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THE USE OF LOW EARTH ORBIT SATELLITE TECHNOLOGY TO TRACK DOD ASSETS IN THEATER

GRADUATE RESEARCH PROJECT

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Acknowledgements

I thank the Lord for giving me the stamina and ability to complete this work. It is not flawless, nor am I. I will say, however, that it was done to the best of my ability with the help and support of many individuals to include my lovely wife and my clever son …age two. Appreciation also goes out to both Dr. Vaughan and my advisor Dr. Cunningham at the Air Force Institute of Technology, whose superior contributions greatly enhanced the quality of this project. In addition, my thanks and gratitude to all those who provided input at USTRANSCOM J4, especially my sponsor, Colonel Carm Walgamott and his action officer for this project, Major Richard MacKeen, whose input kept me on course ensuring a quality product for the benefit and furtherance of intransit visibility.

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Abstract

This paper addresses one possible solution to the enormous task of monitoring assets and unit equipment in theater. In recent months, the ability to track intra-theater shipments has been identified as one of the weakest links in our current intransit visibility (ITV) structure, and the DoD has placed great importance on giving senior leaders visibility on equipment and cargo transiting their geographic areas. We have highlighted our difficulties and spent much time and effort honing our skills and improving our automated collection of data. Our efforts have given impetus to multiple technologies that are currently assisting the DoD in obtaining accurate location of assets in theater. The technologies associated with these efforts are referred to as Automated Identification Technologies (AIT). Although current "standard" devices to include radio frequency identification (RFID) seem to be ameliorating the ITV problem, this paper introduces an intriguing new technology currently being developed and used in the private sector—that of monitoring assets with the aid of low earth orbit satellites (LEOs). This technology has been demonstrated in the commercial trucking industry through ORBCOMM's Vantage Tracking devices that allow the military's GPS and commercial LEOs to pinpoint location of mobile shipments. This paper examines the current state of AIT in the DoD with concentration on RFID in the Republic of Korea. It also addresses the commercial use of satellite technology, and examines one possible scenario involving the integration of LEO satellite technology into the current DoD ITV structure.

I. Problem Statement

Theory

According to Griffin, during World War II, government officials and scientists in England and the United States worked to help the military deploy its resources more efficiently and effectively (Griffin, 1999: 49). The techniques and processes developed while tackling the war's most critical issues led to essential, complex mathematical procedures used to solve the logistical problems that we still face today in the United States armed forces. The ideas established during the war were later used by giant American corporations in some of their most daunting tasks involving employment of manpower and resources. The management theory that naturally evolved out of these situations has come to be known as the Quantitative Management Perspective (QMP) (Griffin, 1999: 49).

Operations Management (a subset of QMP), as explained by Griffin, is a less mathematical process that involves techniques that are generally concerned with helping the organization produce its products or services more efficiently. For instance, Operations Management techniques for today's industry include solutions for problems such as planning flight schedules for a major airline, and developing shipping routes for the trucking industry (Griffin, 1999: 49). These two particular theories in management apply directly to the massive logistical effort involved every time the United States military becomes involved in any operation or contingency. Out of necessity, this effort involves more than just moving the assets into the theater of operations. It also entails the tracking of this equipment during deployment, sustainment and redeployment, which requires a process that is well thought out and effectively engaged.

It is the endeavor of this paper to determine whether or not the use of LEOs will improve visibility of assets in the DoD during these logistical efforts. A careful examination of the use of this technology in commercial enterprise may provide an avenue to project how well it would work if employed militarily. To this end, a brief history of ITV and problems encountered in pursuit of a workable ITV strategy will precede an example of the infrastructure needed to support the current RFID AIT plan. The paper will then shift its focus to commercial applications in the realm of satellite tracking, with concentration on LEOs. Next, a possible plan for integration of satellite tracking technology into the military's existing ITV/AIT network will be presented, along with data concerning industry and DoD ITV efficacy. Finally, benefits and solutions to past and existing problems with ITV will be discussed should the DoD adopt this new technology.

History

Since the end of the Cold War, we began a drawdown that resulted in the need for the military to become an expeditionary force. That is, whenever embroiled in a controversy, we no longer have the luxury of a large amount of assets and personnel stationed abroad that we could tap into as we used to, which forces us to move everything we need to fight the war every time something comes up. Therefore, the need for precise measurement and tracking has now become paramount as the very success of the operation is at stake if we can't make it happen logistically. Moreover, the warfighting

CINCs, not having immediate access to what they need to engage, have become concerned with the tracking of personnel and equipment into and within the theater of operations. It is the entire process that makes up intransit visibility (ITV) that they are depending on.

Consideration should be given at this point to the concept of ITV with AIT acting as facilitator. With AIT, we are currently working on the ability to give warfighting CINCs the information that they need, to include exact location and delivery time of personnel and assets. We are doing this by using the great number of standard devices already mentioned. In the future, the list may also include real-time visibility through space-based technologies.

According to the Defense Intransit Visibility Integration Plan, ITV is

> the ability to track the identity, status, and location of DoD unit and non-unit cargo (excluding bulk petroleum, oils, and lubricants); passengers; medical patients; and personal property from origin to the consignee or destination designated by the CINCs, Military Services, or Defense agencies, during peace, contingencies, and war. (DoD, 1997: B-1)

In an effort to secure this ideal of ITV, USTRANSCOM "is developing the Global Transportation Network (GTN) as a command and control information system to aid in satisfying its mission of global transportation management…GTN is the heart of DoD's ITV operation. It will be DoD's single source of intransit shipment information" (DoD, 1997: 1-3). GTN is further defined as a complex network of DoD and commercial computer systems that is fed information from 19 military systems spanning all 4 services, and from 28 commercial carriers. The GTN architecture enables the processing of 2 million data transactions daily (Global Transportation Network, 1999).

Data collected from ITV/AIT systems are stored in the Global Transportation Network (GTN), and are directly reflected in the Global Command and Control System (GCCS) and the Global Combat Support System (GCSS). These databases give the warfighting CINCs the vital information they need to conduct operations effectively. The following paragraphs illustrate the need for improved tracking systems interfacing with these databases especially during the ever-changing climate we find ourselves in—the shrinkage of our overseas presence.

Operations Desert Shield and Desert Storm required an unprecedented movement of personnel and supplies from the continental United States to the Middle East Theater of operations. Although transportation personnel were able to meet this increased logistical challenge, their success was hampered by their lack of ITV of assets moving into and out of the theater (DoD, 1997: iii). Simply stated, poor ITV had a severe impact on operations. For example, more than 20,000 of the 40,000 shipping containers entering the theater had to be stopped, opened, inventoried, resealed, and reentered into the transportation system because their contents were unknown. The effect of these inefficiencies was the unnecessary delay of time-sensitive cargo to the supported CINC, which correspondingly resulted in the reordering of the same item more than once (DoD, 1995: 1-1).

Following Operation Desert Storm, the DoD continued its large-scale drawdown. The restructuring was aimed at reducing inefficiencies throughout each branch of the armed forces, and it marked the beginning of a new era of military strategy—shifting from one of *forward presence* to one of *force projection*. The philosophy was that we would reduce our military footprint around the globe by reducing the number of permanent military bases on foreign soil, thereby creating an efficient, cost-effective military force. One disadvantage of this stateside consolidation was the loss of a large portion of the military's ability to preposition equipment and personnel close to the anticipated battlefield—a disadvantage that has upped the ante for those involved in ITV, as it has increased the amount of assets in the system at any given time (Danigole: 1999).

Not knowing where your equipment is or when it is to arrive when you are conducting theater warfare or supporting a contingency is a predicament that commanders never want to find themselves in and will do almost anything to avoid. A system of intransit visibility that can handle this ever-increasing quantity of assets in theater with improved automated identification technology and connectivity with GTN will ensure that they never have to face such a scenario.

The DoD has acknowledged that effective logistics and accurate accounting of the same are critical to our national security. The unprecedented flow of material, provisions, equipment and repair parts is absolutely vital in the support of forward deployed forces, and permits continued power projection of the United States armed forces (Hughes, 1994: 1). The focus of this paper is to address the critical issue of maintaining visibility of assets in the theater of operations. The tracking of these assets from the time they arrive in-theater until they reach their final destination at the forward operating base (FOB) remains the weakest link in ITV. As we improve the system with which we monitor in-theater assets, warfighting CINCs will be able to more correctly ascertain material location. A more accurate accounting of assets will have a direct impact on national security objectives, allowing us to address the critical nature of logistical processes in theater.

ITV as a System

The idea that these ITV processes comprise a "system" further enhances our understanding of its inner workings. According to Griffin, a system is an interrelated set of elements functioning as a whole and is essentially made up of four elements. First, are the *inputs* into the system from the environment. We can categorize the military as the "environment" that our intransit visibility machine is in, and the inputs are the warfighting equipment and people needed for the operation. The second part of our system is the *transformation* process where the assets and personnel are merged into an expeditionary force that is singular in its purpose. The third facet is the *output* of the newly formed unit back into the environment (military in the theater), where the warfighting CINC receives and employs it. The final, and crucial, part of the system is the *feedback* directed back into the system after the environment has the "system's" product in hand (Griffin, 1999: 51). In the context of intra-theater operations, this feedback is critically linked to the massive databases that CINCs draw from (GTN, GCCS, and GCSS). The CINCs are able to both receive feedback from it (keep their eye on what's coming), and to put feedback into the system (their current requirements).

Lessons involving breakdown of this system tracking are plentiful. To convey the weight we have placed on the ITV shortfalls following the Gulf War, General Hansford T. Johnson, former commander of The United States Transportation Command (USTRANSCOM), stated that

> ultimately, the Global Transportation Network will be *the* automated data processing system for USTRANSCOM. We will still have something like JOPES…for various operations plans. But you have to have a way of communicating the transportation requirement from JOPES to the mode operator. Then you have to follow the shipment, advise the customer when it is arriving, and provide feedback. GTN

> will do that. But in doing so, it will allow us to have total asset visibility, at least for the time the cargo is in the transportation system. It allows us to execute our missions with better, more timely information. It allows everybody in the system to know the same thing at the same time. (Matthews, 1996: 26)

This quote consolidates many concepts together into a concise mission statement for ITV. Accountability of supplies and information regarding its location and status is critical to theater warfare or when supporting a contingency. Poor information not only spells trouble for the military with its multi-billion-dollar logistical train, but also for the supported CINC as stated earlier.

Especially noteworthy for this paper are his statements “follow the shipment” and “total asset visibility”. In my opinion, tracking assets with the aid of LEOs would provide for everything General Johnson envisioned. It would also take his concept of ITV one step further by helping to secure not only inter-theater, (cargo in the transportation system), but also intra-theater ITV and place it at the fingertips of the warfighting CINC.

A Possible Solution

Satellite tracking would assist us in securing a piece of total asset visibility, giving us the ability to track shipments all the way to the forward operating base (FOB), without the need for the massive infrastructure required for current tracking technologies. Equipment monitoring would be accomplished by attaching small communications devices and GPS receivers to selected theater assets. Signals containing the equipment’s location, specification, speed and other critical information could be automatically passed on to the satellites that have coverage in the area of operations. From there, this information would be stored in the satellite until it came into contact with the nearest earthstation, where the data would be downloaded, and then subsequently forwarded into the GTN system. Assets could be monitored continuously, or only at predetermined intervals and/or events. The industry's stated "standard" time from data uplink to entry into the users system is six minutes, but responses below one minute are not uncommon. Data is uplinked to satellites via burst technology, and therefore has an inherent high degree of security built in without encryption. This technology is already being used effectively in private sector trucking industry, saving corporations millions of dollars through effective management of trailer assets (Glazar, 1999).

Research Question

Can intransit visibility be improved with the incorporation of LEO satellite-based tracking of assets?

Due to its critical nature, asset tracking in the DoD is an area on which considerable effort has been expended. The intention of this research project is to substantiate satellite tracking technology as a viable option for United States armed forces ITV. Use of this technology could provide decision makers the vital link they need to pinpoint equipment location expeditiously through standard electronic databases. Adoption of satellite tracking of DoD assets entering theater via airlift movements may provide the critical connection between inter-theater and intra-theater ITV, providing capability to activate immediately when exiting aircraft arriving into theater. This would afford unit movement visibility en route to the FOB, and in the future, could substantially reduce the need for massive infrastructures, and significantly decrease the number of personnel usually needed to perform manpower-intensive ITV tasks.

Commercial industry has already proven that satellite technology has great merit, boasting a superior record when employed in the tracking of trailers for the trucking industry. The common thread existing between the trucking industry and the DoD is that we are both interested in monitoring movement of our equipment over large distances.

