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THESIS

MODELING AND SIMULATION OF A GLOBAL BROADCAST SERVICE REACH BACK ARCHITECTURE FOR INFORMATION DISSEMINATION MANAGEMENT

by

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September 1998

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The Global Broadcast Service utilizes commercial direct broadcast satellite technology tailored specifically for military application. With this service, the military directly addresses oversubscribed communication paths and introduces a quantum leap in information dissemination. However, the potential for information overload comes with the ability of this service to readily deliver multi-megabit per second data. Therefore, to make the Global Broadcast Service a value-added addition to command and control, an information management process must be developed concurrently.

This project builds a Global Broadcast Service model (using Extend™) to provide a tool to analyze information dissemination management. Recent technologies such as asymmetric networking and automated radio frequency management are integrated into the model. In this thesis, asymmetric networking is equated to Global Broadcast Service "reach back," and automated radio frequency management is equated to the functionality of the "Automated Digital Network System." Using a simulation, an initial analysis of various reach back channels is provided. The resulting model and analysis serve as a foundation for future process development for Global Broadcast Service Information Dissemination Management.

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I. INTRODUCTION

A. PURPOSE OF RESEARCH

The Global Broadcast Service (GBS) and its ability to provide multi-megabit per second (Mbps) data rates will revolutionize military communications by dramatically increasing the dissemination of information to both operational commanders and lower echelon users. History has shown, however, users quickly can become overloaded with data. Even without the GBS, users have often received information that is irrelevant or is not used (because it was not known that the information was available). The fielding of the GBS only exacerbates this problem, especially if there is no process to address information dissemination management (IDM). The GBS offers an extremely robust communications delivery capability, but unless the information is managed carefully, it may create as many problems as it solves.

In addition, the requirement to give commanders positive control over limited communications resources often competes with the requirement to give users immediate access to relevant information. At any given moment decision makers and users are competing for limited resources. This dilemma is especially pertinent to the capabilities and challenges offered by GBS. For example, the commander can exercise more control by "smart pushing" GBS products. However, the user can ensure more information relevancy by interactively requesting products via "pull". A balance between the two methods of information delivery must be found in order to make the GBS a significant factor in achieving Joint Vision 2010's goal of information superiority and full spectrum dominance.

The balance between smart push and user pull is dynamic and depends on such factors as geography, communication resources, and tactical, operational and strategic conditions. Thus, it is just as important to develop a process to identify the balance as it is to find the balance itself. This thesis provides a tool to analyze and develop the GBS IDM process by using modeling and simulation to implement recent critical technologies (primarily asymmetric networking) into the GBS architecture.

B. SCOPE OF THESIS

The GBS model developed in this project uses a relatively inexpensive commercial off-the-shelf (COTS), object-oriented modeling tool. This tool, Extend by Imagine That! Incorporated, costs less than $1000 and operates on a PC (personal computer). [Imagine That!] Simulation of the model provides an initial assessment of various reach back channels. The assessments were augmented by qualitative research efforts. Experiments and demonstrations that were drawn upon were conducted by the Naval Research Lab (NRL), the Naval Postgraduate School (NPS), and the National Reconnaissance Office Operational Support Office (NRO/OSO). As a result, this project's work serves as a foundation for future GBS IDM process development. The GBS Extend model is one tool that can be used for this development. Likewise, any subsequent analysis undoubtedly will assist theater information management (TIM) in finding the right balance of smart push and user pull in various real world situations.

It should be noted that the high-powered GBS space segment is designed upon relatively new technology. The GBS ground segment, however, is designed on innovative, cutting-edge technology. The ground segment must continually utilize the latest information networking advancements in order to enable the transformation of GBS into a fully interoperable, end-to-end system. Two key technologies are implemented into the GBS Extend model in order to improve the IDM process. One technology is satellite-based asymmetric networking. In the GBS program, this technology is coined as "GBS reach back" (RB). A second technology is automated radio-wide area network (radio-WAN) management. The Navy demonstrates this technology with ADNS (Automated Digital Network System). The implementation and maturation of these two technologies are critical for making the simplex GBS system, an efficient, virtual two-way interactive system which will be conducive to the growing World-Wide-Web (WWW) browsing nature of information users.

Enabling efficient, interactive dialogue between the information user and producer, via reach back and ADNS, alleviates some of the burden on the GBS TIM. Nevertheless, the information management question still remains: "What is the right mix of pre-identified and user-initiated broadcast products?" As mentioned before, the answer is dynamic and depends on a variety of factors. This project uses Extend to develop a model which can later be used to analyze these factors. Unfortunately, Extend effectively looks at the physical nature of the GBS information flow, but does not conclusively address the qualitative nature of information relevancy. This deficiency should be alleviated by integrating conclusions from both the Extend model simulations, lessons learned from past and ongoing GBS reach back experiments and demonstrations, and real world GBS data flow analysis.

A major thrust of this project is the initial analysis of GBS back channel performance in a simulated environment of multiple users with multiple reach back channels. The project model assumes the implementation of ADNS and GBS reach back and involves Information Technology-Twenty First Century (IT-21) standards for Pacific area of responsibility (AOR) US Naval forces. Information flow is representative for a "well-equipped" early millennium carrier battle group (CVBG) in transit in the Pacific AOR. It is hoped that ongoing GBS reach back research and future GBS real world traffic analysis can be used to support and improve the model developed in this project.

C. THESIS ORGANIZATION

To be qualified to develop an asymmetric network model of GBS with automated radio frequency management, an understanding of the GBS, reach back (including the ADNS interface), and IDM is required. Chapter II (Background) provides a brief description of these requisite topics. Once the basics are known, the GBS concept of operations (CONOPS) and its application in various AORs must be understood. Chapter III (GBS CONOPS) outlines the Mission Need Statement (MNS), Operational Requirements Document (ORD), and GBS Joint CONOPS. Appendix D outlines the various theater Commanders-in-Chief (CINC) CONOPS draft documents. Chapters II and III are for the reader's reference and provide essential background information for the reader unfamiliar with the GBS. Chapter III and Appendix D will be of particular interest to those interested in comparing the CINC philosophies on GBS use.

The details of the project are provided after the background chapters with the modeling and simulation process and analysis being described in Chapter IV, including a discussion of the RB channels modeled and the ADNS interface. The Extend Block Definitions (Appendix F) should prove helpful when reviewing this chapter. A summary of the general impacts of GBS reach back and specific back channel assessments are presented in Chapter V. Chapter V also provides recommended areas for model improvement and further study. The last two appendices (Appendixes J and K) are the glossary and acronym list, respectively. It is recommended that these two appendices be made readily available for frequent reference during review of this document.

II. BACKGROUND

A. GBS OVERVIEW

1. History

The GBS concept began with the launch of the first direct broadcast satellite (DBS) in 1974 and with the subsequent introduction of home satellite television (TV) service in California in 1976. [Morrill] The C-Band satellites of these early television receive-only (TVRO) systems used approximately 24 low-powered single-channel transponders. As a result, TVRO consumers had to use large, relatively expensive dish antennas (typically 6 to 12 feet) to receive adequate reception. [Andrews] Since these systems offered a limited number of broadcast TV channels and required the use of large, expensive earth station terminals, the military initially did not envision the technology as a source for meeting multiple communications needs. Nevertheless, the idea of injecting one signal to a satellite and broadcasting to multiple widely dispersed "end-level users" simultaneously was successfully conceived and proven.

The allocation of higher frequencies for DTH (direct-to-home) use and the advancements in satellite and communications technology led to another generation of satellite TV systems in 1994. These high power Ku-band DBS systems enabled consumers to receive broadcast TV with less costly, 18-inch dish antenna systems. Likewise, digital video compression allowed DBS systems to broadcast more channels from one transponder. The first satellite, a joint venture of *United States Satellite*

Broadcasting (USSB) and *DirecTV*, was capable of broadcasting 75 TV channels to the continental United States (CONUS). *USSB* and *DirecTV* provided DBS service to over one million customers in only the first year of operation. [Godwin]

That same year, the Defense Science Board's (DSB) study entitled, *Information Architecture for the Battlefield*, recommended that the utility of DBS be looked at to improve information dissemination to all levels of fighting forces. [Morrill] This recommendation followed the earlier 1992 report, *The Conduct of the Persian Gulf War – The Final Report to Congress*, which highlighted that current military and civilian satellite communication systems were oversubscribed and "limited in ability to provide responsive, high capacity communications to deployed, mobile tactical units." [MNS] Consequently, the Department of Defense (DoD) urgently needed to find some communications solutions. The result was the use of DBS as a partial solution to the DoD's communications deficiencies.

