Proposal of Naval Investment Strategy for Blue Force Tracking

Matthew Luke
Space Systems Certificate Program
Naval Post Graduate School
Monterey, CA

Alan Walker
Space Systems Certificate Program
Naval Post Graduate School
Monterey, CA

Kimberly Riggle
Space Systems Certificate Program
Naval Post Graduate School
Monterey, CA

***Abstract* — Digital interoperability is defined as the ability to exchange information—including command, sensor, intelligence and electronic warfare information—with all those involved in warfare support [1]. Digital interoperability can enhance situational awareness by allowing each war fighter to understand their position on the battlefield. One way of doing this is through the Army led program called Blue Force Tracker. The Army will be retiring BFT for Blue Force Tracking 2. The Navy has not decided in the need to invest in BFT2. This paper will define digital interoperability, analyze the Navy's requirements for digital interoperability, analyze available solutions to accomplish those requirements, and provide a recommendation on a solution to meet the Navy's requirements for digital interoperability.**

Keywords—Blue Force Tracker, situational awareness, interoperability, Navy

I. INTRODUCTION

Digital interoperability is defined as the ability to exchange information—including command, sensor, intelligence and electronic warfare information—with all those involved in warfare support [1]. Digital interoperability can enhance situational awareness by allowing each war fighter to understand their position on the battlefield. One way of doing this is through the Army led program called Blue Force Tracker (BFT). BFT allows for tracking of friendly forces by position along with the passage of text messages through the use of unencrypted commercial L-band satellites. The Army is moving to an encrypted system, BFT 2, and will shut down the legacy BFT system when BFT 2 is fielded. Should the Navy invest in the BFT 2 system upgrade or is another digital interoperability system a better investment?

To understand how the Navy can best maintain digital interoperability, both a definition of digital interoperability and the Navy's requirements for it are required. While the definition as stated above seems simple, the type and amount of information to be exchanged has been increasing and evolving over time. Addressing the Navy's requirements in detail will help determine whether BFT 2 is a suitable upgrade. The digital interoperability advantages currently provided by BFT also play into whether BFT 2 is a valuable investment. Analyzing the requirements and how they impact the fleet will help determine the impact that losing BFT will have on the fleet and the military.

To further analyze the investment strategy, it is critical that BFT 2 is defined and its advantages and disadvantages addressed; in particular, how closely BFT 2 fulfills the Navy's requirements. Alternatives to BFT 2 that fulfill the digital interoperability and situational awareness requirements will also be explored to see how they fit Navy requirements. Comparative analysis of this information will ultimately lead to a recommendation for procuring the optimum digital interoperability system.

II. DIGITAL INTEROPERABILITY

There has been a recent emphasis in the Department of Defense (DoD) in regards to digital interoperability. However, digital interoperability needs to be defined, as do the Navy's requirement for such a system. The importance of digital interoperability also must be clearly understood.

A. Defintion

Digital interoperability, network centric warfare, information dominance, information superiority and networked operations are all expressions that show the latest effort by the Department of Defense (DoD) to connect the forces as a networked system of systems. These phrases have been used indiscriminately and are their meanings are often obscured. It is important, then, to clearly define digital interoperability as it applies in the US Navy.

One basic definition found in the civilian air sector states that "a basic airborne network consists of a number of air vehicles that can communicate with each other through wireless communication" [2]. Though, digital interoperability involves more than the seamless transfer of information among entities. It is also more than just a set of standards to allow for communication by different warfighters. It is about the ability to not only share, but use the information in such a way that it gives the US Navy an advantage. Digital interoperability is "characterized by the ability of a networked organization to develop and exploit an information advantage to improve organizational performance" [3]. Digital interoperability can be considered as a system of systems network, where information flows to the people that need it, where they need it, when they need it and in a way that can be easily understood. Thus, digital interoperability is the ability to easily transfer information to support increased war fighting capabilities.

