition passes through the system silently. Processing ability embedded in either smart data carriers or in the network control system can flag when pre-determined conditions are not met. This may be a missed connection, failure to maintain cargo temperature, or other pre-programmed criteria. This enables the carrier/customer to react quickly to rectify problems and preserve cargo integrity and timely arrival.

Table III-1 shows the association between most of the LOS variables, and what impact that variable may have on cost, and subsequently the price charged for the transportation service. This is a very rough approximation, but gives a general guide to the relationship between LOS variables and cost. In Table III-1, I assume that 'convenience' may be fairly easy and inexpensive to improve. An increase in convenience may only require a schedule change, or other operational decision. At the other end of the LOS range of complexity, Tracking Ability, and the ability to manage cargo in transit may be very costly.

| | LOS | Cost |
|---|---|---|
| 1 | Convenience | Low |
| 2 | Reliability- Increased reliability is extremely important for modern logistics managers | Medium |
| 3 | Time- Time saving is a critical benefit | Medium |
| 4 | Loss/damage | High |
| 5 | Tracking & Management ability- Increasingly important, in part to assure reliability | High |
| 6 | Ability to manage cargo in transit/Flexibility | Perhaps Highest Cost |

*Table III-1*

*Comparison between LOS and Cost*

One should not overlook the advantage to be gained by managing empty assets, which are constantly moved by carriers suffering from re-positioning problems. This is a $14.5 billion dollar problem (worldwide) today[1]. The average marine container spends approximately 70% of the time empty and idle, or being re-positioned.

[1] Survey by Mercer Management Consulting. Quoted from SynchroNet,Inc. Presentation, MIT February 1999

In Chapter I, Three scenarios were used to illustrate examples of ID technology, and the variance of the data supplied by different technologies. I use the scenarios again, in this report, to illustrate LOS and cost as it applies to the specific case in each scenario.[2] Some of the terms, such as 'granularity' can be used again in the LOS/Cost context to show that, in simplest terms, higher granularity costs more.

By 'granularity' I mean frequency and density of data. In other words, higher granularity would mean that freight is 'scanned' more frequently in the network and the quantity and type of data available is more complete.

For instance: an OCR system provides signpost data only when the container passes by a reader and only reads the ID of the container (low granularity). Satellite tracking on the other hand can continuously track the container and its contents, and when matched with a more sophisticated tag, can provide many details about the freight while it is in motion. A comparison of data granularity can be even further simplified by Figure III-1, if the LOS variables are imagined as linked to the 'granularity' of data required to provide an increase in the variables. There is a correlation between granularity of data and the cost of that corresponding LOS variable. This is certainly not exact, but there is a relationship. Less complex variables (for instance convenience) require less frequent or lower density data (less granularity). Complex LOS variables (for instance Cargo Flow Management) requires high density and frequent data.

To simplify,

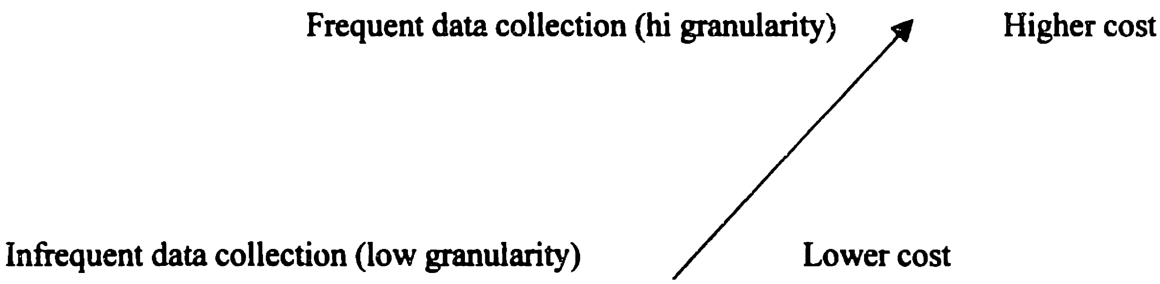



*Figure III-1*

*Comparison of Data to Cost*

Figure III-2 simplifies this even further.

In general:

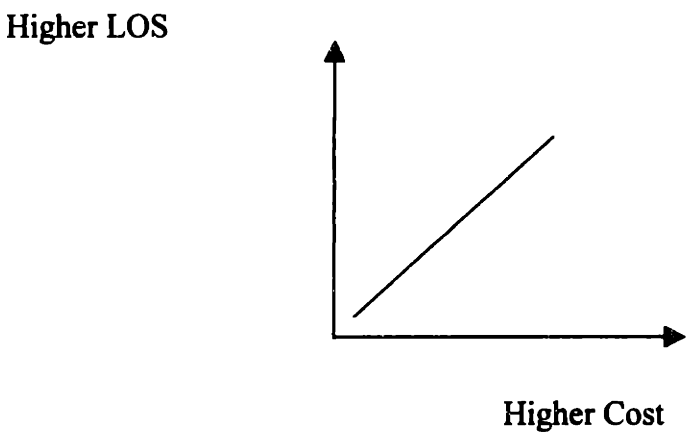



*Figure III-2*

Table III-2 shows the frequency of 'reads' or 'scans' by the different technologies. (By now we are accustomed to relating technologies to scenarios. It is not intended that this relationship is fixed in any way, this is strictly to provide examples for discussion). The connection between high granularity data required for Cargo Flow Management, with the

[2] The three scenarios are useful tools to conduct the analysis. They will not limit the exploration of new business strategies. For example, it is possible that the best strategy will reflect some combination of scenarios 2 and 3.

Satellite technology costs vs. the lower cost OCR and less complex LOS variables such as convenience should be clear.

| Scenario | 1 | 2 | 3 |
|---|---|---|---|
| **Technology** | **Optical Character Recognition** | **RFID** | **Satellite Positioning** |
| **Automated Locations:** | | | |
| Shipper's Premises | | | X |
| During Truck Movement | | | X |
| Rail Yard Entrance | X | X | X |
| Transfer to Rail | | | X |
| During Rail Movement | | X | X |
| Transfer from Rail | | | X |
| Rail Yard Exit | X | X | X |
| During Truck Movement | | | X |
| Port Entrance | X | X | X |
| Transfer to Ship | | X | X |
| During Ocean Voyage | | | X |
| Transfer from Ship | | X | X |
| Port Exit | X | X | X |
| During Truck Movement | | | X |
| Receiver's Premises | | | ↓ |

*Table III-2*

*Comparison of the Typical Automatic Reading Frequency of the Technology Scenarios*

In Table III-2 the emphasis is on the ocean container, not the freight.

**BENEFITS**

Some Benefits that can be attained by use of ID technologies are:

1. Fewer manual data entry mistakes. (Greater accuracy)
2. Faster cycle time at gate.
3. Easier locating of containers inside terminal.
4. Less labor. ( Or increased production with *no increase* in labor)
5. Less delay loading vessels since it is easier to pre-plan loading.
6. All of the LOS advantages in Table 2-1
7. Automation of processes

Figure III-3 shows the relationship between Benefits and Cost, which is almost exactly the same as Figure III-2, Relationship between LOS and Cost. Obviously Benefits and LOS are very closely related. One way to rationalize this is to consider LOS the impact on the customer (owner of cargo), and Benefits as the internal gain (resulting in savings) for the ocean carrier or terminal operator.

In general:

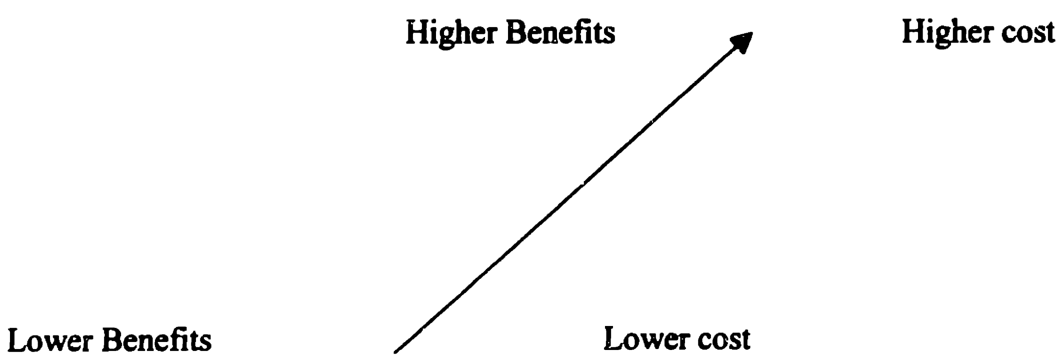



*Figure III-3*

*Relationship between Benefits and Cost*

Table III-3 shows the relationship between cost, the technology used in the Scenarios and some of the components of benefits that are involved.

| Scenario | 1 | 2 | 3 |
| --- | --- | --- | --- |
| Technology | **Optical Character Recognition** | **RFID** | **Satellite Positioning** |
| Cost | Moderate | Moderate-High | Very High |
| Benefit component | | | |
| Granularity | Low | Moderate | Very High |
| Increase Reading Frequency | Difficult | Possible | Inherent, Constant ability |
| Level of Automation | Semi-automated | Fully-Automated | Fully-Automated |
| Reading Accuracy | Moderate-High | High | High |

*Table III-3*

*Comparison of the Technology Scenarios with Cost and Benefits. The Benefit elements are compared horizontally with change in this element by Scenario*

## SCENARIOS

The following subsections include a discussion of three scenarios and an evaluation of the technology employed using the three axes evaluation framework.

### Scenario 1

In scenario #1 we have a privately held terminal operator wishing to both improve his own efficiency and provide improved data to his customers, without the cost of investing in RFID technology to attach to assets, such as containers and chassis, which are not his property. In this case he chooses Optical Reading technology. This choice provides a high level of service at the gate of his facility, but does nothing for the rest of the origin-to-destination movement outside his terminal. The LOS in this case is 'event' or 'signpost' data, that can be fed to a customer's (an ocean carrier) database for fleet management or other purposes, including providing more timely data to the carrier's customers. While OCR gate management is much less labor-intensive than manual data entry, labor is still constantly required in this case to monitor and intervene when the OCR technology fails to correctly read the data from a container (approximately 15% of the time). The actual additional cost of the continuous labor effort to this technology depends on the details of the labor union contract. Output from the optical reader should be integrated into a company's overall information system. The intent with this scenario is not really increased LOS to the customer, but rather it is internalized as cost savings in two areas, better turn around gate time for trucks (which may result in a 'convenience' LOS gain for the customer), and less labor at the gate.

