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Boarding Team Communications
Phase I
Product Development and Evaluation

FINAL REPORT
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N O T I C E

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16. Abstract (MAXIMUM 200 WORDS)

The U.S. Coast Guard (CG) Research and Development Center has developed Boarding Team Communications (BT COMMS), a wireless ad hoc mesh network solution for the CG Boarding Team below-decks connectivity problem. BT COMMS works where UHF/VHF radios do not and overcomes the problems associated with conventional radio frequency voice repeaters. BT COMMS has proven its capability for providing 100 percent connectivity in critical boarding areas during exercises on a variety of vessels. During *simulated* scenarios conducted at the Department of Defense Interoperability Communications Exercise, BT COMMS has also shown that it is capable of connecting the boarded vessel to the parent cutter, the CG sector and with afloat and land-based agencies using disparate radio systems. Functional specifications for BT COMMS will be developed with operational field units during the next phase of this project. They will serve as input to the System Development Life Cycle process. When completed, the CG will have a reliable below-decks connectivity system that can be deployed with Boarding and Inspection Teams and/or Maritime Security Response Teams.

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EXECUTIVE SUMMARY

U.S. Coast Guard (CG) Boarding Teams (BT) are not able to communicate when searching or inspecting below-decks on large vessels (> 600 feet), significantly impacting team safety and situational awareness. The CG Research and Development Center has developed BT COMMS, a wireless ad hoc mesh network solution to this problem. BT COMMS, unlike UHF and VHF radios, provides connectivity for BTs in critical search and inspection areas. It also overcomes the problems typically associated with conventional radio frequency voice repeaters.

BT COMMS uses smart routers as portable wireless repeaters (PWR), handheld end user devices and a radio gateway. A major advantage of BT COMMS, unlike other wireless networks, is that it does not use a central server or router; rather, each of the PWR and communicators serve as individual and independent routers for device authentication. BT COMMS uses a cryptographic overlay mesh protocol that is loaded onto the system components, enabling scalable, mobile, secure and interoperable communication.

The BT COMMS system was subjected to rigorous and thorough testing in a variety of below-decks shipboard environments during which its capability to provide 100% connectivity in critical below-decks boarding areas was clearly demonstrated. An initial concept of operations for PWR placement onboard a vessel and work-arounds for major obstacles to RF propagation was established based on test results.

A group of CG subject matter experts (SME) rated BT COMMS against the radios currently used by BTs. They worked with a tool called MOSAIC which is a structured, repeatable format for capturing requirements, identifying capability gaps, and evaluating technologies against current or future requirements. The SMEs first developed and refined a list of requirements for a BT below-decks connectivity solution. Then, using MOSAIC, they rated BT COMMS and the CG radios as they currently exist. The SMEs then rated each system on capabilities they are expected to have in the future. SME ratings clearly indicated their strong preference for the BT COMMS solution.

BT COMMS was also subjected to rigorous testing throughout the Department of Defense Interoperability Communications Exercise (DICE). During the testing, BT COMMS showed that the network could provide the following capabilities:

- Voice communication between a boarded vessel and parent cutter
- Establish a wireless mesh network to simulate a shipboard below-decks environment
- Voice communication below-decks using disparate radio systems
- Voice communication with a sector command center
- Voice communication with afloat and land-based agencies using disparate radio systems
- Connections with the ".mil/.smil" network.

The capabilities demonstrated in the simulated DICE environment will be fully developed during later phases of this project.

Functional requirements for BT COMMS will be developed during a series of end user operational field tests during the Phase II of the project. These requirements will serve as input to a System Development Life Cycle package for CG acquistion. End users will provide feedback on human factors issues associated with the system (e.g., ambient noise in engine rooms). Ultimately the CG will have a system that will be deployed with boarding and inspection teams and/or Maritime Security Response Teams, giving BT level of safety, security and situational awareness hitherto not possible.