B. Navy Requirements

In October of 2009 the US Navy created the Information Dominance Corps whose mission is to deliver capabilities in information, intelligence, human-derived information, counterintelligence, networks, space, and oceanographic disciplines [4]. This shows the importance of information dominance and digital interoperability to the US Navy. Furthermore, the "DoD seeks to achieve sufficient interoperability to ensure successful joint, multi-national, and interagency operations at all levels of warfighting, and across the spectrum of potential engagement scenarios" [3].

The US Navy wants digital interoperability but what does that mean? As defined in the previous section, it is not only the ability to transfer information but to do so to increase warfighting capabilities. This means that "interoperability is not an end in itself, but a means to an end," and that end is increased capabilities [3]. The capabilities gained from information transfer are verbal communications and situational awareness. Situational awareness is an accurate understanding of one's environment. In a detailed way, it is "knowledge of the current battlefield area such as positions of friendly and enemy units" and its "data is time-dependent" [5].

Situational awareness is "achieved through the exchange of state information among individual vehicles in a timely, reliable, and secure fashion" [2]. The state data that should be exchanged includes data such as position and velocity data, terrain, obstructions, environmental conditions and video or photography of the area. Ideally, every platform would share its view of the world with every other platform and these views would be coalesced into one seamless picture that mirrored reality and could be understood and used by the user. The transfer of video, forward looking infrared, imagery, threat warnings, position and direction of travel of allied and enemy forces, and verbal communications to the units that need it is what the US Navy is moving towards.

To obtain such a reality, the technology needs to mature since bandwidth is limited. Since the Navyis going to a smaller more nimble force, often with units operating well out of line-of-sight of other units, satellite or HF communications are the only options. While there have been advancements in HF data transfer, it is still in the early stages of development as compared to satellite communications. However, satellite communications are limited in bandwidth and are limited in the amount of data that can be provided. Using only the limited bandwidth available, it makes sense to build the situational awareness picture one element at a time. Since units already have digital maps and terrain elevation databases, transferring of real-time imagery, FLIR or video should be last on the list of requirements, since it is also the most bandwidth intensive. Higher on the list should be position and direction of travel of friendly and enemy forces and verbal communications. Threat warnings should be high on the list as well, but need to be tempered with the ability to ferret out false alarms, as to not overburden the users.

To further detail the requirements, any digital interoperability architecture needs to be structured to have "reliable transmission, efficiency, and an acceptable speed of service" as well as real-time data, availability and security [5]. "Reliable transmissions mean accurate and timely broadcast" which leads to the requirement for real-time data and an acceptable speed of service to ensure the data accurately reflects the current situation [2]. However, since information can be sent repeatedly, "reliability can be traded for faster speed of service" [5]. Efficiency is important to be sure all users' needs can be met despite bandwidth limitations. Availability is important as well since the fleet will quickly come to rely on this seamless exchange of information.

Another incredibly important aspect of digital interoperability is security. To maintain information dominance the information must not be shared with the enemy. "Vehicle states should not be known by un-authorized parties" [2]. To allow the enemy to intercept this information puts the fleet at a higher risk as compared to not having this information at all.

C. Advantages of Digital Interoperability

Digital interoperability is key to gaining the advantage on the battlefield. An understanding of where friendly and enemy units are helps to prevent fratricide and also allows units to avoid unexpected engagements with the enemy. In fact, the BFT systems "have proven their value in reducing fratricide: ground forces in Iraq using the Force XXI Battle Command Brigade and Below tactical communications system (FBCB2) had no friendly fire deaths" [6]. Environmental and terrain data help to combine with unit location data to give an overall picture and allow for the use of the environment to the warfighter's advantage. Video, FLIR and other imagery can not only reveal enemy positions, it can give the tactical advantage to the warfighter by allowing ingress and egress routes to be planned and replanned and create an understanding of the environment and its hazards.

Digital interoperability "draws together a powerful set of warfighting concepts and associated military capabilities that enable warfighters to exploit information in order to bring assets to bear in a rapid and flexible manner" [3]. Digital interoperability allows for planning changes in accordance with the current situation and gives the adaptability needed as the force reduces and becomes more nimble. This also "enables further collaboration and self-synchronization and improves sustainability and speed of command, which ultimately result in dramatically increased mission effectiveness" [3].