This table illustrates the principal choice made in the Scenario #1 example:

| Carrier/Customer pairing | LOS choice | Cost/Benefit associated with choice |
|---|---|---|
| Independent Terminal and Ocean Carrier customer | Provide event Data by OCR (signpost) technology, at some internal cost saving. | Lowest cost compared to RFID or satellite solution |
| | | Potential Internal cost savings by fewer manual data entry errors |

*Table III-4*

*Pairing of LOS to Cost by customer/supplier (Scenario 1)*

**Scenario 2**

In Scenario # 2 there is a more technically advanced operation. In this case the containers are tagged with RFID tags, either as license plate tags or with a higher level of information (variable data about the container's contents). Event logging can occur in the network, wherever readers are installed (as in scenario 1, but with greater data richness and granularity, thereby improving accuracy). This gives an improved ability to 'manage' the freight while it is in transit as long as there is a sophisticated network management system to take advantage of the RFID location reports. The container can be re-routed based on event monitoring (signpost) information (for instance if a vital connection is missed). The container can also be self-monitoring for damage, temperature control, etc. if equipped with a more sophisticated tag. In the USA, RFID tags are being used experimentally as freight identifiers, toll collection devices, and to automate customs transactions, all done by one tag. Given intelligent proliferation of standards this will become increasingly common and will eventually become standard practice.

| Carrier/Customer pairing | LOS choice | Cost/Benefit associated with choice |
|---|---|---|
| Ocean Carrier/Shipper Possible integration with RR, All Terminals. | RFID with sophisticated tag To provide location, condition, & status data. | Fairly high installation & maintenance. |
| | Or, low granularity signpost data only, as in Scenario 1 but with greater accuracy. | Asset & Freight Management cost savings |

*Table III-5*

*Pairing of LOS/Cost by Carrier/Customer (Scenario 2)*

**Scenario 3**

In Scenario 3, continuous tracking in real time is possible, bringing a multitude of management options into play. We are no longer limited to 'signpost' event type data, but can access continuous real-time location and condition information (if fitted with appropriate package of equipment). This will have a tremendous impact on managing freight in transit. In addition, it facilitates management and rationalization of empty containers. This ability should lead to better equipment utilization and overall fleet efficiency.

In the scenario examples I have implied that certain LOS is associated with certain suppliers. This was done for simplicity in early explanation of the relationships. This dependency is not always the case. Choice of LOS is independent of the types of suppliers or customers; it probably should be made for each pair of carrier/customer. The pairings we have made in the scenarios should not be thought of as fixed.

| Carrier/Customer pairing | LOS choice | Cost/Benefit associated with choice |
|---|---|---|
| Ocean carrier/ Shipper | Satellite Tracking & providing continuous tracking & condition monitoring | Highest cost |
| | | Highest potential management improvements |

*Table III-6*

*Pairing of LOS/Cost by Carrier/Customer (Scenario 3)*

## COST

Some of the cost factors during the life cycle of an ID technology are listed here. Our scenarios illustrate the elements of cost visible in each level of technology:

1. Acquisition
2. Installation
3. Operation
4. Maintenance (such as battery replacement)
5. Disposal

Table III-7 divides relative cost into three groups, low, medium, and high cost for each cost item. Benefits resulting from using the new technology are not reflected here; this is only a comparison of costs.

| Cost Item | Scenario<br>1 | 2 | 3 |
|---|---|---|---|
| Acquisition | Low | Medium | High |
| Installation | Medium | Medium | High |
| Operation | High | Low | Medium |
| Maintenance | Medium | Low* | Medium |
| Disposal | Low | Low | Low |

* Low for passive backscatter tags, higher for active tags

*Table III-7*

*Costs compared to Scenarios*

Of course, cost and LOS cannot be separated. Recognize I am focusing on the cost of the tag or tracking technology. The higher technology cost should bring benefits- either operating cost savings or business improvements. Higher LOS will probably gain higher revenue. Once a LOS offering is chosen, it is necessary to properly integrate the variety of LOS into the ocean carrier's business model, understanding the direct relationship between LOS and Cost as this is accomplished.

Such integration is no simple task. In fact research indicates that as yet no one has a complete logistical solution from origin to destination in international commerce. This may change rapidly as this technology is expanded and developed. The term 'solution' I interpret as the solution to integrating LOS into the business model for the origin to destination container movement, resulting in a wider range of LOS choices available to the customer, as in Figure III-2. (For instance, the addition of ability to manage freight in transit) This is all interrelated.

This seven-step integration and product life cycle process shown in Figure III-4, was identified as the path taken by new technology as it is introduced to the freight identification industry:

Step 1 Development of the technology

Step 2 Proliferation of options

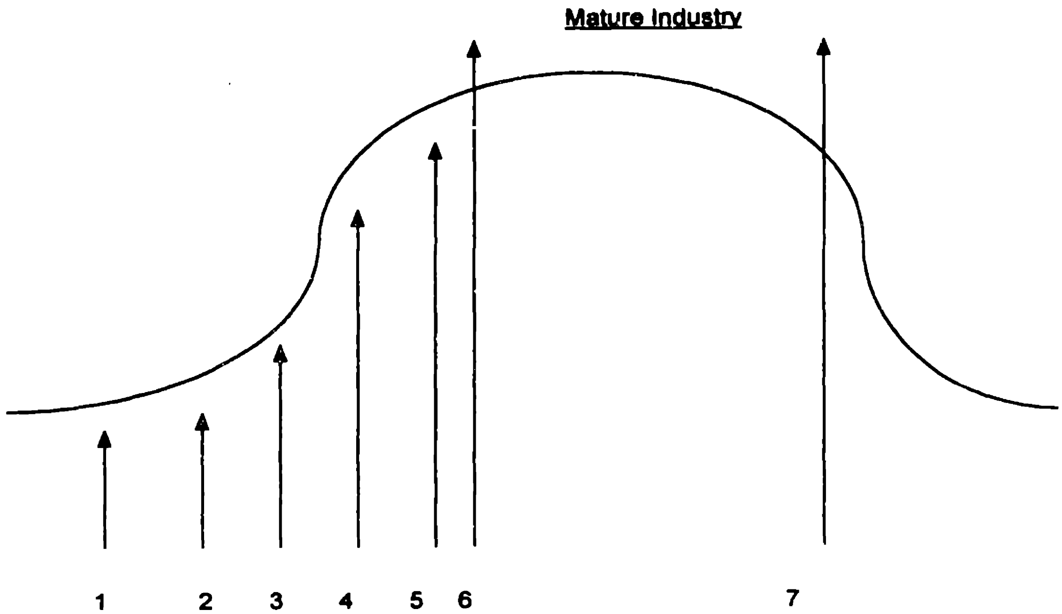
Step 3 Creation of standards and technical specifications

Step 4 Creation of user-driven standards

Step 5 Consolidation of technology around user standards

Step 6 Improvement and expansion of technology

Step 7 Increased user acceptance, more applications




*FigureIII-4.*

*Product Life Cycle*

The steps in the graph roughly match the seven-step technology development timeline.

We are at approximately the step 2 to 3 stage of RFID and tracking technology now. I anticipate growing adaptability and utility of RFID and tracking solutions that can be integrated into a carrier's existing business processes as the technology matures. This can change quickly.

As this technology becomes mature in the business sense, the volume of installations will markedly increase, resulting in lower cost components. Between steps 6 and 7, expect considerable proliferation of options and resulting lower costs. This is the case for all hi tech products.[3]

Another side of LOS/Cost and value is the value to the carrier's internal functions. By this I mean equipment management and other administrative tasks. This can have significant impact on a carrier's cost of operations, since use of ID technologies may increase utilization of equipment, therefore possibly reducing the quantity of equipment needed to meet the carrier's commitments. The reduction in capital cost, maintenance cost and administrative cost from this should be substantial. The added benefit of the ability to plan positioning of equipment better could have significant impact on a carrier's operations.

From this internal efficiency, it is not difficult to envision a proportional relationship in benefits. In this example, an X% efficiency gain in equipment utilization may result in an Y% reduction in vehicles in that transportation sector, with both capital cost savings plus a further Z% reduction in undesirable pollution emissions, simply from less vehicles. This could be a very valuable benefit in the field of 'Green Accounting'. At this time it is impossible for us to estimate the value of this to an ocean carrier, but depending on the carrier's location and the legal and social forces it is exposed to, it could be very valuable.

[3] Adapted from: Moore, Geoffrey A. Crossing the Chasm, Marketing & Selling High Technology Products to mainstream Customers, Harper Business 1991

There are other cost issues that are much more difficult to assess. What is the impact of an earlier decision to invest in these technologies? A later decision? Is it favorable in a discounted cash flow computation, or unfavorable due to an unknown life cycle? What is the life cycle period that justifies the investment (payback period)? What decision process to use? How would a decision tree for this be constructed? What discount rate to use? All of this will significantly affect the cost relationship to the other axes.

It is entirely likely that many ocean carriers will want to offer several LOS packages, and pass the LOS choice along to the customer. This is still in line with the 'LOS choice by provider' rule, only the provider has elected to make several LOS choices available for his customers by charging customers to take advantage of the different technologies provided. For example, an ocean carrier could offer a premium service with automated Electronic Data Interchange (EDI) confirmations when the customer's container has left the terminal for delivery. In the Scenario #3, where an ocean carrier elects to make different LOS choices available to the carrier's customers, this is a product differentiation strategy. For high value cargoes, where exacting data regarding location, progress, security of the cargo, and delivery status is crucial to the customer, this LOS could be offered. Although the higher LOS will have a higher cost directly associated with it, it should earn higher revenue. The increased revenue can be derived in at least two different ways: by charging a higher rate, or by keeping rates low and winning market share from competitors through more attractive service.

# CHAPTER IV

## Legal and Institutional issues[1]

There seem to be major blocking issues involved with at least one of the primary types of Smart Data Carrier technologies. Some of these issues cover all of the technologies to some degree. In addition to this there are often institutional blocking issues within businesses. The highlights of these issues are:

1. Enablers to new technology
2. Inhibitors of new technology
3. Standards and interoperability issues
4. Business process issues, which at times are impacted by legal enablers or constraints

We will briefly elaborate on each one.