Leveraging DBS technology is viable for the military for many compelling reasons. Word-wide coverage, low cost, multimedia data, small terminals, and cutting-edge technology are just a few reasons. For instance, commercial DBS technology currently allows a consumer to get over 200 channels of high quality digital television and up to 400 kilobit per seconds (kbps) of Internet download service from one 21-inch elliptical receive antenna. In addition, set up costs can be as low as $500 and dual video-data service as low as $50 per month. [DirecDuo] Furthermore, increased consumer demand will drive costs down, and information technology evolution will translate to more capability (increased number of channels and higher data rates). Likewise, with the implementation of an open architecture and a streamlined acquisition process, the GBS Joint Program Office (JPO) can immediately field DBS technology to military users while capitalizing on the latest information and networking advancements in the commercial sector. Hence, DBS leveraging becomes a smart, highly efficient way of quickly introducing low-cost, cutting-edge communications to highly mobile and dispersed military units.

To leverage technologies like DBS, the military uses advanced concept technology demonstrations (ACTDs). ACTDs help to meet critical military needs by quickly designing, demonstrating, proving, and fielding new technologies to the battlefield. An example of an ACTD that helped fuel the GBS program is the Battlefield Awareness and Data Dissemination (BADD) ACTD. BADD provides the tools to obtain information superiority in support of the Bosnia Command and Control Augmentation (BC2A) initiative. The JBS (Joint Broadcast Service) was the data dissemination portion of the BADD ACTD and is essentially the precursor to GBS. [Morrill]

In January 1996, the JBS took the COTS broadcasting technology and used it to augment information dissemination in the United States European Command (USEUCOM). In less than ninety days, the JBS leased a transponder from a commercial DBS system and used it to inject critical information to units involved in Operation Joint Endeavor (Bosnia). [Morrill] Meanwhile, the GBS test bed at the NRL (later moved to the Pentagon with the JBS) was also set up and researching the development of DBS technology. The GBS test bed, the JBS and the commercial transponder leases comprise what is considered GBS Phase I.

Another concurrent development involved the Navy's use of C-band satellites to increase bandwidth to the fleet. The idea originated from a 1991 master's thesis from the Naval Postgraduate School (NPS), and the project is now known as Challenge Athena (CA). CA first started aboard the USS GEORGE WASHINGTON (CVN 73) in October 1991 and delivered simplex data (mostly imagery). By late 1992, CA was providing duplex data rates of up to 1.544 Mbps. The use of newer satellites in CA III will provide up to 3 Mbps. [Hampton] With Challenge Athena, wideband commercial satellites provide the increased bandwidth that is not allocated from the DSCS III (Defense Satellite Communications System III) satellites. The additional surge capacity of CA has given commanders aboard big deck Navy ships the flexibility to support today's bandwidth intensive mission requirements. It is not hard to understand why Naval operational commanders quickly came to demand CA service for their deployments. The biggest communications pipe available next to CA is DSCS SHF (super high frequency). The division of SHF resources to the four Services and to the primary agencies leaves the apportionment to the big deck Navy ships at 768 kbps maximum (often less). It should be noted, however, that DSCS III SLEP (Service Life Extension Program) will provide up to 7 Mbps (for 7-foot antenna users). [Lindberg] Clearly, CA is a successful demonstration of the military use of commercial satellite technology in attempt to answer the operational demand for greater bandwidth.

Likewise, since 1993, NASA's ACTS (National Aeronautics and Space Administration Advanced Communications Technology Satellite) program has been demonstrating technologies that have been adopted by the GBS Phase II system. For example, the ACTS uses high data rate, large bandwidth Ka-band transmission, and steerable multi-beam high gain transmit antennas, which is similar to the GBS Phase II payload. Other demonstrated technologies by ACTS include on board digital regeneration, nx64 kbps circuit switching, and real-time circuit allocation processing. Although the ACTS design life passed in 1997, the satellite continues to support various communications experiments and demonstrations. [ACTS]

Advancements from the JBS (including BADD), the GBS Phase I test bed, Challenge Athena, and ACTS have helped shape the GBS Phase II system architecture. Consequently, high bandwidth information dissemination via the GBS employs not only the commercial DBS technology, but also the lessons learned from these programs. For example, in addition to the advances highlighted above, the GBS introduces the use of multimedia variable rate throughput, transportable uplinks and shipboard terminals, which were demonstrated by at least one of the programs mentioned. Undoubtedly, the GBS Phase III system architecture will also benefit as the programs continue to support experiments and demonstrations and provide operational lessons learned. With the success of these demonstration programs (combined with the 1992 report), it is no surprise that the GBS program received keen interest from the highest levels of the military. As such, the GBS program was designated an Acquisition Category-1D

(ACAT-1D) program and given an aggressive two year timeline (from process development to deployed capability). Historically, an ACAT-1D timeline averages ten years. [Delpino, Leonard and Yarbrough]

The MNS for the GBS was signed on 03 August 1995, the ORD was signed on 07 April 1997, and the contract award (for the ground receive suite) was granted on 17 November 1997 to Hughes Information Systems of Reston, Virginia (now part of Raytheon). With the launch of Ultra High Frequency Follow-On number 8 (UFO-8) on 20 March 1998, the program transitioned into Phase II. UFO-9 and 10 are planned to be launched in October 1998 and March 1999, respectively. [Delpino, GBS Program Update]

The Air Force is the System Manager (SM) and the Navy is the System Operations Manager (SOM) for the GBS. The SM is responsible for the funding and execution of the GBS while the SOM is responsible for operation and maintenance of the GBS-configured satellites, the SBMs (satellite broadcast managers), and the PIPs (primary injection points). Likewise, the Army is responsible for the TIPs (theater injection points) and their CONOPS development. [SCOC]

2. Three Phases of GBS

As shown in Figure 1, the GBS life cycle is divided into three phases. The JBS, the test bed, and the commercial leases make up Phase I, which continue operation in order to provide technology and CONOPS development and lessons learned. The JBS and GBS test bed uplink facility are co-located at the JIMC (Joint Information

Management Center) in the Pentagon, but the test bed is moving to Norfolk, Virginia. Phase II utilizes a GBS payload riding on three UFO satellites (UFO 8-10) and provides an interim capability. Phase III is planned to be operational in 2009. It will have increased numbers of transponders and spot beams per satellite, and the possibility of duplex Ka capability. The expected five satellites for GBS Phase III are speculated to have seven spot beams and twelve transponders each, for a maximum of 270 Mbps of throughput per satellite. [PACOM] In addition, more users will have access to the GBS, e.g., users with "manpackable", highly mobile or airborne receive suites.