Aircraft, special operations forces, and small boat operations would be able to communicate with their ship and be re-tasked, given direction or warned of newly formed dangerous areas. The aircraft can send data back to the ship providing real time intelligence from its sensors to be distributed to other areas of the battlefield in a timely manner. For example, a helicopter can go out over the horizon to investigate a contact and then once the data is evaluated be given the order to strike.

III. Blue Force Tracker

Blue Force Tracker (BFT) is an Army-developed, real-time, Command and Control/Situational Awareness enabling system that is currently used across the services [7, 8, 9, 10]. The BFT system combines the GPS positional data of various units into a single operational display of the battlefield with icons representing each BFT equipped friendly unit. This provides greater situational awareness and ultimately allows friendly forces to respond faster than their adversaries [11]. By virtue of tracking friendly forces, the system has saved many lives by preventing friendly fire incidents [11]. The Army fields both a secure, terrestrial system that communicates over their radio network and BFT which uses an unsecured commercial L-band satellite network, though the non-line-of-sight capable BFT is used by 80 percent of forces [8, 11].

Prior to the implementation of BFT, the Army used 10 different stove-pipe systems specially designed to meet the needs of an individual Army contingent [12]. A push towards interoperability prompted a "very-complicated" messaging system for sharing information, but true interoperability from a single system was achieved with BFT, first used during Operation Iraqi Freedom [11, 12]. The Army initially encountered resistance to the technology–soldiers were afraid that commanders would use it to micromanage–but very quickly came to depend on it [13].

A. BFT

The BFT system is composed of transceivers and computers mounted on vehicles and aircraft, 20 leased L-band communications channels provided by 8 satellites from the MSV, Artemis, Inmarsat, Thuraya, and ACeS constellations, and various network operations centers for control [8, 9, 10]. BFT is a half-duplex system where positional data and text messages from a single unit are sent to the satellite, to a network operation center in the US, processed then rebroadcast back along the same path to all appropriate units [8, 9].

Though a significant improvement over any past technology, BFT has severe limitations, many of which will be corrected with the implementation of BFT 2. The primary issues with BFT are bandwidth and lack of encryption [13]. Text message size is limited to a few paragraphs meaning orders have to be sent in multiple messages [13]. The refresh time for positional data is as much as 1 min for aircraft and 5 min (meaning up to 800 m if the unit is moving) for ground vehicles [7, 9, 11]. Service interoperability has also been an issue due to different data protocols and architectures between the different services resulting in the Marines and Army not being able to see each other during Desert Storm [11].

B. BFT 2

BFT 2 is a hardware and software upgrade to the BFT system that dramatically improves the bandwidth issues of BFT [7, 8, 9, 10]. BFT 2 allows for reduced positional refresh time, more messages per channel, and secure communications by virtue of its full-duplex, open IP architecture, and an in-line, AES-256-bit encryption device [7, 9, 10]. BFT and BFT 2 capabilities are summarized in Table 1.

	BFT 1	**BFT 2**
Refresh Time	5 min	4-8 sec
Download Speed	2.6 kbps	122 kbps
Upload Speed	0.27 kbps	2.8 kbps
Messages/min/channel	600	5000
Transmit/Receive	Half-duplex	Full-duplex

Table 1: Comparison of BFT and BFT 2 capabilities [7, 9].

The first step of upgrading BFT involved the Joint Capabilities Release (JCR) software upgrade which the Army implemented in 2011 [8, 10]. JCR will work with both the legacy BFT systems and the new BFT 2 systems [8, 10]. The Army then began fielding BFT 2 hardware systems in 2012 [10, 14]. Once fully upgraded, the software will again be updated to the Joint Battle Command–Platform (JBC-P) [8, 10]. JBC-P has a chat function and improved mapping software that will further improve refresh time [8]. BFT 2 allows for over the air software upgrades that should extend the useful lifetime of the hardware [7].