The basic types of enablers are:

1. Security issues
2. Privacy issues
3. Ownership
4. Intellectual property issues

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[1] This Chapter is adapted from a portion of the The December 1998 Research Report To NIRO, written by Professor J.D. Nyhart and Bart B. Kelleher

5. Dispute settlement

6. Contract law

Some of these may be difficult to envision as enablers, but the idea is that they establish boundaries and limits to business transactions. Business needs these boundaries for the necessary trust in the system that trade requires. They establish the 'comfort factor' that business needs to conduct trade over physical and cultural distances.

Constraints to a new technology are usually liability issues and fraud. One positive factor is that in most of the existing contract law, fraud prohibitions and so on exist and can be easily applied to a new media. The world adapted to accommodate the telegraph, there is no reason why this will be any different.

The issue of standards is more complex. In any communications infrastructure standards are inevitable and necessary. To use our telegraph example, there were alternatives to Morse code in the beginning, but the world quickly adopted a single practice that persists to this day. This is a simplistic view, but illustrates the concept. In newer, more complex technologies, more complex solutions are the result.

As discussed in other chapters, some new technologies are farther down the standards path than others. Satellite communication and positioning is more developed as a standardized international media than RFID. The reasons for this are that satellite telecommunications has been in use for some time, and all of the international agreements are substantially in place. It is a more mature technology and what we propose is really only an added value approach to an existing market. (Satellite communications market).

The area lacking in developed standards is of course RFID. Here are some of the basics. Standards do exist, what is lacking are standards supporting interoperability.

A degree of uniformity is being sought for carrier frequency usage (for RFID), through three regulatory areas, Europe and Africa (Region 1), North and South America (Region 2) and Far East and Australasia (Region 3). Each country manages their frequency allocations within the guidelines set out by the three regions. Unfortunately, there has been little or no consistency over time with the allocation of frequency, and so there are very few frequencies that are available on a global basis for the technology. This will change with time, as countries are required to try to achieve some uniformity by the year 2010.[2]

Three carrier frequencies receiving early attention as representative of the low, intermediate and high ranges are 125kHz, 13.56 MHz and 2.45 GHz. However, there are eight frequency bands in use around the world, for RFID applications. The applications using these frequency bands are listed in Table IV-1 along with the national and geographic coverage of the bands. Figure IV-1 shows the different entities and hierarchy controlling the architecture of the band distribution and use. Any changes or consolidation in frequency packages will have to addressed through this hierarchy.

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[2] From RFID Basics, AIMUSA Website

Not all of the countries in the world have access to all of the frequency bands listed above, as some countries have assigned these bands to other users. Within each country and within each frequency range there are specific regulations that govern the use of the frequency. These regulations may apply to power levels and interference as well as frequency tolerances.

In light of these complications, it may be easier to support the adoption of LEO based GLS positional systems rather than an extensive network of RFID since the various LEO schemes are internationally licensed and approved already in most cases.

The issue of standards is not limited to technical problems. Interoperability is the Mecca that all systems strive for almost without exception, no matter the technology. Without accepted 'language' a communications technology can be useless. Two definitions that explain the goals are:

> 'Interoperability is the ability of different equipment and processes to work together seamlessly in the field. Interoperability requires consistent operating practices and effective business process agreements'.

'Harmonization is about moving towards interoperability. Harmonization can be addressed in small bites or big ones. There are substantial impediments to harmonization and interoperability'.[3]

Some of the impediments mentioned above are:

1. Legacy problems of previously installed equipment, processes and software.
2. Problems of scale and consistency
3. Frequency spectrum issues
4. Lack of clearly defined benefits
5. Focus on short-term requirements, rather than the 'big picture'
6. Concern about government involvement and regulation

Lastly the issue of internal business resistance to change must be discussed. This can be a serious impediment itself to introduction of new technology. What would be the use of a new electronic billing system if the existing billing department (clerks) resisted change and could not be circumvented somehow? This can be a considerable blocking mechanism. Commitment from top management and an understanding of what a new investment may bring about is often the critical factor for eventual success.

[3] Both of these definitions are paraphrased from North River Consulting Groups publications.

| Frequency range | Applications and comments |
|---|---|
| Less than 135kHz | A wide range of products available to suit a range of applications, including animal tagging, access control and track and traceability. Transponder systems that operate in this band do not need to be licensed in many countries. |
| 1.95 MHz, 3.25MHz, 4.75MHz, and 8.2MHz | Electronic article surveillance (EAS) systems used in retail stores |
| Approx. 13 MHz, 13.56MHz | EAS systems and ISM (Industrial, Scientific and Medical) |
| Approx. 27 MHz | ISM applications |
| 430-460 MHz | ISM applications specifically in Region 1 |
| 902-916 MHz | ISM applications specifically in Region 2. In the USA this band is well organized with many different types of applications with different levels of priorities. This includes Railcar and Toll road applications. The band has been divided into narrow band sources and wide band (spread spectrum type) sources. In Region 1 the GSM telephone network uses the same frequencies. |
| 918-926 MHz | RFID in Australia for transmitters with EIRP less than 1 watt |
| 2350 - 2450 MHz | A recognized ISM band in most parts of the world. IEEE 802.11 recognizes this band as acceptable for RF communications and both spread spectrum and narrow band systems are in use. |

| | |
|---|---|
| 5400 - 6800 MHz | This band is allocated for future use.<br>The FCC have been requested to provide a spectrum allocation of 75 MHz in the 5.85-5.925 GHz band for Intelligent Transportation Services use.<br>In France the TIS system is based on the proposed European pre-standard (preENV) for vehicle to roadside communications communicating with the roadside via microwave beacons operating at 5.8 GHz. |

*TableIV-1 Regional dispersion of Frequencies*

As an example of how this frequency structure can be complicated, The Japanese RFID system for toll collection is a good choice. In 1994 the Japanese Ministry of Construction (agency in charge of highway toll functions) decided to look into toll collection devices. Trials were run, many companies, many of them US firms participated. The frequency problem was apparent, and the original choice of a 2.45 GHz band frequency had to be abandoned due to interference. In the USA the 900 MHz band was the usual toll collection transponder frequency, however in Japan these frequencies are used for the police.

After many years the USA and Japan are moving towards the 5.8GHz band for tolls, which is the band used for this purpose from the outset in Europe[4]. No one seems to be sure how long this will take.

[4] This entire story came from ATComm, Inc. one of the original trial participants.

| | | |
|---|---|---|
| International Authorities | ISO/OEC, IATA | AIMI |
| Regional Industry Affiliations | TC68, TC104, TC204 | JTC1, SC17, SC31 |
| National Industry Affiliations | AIAG, CEN, ITI, ANSI, DISA, JBMA, JEIDA | AIM-E, AIM-J, AIM-USA |
| Standard Managing Group | NCITS, X12 | Industry Organizations |
| National Technical Committee | T6, B10 | Regulatory Authorities |

*Figure IV-1*

*Partial table of Standards Organizations*

# CHAPTER V

## Business Strategies

### INTRODUCTION

In this Chapter I will develop and evaluate four business strategies to consider for new business opportunities in the smart data carrier field. The 'Framework for Analysis' developed in the previous report will provide the underpinnings of our evaluative methodology. In comparing the different technologies using the 'Framework for Analysis' one of the technologies falls short of an adequate smart data carrier solution. I will narrow the field to strategies that I feel are viable

This chapter is one of a series produced on the subject of Smart Data Carriers. It is part of a 'building block' approach to the subject and adds to the knowledge gained from previous research on the subject.

In previous reports I have generated several scenarios to demonstrate the possible applications of the various technologies discovered in our research on Smart Data Carriers. In this report I will move away from the scenarios developed in these reports. I will evaluate each technology choice from the scenario demonstrations based on the 'Framework for Analysis' from the last report as a lead in to choosing likely business strategies. In this 'Framework' several criteria for evaluation were identified. These are Level of Service (LOS), Cost, and Legal or Institutional factors. In this report I will use the framework criteria to examine in more depth the technologies that were identified in my research using these criteria. The technologies will be developed into several distinct 'business strategies' along the way. In some cases a combination of more than one technology may be the best approach to use.

## REVIEW OF FRAMEWORK FOR ANALYSIS

The 'Framework for Analysis' developed in the previous Chapter consisted of three axes, reviewed here and shown in figure V-1:

- LOS (Level of Service)- LOS for our purposes consists of 7 elements. Price, convenience, reliability, time savings or loss, loss or damage to cargo, tracking ability and ability to manage cargo in transit. There is an additional benefit to some of these elements reflected in the ocean carriers own in-house management of assets.
- Cost
- Legal and Institutional Factors – Either enabling or inhibiting. In some cases the technology has outpaced the applicable (or non-existent) legal framework.

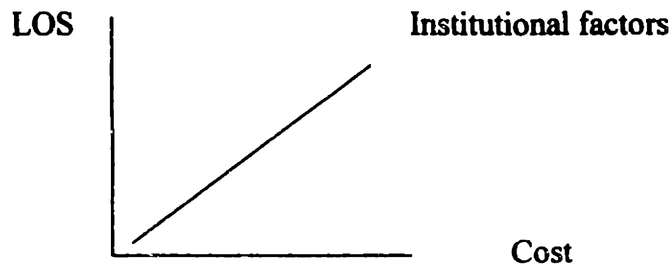


*Figure V-1*

*Three axis framework*

These three axes were chosen as the criteria to evaluate any technology chosen in the implementation of a Smart Data Carrier system. They are useful to illustrate the advantages and disadvantages of technology choices and the trade-off inherent in any such choice. While LOS and Cost are more tangible, legal factors can be more difficult to characterize. Legal factors in the simplest form can be subdivided into those that enhance technology or those that inhibit the introduction of technology to a business environment. LOS and Cost are easier for a manager to understand and assess in most business situations, as they are frequently the criteria a business manager in transportation may think of first in most decisions.

In the rest of this report I will rationalize transportation problems and solutions using these new technologies with the 'Frameworks' axes as measures of the effectiveness of the solutions. I have reduced the technologies under consideration to five by use of the scenarios in the previous reports.