Investigative Questions

1. *What is the current state of intransit visibility, especially as it relates to RFID Automated Identification Technology?*

Current AIT in the DoD incorporates many "standard devices" to include bar codes (both linear and two-dimensional), optical memory cards, radio frequency tags, smart cards and common access cards to electronically track assets and personnel through established databases. These standard devices represent the majority of current AIT technologies in use, however, only those technologies utilized in the movement of unit equipment will be addressed in this paper—with concentration on RF technology given that it is the most capable at present. Considering this constraint, the intensive task of intra-theater ITV will be examined using the Korean peninsula as an example of current RF infrastructure. It will be made evident that significant infrastructure and capabilities are required to ensure visibility of assets in theater as it is moved toward the FOB. Following this discussion will be some conclusions made concerning the state of ITV in the Pacific theater.

2. *How have commercial enterprises employed the use of satellite technology in tracking their equipment?*

There is evidence in the trucking industry today to suggest that satellite tracking of organizational materials is the most effective way of monitoring progression of mobile assets. ORBCOMM currently provides tracking for tens of thousands of trailers across the United States, Canada and Mexico. Asset monitoring is accomplished by fastening a two-way active terminal on each rig that is provided the service. After installation, tracking is totally automatic. Satellites can pinpoint locations of trucks and even monitor load conditions and temperature if the trailer is a refrigerator unit (Cottrill, 1999:43; Hickey, 1999a: 37). This capability has allowed the trucking industry to make significant progress in trailer tracking and security, and has subsequently become an extremely important area of development.

3. How would low earth orbit satellite tracking of assets be effectively integrated into existing DoD systems? How would this integration improve the state of ITV in the DoD?

The DoD currently uses Systems Processes Engineering Corporation's (SPEC) Falcon SATCOM Gateway to track aircraft and assets on their way to the theater. The information processed by this system is uplinked to INMARSAT and then electronically liked to military databases, thus yielding adequate ITV up to that point. However, from the moment of arrival in theater, DoD assets make their way to a number of locations, usually without our knowledge of where they are at any given time. This is especially true during wartime and contingencies in countries where no infrastructure has been developed to aid in equipment tracking. The solution to this problem could possibly be found in a system that accurately tracks assets without the need for theater infrastructure support. The type of system offered by ORBCOMM can be integrated into our existing capabilities beginning at the moment of equipment arrival in the theater of operations. It could be used specifically in conjunction with movement of assets into theater via airlift, picking up where systems like L-Band leave off, or it could be used in a general sense over the whole spectrum of intra-theater asset movements. Stated another way, potential benefits of this technology need not be restricted to one specific function, but could be used over the broad range of ITV requirements, including airlift, sealift, rail, and linehaul movements.

The bulk of Chapter IV deals with a scenario involving the monitoring of a specific unit after their arrival into theater via *airlift* assets. The scenario illustrates a circumstance where the use of this technology would fill a definite void. This is not to say that satellite technology couldn't be of great use tracking unit equipment in movements such as Turbo Intermodal Surge or Foal Eagle where infrastructure and procedures for ITV are already established. In either case, the system would uplink information from assets equipped with tracking devices and forward it to selected military databases, including GTN. This electronic integration of intra-theater ITV information would provide a very powerful tool for warfighting CINCs allowing them ready access to data concerning unit/equipment progress en route to the FOB.

The problems encountered during Desert Storm, and to a lesser degree in Kosovo, highlighted instances where knowledge of DoD assets in theater was non-existent. The proposed system of LEO satellite tracking with direct interface with GTN would provide solutions to these problems, giving real-time visibility to equipment in theater.

Research Design and Methodology

The AIT concept described in this proposal, once accepted as a "standard device," would have to be implemented in such a way as to provide enough data to test my overall hypothesis. This would entail a great deal of time and financing, and it is unrealistic that the scope of this project include the testing of my hypothesis in this way. However, in my interview with Rod Fischer of Systems and Processes Engineering Corporation (SPEC), I was informed of the possibility of SPEC sponsoring a one-time tracking of a selected asset on its journey from the CONUS to its designated FOB. This coordinated effort would at least provide us a window into what satellite tracking technologies could afford the DoD. This is probably the only realistic way the technology could be closely examined by the military within the timeframe of my writing this paper, or shortly thereafter. It is therefore obvious that a set of statistical data cannot be obtained to any significant degree. I have obtained information both from military and commercial sources, and have paid close attention to the analyses that these organizations have done on the efficacy of the technologies currently in place. I have gathered information by conducting interviews, researching journals, accessing military databases and drawing from self-assessments the DoD has completed in operations past. These assessments remain largely subjective and may require a qualitative means of analyzing data contained therein.

In Chapter IV, I compare asset-tracking data from the civilian sector and the military and try to quantify and benchmark processes already in use. Evidence of the efficacy of satellite tracking technologies in commercial industry is provided in an effort to show a relationship between its use and commercial productivity. From that point, it is argued that the LEO satellite technology used in civilian enterprise, if employed in the military would also have a positive effect on the quality of ITV.

Contributions to Theory and Practice

The subject matter has been thoroughly covered and the analysis of the information is presented in Chapter IV. As a result of this study, there is evidence that LEO satellite tracking of assets and personnel is an efficient and effective way to give warfighting CINCs the picture they need of the projection of force moving into and within theater. In addition, the AIT concept discussed may eventually save the military millions of dollars, even though at the outset it might seem to be not within our budget. Moreover, the proposed technologies may prove to be an ideal that has far-reaching effects and should be adopted early enough to receive the full benefit they can offer.

Further, contributions have been made to theory stated early on in this proposal, as once again the systems approach has been tested and borne out, reflecting positively on the overarching theory of Qualitative Management Perspective.

II. The Current State of ITV

IQ1. *What is the current state of intransit visibility, especially as it relates to RFID Automated Identification Technology?*

Introduction

Current AIT in the DoD incorporates many "standard devices" to include bar codes (both linear and two-dimensional), optical memory cards, radio frequency tags, and multi-technical automated reader cards to electronically track assets and personnel through established databases. Although these represent the majority of AIT technologies presently in use, only those technologies utilized in the movement of unit equipment are addressed in this paper—with concentration on RF technology given that it is the most capable at present. Bearing in mind this constraint, the demanding task of intra-theater ITV data collection will be examined using the Korean peninsula as an example of current RF infrastructure. It will be made evident throughout that significant infrastructure and capabilities are required to ensure visibility of assets in theater as they are moved toward the FOB.

TRANSCOM's ITV Vision

The ITV mission of USTRANSCOM as stated in their <u>In-Transit Visibility</u> briefing is to "(p)rovide the capability to track and identify (the) status and location of DoD unit/non-unit cargo and passengers from origin to destination." As the DoD proponent for ITV, USTRANSCOM executes this mission by employing some of the latest state-of-the-art AIT equipment mentioned above. These technologies assist them in carrying out their vision to "provide CINCs, (and) Services…near real-time visibility over all movements, assets and options" (Bass, 1999).

Near real-time visibility principles include timeliness standards that describe exactly when assets transiting into or out of theater must "appear" in electronic databases. For instance, for all sustainment sealift shipments, ITV information must be visible in GTN within 4 hours of arrival or departure. Unit strategic movements and sustainment airlift must be visible in GTN within one hour, and intra-theater and CONUS shipments within two hours. These standards allow for the prompt updating of GTN and aid in subsequent tracking of assets into and out of theater. Timely and accurate source data capture also contributes to the overarching concept of information fusion for the warfighter in theater (DoD, 2000: vii). The ideal of information fusion provides for the ability to access movement data from a single database to aid in battlefield situational awareness (Garrity, 2000).

Pertinent actions to bring about TRANSCOM's ITV vision through FY03 are delineated in the U.S. Transportation Command Automated Identification Technology Integration Plan. Its major tenets are:

- Develop deployable AIT capabilities
- Maintain radio-frequency identification interrogator networks at selected ports
- Use linear and two-dimensional bar codes
- Accept smart card manifests for deployment at aerial ports
- Establish a baseline for future enhancements (U.S. TRANSCOM, 1999)

These tenets will guide expansion of AIT infrastructure to achieve the DoD/ TRANSCOM goals of developing AIT capability at 161 ports, which include deployable capabilities for contingencies and exercises to support customer information requirements. USTRANSCOM will integrate AIT capability into its ports over the next four years. The integration will take place in two phases with plans to integrate RFID—both fixed and deployable—on a limited basis. The overall projected cost of this plan ranges between $33.3 and $46.2 million (U.S. TRANSCOM, 1999: iii, v).

The tenets pertaining to RFID and deployable capabilities, as well as future enhancements are addressed in several different locations throughout this research paper and are at the core if its message. At the macro level, this paper will first define what we do currently in the DoD to track our assets in theater, be it with deployable "fly-away" AIT infrastructure, or with the permanent interrogator networks already established—as in the case of the ROK. Next, a possible "future enhancement" will be addressed in the realm of satellite technology that could perhaps compliment current ITV strategies, and provide solutions to capturing visibility in austere theater locations.

Why Examine RF Technology?

The reason for specifically examining the RF infrastructure in the DoD is that it allows one to look into the type of infrastructure necessary to provide the closest thing we know to real-time visibility of assets in theater. Warfighting CINCs are concerned with capturing accurate and timely ITV information, and have seen superior results with RF technology when tracking ammunition, sustainment cargo, unit movements, medical supplies and mission essential spare parts (In-Transit Visibility, 1999).

As of this writing, most of the RF technology and infrastructure belongs to the United States Army, and therefore it is not used ubiquitously across the full spectrum of ITV. Rather, RF technology is located at key APODs, SPODs and transportation corridors in order to monitor Army movements. The greatest concentration of RF infrastructure, found in the Republic of Korea (ROK), enables the Army to monitor unit movements to any number of TAAs. After a brief description of RF technology and its capabilities and a look at the infrastructure in place in Korea, conclusions are drawn as to the current state of ITV both in the Pacific theater and otherwise.

It is not an easy task to provide CINCs with a comprehensive picture of equipment arriving into theater, especially with decreasing budgets and declining manpower. To address this great undertaking, there has been increased attention in recent years to the military adaptation of commercial off-the-shelf technology (COTS). Indeed, the appropriate use of COTS has tremendous benefits because it allows the DoD to leverage technology to its advantage while saving both the time and cost associated with research and development. A commercial off-the-shelf technology that has shown outstanding ability in its application in the AIT realm is Radio Frequency Identification (RFID) (Danigole, 1999). The company currently awarded the COTS RF contract for the Military Transportation Management Command is the Unisys Corporation. It provides warfighter support in locations such as Kazakhstan, Europe, Korea, Haiti and Bosnia (www.unisys.com, 2000).

RFID, as the name indicates, uses radio signals to provide automated identification of items. While it is similar in function to the bar-code systems that are used for pricing and inventory control in the retail industry, it involves more recent technology and has significantly greater capability. The basic RFID system consists of an antenna or coil, a transceiver with decoder, and a transponder. The transponder is commonly called an "RF Tag" and is electronically programmed with unique information about the tagged item—in the DoD, this unique information usually takes the form of a TCN. The antenna emits radio signals to activate the tag, while reading and writing data, forming a conduit between the tag and the transceiver. The antenna is often packaged with the transceiver to become a reader (or "interrogator"), which can be either hand held or fixed mounted (AIM, 1999). Interrogators can be installed at strategic locations called "choke points" that shipments will pass through at initial staging areas, POEs and PODs. In addition, as in the case of the Korean peninsula, choke points are also located en route to the TAA and other destinations (Radio Frequency, 1999: 17). The interrogator emits radio waves in ranges of 1 inch to 300 feet or more (Garrity, 2000).

When an RFID tag passes through the electromagnetic zone, it detects the interrogator's activation signal. The interrogator then decodes the data encoded in the tag and transmits it to the regional server for processing, recording the exact time each piece passes by (AIM, 1999). Eventually, through a series of electronic interfaces, the information is provided to USTRANSCOM's Internet-based GTN system.

Tags can be categorized as either active or passive. Active tags contain a battery that gives them greater range than passive tags, and they typically have read/write capability. Relative to passive tags, they are larger, more expensive, and are limited by battery life. Passive tags have virtually unlimited life and are more likely to have read only capability (AIM, 1999).

Although the capabilities of a fully integrated RFID system are vast, the DoD may be unwilling to commit itself fully to the technology, as it is still priced significantly higher than other AIT devices. However, according to Kevin R. Sharp, Technical Editor for ID Systems, the technical capabilities of RFID translate into benefits that are impossible to achieve economically with any other automatic identification technology. Tagged items can be quickly and accurately identified, even if an object comes between the reader and the tag. Destination and routing codes can be easily changed, and a system can be designed that purposely presents more than one item at a time for identification (Sharp, 1999).