C. Future Upgrades

In July 2011, the Army issued a call for preliminary designs and prototypes of transceivers for BFT 3 to replace BFT 2 beginning in 2015 [15]. The reasons stated for the desired upgrade are cost to lease commercial satellites and security [15]. The X-band Wideband Global SATCOM (WGS) is the satellite platform that will likely field BFT 3 technology [15]. Prototype system requirements include: 1500 byte file transfer, 30,000 simultaneous 90-byte message/minute transmission with an 85% or greater success rate, two second message latency, and full-duplex capabilities [15].

IV. Alternatives to Blue Force Tracker

Blue Force Tracking (BFT) is not the only product to enable battle space awareness and digital interoperability. Various stakeholders for the Department of Defense have used tools such as Global Command and Control System – Maritime (GCCS-M), Automatic Identification System (AIS), and Automatic Dependent Surveillance – Broadcast (ADS-B), Link 16 and Tactical Targeting Network Technology (TTNT) to connect the warfighter. The key to any battle space awareness solution is to gather and overlay latitude and longitude, in addition to amplifying data, onto a common operating picture. The DoD utilizes manually input data and automated systems fed from the Global Positioning System (GPS). Below is a brief overview of sample systems that have the potential to be an alternate to BFT.

A. Global Command and Control System - Maritime

Global Command and Control System – Maritime (GCCS-M) is the United States Navy's element for the Department of Defense's Global Command and Control

System family of systems [16]. GCCS-M can "receive, display, [and] correlate" geo-locational track information for friend, foe, and neutral subsurface, surface, and airborne units [16]. This system connects naval units through the Global Information Grid (GIG) and data is exchanged through either the Secure Internet Protocol Router Network (SIPRNET), Non-Secure Internet Protocol Router Network (NIPRNET) or the Joint Worldwide Intelligence Communication System (JWICS). Through these networks GCCS-M can receive any data connected to the Global Information Grid, such as BFT. GCCS-M is an open source, application based design which support the Command and Control mission for higher echelon forces, such as Force Commanders by providing a consistent Common Operational Picture [16].

One of the largest disadvantages of GCCS-M is the manpower intensive nature of the information feed into the database. A sailor is required to manually enter position information allowing for error and unnessasary latency.

B. Automatic Identification System (AIS)

Automatic Identification System (AIS) is a shipboard broadcast system that operates within the VHF–30 to 300 MHz–maritime band. The system acts like a transponder and consists of a VHF transmitter, two Time Division Multiple Access (TDMA) receivers, one VHF Digital Selective Calling (DSC) receiver, standard communication links, and a display [17]. A variety of data is transmitted within this link, including, but not limited to the following: Global Positioning System (GPS) information, heading, course, speed, rate-of-turn, destination, and estimated time-of-arrival [17]. AIS can be turned on and off. The use and transmission of AIS is mandatory for commercial vessels. Military units typically adjust their AIS to receive only modes for security reasons; however, military units can transmit at the request of the Commanding Officer. Current AIS data can be manually entered to "spoof" vessel name and aid in deception techniques.

C. Automatic Dependant Surveillance

Automatic Dependent Surveillance-Broadcast (ADS-B) is deemed the future "air traffic management system" [18]. ADS-B is part of the traditional Mode 3/C Identify Friend or Foe (IFF) transponder system and an extension of the new Mode S. There are two types of ADS-B implementations: ADS-B In and ADS-B Out. In ADS-B Out, the platform transponder automatically broadcasts its "digitized individual identification and its position, altitude and other data" over a range of approximately 150 nautical miles [18]. It transmits at a rate of once per secound. Based on a network of ground stations, the broadcast is relayed to control centers for air traffic controllers. In ADS-B In, the platform is equipped to receive other platforms' ADS-B Out signal and display it for traffic avoidance assistance.

ADS-B gathers its position data from a separate GPS unit. The data that is transmitted to air traffic controllers at a higher update rate and with more accuracy than traditional radar [18]. The major disadvantage is the inability of the system to transmit across oceans since it is only a line-of-sight system [18].