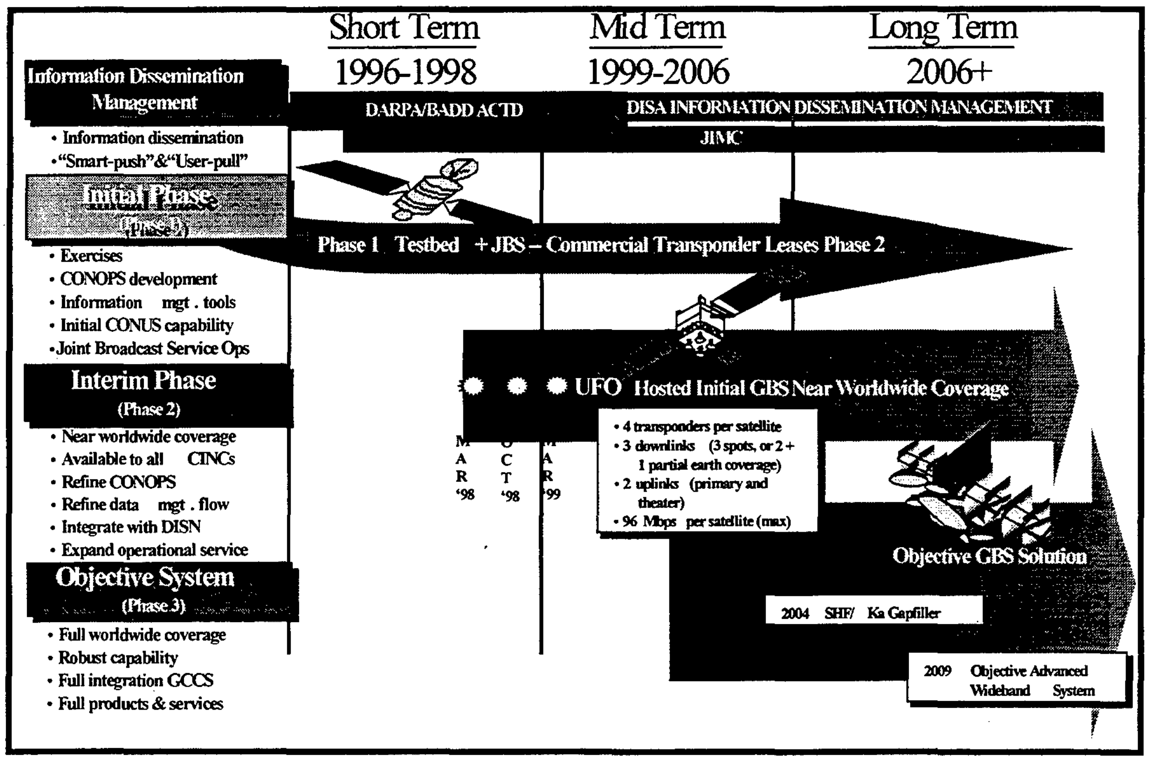


Figure 1. GBS Program Timeline

[Delpino, GBS Program Update]

To bridge any gap between Phase II and Phase III, three SHF/Ka Gapfiller satellites (launched between fiscal years 2004 and 2005) and commercial leases will be used to augment the GBS interim UFO satellites. [GBS]

This thesis focuses primarily on GBS Phase II, the interim GBS architecture. The model is based on the configuration of the GBS payloads hosted on the UFO satellites. Appendix A shows the GBS payload functional components and highlights the various configuration schemes depicted in Figure 2. Based on the combination of the Primary Injection Points (PIPs), Theater Injection Points (TIPs), receive antennas (2), transponders (4) and spot beams (3), various data rates can be achieved. The maximum data rate is 96 Mbps (24 Mbps for each of four data streams using two 500 nautical mile [nm] spot beams). However, if 2000 nm spot beam coverage is required, 1.544 Mbps is the maximum throughput for that wide-beam area. [GBS]

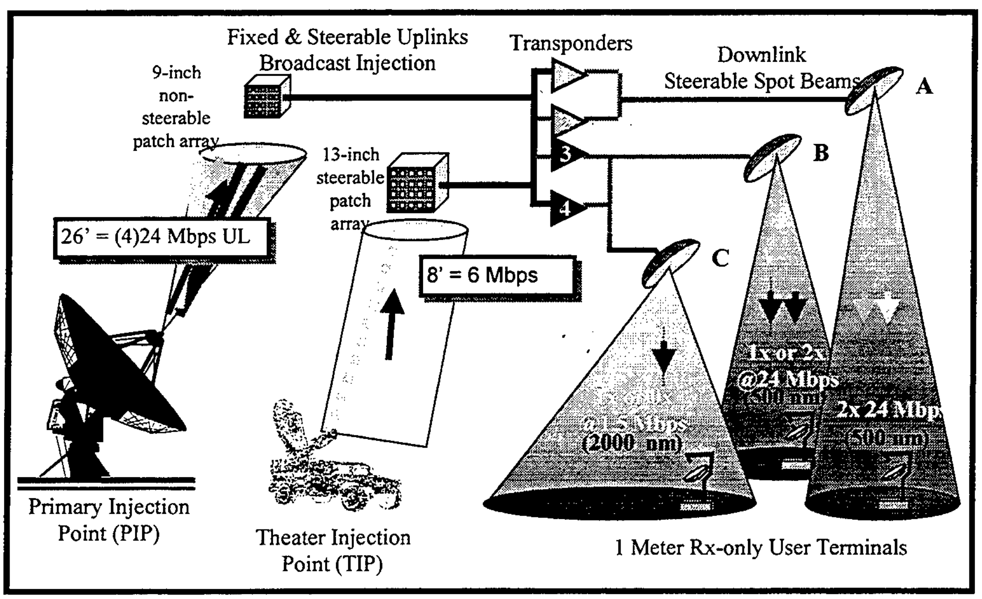


Figure 2. GBS Phase II Payload Capabilities

[McAlum]

3. GBS Phase II System Architecture

The spot beams can be moved within the satellites field of view (FOV) within three minutes (the ORD requires a minimum of ten minutes), but typically will be done within eight minutes. [SCOC] To reconfigure the transponders (e.g., switch from the normal configuration of three 24 Mbps streams and one 1.544 Mbps stream using three spot beams to four 24 Mbps streams using two spot beams), a delay of hours to days is expected depending on the availability of UFO Telemetry, Tracking, and Commanding (TT&C). [GBS]

The nominal coverage of the three geosynchronous UFO satellites is latitudes 65° South to 65° North (see Figure 3). The coverage for most of CONUS is gapped and will be augmented by leased satellites (and ACTS if available). [GBS]

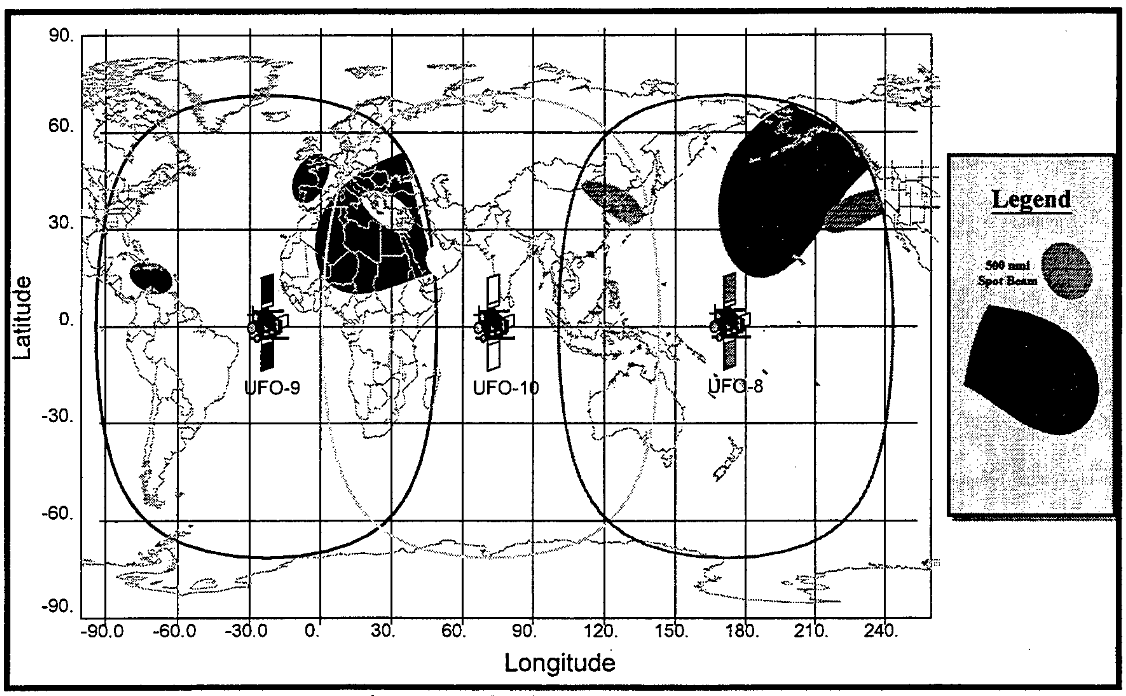


Figure 3. GBS Phase II Coverage
[Delpino, GBS Program Update]

B. GBS REACH BACK

1. Description

"GBS reach back" describes the satellite-based, highly asymmetric network involving the GBS satellite segment, ground segment, and connected end users. An end user requests information via an alternative communication channel, which is processed by the GBS SBM (to get the requested information from the destination). The SBM then relays the requested product to the satellite segment for broadcast back to the end user via a GBS RBM (receive broadcast management) suite. The relatively low throughput of the request channel (as low as 2.4 kbps) compared to the large throughput of delivery channel (up to 24 Mbps) makes the GBS reach back architecture a highly asymmetric network.