Although Sharp approaches the benefits of RFID from a commercial perspective, the technology has been embraced for its obvious military application—as previously stated. In fact, the *Implementation Plan for Logistics Automated Identification Technology* produced by the Department of Defense specifically mentions the need for a comprehensive strategy for using RFID technology stating that it is "best used when standoff container or pallet content visibility or enhanced intransit visibility (ITV) is required" (DoD, 2000: vi). It is the establishment of that capability that will now be explored as we shift our attention to the RF infrastructure that has been built up on the Korean peninsula.

RF in the ROK

For several decades, the threat to U.S. national interest has been very real in the ROK. Consequently, it has been rightfully assigned as one of the two major theater conflicts we plan for during wartime. From this perspective it becomes clear why the DoD, and specifically the U.S. Army, would want to keep a close eye on the movement of unit equipment into theater TAAs—knowledge of asset location equates to power in a wartime scenario. To accomplish the complicated task of keeping track of assets on their way to the TAA, construction of the RF infrastructure on the peninsula began in earnest in early 1996. The concept was to establish an RF AIT infrastructure to capture ITV data of critical sustainment cargo passing through key transportation nodes in country. The functional interrogators depicted in figures 1-6 are those that are currently providing data to the regional ITV server, while the contingency interrogators can be physically established when required (Christian, 1999).

Special attention was given to the effective application of RF technology to monitor the intra-theater movement of ammunition and spare parts. To that end, Kimpo International Airport was established as the key APOD for monitoring movement of spare parts into theater (Fig. 1), while the seaport at Chinhae has been identified as the key ammunition SPOD (Fig. 2) (NOTE: All ports with RFID are shown). To further illustrate this infrastructure in theater, RF collection sites set up for the sole purpose of tracking spare parts (Fig. 3) and ammunition (Fig.4) are shown (Christian, 1999).

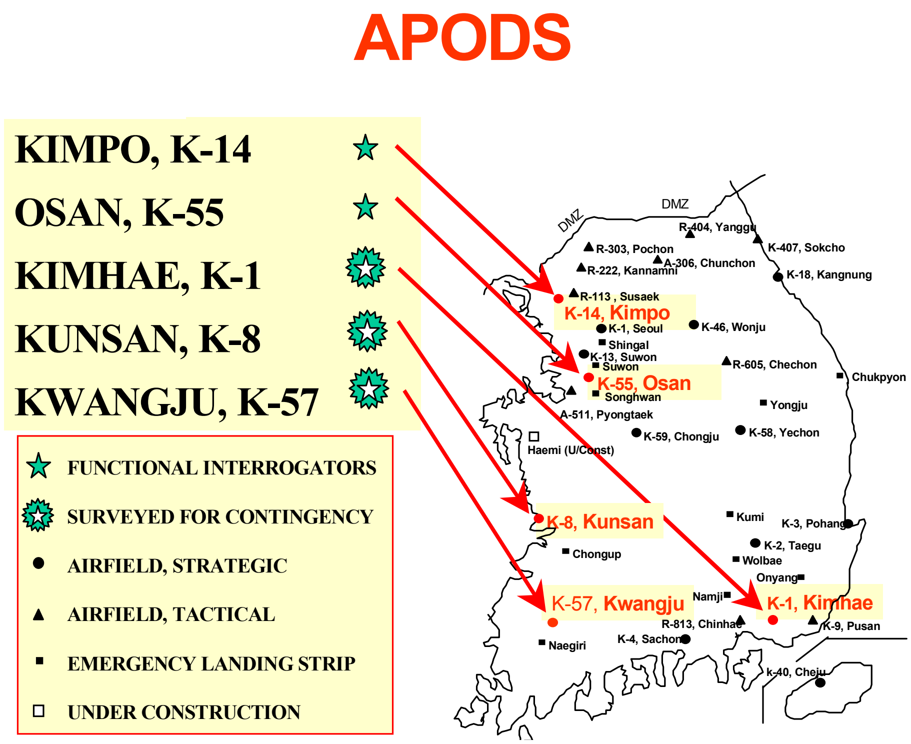

Figure 1. RF Equipped Air Ports of Debarkation (Christian, 1999)

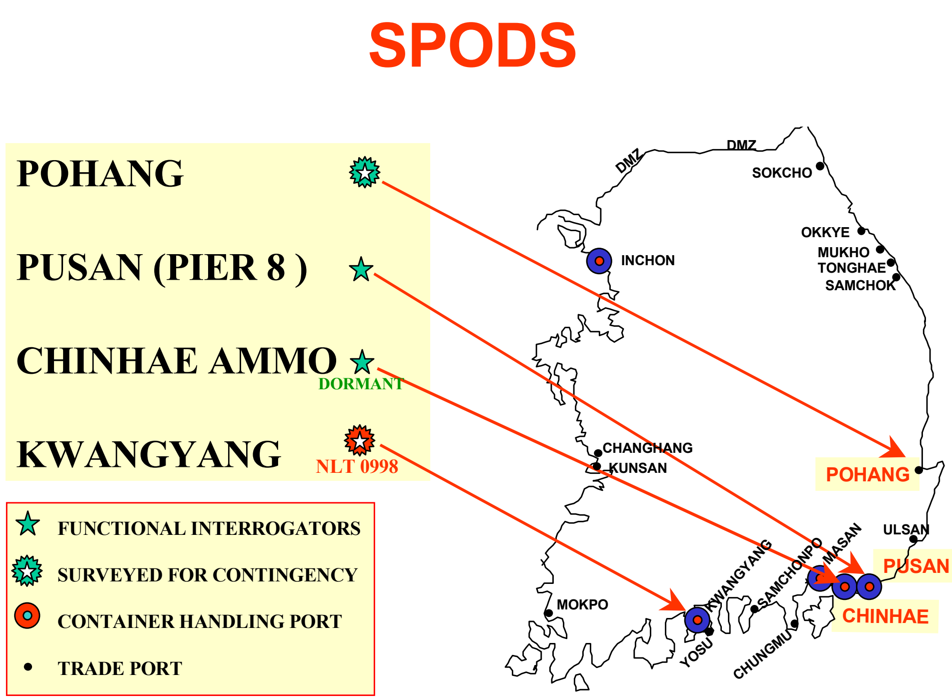

Figure 2. RF Equipped Sea Ports of Debarkation (Christian, 1999)

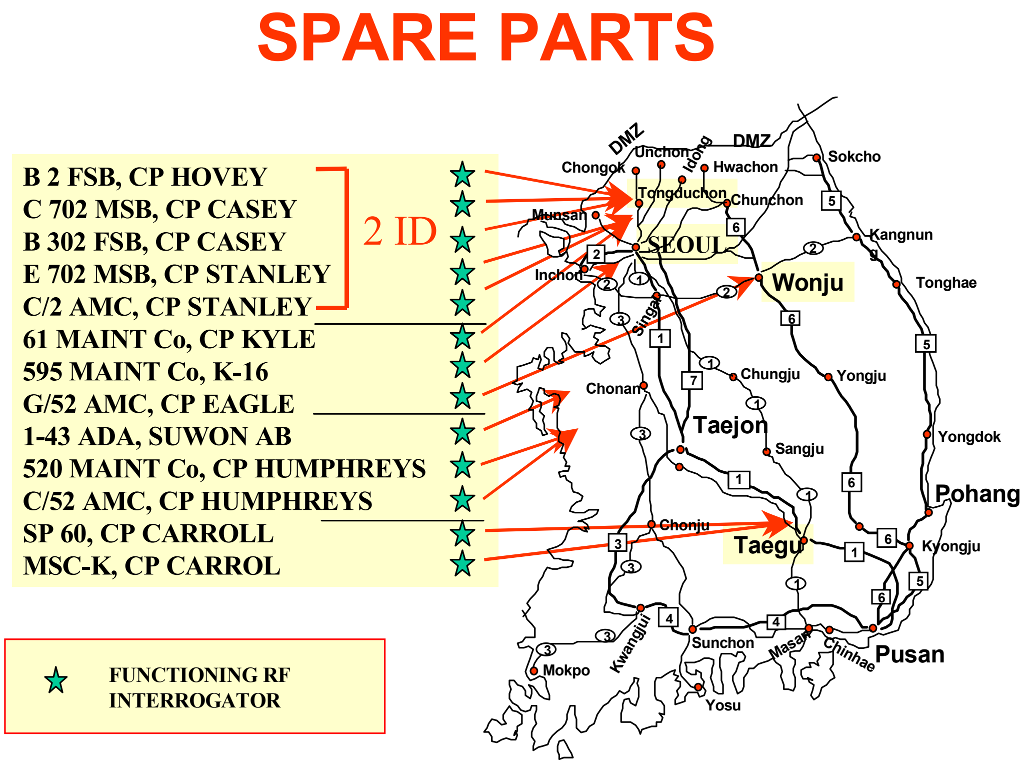

Figure 3. RF Sites for Spare Parts (Christian, 1999)

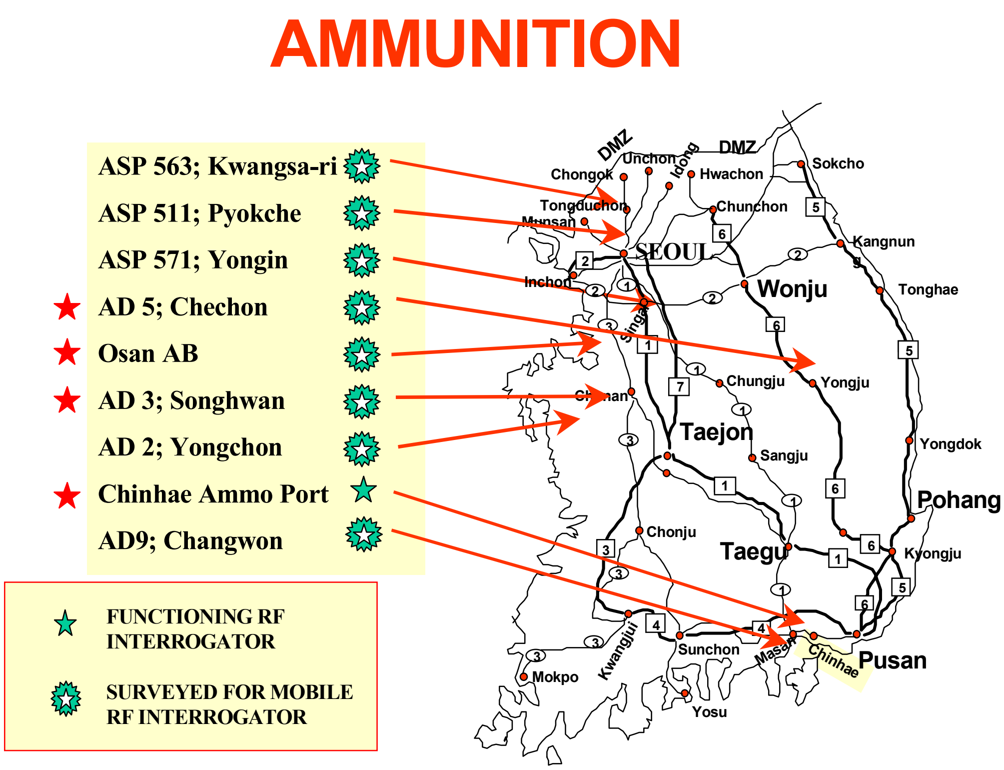

Figure 4. RF Sites for Ammunition (Christian, 1999)

The infrastructure to track spare parts (Fig. 3) is by far the most mature and complete, as there continues to be a great need in theater for the tracking of high-priority Mission Impaired Capability Awaiting Parts (MICAP) (Davila-Martinez, 2000). This infrastructure has been permanently established, while infrastructure laid down for ammunition movement (Fig. 4) is only temporarily set up according to need and only for the duration of ammunition reception or retrograde periods (Christian, 1999).

To date, no permanent rail choke points have been established. However, once activated, the contingency nodes depicted for rail would support the intra-theater movement of unit equipment. These nodes represent excellent locations to choke and identify unit equipment with manned “fly-away” interrogators (Fig. 5) (Christian, 1999).