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LIST OF ACRONYMS

ADM	Admiral
AES	Advanced Encryption Standard
BT	Boarding Teams
BT COMMS	Boarding Team Communication
BTO	Boarding Team Officer
C4IT	Command, Control, Communication, Computer and Information Technology
CAMSPAC	Communication Area Master Station Pacific
CGC	Coast Guard Cutter
CDMA	Code Division Multiple Access
CF	Compact Flash
CG	Coast Guard
CGDN+	Coast Guard Data Network Plus
COMP	Cryptographic Overlay Mesh Protocol
CONOP	Concept of Operations
CRG	CoCo Radio Gateway
DAMA	Demand Assigned Multiple Access
DICE	Department of Defense Interoperability Communications Exercise
DISA	Defense Information Systems Agency
DoD	Department of Defense
EMI	Electro-magnetic Interference
EVDO	Evolution-data Optimized
FEMA	Federal Emergency Management Agency
FIPS	Federal Information Processing Standard
GB	Gigabyte
GHz	Gigahertz
HP	Hewlett Packard
IP	Internet Protocol
JITC	Joint Interoperability Test Command
KU	Kurtz-Under Band
LAN	Local Area Network
LCD	Liquid Crystal Display
LE	Law Enforcement
MB	Megabyte
MHz	Megahertz
MILSATCOM	Military Satellite Communications
MSRT	Maritime Security Response Teams
mWATT	milliwatt
NIPRnet	Unclassified-But-Sensitive IP Router Network
PCRG	Portable CoCo Radio Gateway
PDA	Personal Digital Assistant
PRG	Portable Radio Gateway
PWR	Portable Wireless Routers

QOS	Quality of Service
RAM	Random Access Memory
RDC	Research and Development Center
RF	Radio Frequency
ROM	Read Only Memory
SATCOM	Satellite Communications
SD/MMC	Secure Digital/MultiMediaCard
SDLC	System Development Life Cycle
SIPRNet	Secret IP Router Network
SME	Subject Matter Expert
TCP/IP	Transmission Control Protocol/Internet Protocol
TDMA	Time Division Multiple Access
TFT	Thin Film Transistor
TISCOM	Telecommunication and Information Systems Command
TWC	Tactical Wireless Connectivity
UHF	Ultra High Frequency
U.S.	United States
USS	United States Ship
VHF	Very High Frequency
VoIP	Voice over Internet Protocol
WiFi	Wireless Fidelity
XP	eXtreme Programming

BACKGROUND

U.S. Coast Guard (CG) Boarding Teams (BTs) can have from two to eight members, depending on the impending threat or size of the vessel. BTs board large tankers, deep draft vessels, freighters, large passenger vessels, ferries and commuter boats, many over 600-feet long (see Figure 1). Team members wear 20 to 25 pounds of gear, which in most cases includes a two to three pound radio.

Figure 1. Boarding a Liquid Natural Gas Vessel.

Once on board, the Boarding Team Officer (BTO) will proceed to the bridge of the vessel to contact the ship's master. BT members disperse throughout the ship in teams of two to conduct inspections or searches. Depending on the size of the vessel, some team members might remain with the crew while others will inspect or search critical areas such as the engine room and aft steering.

PROBLEM

The ability to communicate among team members and with the BTO on the bridge is critical to team safety and situational awareness. However, the interiors of boarded vessels present myriad communication problems, to include ambient noise, electro-magnetic interference and reinforced steel in areas such as engine rooms and aft steering.

The radios currently used by BT members do not provide a reliable means of transmitting and receiving critical information below-decks during a boarding. The CG Research and Development Center (RDC) documented the inadequacy of these radios in a test which showed that *they worked less than half the time in a shipboard below-decks environment and could not provide the coverage needed for BT safety (Dewey, 2004)*

USER REQUIREMENTS

RDC personnel surveyed BT members in field units across the United States and Headquarters personnel to garner requirements for an alternative solution to the unreliable handheld radios. BT members told RDC that they wanted a system that will function reliably in all boarding environments and is intrinsically safe. They were unanimous in citing the failure of the current radios and in asking for a system that will provide effective connectivity *anywhere* on a vessel and to all members of the team. They want a system that allows them to talk back to the small boat, to command centers and to other agencies. Some BTs also need to be able to talk to airborne units.

BT members want a system that is hands-free, lightweight, portable, waterproof and affordable. They would also like bone microphones, panic buttons, access to criminal databases, encryption (to at least the level they have currently), a rechargeable battery with a life of 8+ hours, and a system that will float. They stressed the importance of having a closed channel for communication among the team and having a general channel for interoperability with their law enforcement partners. *Primary among their requirements, however, is the ability to communicate with each other throughout any vessel during a boarding.* There was a striking consistency of responses across respondents regarding the urgency of providing a solution to the problem of below-decks connectivity.

ANALYSIS OF ALTERNATIVES

RDC fitted the requirements given by BT members to the available options (see Table 1) for below-decks connectivity. Based on BT member input, a candidate technology had to meet the first three requirements (either now or in future development) to be considered further.