The five technologies under consideration (from the previous reports) are:

- OCR (Optical Character Recognition)
- RFID Active (Radio Frequency Identification)
- RFID Passive
- Satellite (Lo-cost)
- Satellite (Hi-cost)

## THE TECHNOLOGIES

I will work through each technology using the framework as a grading mechanism in order to make a 'first cut' and eliminate some technologies from further discussion. In this section I will also re-categorize the types of RFID in light of developments in this technology.

### OCR

Optical Character Recognition has been used successfully at several container-handling terminals in the USA. It offers the advantages of:

- Smaller initial and maintenance costs
- No investment in equipment beyond the terminal operators' ownership and control.
- Partial automation of tasks (as compared to completely manual systems).

However, in light of the framework, it falls short in several elements. OCR has an inherent limitation of accuracy to about 85% which is a factor of the technology itself. The use of OCR with an acceptable level of accuracy requires some labor in the system. It will not (at this time) support complete automation of the process.

What is the process? In this case it can only be transactional[1] as a truck passes the gate of a terminal. OCR can only be applied at 'signpost' locations, for instance at the gate of a terminal. It can and does identify containers at the gate. This information can then be compared to a database (as 'license plate information' only) and provide information on the freight contained through this process. The information generated at this point can be shared with customers, and some limited actions (management of the freight) could be taken. Remote locating of containers cannot be accomplished.

I use simple Likert type scales as a graphical example of the relative merits of OCR according to the framework axes. LOS is rated low since OCR can capture gate transactions only. Cost is rated high on the scale since it is lower in relation to the higher technology choices (more advantageous if cost only is considered). Since there are no international standards or protocols involved at all then the Legal/institutional rating is relatively high.

[1] By Transaction we mean activity at a terminal gate, at a customers location, or moves within a carriers terminal. It could be a measure of productivity or simply events.

For OCR

| | - | + |
|---|---|---|
| LOS | X | |
| Cost | | X |
| Legal/institutional | | X |

*Graphical representation of OCR vs framework axes*

LOS and Legal/institutional ratings are qualitative rather than quantitative, and are only an estimate relative to the other technologies. Cost is more quantitative and can be directly compared.

OCR cannot provide visibility within the terminal or anywhere else other than the terminal gate since it is line-of-sight only. OCR can only provide limited automation, since it requires at least some labor to function reliably. This points us toward OCR's limited accuracy of 85% without manual intervention by an operator for corrections. One could also say it is only 85% reliable by itself. This has been overcome to a point by use of multiple readers and software to compare and adjust mis-reads but it still requires an operator for an acceptable accuracy level. OCR does not seem to add much to the LOS aspect that is already provided by the present manual operations. In comparison to the other Smart Data Carrier alternatives it falls for short.

For these reasons I will eliminate OCR from further consideration in the study.

**RFID**

In previous reports, I have characterized RFID into active and passive subdivisions. This is appropriate in an analysis of the technologies themselves, but is not quite what is needed in an evaluation of RFID for business applications. RFID tag technology has developed into another nomenclature, data rich and license plate. Sometimes this division is referred to as high end or low end. (High end = data rich; low end = license plate only). The borders of these definitions is a somewhat gray area, since not all read/write tags are data-rich. A few passive tags are read/write- most are not. RFID is not limited to line-of-sight.

All of the RFID options are very accurate, very reliable, provide some timesavings, provide a fairly high level of automation and are convenient. They lack somewhat in the ability to track freight, but do support the capture of information needed to record transactions (gate receipts, delivery time, etc.) very well. Transactional ability may prove essential to many sound business strategies.

All RFID tag systems suffer from immature international and even inter-industry standards. There are a great many differences in standards, suffice to say that as yet there is no interoperability between manufacturers or institutions of many types from industry to national in scope. It is quite common to see the same application using the same or similar technology in identical systems without being able to integrate the two[2]. This is a major stumbling block to growth in sales of this technology. In our discussion with industry representatives this was identified as an area that MIT could possibly make a contribution to expediting the standardization, interoperability, and harmonization[3] of RFID. Knowledge and the necessary skills for integration are often lacking.

Often this involves integration of business processes as much as it does technical issues.

**RFID Active**

Active RFID tags are powered by an internal battery. The inherent advantages to Active tags are the greater range that can be attained with the higher power available, a higher data transfer rate, (currently) the ability to use multiple frequencies and since they have on board power, they support other tasks[4]. The trade-offs are greater size and cost, along with a limited battery life. They can have integral memory.

**RFID Passive**

Passive RFID tags do not have a battery or power source on board. They operate on the principle of reflective backscatter technology, in which the beam of an interrogator provides sufficient power to 'reflect' the data contained in the tag. Until recently this could

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[2] For instance the proliferation of toll collection tags in the USA, each highway authority requiring its own tag. This has improved markedly but is still not a complete integrated system coast to coast.

only be 'write once-read many' data, but now can be read-write as well. They are license plate only.

### The RFID active/passive trade off

The differences between the two RFID tag technologies are:

- Active requires batteries and battery replacement cost, but allows several capabilities to be added.
- Passive may require a more expensive reader.

So, the cost tradeoff is more expensive installation, or more maintenance costs (batteries) deferred until later. The LOS tradeoff is more one-sided, license plate only vs. a much more capable tag. The US rail industry uses the AMTECH passive tag, while the US military uses the Savi active tag. Both serve their intended purposes.

### RFID Data-rich

By data-rich I mean memory capacity, and the ability to store and provide information. One of the most successful of data-rich tags is manufactured by Savi Technology (a Raytheon Company) and is marketed very successfully to the US military. The full use and potential of data-rich tags has not been realized in the commercial market. Data-rich tags can support the

---

[3] Please see Chapter IV for definitions of these terms.
[4] Tasks such as cargo monitoring, processing, data-rich, etc.

concept of 'nested freight' which we mentioned in earlier reports[5]. At this time the use of the data-rich feature is mostly limited to contents (manifest) information, but I feel that data-rich has great potential in a future business strategy, possibly when linked to the very small passive tags as 'contents' monitors. In the LTL[6] business for instance, they could provide individual package transaction or delivery information. This 'auto-networking' concept is a long way from reality, but is a promising idea.

**RFID License plate**

These tags comprise the original 'identification' part of RFID. These tags provide only an ID number when interrogated by a reader. They are very useful and are extensively used. The US railcar identification system relies on AMTECH tags and readers. These tags and readers are based on the same technology as the original ISO[7] tag standard. These tags support the capture of transactional information, and can be linked to a central database and control center providing a range of capabilities. This centralized approach is more typical of civilian or commercial applications. The License plate tag cannot provide positional information, nor does it have any writable or user programmable memory. This is in contrast to the military approach that provides more information in the field (de-centralized) for high mobility and local logistical decisions.

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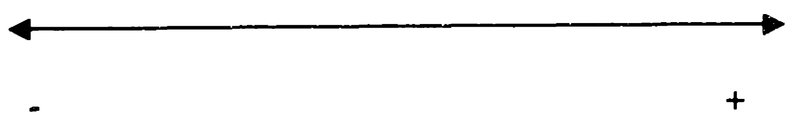
[5] License plate tags can too, with a central database and control center. Data-rich will probably add functionality to this system, as in the LTL example.
[6] LTL, Less than Truckload, commonly small lot transportation or delivery operations.
[7] ISO the International Standards Organization

**RFID Technologies compared by 'Framework for Analysis'**

The following scale of LOS, cost and institutional/legal evaluation is applicable to all RFID technologies. The primary difference between the technologies is cost, and then it is not so much a matter of total cost but a matter of up front or deferred cost. As mentioned earlier RFID active requires periodic battery replacement, but RFID passive requires use of a more expensive reader. The institutional/legal question for RFID is a challenge that has yet to be solved.

| | |
|---|---|
| LOS | P A |
| Cost | PA |
| Institutional/Legal | PA |




*Graphical representation of RFID vs Framework axes*

*A represents Active tags, P passive. There is some LOS and cost variation between the two.*

## SATELLITE-HIGH AND LOW COST COMPARISON

One of the last categories of Smart Data Carriers is technically advancing at a rapid rate. There are products being introduced to the market regularly that show great promise with increasingly lower costs.

One major advantage to satellite technology for smart data carriers is the existence of a worldwide institutional forum that has largely removed any institutional or legal barriers.

Space and the radio spectrum use of satellites has been an international arena for some time. The International Telecommunications Union (ITU) and the stakeholders of the space satellite arena have organized a productive, cohesive regulatory regime. This is quite opposite to the difficulty RFID tags face with regard to standards and a cohesive international regime.

Neither of the satellite technologies capture transactional information by themselves. This leads us to combinations of RFID tags and satellite positioning for an all-encompassing alternative. This will be discussed later in the business strategies. Both satellite technologies may be equipped with sensors, processing ability and memory for monitoring the freight. It is possible that Hi cost may be more capable in the range of added capabilities.

Satellite-low cost is a fairly recent development that is only becoming feasible now. It has been developed in part with support from the US military.

One characteristic of satellite technologies (and products) is the system approach. Obviously the technologies are dependent on an existing satellite constellation and the entire support infrastructure that go along with maintaining and using systems like these. This makes it necessary to 'rent' system time and assets. This is an 'added value' approach to the satellite marketing effort. In these technologies, for this reason it is usual to charge a service charge monthly per unit or per message (or any other billing arrangement that can be worked out) in addition to the initial cost of the remote equipment. This time based cost escalates quite a bit compared to the RFID options. There is an approximate break-even point at a certain number of units. (see NPV analysis in Chapter VIII)

Of course there is a trade off to this system cost. The 'system' already exists and is operational when the customer signs up. The institutional/legal implementation problem of interoperability is largely removed. The institutional/legal problem of security is reduced by the secure nature of the technologies. Custody, contractual and other legal problems do persist, as they do in all of these new technologies.

**Satellite Hi-Cost (or GPS based)**

Until now, satellite-positioning ability was dependent on systems like the USA's Geographic Position System (GPS). This was initially developed for military applications. The US military intentionally degrades the (GPS) signals required for the process in order to limit the usefulness of the system to adversaries. In the USA the U.S. Coast Guard transmits 'differential signals' to raise the accuracy of the system to impressive levels for navigational purposes. In many US ports, harbor pilots use differential GPS to pilot large ships in narrow channels with very good reliability and accuracy. There are other similar systems available today such as GLONASS, and GNSS-2 which are the Russian and European systems respectively. They basically use the same technology.