D. Link 16

Link 16, also called the Tactical Data Information Link (TADIL) – J is "an encrypted, jam-resistant, nodeless tactical digital data link" [19]. The system was created in 1975 and allows for messages to be sent from the TADIL-J message catalog. Link 16 allows for the exchange of location data and air defense threats to create a situational awareness picture. It is a line-of-sight system which uses the Multifunctional Information Distribution System (MIDS) and allows up to 128 nets at a data rate of up to 2 Mbps in the 969 to 1206 MHz L-band frequencies [20]. The MIDS system is expensive, large and has suffered from poor reliability in the past. Used mainly for airborne and shipboard platforms the MIDS has not yet been miniaturized for use in the field. For example, the MIDS Low Volume Terminal 1 weighs 49 lbs and is 9.75" X 13.5" X 7.6" [20]. It has been successful in implementation internationally in that "more than a dozen countries have installed Link 16 terminals on over 19 different land, sea, and air platforms" [19].

E. Tactical Targetting Network Technology

The TTNT is an on-demand mesh network that allows for high data rates and low latency. With speeds up to 2 Mbps and only 2 ms latency for platforms within 100 miles, TTNT can support up to 1000 users [21]. It gains beyond line of sight capabilities by using each member of the network as a node to send data through. Unlike Link 16, TTNT is not a planned network, so that platforms can join and leave as necessary to support the mission. TTNT uses "Statistical Priority Multiple Access which allows for dynamic net join and exit, scalability, and automatic network capacity allocation" [22]. Intended as a targeting tool, TTNT uses internet protocol to connect platforms. TTNT is interoperable with existing systems, using the same message format as Link 16, but does not interfere with the Link 16 network.

V. ANALYSIS AND RECOMMENDATIONS

A. Advantages to BFT 2

BFT is already in use by the Navy and the upgrade to BFT 2 will only increase the capabilities of the system. The improved refresh time with BFT 2 will provide accurate, real-time positional data through GPS, and text communications [9]. The positional data is displayed over a digital map with essential terrain features [8]. Velocity data is not explicitly provided through the system but with a 4-8 second refresh time, heading and velocity can be inferred or communicated. Users of BFT are able to manually input red tracking or other information into the system that can then be viewed by all other users [8]. The JBC-P upgrade will also introduce a chat feature that will further enhance information sharing [8, 10]. BFT 2 is also being fielded by the Army, Marines, and coalition forces meaning that it has the advantages of dispersed research and development costs, production economies of scale, and is guaranteed to share information with all friendly units in a joint environment. The antenna system for BFT 2 is of comparable size and weight to the currently installed BFT system [9]. Finally, the encryption device allows for the transmission of SIPRNET level information [10].

B. Disadvantages to BFT 2

Though BFT 2 does allow for text message communication and will support chat when fully implemented, the passage of other sensor data is not currently possible with the system [6, 8]. Imagery, video, and verbal communications cannot be communicated using BFT 2. BFT 2 does not share sensor information directly between systems in a truly networked fashion but rather is a collection of individual transceivers that send their GPS position to a network operations center which, in turn, broadcasts that position to all other users. BFT 2 also still uses leased, commercial, L-band satellite systems which have many inherent disadvantages including cost, availability, survivability, landing rights issues, and oceanic and polar coverage limitations. Further, plans are being made to upgrade the BFT system to BFT 3 using different satellite communication bands which will ultimately require upgrading the hardware again [14].

C. Alternatives to BFT 2

GCCS-M, AIS, ADS-B, Link 16 and TTNT are all systems that allow for the exchange of information. AIS and ADS-B are civilian systems that allow for control of traffic. These systems are unencrypted and specific to ship or aircraft use respectively. Neither would be appropriate for small ships or land based troops. They are not interconnected with any of the other systems currently on the Global Information Grid. GCCS-M is an excellent program, but it is not a stand-alone network, but instead a place to correlate contacts. GCCS-M should be, and has in the past, be used in conjunction with BFT. Link 16 and TTNT are both excellent options for digital interoperability systems. They are able to transfer data throughout the battle space and meet many of the Navy's requirements. However, Link 16 is limited to line-of-sight, is expensive, and has limited room for expansion due to current bandwidth requirements. While the development of TTNT shows promise, its intended use for full motion video will likely make it a specialized network. However, Link 16 and TTNT could be used as alternatives to BFT 2, even if less than optimal from a network, bandwidth and cost perspective.