Table 1. Analysis of potential solutions.

	Potential Solutions				
User Requirements*	**VHF-FM**	**UHF**	**Conventional RF Repeaters**	**Wireless Portable Repeaters**	**Software-Defined Radios**
1. Connectivity throughout vessel	No	No	No	Yes	No
2. Intrinsically safe	Yes	Yes	No	Yes (future)	Yes
3. Reliable	No	No	No	Yes	No
4. Hands free	Yes	Yes	No	Yes (future)	Yes
5. Lightweight	Yes	Yes	No	Yes (future)	Yes
6. Portable	Yes	Yes	Yes	Yes	Yes
7. Encrypted/secure	Yes	No	No	Yes	Yes
8. Talk to helos	No	Yes	No	Yes	Yes
9. Talk to small boats	Yes	No	Yes	Yes	Yes
10. Closed channel for BT	No	No	No	Yes	Yes
11. General channel for LE partners	No	No	No	Yes	Yes

*Solution MUST meet first three requirements to be considered as an alternative.

SOLUTION

As seen in Table 1, the most promising technology appears to be wireless repeaters. Conventional radio frequency (RF) voice repeaters will not suffice because of two major problems associated with their use:

1. The number of repeaters that can be used between radios is limited, thereby limiting connectivity onboard a vessel.
2. RF repeaters introduce a significant amount of latency into transmissions.

The wireless solution chosen by RDC uses portable wireless repeaters (PWR) that operate on the 802.11 band and can transmit data and video as well as voice. The PWR can be configured to form a wireless ad hoc mesh network which solves many current communications problems through use of a new cryptographic mesh routing protocol (see Figure 2) known as COMP.[1]

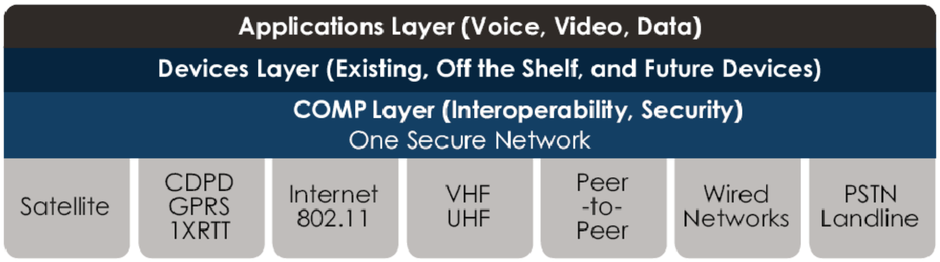

Figure 2. Cryptographic Overlay Mesh Protocol (COMP).

COMP is "transport agnostic" in that it can travel over any system (e.g., satellite, VHF, UHF or wired networks). The combination of the PWR with COMP provides a truly unique BT communication (BT COMMS) solution to the below-decks connectivity problem because it offers three important features not readily available with other repeater solutions. They are:

1. *Scalability* - allowing virtually unlimited network expansion over large areas without being encumbered by the latency problem.
2. *Security* - using Advanced Encryption Standard (AES)-256 encryption for secure transmission.
3. *Mobility* – no central server needed for authentication.

The BT COMMS solution to the below-decks connectivity problem uses handheld end user devices and a radio gateway in addition to the PWR. The PWR have 14 hours of rechargeable battery life, weigh 3 pounds, measure 4" x 8" x 2.5", and have a self-contained 100 mWatt 802.11b router. The PWR transmit data from nearby network nodes to distant peer nodes. This capability produces a very reliable mesh network because each node can reach several other nodes. Should one node drop out of the network because of hardware failure, neighboring nodes simply route themselves around the non-functioning node, a capability generally described as "self-healing" (see Figure 3). The mesh network is described in greater detail in Appendix A.

[1] Cryptographic Overlay Mesh Protocol.

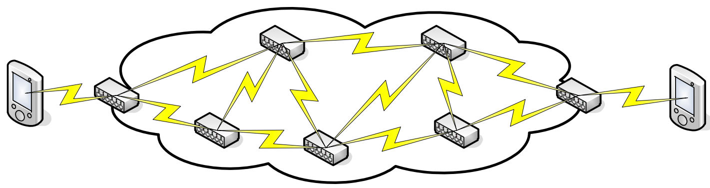

Figure 3. Illustration of a self-healing network.