This technology is based on triangulation between satellites. Three satellites in view are required for position calculations, with a fourth used for a time correction process. They are MEO satellites (Medium Earth Orbit) at about 11,000-mile altitude. There are 24 satellites in the GPS constellation. Recent developments in small personal GPS transponders have cut the size of the GPS equipment dramatically. A vehicle GPS & communications unit is shown in Figure V-1. A communications unit is also required in combination with the GPS for indirect remote positioning to send the position back to a user or central control database. The cost of remote units has decreased quite a bit over the years but is still fairly expensive per unit. (in comparison to Lo cost obviously)


*Figure V-1*

*Trimble Vehicle locating GPS and communication unit*

There are several limitations on GPS technology for our purposes. Basically the processing necessary to provide a position takes place on board the remote unit. This makes two limiting factors unavoidable so far:

- High on board power requirement.
- Necessary to provide a means to re-transmit the position information to the user.

The on-board power requirement is based upon this technologies' reliance on on-board processing. The satellite signals are received and processed into positional information in the remote unit. This information must then be re-transmitted in order to be useful to us. This takes quite a bit of energy to perform. In most common transportation applications today, this technology is used in an operator-attended situation, with an on-board power source such as domestic truck transportation. We need a robust device capable of long time, untethered operation. Table 1 shows the comparison in form factor, acquisition cost and battery between GPS based and GLS satellite technology (what we call Hi cost & Lo cost respectively) The GPS based product is being brought to market by an industry leader. A market shift to GLS products could be predicted by the factors in Table V-1.

From these limitations we can expand to how this impacts our problem and goals. The first impact is the limited ability to provide for un-tethered vehicle applications. We wish to monitor and track unattended containers, and possibly container chassis. So far this technology will not allow this to be done efficiently due to power consumption limitations. Alone, the unit can only be powered for about two weeks with the currently available battery configuration. This is a severe limitation for our purpose and basically eliminates this technology from further consideration until this can be corrected[8]. The large size and transmitter requirements are inconvenient as well, but the battery and power problem precludes the use of this technology by itself. Figure V-2 shows a typical arrangement in a domestic truck application. Notice that this installation is dependent on the truck internal power generation source.

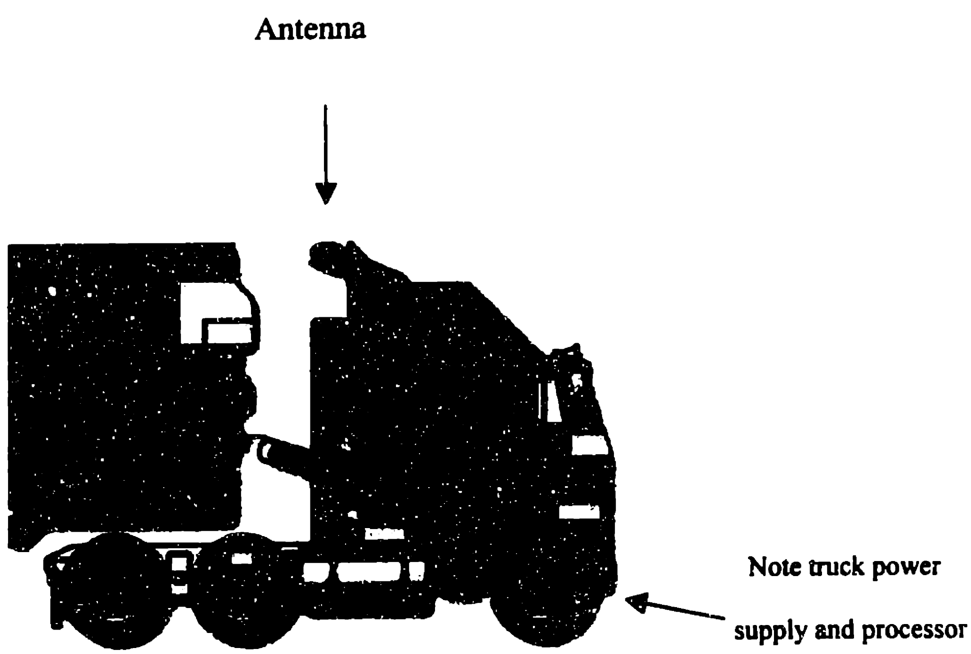



*Figure V-2*

*Current Technology Typical Truck Monitoring & Positioning Installation*

*Note Dependence on truck power source & antenna size*

*There are over 280,000 vehicles worldwide with similar configurations*

[8] Qualcomm 'Trailer track' unit is the latest GPS offering it is intended for un-tethered trailers. See Table V-1.

| Characteristic | GPS based | GLS |
|---|---|---|
| Unit size | 18" X 12" | 2.6" X 6" X 1.2" |
| Antenna size | 18" X 12" | Integral |
| Unit cost | $650-750 | $200 |
| Battery | Lead acid | 4 AA lithium |
| Operating time | Depends on usage | Up to 2 years |

*Table V-1 Comparison between GPS and GLS remote systems*

For Satellite Hi-cost (GPS)

| | |
|---|---|
| LOS | X |
| Cost* | X |
| Institutional/Legal | X |

\- +

*Graphical representation of Satellite Hi-cost 'Framework' comparison*

For Satellite Lo-cost (GLS)

| | |
|---|---|
| LOS | X |
| Cost | X |
| Institutional/Legal | X |

\- +

*Graphical representation of Satellite Lo-cost 'Framework' comparison*

* Cost in this case is high in absolute terms. Institutional/legal is rated in terms of maximum ease of integration.

As one would expect from its' name, this is the most costly technology to adopt.

**Satellite Lo-Cost (or GLS)**[9]

Satellite Lo-cost is a newer alternative. Satellite Lo-cost technology is sometimes called Geographic Locating System. It uses a different approach to the processing required for positioning, and is innovative in that it reduces power consumption drastically and extends battery life to as much as two years. It also promises to be significantly less expensive than GPS based systems. One developer of products using this technology expects a unit price of about $200.

## BUSINESS STRATEGIES

The characteristics of the various technologies (with the exception of OCR, eliminated) lend themselves to certain business applications, and further to a corresponding strategy. Most of these or variations of them are not really new ideas. I will first list the proposed strategies, and then evaluate them each according to the 'Framework".

1. Continental tracking of container chassis by RFID license plate tags (and readers). These tags may be active or passive depending on the particular ocean carrier choice or by capability. For instance in a very large container terminal, the extra range of active tags may be desirable for locating lost containers or chassis in the terminal. The idea is to track the chassis and match containers to chassis by a central database and control system.

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1. Continental tracking of container chassis by RFID license plate tags (and readers). These tags may be active or passive depending on the particular ocean carrier choice or by capability. For instance in a very large container terminal, the extra range of active tags may be desirable for locating lost containers or chassis in the terminal. The idea is to track the chassis and match containers to chassis by a central database and control system. A variation of this is closed loop tracking of containers. An ocean carrier with a dedicated route and primarily using his own containers can capture container transaction information by RFID license plate tags (passive or active).

2. Market data-rich active RFID tags to military, postal, and delivery applications. The military also is still a very large market. NATO and similar organizations will probably be purchasing this technology. Delivery operations (such as some LTL) could be users of this technology. This technology and strategy would require considerable integration and interoperability effort.

3. Tracking containers (or chassis) by GLS system, accessible to the carrier by Internet.

4. A Hybrid combination strategy including GLS and RFID license plate tags. This could also be built upon by providing cargo monitoring, data-rich vs. License plate tags and other features included in the previous strategies. This would provide real time tracking

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[9] GLS- Geographic Locating Systems

and transactional information as well from carefully placed tag readers. While this would no doubt be expensive, it would provide the ultimate in LOS and could be customized to suit each situation. This would be the 'smartest' data carrier.