Since reach back is accomplished by any means of communication available that provides connectivity from the user in question to the GBS SBM, reach back (in the most archaic sense) can be accomplished by message courier, phone call or electronic mail (Email). Figure 4 shows sample configurations for an end user to request information (via dial up, via Defense Information Infrastructure, DII, and via satellite communications, SATCOM). Example transmission systems for dial up include cellular phone and plain old telephone system (POTS). Example DII/DISN (Defense Information System Network) back channels include NIPRNET (Non-secure Internet Protocol Routing Network, SIPRNET (Secure Internet Protocol Routing Network), and JWICS (Joint Worldwide Intelligence Communications System). SATCOM reach back could utilize commercial wide band (i.e., Challenge Athena and *Teledesic*), mobile satellite services, MSS (i.e., *Inmarsat B*, *Iridium*, *Globalstar*, and *ICO*), or military SATCOM, MILSATCOM (i.e., SHF, EHF [Extra High Frequency] and UHF). Another reach back possibility not depicted in Figure 3 is line of sight (LOS) communications systems, i.e., HF [High Frequency] or UHF). HF could be used for long haul communications (up to 500 nautical miles) at 2.4 kbps, but another possible implementation is to use HF as a relay back to a big deck ship and go into the DISN from SHF or Challenge Athena. This HF relay is incorporated in the Extend model and is similar to the Digital Wideband Transmission System (DWTS) for amphibious forces (using UHF relay).

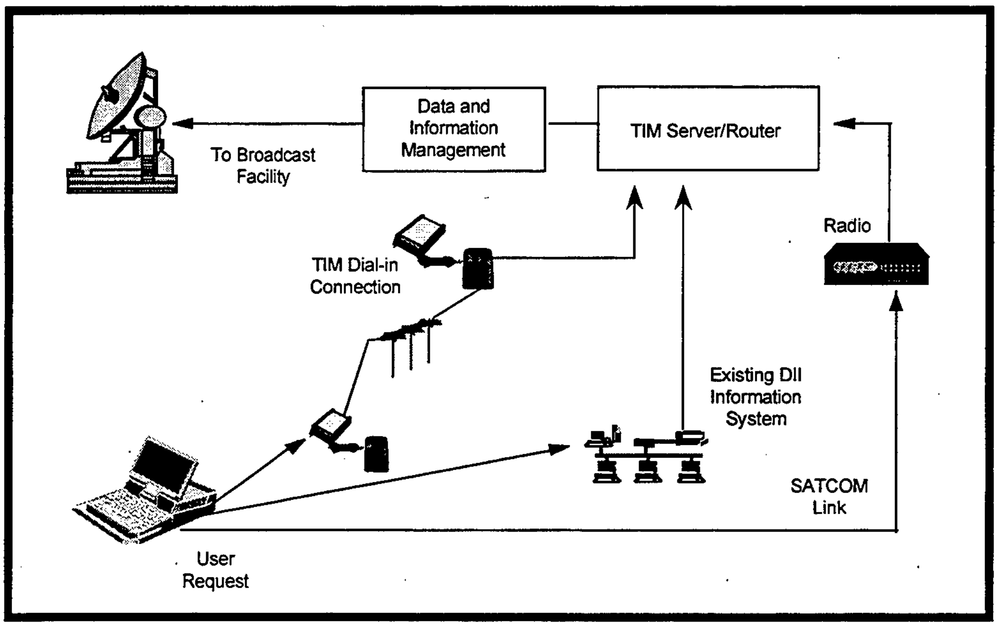


Figure 4. Generic Reach Back Configurations
[ACOM]

The GBS reach back information flow is not much different from the way a home user surfs the Internet via an ISP (Internet Service Provider). In GBS reach back, the TIM (Theater Information Management) server/router acts as the warrior's ISP, but the information is delivered via the GBS instead of going back via the requested communication channel. Of course the home user normally is using a POTS line and the PSTN (public switched telephone network) to reach the ISP. The warrior, on the other hand, uses whatever communication channel is available, often satellite communications.

While web browsing, an Internet user normally utilizes hyper text transfer protocol (HTTP), which is a transmission control protocol/Internet protocol (TCP/IP) application. TCP/IP provides the rules for communication transfer and assumes a bi-directional communication link. However, to use TCP/IP with the one-way GBS system, a technical solution is needed to assimilate virtual two-way communication. Many organizations and experiments address this "tricking" or "bending" of the TCP/IP protocol in order to make a one-way system operate virtually like a two-way system. Completing the communications loop for a one-way system like GBS, makes it an end-to-end system. *DirecPC* is a commercial example of how reach back makes a one-way system work end-to-end. Other experiments and implementations of GBS reach back are discussed later in this section.

2. Four Reach Back Connectivity Modes

Connectivity modes describe the degree in which a GBS user is connected with the SBM and information producers. The four connectivity modes are receive only (RO), manually connected (MC), partially connected (PC), and fully connected (FC). Receive suites can, depending on their connectivity mode, offset limitations of a one-way service. Each connectivity mode offers different benefits to the user and different levels of efficiency for GBS. In the fully or partially connected mode, the receive suite (RBM) can report downlink quality to the SBM. With this feedback information the SBM can adjust the broadcast to improve user reception (e.g., adjust data rate, schedule, or coverage area). Likewise, the fully connected users have the ability to query producers and information providers for additional amplifying information. [GBS] All users in the Extend models are fully connected. Appendix B further describes the differences among the four receive suite connectivity modes.

3. Reach Back Experiments

a. RB in Joint Warrior Interoperability Demonstration (JWID) 1996

This demonstration used a 2.4 kbps EHF MILSTAR SATCOM reach back channel. Users requested information via the SIPRNET using a web-like interface. This interface sent an Email to the information source once the user selected a product item from the workstation software menu. Upon receiving the Email request, the information producers wrapped and delivered the product via the SIPRNET to the GBS uplink facility. Request-to-receipt cycle time took three to five minutes (some exceptions took up to fifteen minutes). Poor weather conditions at the uplink facility and broadcast queue delays probably attributed to the longer delivery times. [Roper]

b. Reach back at the Naval Research Lab (NRL) and in JWID 1997

In November and December 1996, the NRL (with assistance from DISA and OSO) demonstrated a medium data rate (160 kbps) and high data rate (1.288 Mbps) channel capability using the same satellite transponder used for broadcast. Simultaneous occupation of the reach back and broadcast signal did not adversely affect the GBS signal. [NRL] As a result, the NRO/OSO used this single transponder-back channel concept to demonstrate actual "user pull" GBS-facilitated information requests during JWID 1997. The 1997 reach back channel operated at 40 kbps and used direct sequence spread spectrum (to prevent interference to adjacent satellites). A 1.2m very small aperture terminal (VSAT) transmitted the reach back signal. Request-to-receipt cycle time took less than five minutes (some exceptions taking up to 40 minutes). Broadcast queue delays probably were attributed to the longer delivery times. Also, no apparent correlation between file size and delivery time was observed. Although the JWID 97 demonstration placed into action the 1996 NRL findings, the reach back concept does not correspond with the developments of the GBS payload on UFO satellites. With only two receive antennas (one steerable), the GBS Phase II system does not support user reach back via the same satellite. The receive antennas are used solely for broadcast signal injections from one PIP and multiple TIPs (if within 350 nm of each other). [Arthur]

c. *Naval Research Laboratory (NRL) Experiments*

In December 1997 through March 1998, the Naval Research Laboratory combined the concept of GBS reach back with a WWW-browsing functionality. This experiment demonstrated the "user pull" of data using the GBS system and standard TCP/IP protocols. Variable data rates were tested from 2.4 to 64 kbps to simulate ubiquitous back channels (e.g., POTS, cellular phone, 25-kHz UHF SATCOM, and the Planet One Data Phone). The experiment measured forward GBS throughput as a function of back channel data rate. To gain baseline data from error-free conditions, the back channels were hard-wired. Figure 5 shows the results of these tests. The increase of back channel throughput above 19.2 kbps did not result in appreciable increase in GBS throughput. Likewise, the maximum GBS throughput achieved was just over 900 kbps, significantly less than the available 2 Mbps. This inefficiency is possibly attributed to TCP/IP window limitations or congestion control. Nevertheless, the efficiency increases with the addition of TCP/IP threads. For example, two 28.8 kbps back channel single-thread users could both get 900 kbps throughput (leaving 200 kbps unused). Likewise, if a third user was added, all three users could get 666 kbps throughput (using the entire 2 Mbps channel). [Krout]