The handheld communicators consist of an HP5550 Personal Digital Assistant (PDA) and a Panasonic Toughbook CF-29 (see Figure 4). The HP 5550 PDA and the PWR both have an Intel Xscale PXA255 processor running at 400 MHz. The Panasonic Toughbook has an Intel Pentium M processor, running at 1.4 GHz. The Portable Radio Gateway (PRG) has an XTS-5000 holder and connector for interoperability with existing CG equipment. All system components are 802.11b capable (see Appendix B for greater detail).

Portable Wireless Repeater | Handheld Communicators | Radio Gateway

Figure 4. BT COMMS system components.

PRODUCT DEVELOPMENT

Product Evaluations

The RDC conducted a series of product evaluations to ensure that the BT COMMS solution could overcome the numerous below-deck connectivity problems and prove its value for BT use.

Shipboard Radio Frequency Propagation

The amount of reinforced steel that forms a ship's bulkhead is perhaps the most formidable barrier to below-decks communication. CG icebreakers, given their mission, have even greater amounts of heavily reinforced steel in the bulkheads of their watertight compartments when compared to other CG cutters (CGC). The RDC evaluated the BT COMMS solution under these most *stringent* conditions on the CG Icebreaker POLAR STAR.

The primary purpose of the POLAR STAR evaluation was to determine radio frequency (RF) propagation characteristics under conditions of heavily reinforced steel. Using two PWR, our first test *demonstrated the ability of the BT COMMS solution to transmit successfully through the POLAR STAR's watertight barriers with hatches that were "dogged" (closed), sealed and watertight.*

The next assessment on the Polar Star established the maximum range between two PWR under a variety of below-decks shipboard environmental conditions. We found that ladderwells, passageways, wireways and air ducts were efficient below-decks RF propagators and can be counted on for maximum PWR effectiveness. *The results of this evaluation were used to develop an initial concept of operations (CONOP) for PWR placement*.

Applying this CONOP, RDC personnel created a wireless network throughout the POLAR STAR, using its ladderwells, passageways, wireways and air ducts for maximum RF propagation. The below-decks network was established with only seven PWR. Using handheld communicators, messages were transmitted and received throughout the vessel, demonstrating 100 percent connectivity in critical below-decks search and inspection areas.

Electro-magnetic Interference

Electro-magnetic interference (EMI) onboard a vessel is another major obstacle to successful below-decks connectivity. To evaluate the capability of the BT COMMS solution to surmount this obstacle, the RDC used another icebreaker, the CGC MACKINAW as a test platform. This vessel has a significant concentration of EMI, largely due to its diesel-electric propulsion plant. An additional feature of the MACKINAW, which makes it an excellent vessel for PWR assessment, is its ladderwells. The ladderwells are configured like those in large deep draft vessels, i.e. one on top of the other in a linear fashion rather than staggered throughout the ship as on the POLAR STAR.

Capitalizing on the CONOP developed during the POLAR STAR testing, *RDC was able to overcome the challenges of the MACKINAW by judicious placement of PWR in and around high EMI areas, using available ladderwells, passageways, wireways and air ducts.* During this evaluation, we found that motor controls and switchboards were to be avoided for PWR placement because of their effect on transmission and reception. Further, we found that the heated glass on the bridge of the MACKINAW presented an RF shielding effect; however, we were able to overcome it by deploying the PWR outside the compartment. Large cavernous empty holds, as well as water and fuel tanks, also proved to be significant obstacles to transmission. These results were used to further develop the CONOP for PWR placement.

Applying the POLAR STAR and MACKINAW findings, *100 percent connectivity was achieved in critical boarding areas on the MACKINAW using five PWR.* Although the MACKINAW is a much smaller vessel than the POLAR STAR (240' vs. 399'), it presented greater challenges for RF propagation, making it noteworthy that connectivity was achieved with so few PWR.

UHF/VHF Radios versus Wireless Network

A previous RDC test aboard the decommissioned USS SARATOGA demonstrated that UHF and VHF radios work less than half the time below-decks (Dewey, 2004). This finding, of course, has serious implications for our BT members who depend on these radios for safety and situational awareness during boardings. Revisiting the SARATOGA, RDC evaluators, using BT COMMS, were able to *establish 100 percent connectivity throughout the area where the UHF and VHF radios had previously failed.* The superiority of BT COMMS, as compared to CG handheld radios, was demonstrated once again.