**Comparison of the strategies according to the 'Framework':**

1. License plate and closed system License plate tag application:

| | |
|---|---|
| LOS | X |
| Cost | X |
| Institutional/Legal | X |

2. Data-rich RFID strategy:

| | |
|---|---|
| LOS | X |
| Cost | X |
| Institutional/Legal | X |

3. GLS container tracking strategy:

| | |
|---|---|
| LOS | X |
| Cost | X |
| Institutional/Legal | X |

4. Hybrid Strategy:

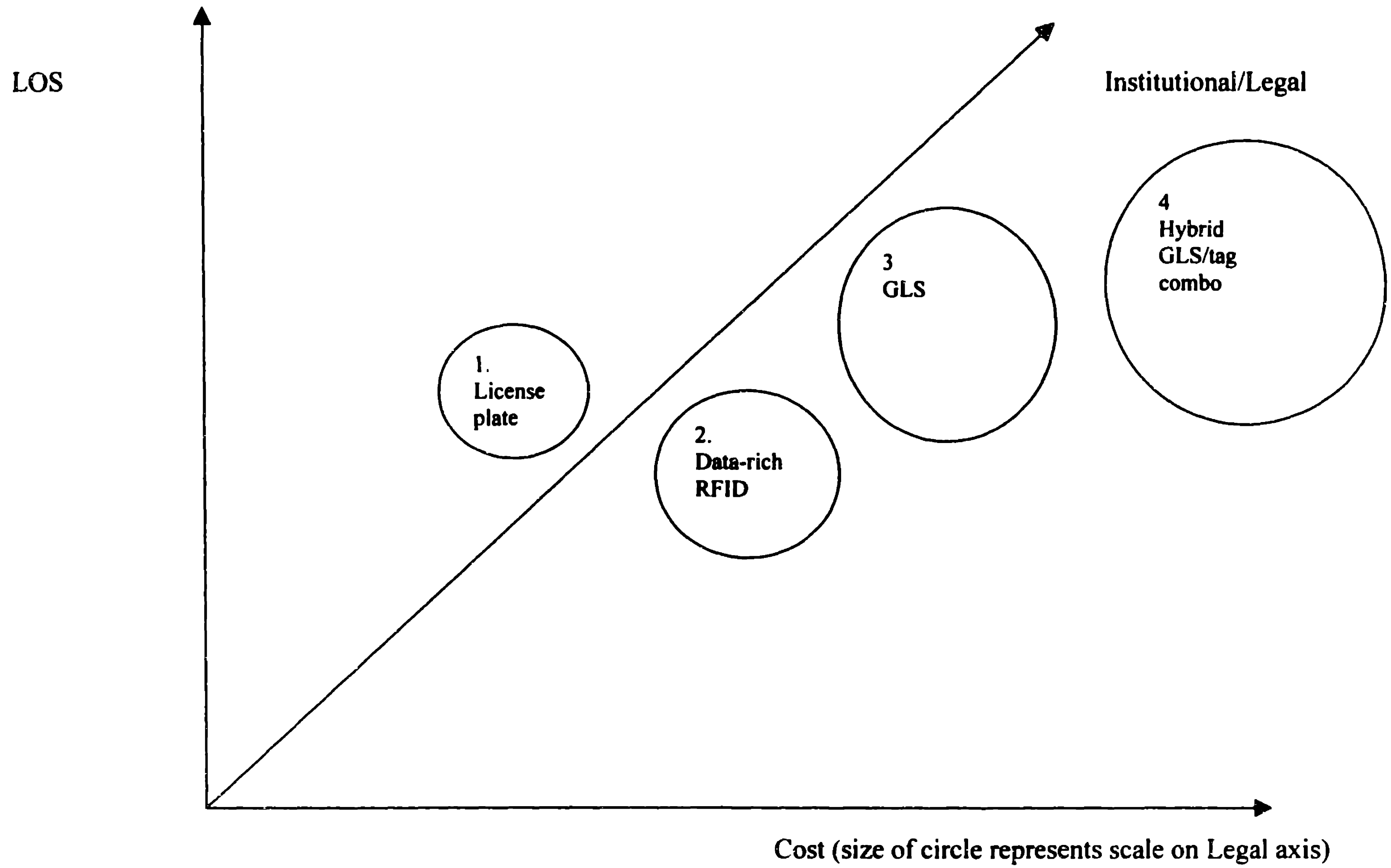
| | |
|---|---|
| LOS | X |
| Cost | X |
| Institutional/Legal | X |

- … +

*Graphical representation of 'Framework 'evaluation of each strategy*

**Strategies portrayed together on all three axes:**

(approximate)



# CHAPTER VI

## Conclusion

In the previous Chapters we defined the components of Smart Data Carriers and identified the variables that can be used to rank and classify Smart Data Carriers. I have focused on devices with characteristics and applications useful for marine containers and operations and transactions that marine containers trigger or encounter in their travels. The other side of this is the effect on the carrier/customer relationship and the changing business environment that these advances in technology may bring about.

Business strategies are developed from a cross section of the available technology and industry 'best practices', properly matched to the customers and market conditions. These technologies and the practices that the technologies support are changing rapidly. It would be appropriate to say that technology advances are making 'best practices' change, rather than the reverse. Simply, what becomes possible changes and drives customer expectations. Supply chain pressures drive customers to be demanding of any advantage that will make it possible for them to manage the flow of goods more efficiently. The ocean carrier needs to develop a strategy that effectively responds to this pressure under a range of circumstances.

The choices of business strategies depend totally on the desires of the ocean carrier, or ultimately his customers. There is a range of choices that our original scenarios still do a useful job of pointing out. The best approach over the long term will probably be a combination of technologies that will enable the ocean carrier to encompass the complete Smart Data Carrier suite of capabilities.

Institutional entities will have to grow into this as well and provide the legal 'protection' for process changes to become common and useful. Often it is a function of business process change that technology brings about that is the limiting factor in introduction, acceptance and growth of technology. It would be no use to have a 'state of the art' electronic tracking and transaction automation system if the business community did not accept the electronic records and exchanges that the system produced. A suitable international set of 'standards' provides the means for this acceptance by the business community. Some technologies seem to have an initial advantage in this area.

The development of complete systems brings into play the integration problem that we have mentioned but not dealt with in detail. Integration of business processes, technology, communications, standards, and all of the linkages necessary for effective use of the Smart Data Carrier capabilities is no simple task. Our business strategy recommendations each entail a different level of integration difficulty. The depth that an ocean carrier wishes to go is a decision that must be wisely made by the carrier. This report provides some of the tools to make this decision.

## Appendix 1

## NPV Analysis Explanation

A brief Net Present Value analysis and assessment is included in this thesis. The intention is to give some comparison of the relative costs of implementing the various strategies. No mention is made of LOS or other internal carrier benefits, which should be compared to the cost for an informed decision. The following page is a graphical summary of the comparison based on the following assumptions.

For RFID, I assumed that no battery replacements would be necessary through the eight-year period. Either use of passive tags would preclude this altogether or the assumption is that the batteries in active tags would last that long. For the satellite GLS tags, battery replacement expense every two years is assumed. RFID tags are priced at $50 each, Satellite tags at $200 each. Satellite includes a monthly charge of $15 per unit deployed.

Maintenance at 2% of initial cost is assumed throughout the life of all three systems. For RFID readers (interrogators) are priced at $20,000. each including purchase, engineering and installation. There is no cost assumed for integration, since I assume that each system would have to deal with this, making it essentially a constant that could be ignored.

Two ranges of RFID costs are shown. That is for 1,000 readers and for 2,000 readers. The axes of the graph of course are:

1. Cost in negative NPV. This is not meant to be confusing. What we are really looking at is the absolute value of cost.
2. Number of units (tags, or tagged vehicles).

The costs do cross, implying a 'break even' point where the carrier would be indifferent to systems from a cost point of view. Of course benefits would influence his decision, but two conclusions could be made from this:

1. At a lower number of units satellite would be cost equal, but more desirable from an LOS point of view and this could be accomplished by tagging chassis rather than containers. (less units)
2. The cost of tagging containers system wide with satellite tags would probably be prohibitive. The best strategy again may be tagging less units (perhaps hi value such as reefers, or chassis only) or tackling a smaller segment of the vehicle population.

A 20% discount rate is assumed, since this could be a relatively risky investment. Obsolescence, integration problems, and other issues could complicate and interrupt an implementation scheme. An eight-year period is assumed for much the same reasons. I felt it would be useless to project a hi-tech investment beyond that period. Even eight years could be too much.

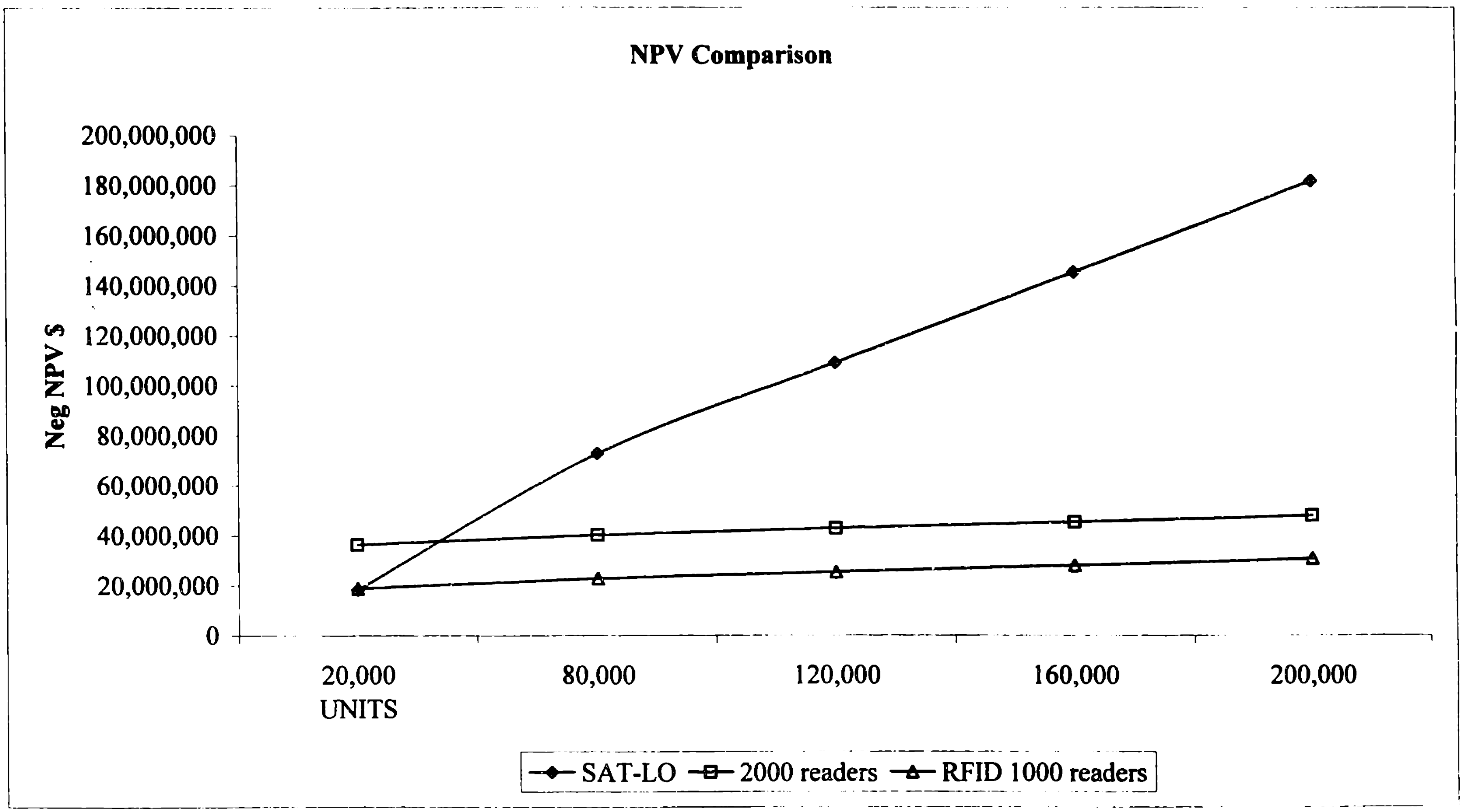

NPV Comparison
Neg NPV $
200,000,000
180,000,000
160,000,000
140,000,000
120,000,000
100,000,000
80,000,000
60,000,000
40,000,000
20,000,000
0
20,000
UNITS
80,000
120,000
160,000
200,000
SAT-LO
2000 readers
RFID 1000 readers