D. Acquistion of Digital Interoperability

Digital interoperability cannot be just bought off the shelf. It requires design of an architecture and implementation strategy that allow for stable intermediate forms. Seeing that a digitally interoperable network is a system of systems, constructing the network in such a way that stable intermediate forms are produced is vital, particularly with the current funding constraints. Therefore, to obtain digital interoperability, a multi-tiered approach is recommended. Using a combination of systems that are then linked at certain nodes (a hub and spoke network) is the best strategy to ensure a robust system-of-systems, that connects all users, but that avoids the complexity and cost of a fully connected network. To meet this, separate systems for voice, situational awareness and data transfer from sensors would be required.

E. Recommendations

The final system should consist of BFT 2 for low bandwidth requirements, situational awareness and text messaging. Unlike the systems that require other platforms as nodes, BFT 2 guarantees beyond line of sight satellite communications. For voice communications, the traditional UHF radio, either satellite based or direct coupled with HF is recommended. Link 16 should be used to address higher data rate technologies, but it is expensive to implement for the individual platform, and already bandwidth limited. TTNT should be incorporated in those platforms that need real-time imagery, and not used for situational awareness that BFT provides. This will allow for those users that need video to utilize TTNT, without eating up band width for basic position and text data that can be handled on the BFT system. These should all be merged into a consolidated tactical picture using systems like GCCS-M and then retransmitted through the appropriate system (BFT, Link 16 or TTNT dependent on the data). The merging of these systems into one digitally interoperable force is the ideal. However, upgrading to BFT 2 will ensure a minimum capability is maintained. Without at least BFT 2, interoperability with NATO forces will be threatened, especially since many other countries may not be able to afford the more complicated, costly and higher data rate systems. Since the Marines are Army are migrating to BFT 2, the BFT 1 systems will soon be useless as the satellites are turned off for that system. US Navy users of BFT 1 will lose the capability to communicate via text over the horizon and understand their tactical environment. For some platforms, this is their only practical way of communicating beyond line of sight. The US Navy must upgrade to BFT 2 to continue on the road to digital interoperability.

VI. Conclusions

With BFT rapidly reaching end of life, the Navy will be forced to upgrade its current digital interoperability system to maintain warfighting superiority. BFT provides positional data and non-line-of-sight text messaging, a capability that will be lost if no action is taken. Further, in order to meet all the digital interoperability requirements the Navy must continue to acquire new technologies that will allow for the sharing of sensor data, voice, etc. while functioning together to enhance situational awareness and command and control. With various systems to choose from and significant budget constraints, the upgrade to BFT 2 is a minimum essentiality. Though BFT does not meet every digital interoperability requirement for the Navy, upgrading to BFT 2 would not only continue the benefits of the system but also dramatically improve upon them. Further, the security of the BFT 2 system places it ahead of the competition. The ideal is a mixture of BFT 2, Link 16, TTNT, GCCS-M, and even radio configured to work in harmony to provide for position, sensor data and imagery, and secure communications. The acquisition of BFT 2 would be a significant step towards that end while the failure to upgrade would only mean losing some of the US Navy's current capability.

References

[1] Department of the Navy. (2008, Feb 28). Navy Interoperability Requirements, Certification and Testing of Navy Tactical C4ISR Systems Implementing Procedural Interface Standards (OPNAVINST

9410.5B). Washington DC: Deputy Chief of Naval Operations (Communication Networks).

[2] Wang, Y., & Zhao, Y. J. (2006, March). Fundamental issues in systematic design of airborne networks for aviation. In *Aerospace Conference, 2006 IEEE* (pp. 8-pp). IEEE.

[3] Mawby, D., McDougall, I., & Boehmer, G. (2005). A network-centric operations case study: US/UK coalition combat operations during operation Iraqi freedom. EVIDENCE BASED RESEARCH INC VIENNA VA.