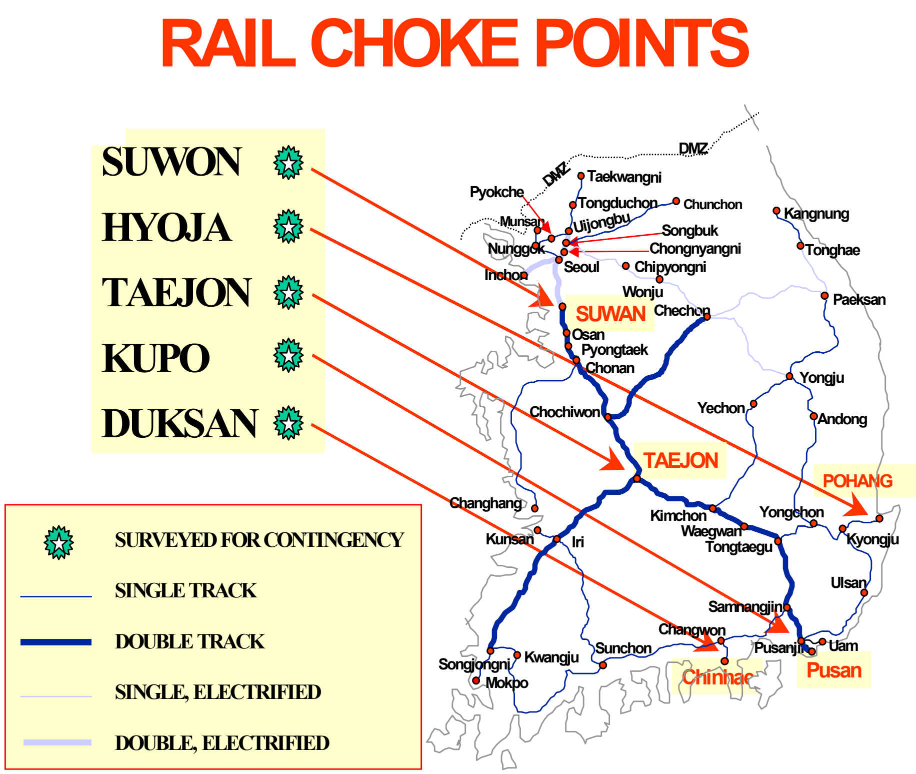

Figure 5. RF Rail Choke Points (Christian, 1999)

Movement Regulating Teams would also employ "fly-away" interrogators to capture ITV on main supply routes. The routes depicted in Figure 6 are those to be used in the tracking of unit equipment to TAAs from APODs and SPODs (Christian, 1999).

The intent of ROK infrastructure is to provide logisticians accurate information on time and content of arriving materials in order to:

- Assist in locating/tracking shipments thereby decreasing redundant requisition
- Provide a means for analyzing shipping time and processes (metrics)
- Develop concepts and experience in DoD initiatives of Focused Logistics and Joint Total Asset Visibility (JTAV) (Christian, 1999)

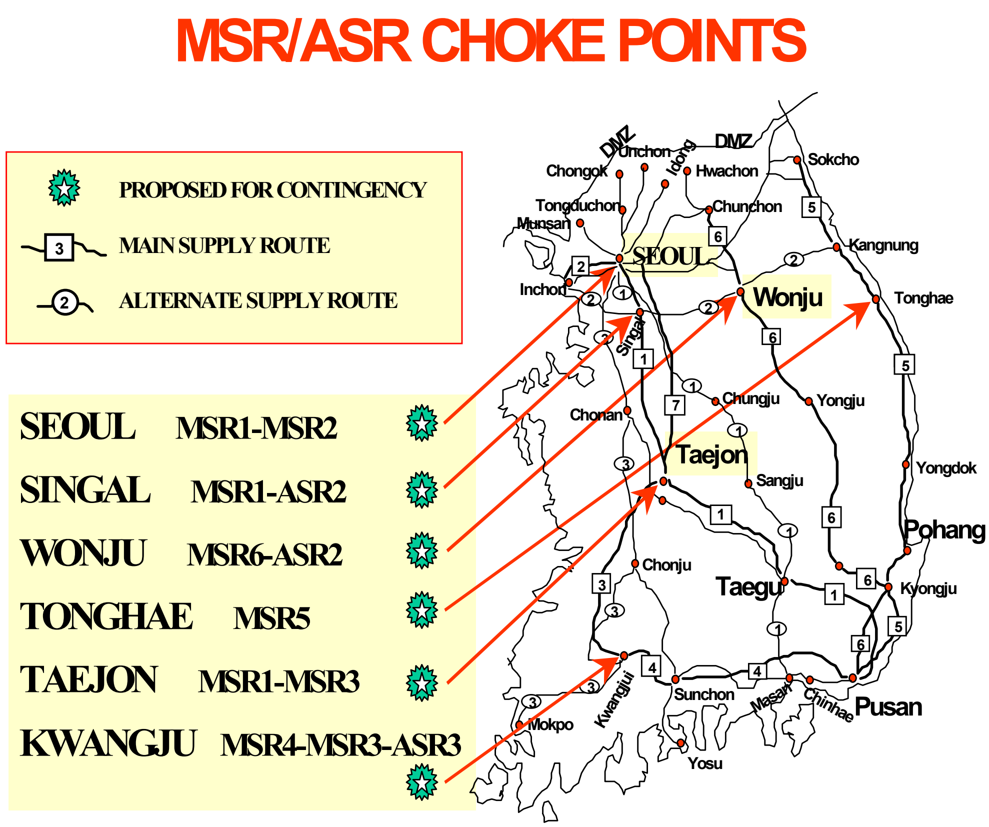

Figure 6. Main and Alternate Supply Route RF Choke Points (Christian, 1999)

Focused Logistics and JTAV are part of the overall plan of providing information fusion in theater. The goal of this fusion is to provide situational awareness to support those involved in the war effort by accurately capturing source data and distributing that knowledge through appropriate electronic databases allowing all concerned parties access to critical theater information (Garrity, 2000).

RF Challenges and Issues

There will continue to be many unique challenges encountered as RF infrastructure is established at contingency locations. These locations will become vital when the peninsula becomes inundated with sustainment equipment and supplies to augment a contingency and/or war effort. It is therefore imperative to ensure that sufficient infrastructure and capability exists when that time comes. What this may mean is laying down infrastructure at additional locations (not depicted) to facilitate complete visibility. Additional funding will almost definitely be required to accomplish this task. During the last two fiscal years, FY99 and FY00, approximately $9 million has gone into the budget for PACOM ITV and AIT projects, much of which will be spent to improve the infrastructure in the ROK. Since 1996 several million dollars have been expended in RF infrastructure on the peninsula (Davila-Martinez, 2000)

Specific challenges for contingency infrastructure include:

1) The lack of a dependable communications infrastructure; 2) Dealing with Korean bureaucracy on issues involving the installation of equipment on non-U.S. property. For instance, when surveying rail choke points, teams had to interface with representatives

from Korean National Rail and the Ministry of Defense; 3) Fly-away interrogators with untethered communications are not yet fielded as of this writing; 4) And, the general "fog" encountered when working "outside-the-box" with no established procedures (Christian, 1999).

After Exercise Foal Eagle '99, additional items concerning the shortfalls for RFID in PACOM were identified. First, it was found that ITV systems monitoring the movement of the tags could not differentiate between two vehicles shipped separately and a single shipping container housing two vehicles. This remains a problem today, because the system as it stands does not accurately account for equipment moving in the theater. Another problem acknowledged during the Foal Eagle hotwash was the issue of interrogating tags on moving trains. The Unisys project manager has identified the need to determine how to define "success" when interrogating tags on a moving train. Currently, trains can exceed the capability of rail-side interrogators depending on how fast they are traveling, only reading a percentage of tagged cargo. Discussion at present centers around whether or not the Services can accept this shortcoming, and if they can, to define a ratio of tags to be read that will satisfy the requirement to provide ITV of the train contents. The hotwash further identified the need for services to develop policies on reuse and return of RF tags to their originating stations. This issue has been brought up in the past, but continues to be a significant concern due to the high cost of tags and high loss/damage rate (Garrity, 2000).

Additional areas of concern and current ITV issues in the Pacific theater are as follows:

- *Data integrity*. This is an ongoing problem that is a result of improper data entry into the ITV system. Once the data has been entered incorrectly either on a tag or directly into a database, it continues to be passed along, thus misrepresenting equipment information in the system.
- *Standardization*. There are numerous ITV databases providing visibility on DoD cargo making standardization of data entry quite difficult, if not impossible. The key is to develop a system that is truly Joint, thereby eliminating the need to translate data from one system to another.
- *Loss/Damage*. The need to develop a cheaper and more reliable form of RF technology remains an issue due to the high cost of replacement. An expendable RF tag is not out of the question.
- *AIT "ownership"*. It is imperative for users in the ITV structure to take ownership of processes that ensure equipment entry into electronic databases. It has been evidenced in the past and highlighted again in Foal Eagle that units desiring visibility on their assets have not incorporated sound ITV/AIT doctrine into their business practices. This has resulted in equipment being improperly marked, incorrectly entered into databases and not accurately accounted for during deployment. A "top down" solution has been suggested which relies heavily on superiors stressing the importance of ITV and ensuring their people are properly trained in AIT technologies. Additionally,

there are still no "standard" ITV/AIT practices at the unit level, which continues to make consolidation of data difficult.

- *Communications bandwidth.* RFID communications are reliant on securing bandwidths in order to operate in theater. Using these bandwidths requires the host nation's permission, and has been a source of contention in the past necessitating close coordination and sometimes excessive payment to the host nation. Additionally, bandwidths are sometimes simply not available for use, thus hampering ITV in theater (Garrity, 2000; Davila-Martinez, 2000)

Summary

Used in the right way, the AIT technology in the ROK can be an effective force multiplier accurately gauging force closure into theater in addition to sustainment activities. Knowledge equates to power, and technologies used on the peninsula have increased both our knowledge and power dramatically. Moreover, advanced technologies employed in theater such as satellite tracking have also proven to be extremely valuable, as they require no infrastructure in theater and therefore face no threat of being lost, damaged or destroyed by the enemy. Although the Defense Transportation Recording and Control System (DTRACS) and Movement Tracking System (MTS) are not addressed in this paper, they represent two of the satellite-based methods of monitoring unit movement that are currently complimenting RF infrastructure in the ROK. The satellite tracking technology offered by ORBCOMM that is presented in Chapters III and IV could prove to be another ideal way in which to augment current ROK ITV capabilities and help to ameliorate the shortcomings delineated above. However, the capabilities afforded by the ORBCOMM product are presented in this paper as a possible solution to ITV shortfalls primarily in locations without infrastructure, and specifically to those shipments arriving in theater via airlift.

The requirements for ITV over the long term will not remain static. The process of gathering information and correctly ascertaining location of unit equipment will continue to mature over time, necessitating innovations that will bring unique capabilities to the table. The "baseline for future enhancements" that the TRANSCOM AIT Plan provides for the ITV structure has been laid in such a way as to facilitate the integration of these innovations, such as those elucidated in the following chapters. In the future, timely and accurate data entry from the Services and feeder systems will continue to be of utmost importance as new systems come on line. This is especially true in the realm of intra-theater ITV where a large gap in asset visibility still exists (Bass,1999).

III. Employment of Satellite Technology in Commercial Enterprise

IQ2. *How have commercial enterprises employed the use of satellite technology?*

Introduction

There is evidence in the trucking industry today to suggest that satellite tracking of an organization's materials is the most effective way of monitoring progression of mobile assets. ORBCOMM currently provides tracking for tens of thousands of trailers across the United States, Canada and Mexico. Asset monitoring is accomplished by fastening a two-way active terminal on each rig that is provided the service. After installation, tracking is totally automatic, and the unit can operate on its own battery power for up to two months. Satellites can pinpoint locations of trucks and even monitor load conditions and temperature if the trailer is a refrigerator unit (Cottrill, 1999:43; Hickey, 1999a: 37).

This capability has allowed the trucking industry to make significant progress in trailer tracking and security and has subsequently become an extremely important area of development. In addition, the technology has the ability to transform the industry and make it one of the most profitable and efficient systems to ever come along, serving to better trucking's standing and perception among competing modes of transportation.

We live in an age where the transportation industry (to include the DoD) is being governed more and more by the need for precise knowledge of shipment location. In the trucking industry, this need has been fueled by what is called Just-in-Time inventory systems, or JIT. This system is based on a production approach in which the firm maintains small quantities of production inputs. The process allows a commercial enterprise to use less warehouse space and save money by having less inventory-related costs (Wood, 1996: 6). These constraints have placed a premium on asset location, due to the precision in which shipments must arrive at their designated drop-off point. The incorporation of a space-age tracking system complements, and in some part ameliorates, the stringent requirements that this new format demands in the transportation industry.

The idea is definitely catching on, as corporate giants such as J.B. Hunt and Schneider National trucking are jumping on the opportunity to use this new technology. The constraints placed on commercial carrier delivery is now sometimes down to a fifteen-minute window where being early is just as bad as being late. It can get hectic on dispatchers—who are tracking these rigs manually—to maintain a certain degree of accuracy, especially during contingency situations, diverts, and the like. But with satellite tracking of trailer assets, the dispatcher *and* management know where the load is in addition to its predicted arrival time with the simple installation of an active communication and GPS system that uplinks with a network of satellites.