Fully Powered Underway Test

Each of the assessments described above were conducted dockside and did not altogether characterize the conditions under which BT COMMS would have to operate during a voyage. Thus, the final Phase I product evaluation took place on a fully powered, underway vessel, the ADM Wm. CALLAGHAN. The CALLAGHAN is a roll-on/roll-off ship, designed to carry wheeled cargo such as automobiles, trailers, or railway carriages. It is 694.5 feet in length, and 91.9 feet in the beam. The propulsion system consists of two LM2500 gas turbines.

Using the CONOP developed during the previous assessments, RDC evaluators were able to establish 100 percent connectivity in critical boarding areas of the CALLAGHAN; that is, from the bridge to the engine room and aft steering. Findings from previous assessments were validated aboard the vessel; passages, ladderwells, wireways and air ducts continued to be excellent RF propagators. Problems with EMI areas were easily obviated applying the CONOP developed during the MACKINAW test.

Although the results of the CALLAGHAN testing were gratifying, a serious human factors issue emerged. Evaluators were not able to understand transmissions in high ambient noise areas. They were wearing the Plantronics M-130 over-ear boom style headset (see Figure 5) which is not capable of reducing, abating or canceling ambient noise. Although the network was working perfectly, users could not benefit from the technology because of the background noise. RDC has already begun the work of identifying an appropriate headset for high ambient noise areas and it will be tested prior to and used during the next phase of BT COMMS testing.

Figure 5. Plantronics M-130 Over-Ear Boom Style Headset.

Interoperability Testing

All networks, whether stand-alone or interoperable, are required to be assessed by the Defense Information Systems Agency (DISA). A network constitutes an information system and, as such, must be assessed and certified before it can be used by Department of Defense (DoD) personnel in an operational environment. Although the CG is not a DoD agency, it follows their guidance as an organization and thus, the wireless ad hoc mesh network is required to submit to test and evaluation before the CG can use it operationally.

The RDC's BT COMMS development team participated in the 2006 Joint Interoperability Test Command's (JITC) DoD Interoperability Communications Exercise (DICE) because DICE is a certifying and authorizing authority for DISA. DICE brings together federal and state agencies to test communications gear in a variety of *simulated* scenarios, ensuring that the systems can interoperate with DoD networks. DICE used a simulated BT environment to evaluate interoperability of the XTS/L-5000 radios, Swiftlink DVM-90 KU Band satellite, and International Maritime Satellite system for voice, data and video services, and Internet services with a simulated Unclassified-But-Sensitive IP Router Network (NIPRNet) and Secret IP Router Network (SIPRNet). Testing in the simulated environment demonstrated that BT COMMS provided reliable wireless voice, data and video sessions and met all critical requirements.

During DICE, BT COMMS demonstrated the capability to:

- Communicate by voice between a boarded vessel and parent cutter
- Establish a wireless mesh network to simulate a shipboard below-decks environment
- Communicate by voice below-decks using disparate radio systems
- Communicate with a sector command center
- Communicate with afloat and land-based agencies using disparate radio systems
- Connect to the ".mil/.smil" network through a mock-up of the SIPRNet and NIPRNet system, and to successfully pass information through their networks (Friedman, 2006).

During the exercise, we also demonstrated our capability for interoperability with the Federal Emergency Management Agency (FEMA), the National Guard, the Glendale Police Department and our Communication Area Master Station Pacific (CAMSPAC) communication trailer, despite each agency having different radio systems. Interoperability among federal, state and local public safety agencies remains as one of the Department of Homeland Security's most egregious problem areas, underscoring the significance of this BT COMMS capability.

DICE conducted rigorous testing of our BT COMMS security. By demonstrating that they could not hack into our system, we assuaged the conventional wisdom that a wireless system cannot be made secure.

MOSAIC

As noted earlier, BT COMMS was developed based on requirements from BT members in operational field units and Headquarters personnel. After being subjected to rigorous product development evaluations, it was now time to assess whether or not the resulting technology met CG needs. To that end, a group of boarding team subject matter experts (SME) was assembled, to include Headquarters asset managers, Headquarters program managers, CG Area representatives and operational-unit members. They compared the relative merits of the CG's handheld radios and the developmental BT COMMS solution. The SMEs used the MOSAIC tool which is a structured, repeatable format for capturing requirements, identifying capability gaps, and evaluating technologies against current or future requirements.