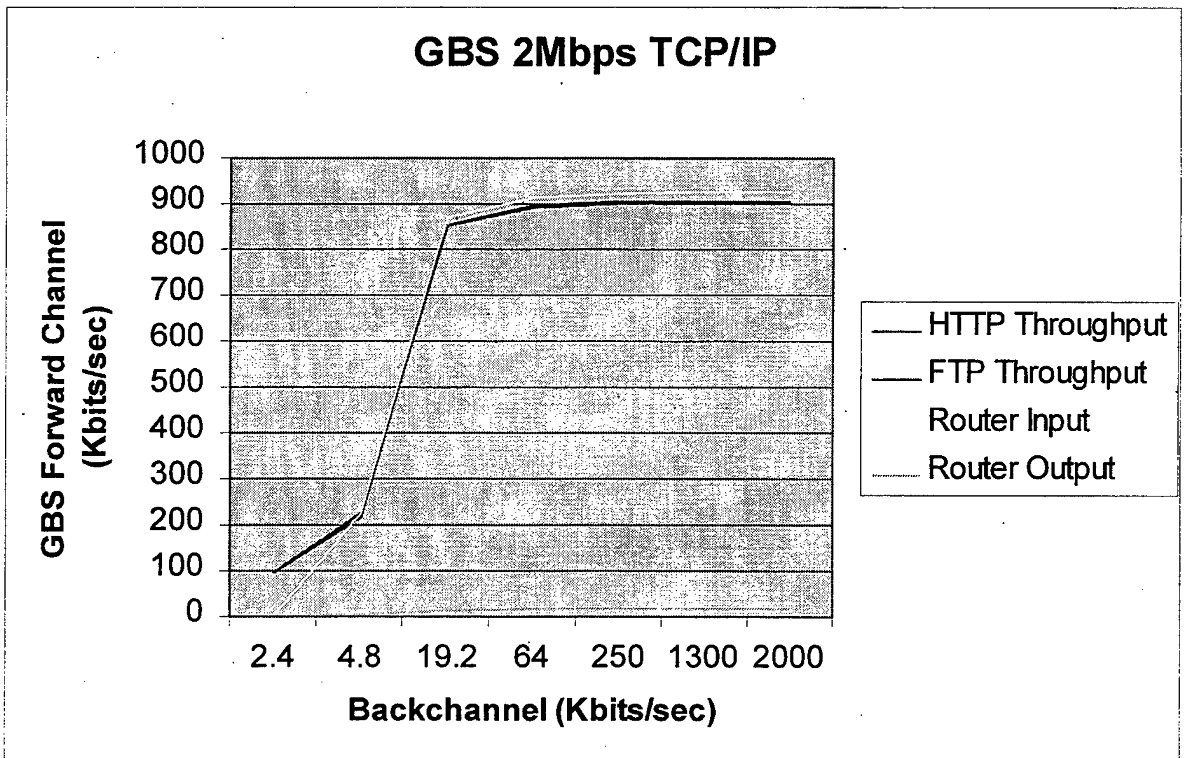


Figure 5. GBS Throughput vs. Back Channel Throughput for Single Thread User [Krout]

d. Naval Postgraduate School:

In June1998, a master's thesis documented the NPS GBS reach back experiment using 25Khz UHF DAMA (Demand Assigned Multiple Access). The NPS GBS Phase I receive suite, the Space and Naval Warfare Systems Command's (SSC) ADNS and UHF equipment, and the GBS test bed successfully implemented UHF DAMA as a possible alternative for user reach back. The experiment setup is shown in Figure 6.

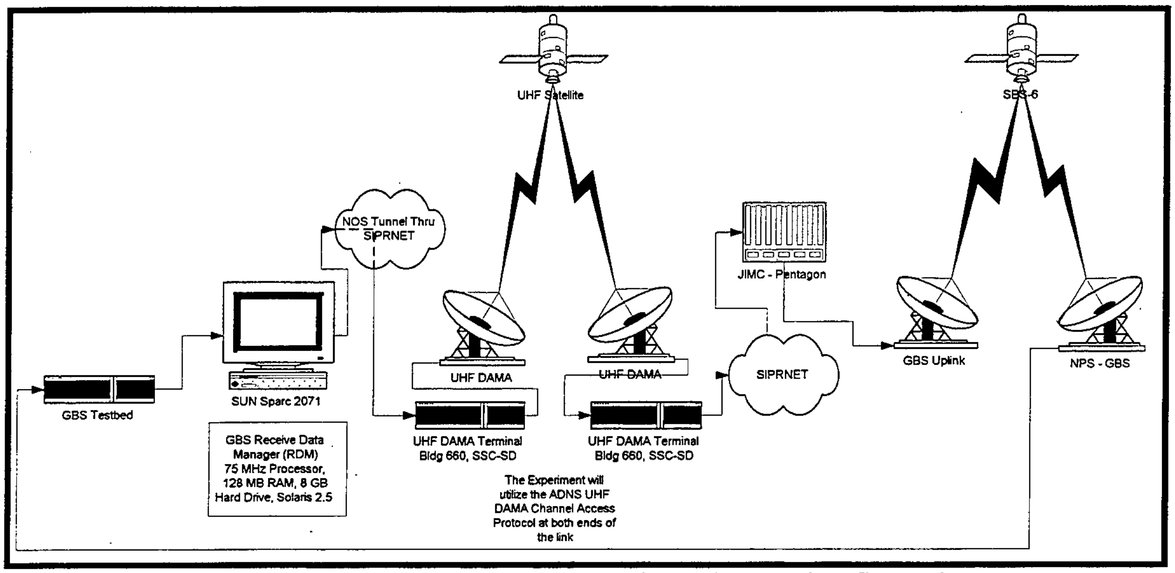


Figure 6. GBS – UHF DAMA Reach Back Test Configuration [Arthur]

Although successful, the long latency of the 25 kHz UHF DAMA reach back channel (attributed to the protocol framing delays and the geosynchronous satellite round-trip delay) caused inherent problems to establishing and maintaining a TCP/IP data connection. To make the TCP/IP work, a third party system is required to "trick" the latency sensitive TCP/IP protocol. The experiment used ADNS as the third party system.

[Arthur] The Extend models also use ADNS to carry similar functions for all reach back channels.

e. Reach Back in JWID 1998

In July 1998, the NRO/OSO and NRL built on the web browsing experiments completed earlier in the year by NRL. The JWID demonstration used various radio frequency (RF) reach back channels instead of hard-wired back channels. Web browsing via various reach back channels such as POTS, cellular phone, 25-kHz UHF SATCOM, the Planet One Data Phone, VSAT code division multiple access (CDMA) SATCOM were conducted successfully from three sites. One of the sites simulated a ship configured with ADNS. Unofficial results achieved maximum GBS throughputs of 150 kbps for the various RF back channels. Again, some of this inefficiency is possibly attributed to TCP/IP window limitations or congestion control. Other possible factors include the latency and BER of the back channels. Nevertheless, just as discussed previously, the efficiency can increase to one hundred percent when additional threads are added. [Krout, Goldstein and Solsman]

4. Commercial Analogies

DirecPC and DirecDuo are making similar developments in satellite-based asymmetric networking. In addition, the Internet Engineering Task Force (IETF) has sponsored a Unidirectional Link Routing (UDLR) working group to look at integrating unidirectional links into the TCP/IP dominated Internet. *DirecPC* uses consumer phone connections to reach back to either a separate ISP or the *DirecPC* NOC (network operations center), which acts as the proxy to the Internet. The request is then forwarded to the destination server and a return web page or product is sent back to the NOC for uplink to a *DirecPC* satellite. [DirecPC] The broadcast is then downlinked back to the user's 21-inch elliptical receive antenna (see Figure 7). The broadcast data rate is 12 Mbps, but the actual realized throughput to the consumer is up to 200 or 400 kbps, depending on the service option selected. The number of users that are sharing the 12 Mbps data stream dictates what each users actual throughput is. [DirecDuo]