Commercial Success Stories

The positive effect satellite tracking is having on JIT inventory systems in the transportation industry is clearly evident. Comcar Industries, based in Auburndale, FL has been doing business with QUALCOMM Inc. since 1993 and to date has had over 3,000 of their trailers equipped with QUALCOMM's Omni-TRACS system. This satellite-based communications system is not only keeping better track of Comcar trailers than ever before, but is also aiding in driver recruitment and retention efforts. In addition, one of Comcar's companies, Commercial Carrier Corp., is employing the QUALCOMM system throughout the Southeast, with its primary "theater of operations" in Florida proper (In this way, its operations are similar to ours as we enter a typical contingency scenario). Drivers are able to send messages when deliveries are completed, and automatic features relay details of the driver's next assigned load and location (Desmond, 1999a: 67).

Another prime example of industry taking advantage of the most recent technology is found in Eaton Corporation's Trucking Information Services Division Data. The system provides real-time two-way messaging allowing dispatchers to more optimally schedule loads and backhauls resulting in a commensurate increase in efficiency and savings to the company. The types of messaging currently being transmitted include hours of service, state line crossings, arrival and departure times, and driver and vehicle performance monitoring (Desmond, 1999b: 48). Systems like these—using what is called exception-based reporting which will only alert when a truck falls behind schedule, is speeding, or ventures off route—are allowing dispatchers to handle more than twice as many trailers while capturing actual odometer miles and GPS location (www.highwaymaster.com, 2000).

Such is the system that Abbot's Plumbing Inc. uses provided by FleetTrack—the employment of which has allowed the business to eliminate the dispatcher's position altogether. Tim Feldman, Vice President of Operations at Abbot's Plumbing says, "I can see the position of all our trucks superimposed on a map of our area just by switching to the right computer screen" (Desmond, 1999c: 34). The system has improved vehicle and trailer security as well, providing remote controls that prevent hot-wiring and theft that the fleet manager can activate from the base station. Other system functions include the ability to monitor cargo door position and entry and exit of driver from the cab. In addition, the FleetTrack system will automatically select the less expensive BellSouth Wireless Data system for message transmittal when within range of existing cell infrastructure (Desmond, 1999c: 34).

A final example of satellite technology successes in the private sector is Western Digital Corp., who suffered over $7 million in losses due to hijackings a number of years ago. Digital now requires all trucks shipping its products to be equipped with devices able to locate trailers via GPS and satellite communications. It has programmed the system to alert during specific events to inhibit theft and enhance the overall security of their product. Since the system was installed two years ago, there have been no losses due to hijacking, a significant statistic (Desmond, 1999d: 28).

It is also easy to see just what satellite tracking can add to commercial operations when considering *customer service* as defined by Wood. It can help ensure the product will arrive when it is wanted by closely monitoring its progress across the country. Additionally, the specific load can be categorized and updated in databases to ensure the desired load arrives at the correct location. Plus, the condition of the load can be continuously monitored as in the case of refrigerated loads where temperature conditions in the trailer are carefully maintained automatically by satellite communication to and from the rig. These specific enhancements to customer service are culminating in higher levels of satisfaction and will consequently give greater credibility to the trucking industry as a whole (Wood, 1996: 8).

In the case of *globalization* as defined by Wood, as we will see later, there is no limit on how far across the earth your product can be tracked because the satellites that comprise the space-based monitoring systems give coverage over the entire planet. This complete coverage allows the whole community of transportation providers and users to expand services, and streamline product production and delivery. The technology today is still in its infancy with only a few of the largest carriers being able to even consider adopting its powerful concepts, but the future seems to hold great opportunity for a wide variety of commercial enterprises (Wood, 1996: 8).

State of Current Technology

The trucking giant J.B. Hunt has recently contracted with Vantage Tracking Solutions—a business unit of ORBCOMM Global—to track 60% of Hunt's fleet of over 35,000 trailers. Vantage will do it by embedding communications and sensor technologies that will be in constant contact with low earth orbit satellites (LEOs). These sensors will detect when trailer is connected to the tractor, and if it is loaded or empty, as well as GPS position and a number of status reports to include conditions inside refrigerated units. All data collected and communicated via this system will be fully integrated into J.B. Hunt's fleet management and logistics systems to support the company's daily operations. Most of these functions are completely automatic, and if information is desired beyond the capability of the automated system, all fleet management would have to do is call up an individual driver and inquire as to his or her status (www.jbhunt.com, 1999).

Don Thoma, General Manager of Vantage, has stated that "J.B. Hunt is a visionary in its industry and has been a leader in utilizing its award winning technology to manage its complex and diverse transportation and logistics business." It is clear that ORBCOMM's network of satellites will be able to keep in close contact with any of Hunt's trailers whether they are moving down the road or parked in a customers lot half way across the country (www.jbhunt.com, 1999).

Now that the largest publicly traded truckload carrier in the United States (with revenues exceeding $1.8 billion) is contracting to use LEO service for satellite data and messaging communications services to monitor 60% of its total rigs, the rest of the industry can't be too far behind its lead—finances permitting. That is especially true when considering that in the next several years the system will probably be refined and cost will become less prohibitive to smaller organizations wanting a piece of the pie. (Note: ORBCOMM also has the ability to track other mobile assets to include rail cars, fishing vessels, barges and government assets. Therefore, the push for the quick maturation of this system, and subsequent deflation of the price may not be too far off) (www.jbhunt.com, 1999).

System Specifications and Capabilities

The Vantage tracker and its integrated sensor is a one-foot-by-two-foot unit installed on the inside of a trailer where it collects location and status data and receives demands from dispatchers (ORBCOMM, 1999: 13). In addition, a quick visit to the Vantage Tracking Systems' webpage revealed that its product is comprised of two essential elements, the first of which is what they call a "tracker unit." This unit is an integrated package developed and manufactured in conjunction with Scientific Atlanta. The main components of this tracker include the ORBCOMM Communicator and integrated antenna, the GPS receiver, the battery and battery charger, plus embedded software. The second element of the Vantage product is referred to as the Sensor Suite—already mentioned earlier in this report—that is constantly monitoring the status of the contents of the trailer, reporting it automatically back through satellite and gateway stations to someone sitting at a console who can fine tune the temperatures inside of a refrigeration unit, or answer specific load questions for the user (www.vantagetracking.com, 1999). Currently, Vantage's tracking system costs in the hundreds of dollars per unit versus the thousands that competitors are charging for their product. (Hickey, 1999b: 37)

Other substantive system specifications include:

- The system can run for 30 to 60 days uncoupled from a power source using its own battery (Hickey, 1999b: 37).
- The product gives visibility on the trailer *separate* (untethered) from the cab (Hickey, 1999b: 37, 38).
- The technology is relatively inexpensive, and can be a cost-effective option for freight companies (Cottrill, 1999: 43).
- Fleet management systems such as the one mentioned earlier can report location of trailers at five to eight second intervals (Mangan, 1993).
- The ground units do not require line-of-sight transmission, which is ideal for trailer and cargo security (Mangan, 1993).

- Transportation giant Schneider National chose ORBCOMM because of its complete global coverage, citing ORBCOMM's ability to track their equipment in the United States, Canada and Mexico (Hickey, 1999a: 12).

These capabilities combine to reduce the incredible stress that JIT has put on the individual carriers who can now rely more heavily on a proven technology to get their job done in today's environment. Moreover, the security of the shipment—the protection and control of transported items against theft vandalism, breakage, and handling—is greatly improved, saving the industry millions.

Without a doubt, security is one of the highest priorities for all parties concerned, and one that is met with equal vigor by the capabilities of Vantage. One of the inherent facets of this technology is that the entire transportation process is monitored from the beginning of asset movement. Anything out of the ordinary, to include a wrong turn, trailer disconnect, or even evidence of a wayward driver is immediately known and communication is sought with the driver. If it is a crime in progress, the trailer can easily be tracked down and recovered.

In summary, transportation capabilities are evolving to meet the demands of an extremely strict, Just in Time Inventory system that has come on very strong in the last decade, and commercial enterprise is meeting this demand through the adoption of a very capable space-based system. This marriage has provided sound proof so far that the technology in use complements every aspect of the transportation industry addressed in this paper. Carriers that are using these systems of satellites provided by ORBCOMM and QUALCOMM are increasing their capabilities, and will potentially increase their profits considerably. The systems that have been presented are, to be sure, still in their infancy. Yet even now they are changing the way business is being conducted in the industry.

IV. Integration of Satellite Tracking into the DoD ITV Structure

IQ3. How would low earth orbit satellite tracking of assets be effectively integrated into existing DoD systems? How would this integration improve the state of ITV in the DoD?

Introduction

The DoD currently uses Systems Processes Engineering Corporation's (SPEC) Falcon SATCOM Gateway to track aircraft and assets on their way to the theater. This product is known as L-Band SATCOM in the military and is currently employed on the C-141, C-5 and KC-10. The information processed by this system is uplinked to INMARSAT and then electronically linked to military databases, thus yielding adequate ITV up to that point. However, from the moment of arrival in theater, DoD assets make their way to a number of different locations, frequently without our knowledge of where they are at any given time. This is especially true for contingencies in countries where no infrastructure has been developed to aid in equipment tracking. The solution to this problem could possibly be found in a system that accurately tracks assets without the need for theater infrastructure support. The type of system offered by ORBCOMM or QUALCOMM could perhaps be integrated into our existing capabilities beginning at the moment of equipment arrival in the theater of operations. The system would uplink information from assets equipped with tracking devices and forward it to selected military databases to include GTN. Consequently, this electronic integration of intra-theater ITV information would provide a very powerful tool for warfighting CINCs, allowing them ready access to data concerning unit/equipment progress en route to the FOB or TAA.

The bulk of Chapter IV deals with a scenario involving the monitoring of unit equipment from the 3rd Infantry Division after its arrival into theater via airlift. Again, this scenario is being used to show the technology's capability to operate without infrastructure in an austere location. The scenario illustrates a circumstance where the use of this technology would fill a definite void, and depicts a situation that may be the most likely place to initially employ the technology. This is not to say that satellite technology couldn't be of great use tracking unit equipment in movements such as Turbo Intermodal Surge or assist in exercises like Foal Eagle where infrastructure and procedures for ITV are already established.

An overview of current capabilities offered by ORBCOMM will precede the scenario illustrating how the technology would be effectively integrated into the existing ITV framework. Discussion will then shift to the examination of the efficacy of the ORBCOMM product as compared to the data collected by DoD from its current ITV structure. Actual statistical data (to be supplied by Vantage Tracking Solutions, an ORBCOMM value added reseller) concerning the efficacy of the ORBCOMM product was not available due to proprietary constraints. The DoD statistics to be presented are those collected from Operation NOBLE ANVIL by USTRANSCOM. Information from both commercial and DoD sources will be examined and conclusions made as to the feasibility of adopting satellite tracking as a way of monitoring assets in the DoD.

ORBCOMM Capabilities

Vantage Tracking solutions, a value added reseller (VAR) for ORBCOMM was formed in the spring of 1997 to fill a need in the trucking industry. Its goal is to provide trucking-based travel solutions to the North American marketplace. Generally speaking, this need was met by Vantage's unique capabilities allowing valuable products to be successfully tracked over a wide geographical area. It was made possible by combining GPS and LEO communication satellite technologies. Today, Vantage is emerging as the market leader in the industry with hopes of outfitting over 43,000 trailers for Schneider National within the next two years (Werrlein, 2000). In addition to Schneider, and the trucking industry in general, there are over a hundred VARs of ORBCOMM technology, many of them having military applications. Some examples include Coast Guard search and rescue operations, Marine Corps and Air Force special operations, and valuable equipment location support that was demonstrated in April of 2000 in a USAREUR demonstration of system capabilities (Glazar, 2000).

Location of assets in theater, especially in austere locations with no AIT infrastructure, is made much easier with a system that needs only to interrogate assets from space. You don't need terrestrial support with such a system, which becomes advantageous in a contingency environment. The ORBCOMM system is made up of 35 satellites that remain in contact with any number of ground-based devices to convey preset message data in accordance with user criteria (Glazar, 2000). When not connected to a power source, the ground devices are powered by a rechargeable lead acid battery that will function up to 45 days at one message transmission per day. In this configuration, the system's capabilities are extended by solar power arrays. When used in corporation with equipment whose power source it can plug into, there is no limit to its capabilities. The device itself is compact, consisting of an 18 x 24 inches GPS antenna that is only ½ inch deep, and a modem that is 10 x 14 x 2 inches (Werrlein, 2000).