Working through the MOSAIC process, the SMEs developed a comprehensive list of requirements needed for an effective below-decks connectivity system. They rated the radios and the BT COMMS solution on those requirements, first as each currently exists, and then as each is expected to be in the future. They used a scale from 0 (fails to meet criteria/standard) to 4 (fully meets or exceeds criteria/standard). The handheld radios received a rating of 2.32 from the SMEs as they exist today, versus 3.44 for BT COMMS. SME ratings for the technologies based on capabilities they are expected to have in the future were 1.57 for the handhelds and 3.09 for BT COMMS. Given the resounding vote of confidence from the SMEs, RDC decided to continue development of BT COMMS for operational use.

SUMMARY

The BT COMMS solution has proven its value to the CG through rigorous evaluation and SME affirmation. Former barriers to below-decks connectivity, such as reinforced steel and EMI, have been overcome by the wireless ad hoc mesh network. Connectivity below-decks in critical search and inspection areas has been established on several vessels under a variety of conditions using CONOP developed during BT COMMS evaluations. These CONOP direct BT members to take advantage of ladderwells, passageways, air ducts and wireways when deploying the portable wireless repeaters. BT are advised to make use of these efficient RF propagators when confronted with heated glass on the bridge, large cavernous empty holds, water or fuel tanks, motor controls and switchboards, reinforced steel and EMI areas. Given the successful BT COMMS product evaluation, RDC will continue to further develop this technology.

THE ROAD AHEAD

Building on BT COMMS success, we have initiated Phase II of the BT connectivity project. The scope of this phase will be limited to connectivity within the boarded vessel. RDC will address development of the next generation of prototype hardware and software, and will examine associated human factors issues. This phase will include operational field tests of BT COMMS during which the RDC will elicit feedback from the users to develop functional specifications for further system development. Phase II is currently scheduled to be completed by the end of CY2007, depending on availability of field personnel.

The functional requirements developed in Phase II will serve as input to the System Development Life Cycle (SDLC), part of the CG acquisition process. RDC will work with TISCOM and the Command, Control, Communications, Computers and Information Technology (C4&IT) directorate to create a complete SDLC package. The goal of the BT COMMS project is to field a system that will be deployed with boarding and inspection teams and/or Maritime Security Response Teams (MSRTs). This system will be deployed during large vessel boardings and will provide uninterrupted voice communications to team members dispersed throughout a vessel, regardless of size or architecture. Ultimately, the device will be intrinsically safe in explosive environments, lightweight, low cost and small enough for boarding team members to carry.

The BT COMMS solution has great potential over and beyond between-the-rails connectivity. Voice, data and video can be passed over the network, between the rails of the vessel and back to the cutter and CG Sectors[2]. The network can provide interoperability among CG Sector assets and port partners, both land-based and afloat. BT COMMS holds the promise for the CG to do business with a higher degree of efficiency and capability.

RECOMMENDATION

BT COMMS has proven to be a reliable and effective solution for the CG below-decks connectivity problem. We recommend that CG-62, the Telecommunication and Information Systems Command (TISCOM) and CG-37RCC initiate funding plans for potential FY09 acquisition of a BT COMMS system for field use. BT COMMS is the appropriate alternative to the unreliable legacy radios and should become the fielded system of choice for the CG.

[2] CG Sectors are integrated Groups, Marine Safety Offices, Vessel Traffic Services and, in some cases, Air Stations,

REFERENCES

Prepared Under the Direction of: Brad D. Friedman. August 2006. United States Coast Guard boarding team communications, spiral 1, version 1 assessment report. Fort Huachuca, Arizona. Joint Interoperability Test Command.

Dewey, John. 2004. Evaluation of UHF/VHF radios for boarding teams. (Memo). Groton, CT. USCG Research and Development Center.

APPENDIX A

MESH NETWORK SYSTEM DESCRIPTION[3]

Mesh Network Subsystem

This subsystem consists of 802.11b wireless smart routers and handheld Personal Digital Assistants (PDA). These provide an 11 Mbps ad-hoc link between each device within range. The ad-hoc link is managed by software running on each device called Cryptographic Overlay Mesh Protocol (COMP). COMP authenticates each device and encrypts the data to Advanced Encryption Standard (AES)-256 for each hop that is made.

The data are encrypted by the end device so the traffic on each link is encrypted twice. COMP also smartly routes traffic so it can deliver data across the most efficient link or across a specified link. All routing decisions, including authentication, are done by each device and no server is used.