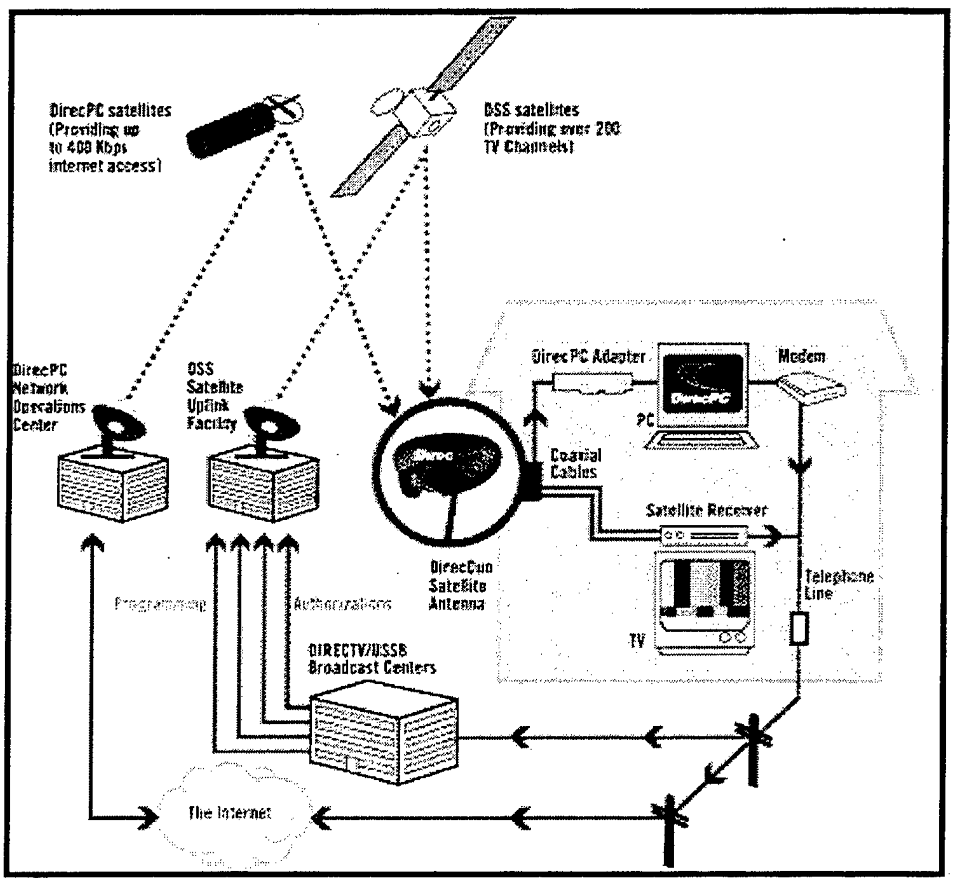


Figure 7. DirecDuo Operation [DirecDuo]

The UDLR working group was chartered to find the best way to solve the asymmetric unidirectional link routing problem. They have proposed a link layer tunneling mechanism, which is very similar to the *DirecPC* and government research solutions. The March 1998 Request for Comment (RFC), "A Link Layer Tunneling Mechanism for Unidirectional Links," is the latest draft of UDLR findings. More profound solutions for asymmetric networks with unidirectional links (e.g., new or improved protocols) may become the object of future IETF working groups. [UDLR]

C. INFORMATION DISSEMINATION MANAGEMENT (IDM)

Collecting, organizing and presenting information about the battlespace (in a fashion easily understood by the end user) reduces uncertainty and empowers effective decision-making. To avoid information overload and to support Joint Vision 2010, IDM implements the C4I for the Warrior concept of automated smart push and warrior (user) pull. [IDM] An effective IDM process for balancing smart push and user pull helps ensure information relevance and timeliness. This thesis develops the tool and provides the initial analysis for future researchers to look at the balance of the smart push and user pull paradigm.

1. Information Management (IM)

Information management is required for the entire intelligence cycle from planning and direction, collection, processing and exploitation, production, dissemination and integration, evaluation, and use. [IDM] IM encompasses all three levels of support (strategic, operational, and tactical) and is critical for achieving information superiority.

2. Information Dissemination Management (IDM)

Information dissemination management is the subset of IM that concentrates on information awareness, access, and delivery. Optimizing these three elements give the warfighter "the right information in the right place at the right time." [IDM] Awareness, access, and delivery are defined in Appendix C. Likewise, effective IDM provides commanders with the ability to implement policy and maximize scarce resources. To enhance IDM, ACTDs are conducted (e.g., Defense Advanced Research Project Agency's [DARPA] BADD ACTD). Command, Control, Communications, and Intelligence (C4I) demonstrations such as BADD serve to provide the tools to improve the IDM process. [IDM]

3. IM and IDM Strategy with GBS

Properly implemented, the GBS is only part of a single interactive dissemination system that distributes information via the most effective and efficient communication paths. GBS IDM functions include compiling, cataloging, caching, distributing, and receiving GBS broadcast products. [IDM] To fully utilize IDM, the GBS must have maximum connectivity with the DII/DISN. This connectivity makes the one-way GBS an end-to-end system. With an IDM-enhanced, fully integrated GBS architecture, IM merely uses the GBS as another dissemination path, albeit a big one. [IBS]

The GBS Mission Needs Statement (MNS) highlights that the "GBS is an extension of the DISN, and will require development of a data management capability and injection scheme in parallel with the space segment." This parallel management program has become known as IDM. The MNS further states that "Data management must include the capability to access and retrieve archived data as well as provide timely dissemination of requested information. Prioritization procedures that allow users to receive the most critical information first and a method for responding to user requests must be developed and implemented." [MNS] As such, Figure 8 depicts what GBS operations would be like without and with IDM implemented.

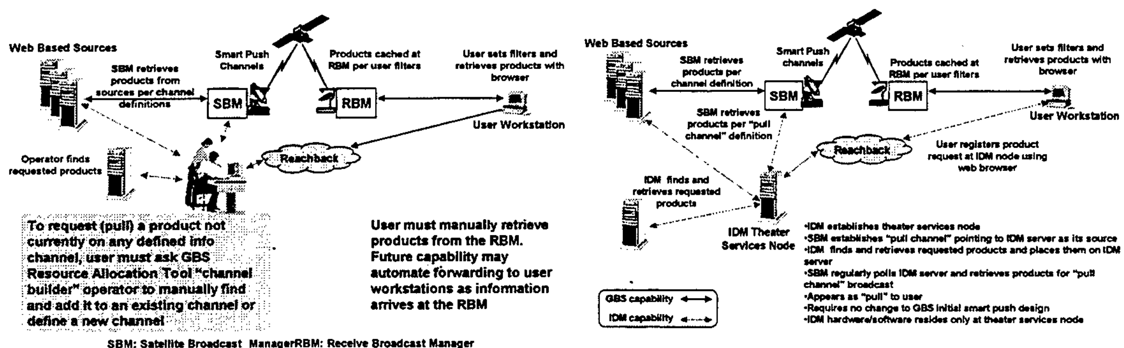


Figure 8. GBS Without and With IDM

[Lee]

4. Role of Theater Information Management (TIM)

The TIM (and the Integrated Broadcast Service (IBS) IME for tactical broadcasts) oversees the automated routing of data in order to enforce policy and optimize resources. The TIM functions have been kept as simple as possible in order to minimize manning and training impacts to the CINC. [PACOM] Identified TIM functions include directing GBS operations, coordinating broadcast schedule, managing apportioned resources, identifying new products, reviewing and validating user profile data base, and auditing user pull. The TIM audits user pull in order to better predict users' needs and identify products for the smart push part of the broadcast. [GBS]

The United States Pacific Command (USPACOM) GBS CONOPS (draft) states, "No one person or organization has the experience, authority or manning to accomplish all the TIM functions." As a result, TIM responsibilities are fulfilled by using current processes and a TIM working group (formed from existing personnel). However, the TIM doesn't replace functions within the CINCs, but instead augments CINC capabilities. TIMs are connected through the DII backbone to the "major networks and news services". [PACOM]

Similarly, a TIM that utilizes a decentralized, "IDM by negation concept" harnesses the full power of technology and lets the users have access to everything that their allocated bandwidth permits. Commanders can restrict user access based on the latest mission priorities and subsequent resource allocations. The centralized approach of giving users access (when requested and approved) adds delay in verification and validation. This delay may prevent users from getting relevant and timely information. However, to make the decentralization of the GBS IDM work, the CINC (and even large units) must promulgate an information priority instruction that augments the priorities listed in Chairman of the Joint Chiefs of Staff Instruction Draft (CJCSI) 6250.01 (currently Memorandum of Policy [MOP] 37). An augmented priority instruction forewarns users on expected information access restrictions, which may have to be imposed for various scenarios.