The messaging can be preset to communicate on a time interval basis, or can be event driven, or both. An example would be the monitoring of an asset across the country where you would want visibility of it every two hours. In addition to that report, you could also program an alert any time the asset was taken off its prescribed course, was delayed for over 30 minutes in one location, had an unauthorized entry, or was disconnected from its power source. The combinations of alerting criteria are numerous. This information, in turn, would then be uplinked to ORBCOMM LEOs, be transmitted to the VAR's server, and then forwarded to the user's database. If it were a commercial company managing its trailer fleet, such questions as "where are all my trailers?" and "which ones are currently available?" could be easily answered. Historical reports highlighting "detention issues" could be called up to ascertain areas that are possibly developing into bottlenecks. Area maps can also be accessed revealing exact position of all equipped assets. Some of these system capabilities have obvious military implications (Werrlein, 2000).

Military Applications

The shift to military applications from this point does not require any momentous leap, keeping in mind the similarity of what we would want to get out of the system to that which an average commercial carrier would require. Instead of a CEO making decisions and determining the best course of action for the organization to take, it is the duty of the geographical CINCs, or more than likely their appointed representatives, to advance their own plans for visibility of incoming assets. No matter how good the ITV was up until the arrival of the assets in theater, with no tracking system beyond that point, assets are no longer visible. The situation that naturally arises out of this incomplete picture is that commanders know their equipment is in theater, they just don't know its exact location. The goal therefore of geographic CINCs is to devise an ITV plan that will track their assets all the way to the FOB or TAA (Young, 1999).

The emphasis in this paper is on regions without suitable means to track assets to an established FOB. While some theaters have begun to address the difficult problem of intra-theater ITV and have to date made substantial ground, others have no infrastructure and thus no way to have visibility on intra-theater assets without deploying ITV teams and "fly away" AIT capabilities. The Korean Peninsula is a good example of the progress made recently with effective RF infrastructure, while moderate strides in AIT have also been made in USEUCOM where RF and DTRACS technologies have been employed with reasonable success. USEUCOM has also been able to take advantage of Europe's well-developed system of highways and railways to facilitate the movement and tracking of military assets. Although LEO satellite tracking through ORBCOMM would compliment these areas where infrastructure already exists, it is not the primary purpose for writing this paper to explain such benefits. It is the southern part of USEUCOM's theater and most of USCENTCOM that is in great need of intra-theater ITV, being relatively austere and underdeveloped.

An "automated closure" of all assets traversing toward the FOB/TAA is the desired end state for the geographic CINC, and anyone seeking knowledge of unit equipment. The real question is…how do we get to that desired end state? We can either saturate region with RF readers and deployed teams that will collect information on assets as they pass certain "choke points" as covered earlier, or adopt an automated system requiring no infrastructure or deployed teams. The former is a process that is labor intensive, demanding hours of training and on-site manual labor, and must rely on millions of dollars of infrastructure to accurately track mobile assets—much of the training takes place during huge movement exercises like Foal Eagle and Bright Star that track force closure in theater. The latter would gradually eliminate a great deal of these requirements if fully adopted, but would require significant investment for monitoring devices up front, in addition to fees for using the service (Christian, 1999).

As stated earlier, there are many military applications to this technology. In fact, there are multiple "pilot" programs being conducted with DoD organizations. According to Mr. Gene Glazar, the Director of government services at ORBCOMM Inc., ORBCOMM is actively seeking military clients to join the several that have already come on board with the company. Military clients include USSOCOM, which has employed approximately 50 devices, and the United States Coastguard with 15-20 devices in use and up to 30 additional coming on line soon. With the addition of seven new equatorial plane satellites due in space by early 2001, ORBCOMM's capabilities for military applications are increasing (Glazar, 2000).

One such pilot program is one that ORBCOMM carried out in April of 2000 for USAREUR. The collaboration with QUALCOMM and SAVI is said to have provided yet another example of the effectiveness of satellite tracking and communications. The concept was to monitor several unpowered assets (containers, flatracks, and trailers) along with powered assets, providing data back to a central collection point. The demonstration was a small-scale event with the SAVI radio frequency tag providing equipment identification, and ORBCOMM providing position data. The information from these sources was made available at all times through the use of a QUALCOMM device (affixed to powered conveyance) which made the transmission to their own system of satellites. The overarching purpose of this demonstration was to illustrate that the process of maintaining visibility on assets could be accomplished without the need for theater infrastructure. In addition, it also demonstrated the integration of SAVI's equipment nomenclature data with position data from ORBCOMM into a single report. The success of this demonstration provided proof of the feasibility of joining of these technologies, thus paving the way for a large-scale test in July of 2000 (Glazar, 2000).

ORBCOMM technology alone does allow for the transmission of equipment nomenclature when used in conjunction with the RF SAVI tag. The USAREUR demonstration was to prove that these technologies in combination with QUALCOMM could be used to form a single report. QUALCOMM devices require a great deal of power to operate and must always be connected to a power source (powered conveyance). ORBCOMM devices, on the other hand, can be affixed to unpowered equipment, trailers or assets and perform on battery power alone giving requisite position reports and nomenclature data. (Recall that the device can function approximately 45 days on battery power at one message per day). The USAREUR demonstration exhibited a likely employment of ORBCOMM's technology—used in concert with SAVI and QUALCOMM. Another likely employment would be the ORBCOMM product used in conjunction with *only* the SAVI tag in a scenario similar to the one illustrated later in this chapter with the 3rd Infantry Division using devices to monitor powered and unpowered equipment. If all equipment was so equipped when entering the theater, it would be automatically tracked from offload to FOB/TAA, barring reconfiguration of cargo (Glazar, 2000).

In light of this most recent demonstration of the emerging capability offered by these commercial enterprises, could this be an appropriate way in which we could begin to address our problem with intra-theater ITV? Is it a technology that could be successfully integrated into our own system providing ITV on assets arriving into theater via airlift? One thing is certain. Whatever program or system we adopt, it must provide the same type of information that is now available through the current ITV structure. What this means is that all the appropriate unit information to include TCN, and other nomenclature defining the vehicle, contents of a container, or pallet makeup must be available to "drill down" to when needed. Second, the system adopted must be able to interface with current military databases, especially GTN. With these requirements met, one must then consider the quantity and type of assets to be involved in the initial pilot. The goal of a pilot program would be the assimilation of a reasonable quantity of assets into the existing ITV structure. The type of assets tracked in the initial phases of implementation of the technology could be high-value assets, or those that are deemed critical for a certain mission's success. Additionally, one must be prepared to evaluate the candidate AIT solution on a number of different levels to include human factors, integration, infrastructure, cost, and manpower. What follows is a discussion of each of these factors and how they impact operations in the realm of ITV (Young, 1999).

A Possible Pilot

Consider the movement of the 3rd Infantry Division to an austere location in Egypt. It has been chosen as the unit to participate in the first pilot program for AMC, testing the viability of the ORBCOMM or similar product in tracking assets all the way to any number of tactical assembly areas.

Human Factors' Concerns. At the outset, there would be a *human factors* element in that they would be dealing with a brand new technology and would have to become aquainted with its peculiarities and operating parameters. The approach currently being implemented by the industry is that of user ownership of the devices. Therefore, personnel would necessarily have to be briefed on its capabilities and operations specifics by expert technicians, namely the value-added reseller responsible for contract initiation and execution. Not only would the contractor perform this critical function, but it would also be responsible for the system's installation and initial operational capability test. From that point, the system is designed to be as hands off as possible, but routine maintenance and repairs (smashed antennas, damaged receivers) would be the responsibility of the user (Glazar, 2000). Also along the lines of user ownership, personnel would have to be instructed as how to remove and affix the device on their rolling stock and equipment if it became necessary to do so.

As far as further military interface required with the device itself, it would most likely be limited, to include:

- The programming of the RF tag and details on how it is incorporated into the ORBCOMM product—the information may be loaded into the device remotely or on-site as required

- The reprogramming of the RF SAVI tag after the completion of the unit move and redeployment back to the states
- The ability to monitor the system for functionality, and determine if any maintenance needed; as well as any special handling required for the unit (Glazar, 2000).

After programming unit and equipment description into the device, the system would ideally operate without human intervention, tracking assets all the way to the FOB/TAA.

Integration of Technology into Current ITV Structure. Critical to the success of any new AIT venture is its ability to *integrate* with existing ITV structure and databases. The following section will explore ways in which the ORBCOMM system or like product will be integrated with the current way we do business.

As the requisite equipment from the 3rd Infantry Division (3ID) is loaded into the cargo hold of several gigantic C-5 Galaxies—flatbed trucks, containerized and palletized equipment, HUMM-Vs, 5-ton trucks, M1 Abrams tanks, and water and fuel trucks—the C-5 crews dutifully update the L-Band laptop computer with load information, thus insuring its transmittal during the 8-hour haul to Frankfurt, Germany, and the remaining 7-hour journey to Egypt. Along with load information, the L-Band Satcomm will automatically transmit the aircraft's position to GDSS, and from GDSS the information will be forwarded to GTN. This will facilitate visibility of the entire movement of the 3ID until their arrival in theater. The L-Band system incorporates INMARSAT, which is a configuration of four satellites in geosynchronous orbit at 22,500 miles above the earth (Fischer, 1999).

Upon landing in Egypt, the C-5 loadmasters prepare to unload the 3ID onto the tarmac to begin the next phase of their journey to the TAAs. For ITV to be assured from this point, the ORBCOMM units must be activated as they are unloaded off the aircraft. Activation could be accomplished by incorporating a "wakeup" system held by the loadmaster, or placed strategically in the cargo compartment to trigger the units as they are exiting the aircraft. In this way, there will be a seamless transition between the tracking of assets into theater and their subsequent handoff to the intra-theater ITV system. This will provide the necessary integration of the new AIT into the existing ITV structure (Fischer, 1999).

Now that the system is up and running, the ORBCOMM satellites are receiving the time-interval position and equipment nomenclature. This data will be transmitted via each unit to satellites overhead, then stored until within range of an earth station at which time the satellite will forward ITV reports to the VAR's server which will in turn forward the information to the Global Transportation Network. Data transfer into GTN could be accomplished through an Internet-based EDI "clearinghouse" providing both an aggregation point and security firewall for data. At this level, the information could take many forms to include raw data, or data manipulated and displayed in appropriate format by the VAR. In addition, the DoD could acquire a mobile earthstation that can be deployed and used to aggregate theater data, thereby ensuring secure collection and transmission.

This process will satisfy another critical requirement for any new AIT, namely the ability for the technology to be electronically linked to the most important military databases from which the warfighting CINC must draw in order to have visibility on intra-theater assets. Once located in GTN, the exact position could be verified by manually accessing the information on the VAR's server. This would give a very appropriate "data quality check" to information stored in GTN that has sometimes in the past been inaccurate (Glazar, 2000).

There is an additional capability with this technology that would allow ITV transmissions from participating assets to be grouped and then transmitted together to reduce the data's exposure to the enemy, and to decrease the costs that quickly build up with multiple transmissions. Current technology allows for a "short-burst" transmission that would convey an entire grouped message report within milliseconds. This capability is inherently secure due to its extremely limited exposure making it difficult to intercept. The transmission could be further masked by transmitting in the commercial range (bouncing between 137 to 138 MHz), where it would tend to blend in with the background noise because it would not be aggregated with other military communications. These two factors combined would make it difficult, but not impossible to intercept the transmission. With this in mind, regional CINC's may still choose to incorporate encryption software for authentication and tighter information security (Glazar, 2000; Fischer, 1999).

Due to the high cost of continuously transmitting this information from mobile assets, position reports could be made every hour or two depending on mission needs and desires of the geographical CINC. Typically, if an asset is moving at a slow rate of speed, reports every hour would be more than sufficient as long as they were accompanied by event-driven alerts to indicate an off-course condition, an extensive delay, or unauthorized entry/exit of a trailer/container. At the other end of the spectrum, VARs of ORBCOMM capabilities could also provide “real-time” visibility allowing the user a *message response time*—the time from device transmission to database entry—sometimes as fast as 1 minute. If something closer to “real-time” ITV is desired, then the units could be programmed remotely to comply with the new reporting scheme, or units could be interrogated at any time to provide position or equipment nomenclature. In addition, users could also be proactive and initiate communication when diverging from mission schedule or route (Glazar, 2000).

Infrastructure Needed. The next element of consideration for the move of the 3ID is the *infrastructure* needed to support operations from the point of their arrival into the theater of operations throughout their travel to their TAAs. Most of the discussion in this section will highlight the system’s independence from in-theater infrastructure and focus on that infrastructure already established in the commercial industry. Indeed, the ORBCOMM system is reliant only upon infrastructure that is already established, and that quite unlike any a logistician would speak of when discussing intra-theater operations.

This unique infrastructure consists of 35 satellites configured in six different planes of orbit. This constellation of satellites gives any VAR using the ORBCOMM product the ability to offer coverage over practically every part of the globe. In fact, they only need four of the six planes to provide what can be considered true “global coverage.” Most holes in coverage, where they do exist, occur only at the most extreme latitudes containing little or no population. By early 2001, a new equatorial plane of satellites will be established to improve upon existing coverage on this part of the earth. This will bring the total of ORBCOMM assets orbiting the planet to 43 (Glazar, 2000).