The Voice over Internet Protocol (VoIP) component resides solely on the mesh network and is capable of traveling through the Unclassified but Sensitive Internet Protocol Router Network (NIPRNET) as encrypted encapsulated data traffic. The VoIP codec is software based and is integrated with the communication device. This software program can reside on all Windows CE, Windows XP and Linux devices. These devices could be PDAs, Workstations, Servers, or Laptops. The communication device provides the ability to talk with an individual or group with a full-duplex communications link or enter a broadcast conference using simplex push-to-talk.

CoCo Radio Gateway Subsystem

This subsystem consists of a Radio Gateway (RG). The RG is a hardware device which resides on the mesh network and is a member of the broadcast conference of the deployed network. The RG and a Portable RG (PRG) will interface to Ultra High Frequency (UHF), Very High Frequency (VHF), and MILSATCOM. When the broadcast conference is keyed, the RG will key up the device it is interfaced with and broadcast on that channel allowing voice only interoperability with legacy radio systems

System Interface Description

The following diagram shows the interaction of the Boarding Team Communication (BT COMMS) subsystems as well as the extension of the Coast Guard Data Network Plus (CGDN+) through SATCOM.

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[3] Excerpted from the System Security Authorization Agreement for U.S. Coast Guard Research and Development Center’s Boarding Team Communications Solution.

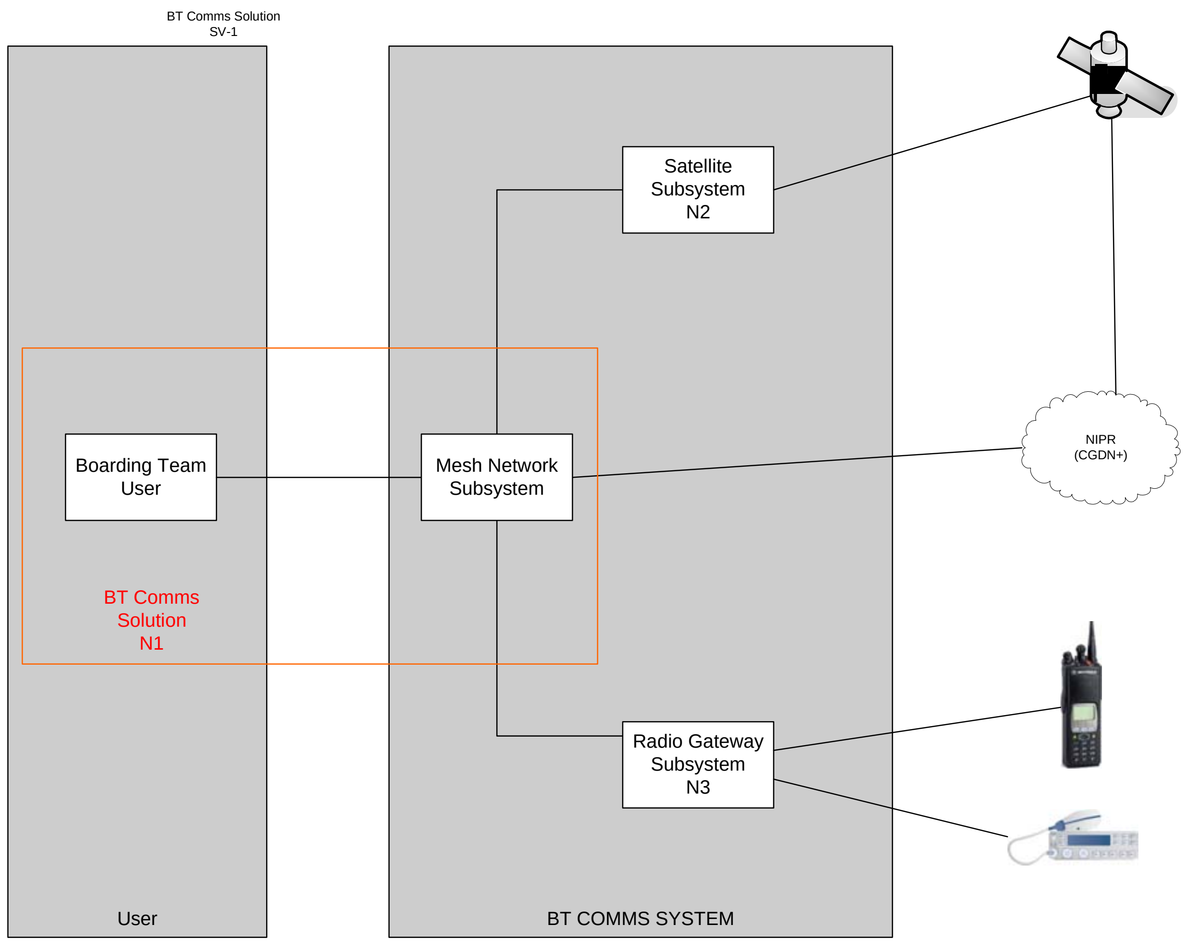

Figure A-1. System Interface Descriptions (SV-1).