III. GBS CONCEPT OF OPERATIONS (CONOPS)

This section outlines the MNS, ORD and GBS Joint CONOPS. Appendix D outlines the GBS CONOPS for various CINCs. Ideally, the CINC CONOPS also serve as annexes to the GBS Joint CONOPS. The outlines are broken up to answer the following questions:

- What must the GBS do?
- How does the GBS provide information?
- What are some key GBS requirements?
- What are some key GBS elements for successful implementation?

A. MISSION NEEDS STATEMENT (MNS)

The MNS outlines user requirements. Specifically, the MNS for GBS responds to the call to "create an interoperable 'system of systems' geared toward enhanced C4I." [MNS] The following outline organizes key points in the MNS that relate to this thesis. The reader is reminded that the outline contains direct content from the MNS and is merely organized by the author for the reader's reference.

1. What must the GBS do?

    - Improve information transfer to deployed forces and free capacity on existing systems for growing two-way C4I requirements.
    - Support the tenets of "C4I for the Warrior" via the concepts of "smart push" and "user pull".
    - Act as an extension to the DISN. However, the GBS is a secondary means of communication and is vulnerable to information warfare (IW) attack.

- Integrate with existing and planned in theater and centralized C4I systems to the maximum extent possible (e.g., Intelink, GCCS, United States Imagery System (USIS), Defense Message System (DMS), and the DISN).
- Use interface methods (i.e., ATM, IP or other widely accepted data transfer standards) that seamlessly support the GBS as a means of data transmission, while avoiding proprietary solutions.

2. How does the GBS provide information?

   - Uses "smart push" which is the portion of the GBS broadcast that provides "packages of information services" that may be predetermined based on existing and known user mission and operational requirements.
   - Uses "user pull" which is the portion of the GBS broadcast that is the result of user requests for ad hoc information requirements via existing/planned communication architectures (e.g., DSCS, UHF, MILSTAR, commercial PCS).

3. What are some key GBS elements for successful implementation?

   - Effective management procedures and robust infrastructure, which support retrieval, injection, and distribution of broadcast information.
   - The ability of users to tailor the broadcast to satisfy emergent requirements.
   - The minimization of GBS manpower and personnel requirements and the operation of the GBS with resources within the existing force structure.

B. GBS ORD

The ORD provides the system requirements that are derived from the MNS user requirements. Specifically, the ORD identifies the Joint Requirements Oversight Council (JROC) approved GBS Phase III requirements key performance parameters (KPPs). The following outline highlights key points in the ORD that relate to this thesis. The reader is reminded that this outline contains direct content from the ORD and is merely organized by the author for the reader's reference.

Appendix E also provides the initial receive suite fielding plan as described in the ORD. It should be noted that there are two classifications of ground receive suites: fixed ground receive suites (FGRS) and transportable ground receive suites (TGRS). In addition, there are seven different configurations based on the users capabilities and needs. These configurations vary in number, type of data (e.g., Ethernet, serial or asynchronous transfer mode), and level of classification. Appendix E illustrates these configurations.

1. What must the GBS do?

- Provide worldwide, high capacity, one-way transmission of a variety of data, imagery, and other information in support of joint forces. Initial worldwide coverage is from 65° North latitude to 65° South latitude, 180° West to 180° East longitude. Final global coverage is from 90° North to 65° South latitude, 180° West to 180° East longitude.
- Transmit high data rate bit streams from a limited number of fixed and deployable injection terminals, which are controlled by the CINCs and managed by the broadcast management segment in each satellite's field of view.
- Receive and send information products from many distributed locations via the broadcast management segment.
- Integrate fully into the Defense Information Infrastructure (DII) by connecting into the existing and future communications architecture through established DISN gateways (when practicable).
- Act as a non-critical command and control system, which incorporates minimal survivability and hardening features. Critical command and control information products still may be transmitted over the GBS, but not as a primary means.

2. How does the GBS provide information?

- Uses the SBM to accept, coordinate, and package (if required), information (general broadcast products, smart push products, user pull products) from national and theater sources to be broadcast based on the direction and priorities of the supported CINC, commanders, and their functional users.

- Uses "smart push," which constitutes the standard products and theater tailored information that are placed on a broadcast as they become available, in accordance with established user needs and priorities, and in conformance with the CINC's dissemination policy
- Uses "user pull," which includes other information products that are one-time needs identified by a user in response to operational circumstances. The GBS user pull requests for specific information utilize other communications systems from the users to the information source, TIM, or SBM. The impact of these requests on existing tactical and strategic communications systems are minimized with user profiles.

3. What are some key GBS requirements?

- Application of CINC dissemination priorities to information destined for broadcast in the AOR, and the coordination of this effort between the SBM and the Theater Information Managers (TIMs).
- Satisfaction of user requests (forwarded by the TIM), which are unable to be satisfied by other means, and the coordination of this effort between the SBM, the TIM(s) and the information producers.
- Interface protocols and standards that allow information producers to submit information in a form acceptable by the SBM for GBS broadcast.
- SBM capability to conduct both transmit management and receive management functions. The transmit function will manage the information flow to the appropriate injection point for transmission to the satellite. The receive function will support the filtering of user determined relevant information from the broadcast streams and the dissemination of the receiver information from receive suites to end users' servers or application.
- PIP capability to uplink up to 94 Mbps to the UFO GBS space segment.
- TIP capability to uplink up to 24 Mbps to the UFO GBS space segment (6 Mbps for Phase II threshold). Three TIPs will be fielded during Phase II and fourteen will be fielded during Phase III.

- RBM (receive broadcast manager) capability to provide automatic uninterrupted power for 20 minutes when power fails (10 minutes for Phase II and III threshold).
- RBM capability to adjust the receive data rate automatically within 10 seconds when there is a change in the broadcast data rate.
- RBM capability to receive four transponder streams simultaneously from a single satellite (one transponder data stream at a time for Phase II threshold).
- RBM capability to operate in an unattended mode during steady state broadcast data rate operation.
- RBM capability to acquire and continuously receive satellite downlink in less than 3 minutes after initial hardware setup (5 minutes for Phase II threshold).
- RBM capability to provide a minimum downlink availability of 97% for terminal elevation angles greater than 10°.

4. What are some key GBS elements for successful implementation?

- Primary operational control over what, when, and to whom information is disseminated in a particular AOR (provided by the TIM).
- The capability for "smart push" and "user pull," which gives warfighters the right information, at the right time, and in the right place.
- Oversight of the SBM's management of the broadcast resources across the GBS system (responsibility of the GBS system operational manager (SOM), which is the Navy).
- The use of organic communications to accomplish virtual theater injection when a TIP is not available or is not an effective means of injection when compared to the PIP.
- The minimization of additional manning for the PIPs, TIPs, SBMs and possibly, the operation and maintenance of receive suites. No initial training requirements are required for the SBMs and PIPs because they are contractor operated and maintained. Training provisions must be available when it becomes desirable to transition from contractor to government operation and maintenance.

C. GBS JOINT CONOPS

The GBS Joint CONOPS describes the overall system architecture and CONOPS based on the MNS, the ORD, and program developments. Due to the evolution of technology and concepts, the GBS Joint CONOPS is a fluid, dynamic document. It should be noted that the GBS Joint CONOPS is the responsibility of U.S. Space Command. Many of the points in the GBS Joint CONOPS are common to the CINC CONOPS drafts. CINC GBS CONOPS have been outlined in Appendix D. The reader is reminded that the following outline contains direct content from the GBS Joint CONOPS and is merely organized by the author for the reader's reference.

1. What must the GBS do?

   - Act as an extension of the DISN to give tactical users information at high broadcast data rates – through "smart push" and "user pull" concepts.
   - Distribute data products simultaneously and quickly by using a point-to-area approach.
   - Provide high quality delivery of data products at bit error rates of 10^{-10}.
   - Provide video requirements, smart push data requirements, and user pull for broadcast schedules.