Along with this “orbiting infrastructure” are earthstations, or gateways strategically located on terra firma. These stations are placed throughout Europe to include Italy, Germany and Spain and also in locations such as the Mideast, Korea, Japan and Mexico. Their function is to provide a point for collection of satellite transmissions where the data can subsequently be forwarded to VAR and user systems. Typically, routing of transmissions usually include a period of time where the satellite will store the information until it travels within range of a gateway. This “store-and-forward” process translates into an industry standard of 90% of transmissions being downloaded into user databases within 6 minutes, and 98% within 15 minutes (Glazar, 2000).

What this independence from intra-theater infrastructure means to the warfighter is increased visibility of assets especially in remote, austere locations such as the one that the 3ID now finds themselves in. In addition, it also eliminates the need for personnel to be brought into theater whose sole purpose is that of tracking assets enroute to the TAAs. The effect is like having an infrastructure built in wherever you go that would enable automated tracking without human intervention. Its applicability would be broad, and well suited to the tracking of assets arriving into theater via airlift. It would be impossible to equip every location we fly into with an infrastructure, and too costly even if it was possible. In addition, those areas that we have identified for deployed AIT will by no means be sufficient to cover every situation that could arise. Our resources—personnel *and* equipment—are much too scarce. (Not only are the tags and infrastructure expensive, but retrieval of deployed RF devices and their loss/damage has also become a great cost) (Carpenter, 1999). Satellite tracking of assets can be considered an extremely flexible system, with the capability of being employed in the current ITV structure without dependence on big and expensive infrastructures. This flexibility will allow successful tracking operations in any location be it austere or otherwise. It is also noteworthy to mention that in theaters where significant infrastructure already exists it would serve to complement and enhance our capabilities by offering an additional means to locate DoD assets.

Another problem that could be avoided with the use of this technology is the unavailability of usable frequencies, especially noted when using RF data transfer. Host nations sometimes will not allow the use of certain frequencies for RF tag technologies, and even when they do, many times there is great cost associated with their use (Carpenter, 1999). Host countries also regulate communications between ORBCOMM devices and their LEO counterparts, thus requiring approval obtained by the licensee. Authorization for DoD use during operational scenarios is handled separately on a case by case basis. (Glazar, 2000)

<u>Cost and Manpower Issues.</u> Automation is a key concept when addressing any type of AIT, and it has been specifically mentioned several times up to this point. Automated data transfer without infrastructure and human intervention may be the biggest gain in using satellite technologies. This is true because of the tremendous *cost* associated with infrastructure maintenance, and *manpower* employed to make the current system work—for permanent and deployed systems. Important to this discussion is the significant reduction in manpower realized when employing a system that has perfected automated data collection.

As the 3ID proceeds to the TAAs, noticeably absent will be the presence of choke points, remote readers and deployed teams tracking their movement. For the execution during the unit move, equipment and rolling stock would be tagged and data transferred automatically given the asset was equipped with a monitoring device at the home station. Everything from initial entry into GTN, to the monitoring of the asset through the theater enroute to the FOB would be automatic. Containerized and palletized loads could be tracked to the FOB/TAA on the division's flatbed trucks equipped with monitoring devices. Rolling stock would either be moved in the same manner, or if the intention was to drive it to the FOB/TAA, each piece could be individually tagged. Terminals would be updated as the equipment arrives at the FOB/TAA and is unloaded, signifying the completion of asset tracking. As a result of this process, no matter how austere or underdeveloped the country, a comprehensive intra-theater picture of ITV on the 3ID could be realized if all assets were so equipped.

Automation could spell great savings for DoD in deployed infrastructure costs, and would enable the DoD to free personnel who may be of better use elsewhere. It is hard to put a dollar value on the latter, although one could imagine the savings would be quite great. One also must consider that by taking these personnel out of theater, decision makers would be decreasing the exposure of our forces in the potentially dangerous contingency or wartime environment. On the former, however, a dollar value can be assessed. In fact, according to the U.S. Transportation Command Automated Identification Technology Integration Plan, the 5-year costs for AMC and MTMC for deployable AIT are $8.6 million and $6.8 million respectively. A quick reference to the plan shows this figure to be over 35% of the total cost to implement TRANSCOM's entire AIT plan. Deployable AIT would provide temporary ITV capabilities within 72 hours at airports or seaports having no permanent AIT configuration. This deployed capability would enable the operation at only 25% of these ports during contingencies and exercises (U.S. TRANSCOM, 1999: 2-1; 3-2,3). It is clear from reading the plan that there could well be a need for the type of flexibility that satellite tracking technologies could afford. It may not only enable the DoD to decrease its investment in deployable AIT, but may enable a significant increase in coverage at ports without ITV capabilities. It could also act as a force multiplier in areas with established infrastructures, complementing these systems where infrastructure is lacking. As the new technology becomes more ubiquitous, additional savings would also be realized to include:

- reduced training and maintenance on deployed systems.
- reduction, or elimination of contracted AIT functions.
- the freeing up of pallet positions on airlift missions
- reduced need for "Mystery Box" @ $8-8.5K each and MARC L-Band Satcomm units @ $5-6K each (Fischer, 1999).
- the freeing up of personnel currently engaged in deployed AIT disciplines.

NOTE: The intention of a breakdown of costs associated with the current and projected AIT structure is in no way meant to be a complete cost analysis as you would find in a detailed corporate report. This section serves the purpose of collating various unit and service costs of both the existing and proposed AIT systems in order to take a first step in their cost comparison.

With regard to maintenance of the current AIT structure, it is reasonable to assume that the DoD could potentially save resources by replacing the RF infrastructure that has proven to be problematic. RF units are still quite expensive and continue to have a high damage rate when used in their current capacity. In addition to this, keeping track of the units themselves has proven to be quite illusive, as many are lost during both exercise and contingency. This is partly why USTRANSCOM has stated in no uncertain terms that they will not fund a tag management program, relying rather on the users of the technology to both fund and replace tags when needed (U.S. TRANSCOM, 1999: v). Moreover, the infrastructure at the fixed AIT sites is maintenance prone, and is demanding of continual resources and time.

Another point of interest arises when considering personnel who are not normally associated with AIT functions, but would benefit from increased visibility of assets. For instance, in Europe the U.S. Army currently has 30-40 people at any one time searching for trailers and railcars on which they have lost visibility. Without anything to readily identify the equipment, some assets spend weeks out of commission, lost in the system. This comes at an incredible cost to the government, but does not get quantified when determining the cost of our current structure. In this area, the commercial industry is beginning to see the advantages of a product such as that offered by ORBCOMM. It has realized a 40% increase in revenue opportunities due to the accurate tracking of equipped trailers (Glazar, 2000). This benefit has been realized through the use of the ORBCOMM product, capitalizing on its ability to monitor trailers that are not attached to cabs (untethered) as delineated in Chapter III. This capability would most likely translate directly into the DoD as savings in expenditures in both personnel and asset utilization.

Cost and Benefits of Satellite Technology. Now that we have discussed some of the cost and manpower related issues that pertain to the current ITV/AIT infrastructure, a brief overview of the costs of incorporating satellite technologies will be addressed, followed by projected future costs and possibilities of this innovative approach to ITV.

As technology and applications of satellite communications mature, there will be greater opportunities of employment using this technology that may benefit the unique environment of the U.S. military. Part of the maturation process will inevitably include the device's reduction in size, increased capability and decreased cost. This progression—similar to that with many other high-tech products—may provide incentives for the DoD to adopt this program for the tracking of its mobile assets. Moreover, an additional manner in which this system is beginning to gain credibility is in the wide number of applications in existence today that are being demonstrated and refined. In fact, there are already over 130 VARs providing applications all over the map, to include those for military use stated earlier. As VARs are added to the list, the system will become more complete and the technology will eventually reach a mature state. As the product continues to prove itself in this way, it may in due course be considered a viable technology suitable for the needs of the DoD for asset tracking (Glazar, 2000). But what will it cost?

If 50-100 ORBCOMM unit were purchased, the cost would be approximately $650-750 per device. Naturally, if greater quantities were bought, the cost could be significantly lower. The monthly charge for using the satellite service from the point of purchase depends on the size and frequency of transmissions. There are two different categories of transmissions; messages (> 6 bytes, optimum 250 bytes) and reports (< 6 bytes). Messages would be used by exception to convey position, time and nomenclature, while reports would be used as the optimum mode of transmission and include only position and time. For 120 reports a month the cost would be approximately $25, and for 4 messages a month the cost would be $8. The costs would be averaged over all devices under contract to reduce the cost of the user (Glazar, 2000).

To put this cost in perspective, bear in mind the $40K price tag for each L-Band Satcomm unit placed on C-5, C-141 and KC-10 aircraft to track status and location, and add to that the $300K cumulative annual cost for satellite transmissions for AMC alone (Fischer, 1999). NOTE: The L-Band Satcomm units are placed on airlift aircraft specifically for the purpose of tracking *aircraft* on their way to the theater and intra theater. The tracking of the *cargo* when offloaded is the issue at hand.

The cost of these units is presented partly to illustrate the importance—in dollar value—that we put on ITV today. In addition, the figures are also useful in that they reveal the cost of a comparable AIT system already employed by the DoD.

As stated earlier, the cost of the device would definitely come down as the technology became more advanced. By advanced it is meant that the devices would, in due course, be minimized in dimension and cheaper to produce, while at the same time endowed with superior capacity for data transfer. In fact, the industry has already produced processors as small as one square inch to replace the 18 x 24-inch modems currently in use. Although these will not be coming on line anytime soon, it speaks to the much-anticipated miniaturization of the technology (Glazar, 2000). The result would be a more user-friendly device that is easier to install and less costly to employ. With this prospect, the DoD may benefit from a plan that provided the option of a more ubiquitous use after initial testing in a pilot program. It may be that only high-value assets, or those categorized as absolutely needing visibility would be outfitted with the devices at first. But as soon as it became a proven technology from the military's perspective, more units with greater applications could be engaged. The integration of the technology would most likely start at the container and pallet level, then on to rolling stock, and ultimately individual pieces of unit equipment deemed necessary to monitor. Indeed, it could eventually be accepted as a standard item attached to every piece of military equipment, being simple to use and monitor, while being virtually invisible in its application.

The next leap in technology after this is the elimination of GPS position and time updates—thereby eliminating the need for the GPS antenna from the package—placing sole reliance on LEOs for position and time updates via triangulation of three or more satellites. With this improvement, the device would be reduced to the size of a postage stamp needing only a power source for successful operation. In this case, it would most likely be powered by the equipment it was attached to, e.g. rolling stock, or by a lithium battery (Glazar, 2000). The resulting technology would be definitely easier for the DoD to employ, and much more affordable as well. Furthermore, the goal of intra-theater ITV via the effective use of AIT would be met by a proven technology that is <u>feasible</u> to employ.

As mentioned earlier in this section, the ORBCOMM product underwent a critical demonstration regarding its asset tracking capabilities in April of 2000. During this USAREUR exercise its product was teamed with both QUALCOMM and SAVI technologies in an effort to show the efficacy of the system. It promoted the ideal of near-real-time visibility of critical assets in theater, while keeping theater CINCs informed as to where their warfighting equipment is at any given moment. Its desire was to promote the technology as a viable solution to identified ITV shortfalls highlighted in Desert Storm and Kosovo, providing the capability of pinpoint location of assets in any theater of operations regardless of infrastructure. Among other things, experts evaluated hardware performance, substantiated the concept of employing ORBCOMM technology in union with both QUALCOMM and SAVI products, and established baselines for further system tests (Glazar, 2000).

Analysis of Data

The marketplace for these types of systems is becoming increasingly competitive, and military outreach efforts have intensified in recent years. ORBCOMM has established itself as an industry leader, backing the quality of their product with a proven track record. Their goal is to increase productivity and efficiency of existing assets by maximizing their use, while quantifying the results of their efforts in easy to understand statistics. The following illustrates their success in both of these areas

Vantage Data. Although statistical data was not available due to proprietary constraints, sufficient evidence of the efficacy of the ORBCOMM product has already been presented in this and previous chapters. The following evidence illustrates corporate industry's enthusiasm for the technology.