[4] Department of the Navy. (2009, Oct 6). The Information Dominance Corps (OPNAVINST 5300.12). Washington DC: Office of the Chief of Naval Operations.

[5] White, D. A., Young, L., & Kelsch, G. R. (1998, October). Modeling and simulation of situational awareness in the tactical internet. In *Military Communications Conference, 1998. MILCOM 98. Proceedings, IEEE* (Vol. 3, pp. 872-876). IEEE.

[6] Jacobus, C., Cohen, C., Haanpaa, D., & Siebert, G. A Personal Blue Force Tracking System.

[7] Blue Force Tracking 2 and C2SA Service. (2013). ViaSat. Retrieved from http://www.viasat.com/government-communications/blue-force-tracking

[8] Slabodkin, G. (2011). Next-gen Blue Force Tracking system gets major boost. *Defense Systems*. Retrieved from http://defensesystems.com/articles/2011/02/28/c4isr-1-blue-force-tracking.aspx

[9] Abejon, Al A. (2012, Sept 11). Blue Force Tracking – Aviation update. Naval Air Systems Command, NAVAIR/BFT – AVN PMR.

[10] Force XXI Battle Command Brigade=and-Below – Blue Force Tracking (FBCB2-BFT). (2012). IHS Jane's, Combat Management, C4ISR & Mission Systems: Land.

[11] Rider, T. L. (2004). Blue Force Tracking to Expand Across Force. *Army AL&T*, September-October 2004, 2-5. Retrieved from http://asc.army.mil/docs/pubs/alt/archives/2004/Sep-Oct_2004.pdf

[12] IHS Jane's Defence Insight Report – November 2012. (2012). IHS Jane's, Defense Insight Reports, C4ISR & Mission Systems. Editor Geoff Fein.

[13] Tiron, R. (2003). Army's Blue-Force Tracking Technology Was a Tough Sell. *National Defense Magazine*, December 2003. Retrieved from http://www.nationaldefensemagazine.org/archive/2003/December/Pages/Armys_Blue3685.aspx

[14] Army advances networking, force-tracking technologies. (2012, Sep 06). M2 Presswire. Retrieved from http://search.proquest.com/docview/1038103058?accountid=12702

[15] Blue Force Tracking – 3 (BFT-3) Improved Satellite Network Requirements. (2011). Department of the Army Solicitation. Retrieved from https://www.fbo.gov/index?s=opportunity&mode=form&tab=core&id=e24d79c5e3d58ecf6226e7bccb001add

[16] IHS Jane's Military Communications – May 2013. (2013). IHS Jane's Communications, Systems.

[17] IHS Jane's Defence Insight Report – November 2012. (2012). IHS Jane's, Defense Insight Reports, C4ISR & Mission Systems. Editor Geoff Fein.

[18] IHS Jane's Electronic Mission Aircraft – January 2011. (2011). IHS Jane's, Electronic Mission Aircraft, Payloads.

[19] Hura, Myron, Gary McLeod, James Schneider, Daniel Gonzales, Daniel M. Norton, Jody Jacobs, Kevin M. O'Connell, William Little, Richard Mesic and Lewis Jamison. Interoperability: A Continuing Challenge in Coalition Air Operations. Santa Monica, CA: RAND Corporation, 2000. http://www.rand.org/pubs/monograph_reports/MR1235Deakin, R. S. (2010). Battlespace Technologies: Network-Enabled Information Dominance. Artech House.

[20] Data Link Solutions. (2009). MIDS LVT 1. Retrived from http://www.rockwellcollins.com/~/media/Files/Unsecure/Products/Product%20Brochures/Communcation%20and%20Networks/Data%20Links/MIDS%20LVT/MIDS%20LVT%20data%20sheet.aspx

[21] Deakin, R. S. (2010). Battlespace Technologies: Network-Enabled Information Dominance. Artech House.

[22] Rockwell Collins. (2009). TTNT White Paper: Tactical Targeting Network Technology and Connectivity. Retrieved from http://www.sldinfo.com/wp-content/uploads/2009/11/TTNTWhitePaper1.pdf