Exhibit 1-1

Analysis of RFID vs. Satellite Positioning for
Containers and freight

| | | Number of gates | | | | Total Readers required | |
|---|---|---|---|---|---|---|---|
| <u>Terminals</u> | Owned | 26 | | 10 | | 260 | |
| | Others | 100 | | 10 | | 1000 | 1000 |
| <u>Rail Ramps</u> | | 240 | | 2 | | 480 | |
| <u>Other points</u> | | 60 | | 2 | | 120 | |
| | | | | | | 1860 | 2000 |
| | | | $20,000 each | | at 1000 readers | 20,000,000 | |
| | | | | | at 2000 readers | 40,000,000 | |
| | | | # of tags | | tag cost | 3,000,000 | |
| | | | Price of tags $ | 75 | | | |
| | | | | | Total investment | -23,000,000 | -43,000,000 |
| | | | | | Maintenance 1% | -230,000 | -430000 |
| | | | | | Total first yr cost | -23,230,000 | -43,430,000 |

Satellite Lo-Cost Option

| | | | | |
|---|---|---|---|---|
| # of units | 40,000 | RFID tags 40,000 | | |
| Cost each | 200 | | | |
| Total investment | 8,000,000 | Plus monthly cost of | | |
| Yearly cost | 15,200,000 | | (#units X $15 per month) | 600,000 |
| Battery repl cost (every two yrs @ $27 ea) | 1,080,000 | | | |
| Incluing maintenance | 15,352,000 | Monthly times 12 | | 7,200,000 |
| | | Maintenance cost | | 152,000 |

NPV Comparison (by Year)

**<u>RFID</u>**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| at 1000 readers | -23,230,000 | -230,000 | -230,000 | -230,000 | -230,000 | -230,000 | -230,000 | -230,000 |
| at 2000 readers | -43,430,000 | -430,000 | -430,000 | -430,000 | -430,000 | -430,000 | -430,000 | -430,000 |

at 1000 readers NPV= (20,049,213)
at 2000 readers NPV= (37,483,312)

**<u>Lo-Cost Satellite</u>**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| | -15,352,000 | -8,280,000 | -7,200,000 | -8,280,000 | -7,200,000 | -8,280,000 | -7,200,000 | -8,280,000 |

NPV= (36,304,581)

## Appendix 2

## RFID Tech

### RFID Active vs. Passive technical appendix

Frequency choice is another factor common to both Active and Passive tags. Low frequency tags (30 to 500 KHz) systems have generally shorter ranges and lower cost, combined with lower data transfer rates. Higher frequency tags (850 to 950 MHz and 2.4 to 5.8 GHz) are generally characterized by longer ranges and higher data transfer rates. Table A-1 shows the frequency bands with their characteristics and typical uses.

**Table A-1. Frequency Bands and Applications**

| Frequency Band | Characteristics | Typical Applications |
|---|---|---|
| Low<br>30-500 kHz | Short to medium read range<br>Inexpensive<br>low reading speed | Access control<br>Animal identification<br>Inventory control |
| Intermediate<br>10-15 MHz | Short to medium read range<br>potentially inexpensive<br>medium reading speed | Access control<br>Smart cards |
| High<br>850-950 MHz<br>2.4-5.8 GHz | Long read range<br>High reading speed<br>Line of sight required<br>Expensive | Railroad car monitoring<br>Toll collection systems<br>Freight ID systems |

Active tags are probably the most suited for the type of 'network' required in freight tracking. Active tags offer:

- Longer ranges.
- Read/Write capability.
- Faster data transfer rates.
- Use of two (maybe more) frequencies.

Only one ocean carrier already uses active tags for container identification. RFID-Active is admittedly more costly, but complies better with the requirements.

The cost factors involved that are unique to RFID-Active are:

- Higher acquisition and possibly installation cost.
- Higher maintenance cost (battery replacement).

Compared to the elements of LOS, Active tags are convenient, they are less costly than either of the satellite alternatives, and they are very reliable and accurate. Some sources claim more than 99.99% accuracy. They support automation and productivity gains. As for trade-offs, RFID Active tags are limited to 'signpost' applications as is OCR (and RFID-Passive). RFID tags provide limited ability to manage freight in transit, but are weakest when the location of a container is unknown (in transit). Any data contained in the tag including its identity is accessible only when the container (and the tag) pass by a fixed reader (interrogator). The ability to manage is related in this case to the data contained in the tag. For instance, an active tag that is read/write capable and has some processing ability may be pre-programmed at its origin contents of that container as in the 'nested freight concept'.

Monitoring of the freight contained could take place up to a point. The tag could be connected to a temperature monitoring system in the container, and its data could be read when an interrogator reads the tag. The draw back to this is that it is 'after the fact' information and may not be timely enough to prevent loss to the cargo. Unlike OCR a portable truck mounted RFID reader can locate tagged containers within a terminal.

**RFID-PASSIVE**

RFID-Passive is commonly used for animal control, industrial uses such as laundry and tool control, and for access (security) applications. It would be admirably suited for the 'nested freight' concept discussed earlier. Passive tags can be extremely small, and quite low cost. They can be sewn into garments, implanted under the skin of animals, and hidden in various pieces of property (inventory) or ID cards carried by personnel. They offer a non-line-of-sight alternative to bar code technology. They do not need to be properly oriented to the reader as some bar codes do. They have been successfully used for airline baggage control, but are slightly more expensive than airlines wish to pay at this time. Their cost is dropping continuously, along with increasing improvements to the technology itself over time. They require hardly any attention by an operator or maintainer. Some of the latest passive tags introduced to the market include a read/write capability.

RFID-Passive tags have limitations in an Smart Data Carrier application that include:

- Short range.
- Require a higher-powered interrogator installation (possibly more costly).
- Only one frequency.

The advantages are:

- No maintenance (no battery).
- Cheaper tags.
- Ease of operation.

In summary these are very useful but do not offer the all of particular characteristics (by themselves) needed for a complete Smart Data Carrier in freight monitoring system applications. In combination with other technologies they may provide part of a desirable 'In-Transit' freight management ability.

## Appendix 3

## Satellite Technical Information

One way of differentiating positioning systems is by the definitions given in 'Positioning Systems in Intelligent Transportation Systems' by Drane & Rizos. The authors describe positional systems as either:

- Self-Positioning
- Remote Positioning

In self-positioning, the objects themselves determine where they are (as in GPS based systems). In remote positioning, a central operations center determines the location of the objects. A self-positioning system can function as a remote system if the object transmits its position to a central operations center using a communications link. This is called *indirect remote positioning*

The Satellite Lo-Cost option described in this report is an example of an indirect remote positioning system.

The first comparison between Hi and Low cost Satellite is accuracy. Differential GPS can provide accuracy to probably less than a meter. This may not be necessary to meet our goals. Certainly accuracy limited to the width or length of the container can be tolerated.

Low cost Satellite has not been a viable option until recently since there was no practical alternative to the on-board power, on-board processing, and size limitations.
At the present time however, there is at least one new provider on the horizon who proposes to use a small tag-like transponder on the container, and move the processing back to a central location. Removing the processing from the remote unit enables the power consumption to be drastically reduced to a projected two-year or more battery life, using readily available low cost batteries. Basically these tags will transmit a very short data stream that will be used by the central location-processing center to calculate the position of that particular tag.

GPS uses a constellation of 24 satellites orbiting in 12 hour intervals, 4 of which must be in view for position. They are MEO (medium earth orbit) at an altitude of about 11,000 miles. The positioning system is a calculation of 'range spheres' providing an intersection or 'triangulation' position

Recently, many new satellite constellations are being launched and put into service. Most of these are not GEOs (Geostationary earth orbit) or MEOs but are Low Earth Orbit (LEOs). These are obviously at much lower altitudes (hence the name), taking less power to communicate with them as a result. For communication purposes they have many advantages such as lower cost, and lack of delay in reception due to distance (GEOs have up to a .5 second delay making telephone conversation interesting at times, MEOs .1 to .35).

There are disadvantages to LEOs as well. They are not geo-stationary, but are constantly moving at a very rapid rate from an earth's surface perspective (approximately 7 KM per second). This has three implications:

- Complicated positional calculations.
- Requirement for many satellites.
- Requirement for 'hand-offs' between satellites.

The complicated positional calculations are a function of the high velocity of the satellites themselves that make the required geometry change constantly at a rapid rate. Nevertheless, LEOs seem to be the wave of the future for portable telephone systems and bandwidth additions to the available spectrum for public and business communications. It is expected that 500 broadband satellites will come on line in the next 10 years (mostly LEOs).
This will encourage lower prices for satellite bandwidth, which may reduce satellite time re-sellers prices (our GLS).

One of the aftermarket sales opportunities for these new satellites and their owners is called Geographic Location Systems (GLS) similar to GPS in some ways, but really a new technology based on these newly available satellites. One new entity funded until now by US military research, has developed a GLS system using Code Division Multiple Access (CDMA) technology for communicating and a Doppler ranging based positional fix algorithm for position. It will support accuracy to about 1 to 3 meters and the remote unit is about the size of existing rail and container RFID tags. The cost is expected to be about $200 per remote unit, with a monthly fee for tracking and reporting services that will deliver internet based GLS information to a customer's door.

CDMA technology has a few characteristics of its own. This was developed as long ago as WWII for secure radio communications. It is an anti-jamming and security technique in that a signal received by a non-system receiver will appear to be only 'noise'. In this way, it adds a security element to the data entrusted to it. It has been chosen by one developer as a superior technology for GLS applications. The advantage to CDMA is the probable greater bandwidth available using this technology. This has not been completely proven as a technical fact yet.

We include some information on LEO systems, since they were overlooked in the original technology scan. Two examples are Iridium and Globalstar. Basically the difference is in the orientation of the orbits, Iridium choosing a polar orbit, which gives maximum coverage density at the poles. Globalstar uses CDMA technology that may give increased bandwidth. It does have security enabling features. Globalstar uses a 'bent pipe' repeater system in which no processing is done in the satellite. This may be preferable for GLS purposes.

Some sources feel that LEO based satellite systems are the area to watch in the near future for communications and GLS functions. They may become the standard.