As stated earlier in this chapter, commercial industry has realized a 40% increase in revenue opportunities due to the accurate tracking of equipped trailers. This kind of result has led Schneider National to adopt ORBCOMM technology, believing it to provide significant enhancements to their services. Don Schneider, President of

Schneider National, feels that the "high reliability of coverage and data integrity" of LEO satellite-based tracking is the best solution for their intermodal operations. Schneider sees ORBCOMM as the emerging leader in the realm of LEO satellite technologies, allowing them to capitalize on ubiquitous coverage to track trailers not attached to conveyance. (Hickey, 1999a, 12) It is this capability of tracking untethered trailers that Schneider believes to be a critical service. According to Paul Mueller, Vice President of Communications and Networking Services at Schneider, ORBCOMM affords a complimentary service compared to QUALCOMM. His argument stems from the company's need to track assets moving through several different modes of travel. He states that Schneider is "increasingly in circulation where a Schneider trailer may be under third-party power—either on rail, or with third-party players. So the visibility of the trailer becomes more important" (Hickey, 1999b, 38) In this way then, no matter the mode of travel, Schneider can have visibility on all of their assets, providing an accurate means of quantifying system performance—among other things.

It can be argued that if the DoD adopted LEO satellite tracking technology, the positive effect would be comparable to that found in commercial industry, resulting in accurate accounting of all assets that would yield statistical data that is easily quantifiable. (This is in addition to the potential cost savings also realized in commercial industry). Currently, the DoD doesn't do a lot of quantitative analysis on the efficacy of their own ITV, and may be able to benchmark the industry's ITV solution, depending on requirements of the military.

With these things in mind, I will compare the findings above to that collected in the DoD during Operation NOBLE ANVIL in an effort to highlight the relationship between LEO technology and improved tracking performance in commercial industry. It may be evident that the technology used in commercial enterprise, if employed in the military would have a positive effect on the quality of ITV.

USTRANSCOM's Metrics. According to USTRANSCOM, the evaluation of ITV and AIT performance during Operation NOBLE ANVIL was a largely subjective process based on anecdotal evidence collected from ITV providers and customers. (Existing quantitative data is presented in following paragraphs). In other words, there is no concrete statistical database with which one could quantify and rigorously analyze at USTRANSCOM. Rather, the data that was collected came from reports in the field—from ITV teams that is—that generally summarized ITV systems progress, and from analyzing the efficacy of the collection systems currently in use. This data was then translated into specific ratings in a stoplight-type format (Fig. 7). Evaluation of ITV also included basics such as checking that the requisite systems and processes were in place, and whether or not ITV was executed properly. USTRANSCOM found that availability of ITV was directly dependant on the quality of the data input into the system, coupled with the timeliness of the data entry and processes to ensure its availability (Bass, 1999).

How then do you draw conclusions and make comparisons with *subjective* figures collected by the military with *objective* findings from Vantage? Before this question is addressed, a brief listing of quantified ITV data from Kosovo will be presented, followed by key points elucidating successes and failures USTRANSCOM saw in their data collection.

The only quantitative numbers concerning assets tracked into and within theater come from three different data collection sources…CAPS II, RCAPS and CMOS. (There was no specific quantitative data collected for DTRACS and RFID). As far as cargo transiting the theater, RCAPS was able to capture visibility on 84% of the assets the DoD had specifically targeted for monitoring, while CAPS II and CMOS captured 77% and 32% respectively (Bass, 1999). The subjective rating for process and execution for all systems are represented in Figure 7. NOTE: CAPS has been replaced by the Global Air Transport Execution System (GATES). GATES has now become the AMC air port management system.

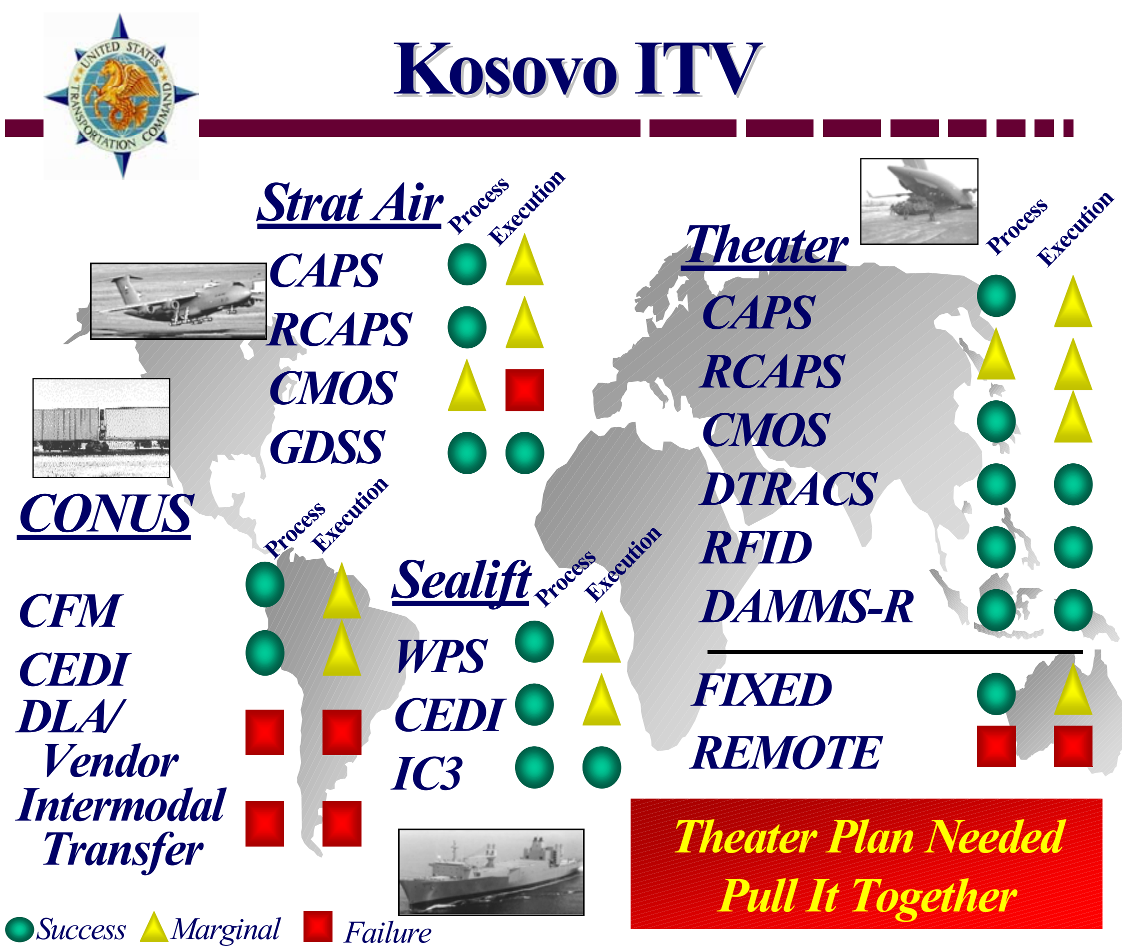

Figure 7. USTRANSCOM ITV ratings for Operation NOBLE ANVIL (Bass, 1999)

According to USTRANSCOM, mature established systems with well-defined processes and protocols received relatively good *subjective* marks, while the shortfalls identified in ITV collection were directly related to poor execution. Specifically, negative impacts from ops tempo, inadequate training and low manning led to marginal execution. Key to the smooth implementation of the ITV process is proper training, appropriate "top-down" emphasis placed on the critical nature of timely data entry, and accurate accounting of DoD equipment. Also germane to the discussion of intra-theater ITV, is the intermodal transfer of assets as they move throughout the theater. That is, some breakdown in ITV occurs where there is no data transfer between modes, or in some cases between carriers in the same mode (Bass, 1999).

Conclusions and Recommendations

The conclusions that were reached by USTRANSCOM indicate the biggest challenge ahead for ITV is that faced in the intra-theater realm (Fig. 7) A comprehensive picture of the entire theater has never been achieved and was highlighted again in the Kosovo war. Failing to capture ITV over a large piece of theater movement during this campaign, particularly between those locations that were more austere and less established with infrastructure, was cited as a noteworthy example. An additional challenge was found to be the availability of bandwidth in theater for RF technology. With these essentials in mind, USTRANSCOM is encouraging CINCs to develop interim and long-range theater ITV plans to include the use of AIT technology (Bass, 1999).

This is where LEO satellite tracking of assets could be of most use to the process and execution of ITV. For the process itself, ORBCOMM or a similar reputable company could bring to the table its satellite infrastructure, and data transferal capabilities allowing server connectivity to military databases. The technology, as shown in Chapter III and presented in this chapter, has already been successfully employed in commercial enterprise. The military use of this technology requires no great leap as shown in the application also brought forth in this chapter. For the actual execution during a unit move—as in the case of the 3ID scenario—equipment and rolling stock would be tagged and data transferred automatically given the asset was equipped with a monitoring device at the home station and there was no reconfiguration of cargo after transport into theater. Everything from initial entry into GTN, to the monitoring of the asset through the theater enroute to the FOB would be automatic. The 3ID's containerized and palletized loads could be tracked to the FOB/TAA on its own flatbed trucks equipped with monitoring devices. Rolling stock would either be moved in the same manner, or if the intention was to drive it to the FOB/TAA, each piece could be individually tagged. Terminals would be updated as the equipment arrives at the FOB/TAA and is unloaded, signifying the completion of asset tracking. As a result of this process, no matter how austere or underdeveloped the country, a comprehensive intra-theater picture of ITV on the 3ID could be realized if all assets were so equipped. This would remain true even if 3ID equipment was transferred between different modes of travel.

With the evidence from commercial industry presented and a clear situation where LEO technology is applicable in the DoD, it is reasonable to assert that if the DoD did employ LEOs as a standard AIT device, there would be an improvement in asset tracking capabilities. Additionally, the standardization of data collected could be addressed as a feasible application of satellite technology is developed for DoD use. All data transmissions would most likely be modified by a VAR application and then be passed on to GTN in similar format, allowing for consistent and standardized information flow into the ITV structure. Although availability of bandwidth is currently not an issue with this technology the problem of obtaining frequencies for data transmission would still exist as host countries continue to regulate satellite uplink transmissions. Other concerns addressed in this paper to include damage and loss of AIT devices, "ownership" of AIT processes, and data integrity would remain issues to be addressed as they are inherent even in the solutions to current ITV problems. As previously stated, a strong emphasis from senior leadership on these and other issues will go a long way in preventing the contamination and disruption of ITV processes.

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Vita

Major Bryan C. Watt was born in Portland, Oregon. After graduating from Oregon City High School in 1983, he entered Oregon State University, and enrolled in the ROTC program. In 1987, he graduated from Oregon State with a Bachelor of Arts in Political Science. He was awarded a Master of Aeronautical Science from Embry-Riddle University in 1998. Following his Commission, Major Watt attended Undergraduate Pilot Training at Laughlin AFB, Texas. Upon his graduation in 1989, he was assigned as a T-38 Instructor Pilot for the 86th Flight Training Squadron (FTS), Laughlin AFB, Texas, where he served as Assistant Flight Commander and as the 86th FTS Unit Standardization and Evaluation Member. In April of 1993 Major Watt was assigned to the 75th Airlift Squadron at Travis AFB, California as a C-5 pilot. While at Travis, he served as Instructor Pilot, Evaluator Pilot, and Assistant Fight Commander of Standardization and Evaluation. In October of 1996, Major Watt was assigned to the 56th Airlift Squadron at Altus AFB, Oklahoma and served as C-5 Evaluator Pilot, 97th Operations Group Executive Officer, and Chief of 56th Standardization and Evaluation. While at Altus, Major Watt also served as Presidential Advance Agent for Air Force One.

Major Watt is a Senior Pilot with over 3000 flying hours. He was selected by Air Mobility Command to attend the Advanced Study of Air Mobility program in 1999. He has recently been assigned to the United States Transportation Command at Scott AFB, Illinois.

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14. ABSTRACT This paper addresses one possible solution to the enormous task of monitoring assets and unit equipment in theater. In recent months, the ability to track intra-theater shipments has been identified as one of the weakest links in our current in transit visibility (ITV) structure, and the DoD has placed great importance on giving senior leads visibility on equipment and cargo transiting their geographic areas. We have highlighted our difficulties and spent much time and effort honing our skills and improving our automated collection of data. Our efforts have given impetus to multiple technologies that are currently assisting the DoD in obtaining accurate location of assets in theater. The technologies associated with these efforts are referred to as Automated Identification Technologies (AIT). Although current "Standard" devices to include radio frequency identification (RFID)seem to be ameliorating the ITV problem, this paper introduces an intriguing new technology currently being developed and used in the private sector – that of monitoring assets with the aid of low ear orbit satellites (LEOs). This technology has been demonstrated in the commercial trucking industry through ORBCOMM's Vantage Tracking devices that allow the military's GPS and commercial LEOs to pinpoint location of mobile shipments. This paper examines the current state of AIT in the DoD with concentration on RFID in the Republic of Korea. It also addresses the commercial use of satellite technology, and examines one possible scenario involving the integration of LEO satellite technology into the current DoD ITV structure.							
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