Functional Description:

System Transport:

Transport is the movement of information and/or knowledge among users, producers, and intermediate entities. BT COMMS solution provides reliable, secure, transport by utilizing COMP. COMP authenticates, encrypts, routes, and provides Quality of Service (QOS) for data riding along the network.

Switching, Routing, and Transmissions:

The switching, routing, and transmission functions are also based on COMP. COMP is what creates and manages the wireless network. It runs on each wireless device and works independently from each instance making it a server-less protocol. COMP is responsible for routing the data and ensuring that it arrives at the desired destination. COMP is transport agnostic; it can be the transport or it can travel over existing TCP/IP network transports as well.

Spectrum Supportability/Electromagnetic Environmental Effects:

The satellite subsystem uses Time Division Multiple Access / Demand Assigned Multiple Access (TDMA/DAMA) technology which support the CG/DoD goal of a network-centric environment. In this architecture, the satellite terminals become part of the underlying data network and the satellite bandwidth becomes shared among users.

Quality of Service:

The BT COMMS System will meet the quality requirements. These requirements include Random Bit Error Rate, Voice Quality, Voice Compression, One-way packet delay, Jitter (delay variation), and packet loss. The implementation of a converged network, where all user traffic is packetized and competes for the limited satellite bandwidth, necessitates a means of differentiating traffic at the packet level and making independent decisions on how best to service that traffic based on its particular characteristics (i.e., real-time vs. non real-time) and the indicated importance (priority). By design COMP has implemented a QOS mechanism which is designed to guarantee that voice traffic is allocated the necessary transport resources. This is done through a combination of guaranteed bandwidth and a precedence and preemption mechanism.

Security:

COMP manages security for the BT COMMS system. Currently, COMP is in the Federal Information Processing Standard (FIPS) 140-2 queue for certification. COMP meets all FIPS standards for encryption and authentication. The current version of the BT COMMS system uses an AES-256 bit encryption from end point to end point and also from hop to hop. This means that the data are encrypted twice while traveling over the mesh network. Further, all devices not using the COMP protocol cannot access the wireless network since they do not have the required authentication protocols in place and are ignored by the network.

Availability/Reliability:

The RDC has tested BT COMMS on various vessels including an aircraft carrier. BT COMMS is capable of delivering information to all users within the ship. BT COMMS will provide reliable information exchange services to boarding team members on demand and will be responsive to the criticality of the information it carries.

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APPENDIX B – SYSTEM COMPONENTS

TECHNICAL SPECIFICATIONS

Portable Wireless Repeaters (1st Generation).

- Intel XScale PXA255 processor running at 400 MHz
- 100mWatt 802.11b wireless card
- 14 hours of rechargeable battery life

HP5550 PDA.

- Microsoft Windows Mobile 2003 Premium
- Intel XScale PXA255 processor running at 400 MHz
- 128 MB RAM
- 48 MB ROM (~17 MB accessible)
- Expandable flash memory (SD/MMC slot)
- 1250 MAh Lithium Ion battery
- Built-in WiFi (wireless 802.11b LAN)
- Built-in Bluetooth
- 3.8-inch (96mm) TFT transflective color display
- Built in speaker, mic and mini stereo jack
- Built-in fingerprint scanner
- Built in vibrating alert

Panasonic Toughbook CF-29.

- Microsoft® XP Professional
- Pentium M processor running at 1.4 GHz
- 256 MB RAM
- 60 GB Hard Drive
- 13.3" outdoor-readable TFT Active Matrix Color LCD with touchscreen
- 7.9 lbs., including battery, floppy drive and handle
- Full magnesium alloy case with handle
- Moisture- and dust-resistant LCD, keyboard and touchpad
- Sealed port and connector covers
- Shock-mounted removable hard drive in stainless steel case
- Integrated 10/1000 Network Card
- Integrated 802.11 a/b/g wireless LAN
- CDMA 1xEVDO

Portable Radio Gateway.

- XTS-5000 holder and connector
- WiFi 802.11b wireless card