**COMPARISON OF GLOBALSTAR AND IRIDIUM SYSTEMS**

| CHARACTERISTIC | IRIDIUM | GLOBALSTAR |
|---|---|---|
| Orbit Altitude | 900 KM | 1389 KM |
| Geometry | Polar Orbits | Inclined 52 degrees |
| Number of Orbits | 6 | 8 |
| Satellites per Orbit | 11 | 6 |
| Coverage | Maximum at Poles | Up to Latitude 70 Degrees |
| Total number of Satellites | 66 | 48 Including Spares |
| Number of Beams per Satellite | 48 for Earth to space at L Band | 48 for Earth to space at L Band |
| Intersatellite Links | Provided at K Band | None |
| Repeater Design | Onboard processing of packets | Analog 'Bent Pipe' |
| Multiple Access | TDMA | CDMA |
| Satellite Lifetime | Up to 6 years | Up to 7.5 years |

*TableIX- 2*

*Characteristics and Comparison of Technical Details of Globalstar and Iridium*

## ANOTHER OPTION

One last positional option not available yet but deserving mention is the cellular telephone based Global System Mobile (GSM). Cellular telephone systems are based on a series of 'grids' or cells that allow the system to be sub-divided into manageable portions. They are usually hexagonal cell configurations. For some time it has been realized (and it is a requirement to implement in the USA by a certain date) that cellular technology could provide position as well as communications. There are several advantages to a cellular based system:

- Makes use of already installed cellular infrastructure.
- Cellular systems already have a frequency spectrum assigned.
- In areas of worst propagation, there are a maximum number of cells. (superior coverage in urban areas)
- There is already widespread use of cellular telephony.
- The technology provides a built in communications link.

The disadvantages are considerable:

- Poor (or non-existent) coverage in rural and remote areas.
- Low accuracy
- Limit to number of users (available spectrum).

It is almost a certainty that future generations of cellular telephones will include this positioning capability. This may give a feasible alternative or 'back-up' technology to other systems. A nation like Japan with an already existing cellular system may want to explore this option.

## RFID Glossary

(Glossary is in two parts, RFID and satellite; satellite follows RFID)

| | |
|---|---|
| Active Tag | Colloquial term for a radio frequency transponder powered partly or completely by a battery. Batteries may be replaceable or sealed within the device (when the term unitised active tag is sometimes used). Compare Passive Tag. |
| Active Transponder | A battery-powered data-carrying device that reacts to a specific, reader produced, inductively coupled or radiated electromagnetic field, by delivering a data modulated radio frequency response.<br><br>Compare Passive Transponder (Tag). |
| Amplitude Modulation (AM) | Representation of data or signal states by the amplitude of a fixed frequency sinusoidal carrier wave. Where data is in binary form the modulation involves two levels of amplitude and is referred to as Amplitude Shift Keying (ASK). |
| Backscatter Modulation | A process whereby a transponder responds to a reader/interrogation signal or field by modulating and re-radiating or transmitting the response signal at the same carrier frequency. |
| Capacity - Data | A measure of the data, expressed in bits or bytes that can be stored in a transponder. The measure may relate simply to the bits that are accessible to the user or to the total assembly of bits, including data identifier and error control bits.<br><br>Compare Capacity – Channel. |
| Capacity - Channel | A measure of the transmission capability of a communication channel expressed in bits.$s^{-1}$ and related to channel bandwidth and signal to noise ratio by the Shannon equation;<br><br>Capacity, $C = B \log_2 (1 + S/N)$, where B is the bandwidth and S/N the signal to noise ratio.<br><br>Compare Capacity - Data |
| Compatibility | The condition that exists between devices or systems that exhibit equivalent functionality, interface features and performance to allow one to be exchanged for another, without |

| | |
|---|---|
| | alteration, and achieve the same operational service. |
| | Compare Interoperability. |
| Data | Representations, in the form of numbers and characters for example, to which meaning may be ascribed. |
| | Compare with Information. |
| Data Capacity | See Capacity - Data |
| Data Rate (Data Transfer Rate) | In a radio frequency identification system, the rate at which data is communicated between transponder and the reader/interrogator, expressed in baud, bits.$s^{-1}$ or bytes.$s^{-1}$ |
| Electromagnetic Coupling | A process of transferring modulated data or energy from one system component to another, reader to transponder for example, by means of an electromagnetic field. |
| Electronic Data Interchange (EDI) | Communication of a data message, or messages, automatically between computers or information management systems, usually for the purposes of business transactions. |
| Factory Programming | The entering of data into a transponder as part of the manufacturing process, resulting in a read-only tag. |
| | Compare Field Programming. |
| Field Programming | Entry of data by an original equipment manufacturer (OEM) or user into a transponder by means of a proprietary programming system, usually undertaken before the device is attached to the item to be identified or accompanied. This facility is usually associated with Write Once Read Many (WORM) and read/write (RW) devices. |
| | The data entered into a transponder may be by a combination of factory and field programming. |
| Global Locating System (GLS) | Satellite based locating (positioning) system using Low Earth Orbit (LEO) satellite constellations. See GPS |

| | |
|---|---|
| Global Positioning System (GPS) | Satellite based positioning system using geo-synchronous orbit satellite constellations |
| Hybrid Device | Tag or transponder having more than one capability or function. For instance, combining License Plate ID with cargo specific data in an RFID tag having variable data capacity, and possibly GLS capability. |
| Inductive coupling | A process of transferring modulated data or energy from one system component to another, reader to transponder for example, by means of a varying magnetic field. |
| Information - general | Something which is meaningful. Data may be regarded as information once its meaning is revealed. |
| Interoperability | The ability of systems, from different vendors, to execute bi-directional data exchange functions, in a manner that allows them to operate effectively together. |
| Interrogation | The process of communicating with, and reading a transponder |
| Interrogator | A fixed or mobile data capture and identification device using a radio frequency electromagnetic field to stimulate and effect a modulated data response from a transponder or group of transponders present in the interrogation zone. Often used as an alternative term to Reader.<br><br>See also Reader. |
| LICENSE PLATE | A reference number which uniquely identifies the tag. (License Plate) |
| Memory | A means of storing data in electronic form. A variety of random access (RAM), read-only (ROM), Write Once-Read Many (WORM) and read/write (RW) memory devices can be distinguished. |
| Multiple Reading | The process or capability of a radio frequency identification reader/interrogator to read a number of transponders present within the system's interrogation zone at the same time. |

| | |
|---|---|
| Omnidirectional | A description of a transponder's ability to be read in any orientation. |
| Passive Transponder (Tag) | A battery-free data carrying device that reacts to a specific, reader produced, inductively coupled or radiated electromagnetic field, by delivering a data modulated radio frequency response. Having no internal power source, passive transponders derive the power they require to respond from the reader/interrogator's electromagnetic field.<br><br>Compare Active Transponders (Tags). |
| Protocol | A set of rules governing a particular function, such as the flow of data/information in a communication system. |
| Radio frequency identification system | An automatic identification and data capture system comprising one or more reader/interrogators and one or more transponders in which data transfer is achieved by means of suitably modulated inductive or radiating electromagnetic carriers. |
| Radio Frequency Tag | Alternative term for a transponder. |
| Range - Read | The maximum distance between the antenna of a reader/interrogator and a transponder over which the read function can be effectively performed. The distance will be influenced by orientation and angle with respect to the antenna, and possibly by environmental conditions. |
| Range - Programming | The maximum distance between the antenna of a reader/interrogator and a transponder over which a programming function can be effectively performed. Usually shorter than the read range, but may be influenced by orientation and angle with respect to the antenna, and possibly by environmental conditions. |
| Read | The process of retrieving data from a transponder and, as appropriate, the contention and error control management, and channel and source decoding required to recover and communicate the data entered at source. |
| Readability | The ability to retrieve data under specified conditions. |
| Reader/Interrogator | An electronic device for performing the process of retrieving data from a transponder and, as appropriate, the contention and |

| | |
|---|---|
| | error control management, and channel and source decoding required to recover and communicate the data entered at source. |
| | The device may also interface with an integral display and/or provide a parallel or serial communications interface to a host computer or industrial controller. |
| Read Only | Term applied to a transponder in which the data is stored in an unchangeable manner and can therefore only be read. |
| | See also Factory Programming. |
| Read Rate | The maximum rate at which data can be communicated between transponder and reader/interrogator, usually expressed in bits per second (bps or bits.$s^{-1}$). |
| Read/Write | Applied to a radio frequency identification system, it is the ability both read data from a transponder and to change data (write process) using a suitable programming device. |
| | See Reader/Interrogator |
| RF Tag | Alternative, short hand term for a transponder. |
| Satellite Transponder | Tag or data carrying device for use with a satellite based GLS or GPS system. Satellite Transponders do not contain variable data by nature. |
| Tag | Colloquial term for a transponder. Commonly used term. |
| Write | The process of transferring data to a transponder, the internal actions of storing the data, which may also encompass the reading of data to verify the data content. |
| Write Rate | The rate at which data is transferred to a transponder and stored within the memory of the device and verified. The rate is usually expressed as the average number of bits or bytes per second over which the complete transfer is performed. |
| Write Once Read Many (WORM) | Distinguishing a transponder that can be part or totally programmed once by the user, and thereafter only read. |

## Satellite Glossary

| | |
|---|---|
| CDMA | Code division Multiple Access |
| EIRP | Effective Isotropic Radiated Power. The product of the input power to an antenna and the gain relative to an isotropic source. |
| GEO | Geosynchronous earth orbit satellite |
| GSM | Global Satellite Mobile |
| LEO | Low earth orbit satellite, further divided into Big LEOs; those providing all services including voice communications, and Little LEOs; those providing data services only. |
| MEO | Medium earth orbit satellites |
| OCR | Optical character recognition |
| Remote-positioning operations | Position calculations of remote unit carried out by a central center. |
| RFID | Radio frequency identification |
| Self-positioning | Remote unit carries out positional calculations on board. |
| Signpost | Locating system using fixed infrastructure, can only provide intermittent positional information. The best analogy may be 'signpost information is discrete, satellite based tracking can be continuous'. |
| TDMA | Time delay multiple access. Used to enable utilisation of bandwidth for more channel capacity. |
| Terrestrial | Communications by older technologies; HF radio, etc. |

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