2. How does the GBS provide information?

   - Collects the deployed user's "user profile," which consists of the type, priority, and desired delivery times of required information. The TIM validates the user profile against CINC policies and priorities for the use of infrastructure resources and forwards the profile to the SBM. The TIM can then coordinate with the SBM and the information producers to determine broadcast update requirements.
   - Uses "smart push," which takes advantage of GBS's capability to simultaneously disseminate information to many users. The primary goal of smart push is to give the users within the CINC's

AOR the majority of their predictable information needs.

- Evaluates "smart push" products to ensure their priority, bandwidth, and spot beam requirements fall within CINC priorities and allocated resources.
- Uses "user pull," which gives authorized users in the theater direct access to information both inside and outside the theater. This approach uses existing communications means, in concert with GBS, to create a virtual two-way network for interaction.
- Fills "ad hoc" user requests on an as available basis (accommodated dynamically, based on user and/or mission priorities). Feedback from the user pull information can be used to better predict users' needs and identify products for the smart push part of the broadcast.
- Uses the regional broadcast (via PIP) as the preferred method of broadcast if information producers have sufficient DII connectivity to the SBM.
- Services each GBS satellite with one satellite broadcast manager and one primary injection point. The GBS also can inject information products directly from the theater.
- Provides one-way distribution of information.

3. What are some key GBS requirements?

- The maintenance of end user profiles (description of user receive configuration, product requirements, location, CINC priorities, etc.) at the SBM in order to enable the development of "smart push" and to enable access control.
- The capability of a "virtual injection" from theater by sending information from the theater to the SBM via an alternative communications link within the DII.
- TIP broadcasting provides direct theater injection for in-theater information producers lacking DII connectivity, eliminates the projected delay associated with transmitting theater generated information to the PIP for broadcast and supports high priority operational requirements. Using TIPs also increase the commander's control over the information dissemination process.
- Quality feedback reports to the end user (for users with receive suites connected to other communications paths, to request only missing file segments, thus significantly reducing the GBS bandwidth required to correct errors).

4. What are some key GBS elements for successful implementation?

- Adoption of new technology and lessons learned (the GBS and BC2A Program Managers ensure that JBS and BC2A lessons learned are incorporated into the GBS program, and BADD is attempting to develop software tools and applications that will facilitate the distribution and management of information).
- Utilization of a variety of information producers (agencies, fusion centers, creators of value added products, sensors and sensor ground sites, etc.). Information producers desiring to transmit information over GBS must provide the following: metadata headers for all files, a catalog of specific products passed to the SBM, and updated products to ensure the most current information is available to users.
- Reliance on a Theater Information Management (TIM) function, which is performed at the CINC level (to account for limitations in user equipment, payload configuration, commander in chief (CINC) priority and for policy development and operational control).
- CINC organization of the TIM functions within their AOR (to provide direction, guidance, and policy for the operation of apportioned GBS resources).
- CINC guidance (including who is authorized access to GBS, what information is releasable to coalition partners, what kinds of information will be transmitted over GBS, when GBS coverage is needed by users, and a rationale for GBS employment within the AOR).
- CINC priorities (including which users will be serviced first, which types of products will be transmitted first, and which areas will receive coverage first). The TIM must consider priorities, equipment configuration, and environmental conditions in the decision process.
- Simplicity of the TIM functionality (to minimize manning and training impacts to the CINCs). The six TIM functions are directing GBS operations, coordinating the broadcast schedule, managing the apportioned resources, identifying new products, reviewing and validating the user profile data base, and auditing user pull. The TIM must balance demand with available resources and work with users to meet their requirements.
- GBS Resource Allocation Tool (GRAT). This tool will allow information managers to plan their allocation of GBS broadcast resources in order to share and reallocate available bandwidth

among various users, information products, multi-media types (data, video, audio), and security levels, without interruption to the broadcast.

- Successful implementation of IDM (vital to ensure the efficient flow of information from producers to users). IDM is envisioned to look across all information dissemination in DOD and develop the capability to efficiently route information from source to user.
- Fulfillment of five IDM functions (including compiling, cataloging, caching, distributing, and receiving).
- Balanced management responsibilities between the TIM and SBM (key to effective use of the GBS communications resources).
- SBM traffic analysis (enabling the TIM audit function). In addition, the GBS system is capable of conducting system performance assessments and trending, network management, and quality control. SBMs use this information to conduct traffic analysis and provide TIMs with an assessment of how well information is flowing over their allocated resources.
- Consolidated scheduling. Due to limitations in the design of the GBS Phase II architecture, there will always be more CINCs than satellite hardware resources, therefore the cornerstone to integrated GBS operations is the combination of broadcast information into one schedule.
- Fulfillment of eight basic SBM functions. These functions include building a schedule and program guide, coordinating information products, conducting traffic analysis, constructing and transmitting the broadcast stream, providing for data protection, technically controlling the GBS broadcast, remotely controlling the enabling/disabling of receive suites, and establishing and maintaining the user profile data base.
- Dynamic mix of "smart push" and "user pull."
- Dissemination of broadcast information to lower echelon units via interface with existing tactical networks.
- User profiles (which are prepared by the user and provided to the TIM either automatically via their GBS receive suite (fully connected mode only) or via other standard means of communication, e.g., SIPRNET, telephone, etc.).
- Deliberate planning process for identification of the majority of the smart push information requirements. Other smart push information is developed during the initial stages of the conflict and remain relatively constant (with some fine-tuning) for the duration of hostilities.
- Predesignated process for user pull requests (to go directly to the

appropriate information producers). The communications media could be SIPRNET, N-level (unclassified-but-sensitive) Internet Protocol Router Network (NIPRNET), JWICS, Fax, GBS, telephone, etc.

As already mentioned, this chapter provides a ready reference as well as a foundation to understand the GBS Concept of Operations. Using this chapter and Apendix D is useful in any attempt to design and implement the existing or future Global Broadcast Service architecture. The MNS and ORD are included in the work in order to maintain the "big picture" on what the GBS should actually accomplish. Frequent reference to these documents is important to the development of a realistic architecture. The following chapter describes the author's attempt in designing a GBS architecture model, which focuses on the implementation of GBS reach back (including ADNS).

IV. GBS MODEL DESIGN AND ANALYSIS

A. INTRODUCTION TO EXTEND

1. What is Extend?

Extend, Version 4 is a modeling program developed by *Imagine That! Incorporated.* This simulation software supports discrete event, continuous, and combined discrete event/continuous process models and simulations. Extend can simulate any process or action; however, the simplicity of its building blocks dictates that a user fully understands the process to be modeled. In actuality, the one of the biggest limitations to an Extend model is the user's imagination. The GBS reach back model is a discrete process model, but does include some continuous process blocks.

The libraries in Extend contain building blocks that perform various functions, which represent basic processes or actions. Appendix F provides function descriptions of common Extend blocks that were used in the GBS reach back model. The block icons are connected in a logical sequence representative of the process or action to be simulated. Double clicking on the icon displays a dialog box for the user to provide inputs. Example inputs include the maximum size for a queue, an equation, or a selection of a probability distribution. Once the blocks are made, connected and parameters inputted, a simulation run can be conducted. While building the model, tools such as timers and plotters can be strategically located to collect data and evaluate model performance. In addition, attributes can be assigned to the discrete items as they pass through certain blocks. This function provides the ability to place time stamps throughout sections of the model to evaluate timeliness. More detailed explanations of Extend can be found in Rieffer (pp 81-91) or the Extend Users Manual. In addition, Appendix F includes definitions of selected blocks used in the reach back model.

2. Limitations of Extend

Extend can lock up a PC, even a 400 megahertz (MHz), 64 megabyte-RAM (random access memory) machine, if the model gets too large (greater than approximately 50 megabytes [Mb]). Lock up was common when trying to copy for testing and debugging and when the PC tried to auto save the model. A user should decide how granular and detailed the model should be prior to modeling with Extend. The 50 Mb-GBS reach back model did not inhibit Extend, but did cause significant delays in programming and data collection (depending on the number of time steps simulated). For instance, hours of design time were lost due to the programming problems experienced when the model size approached 50 Mb. Likewise, to simulate one hundred seconds, one simulation run would take over one hour. In addition opening and saving the model exceeds five minutes when working with greater than 50 Mb-sized models.

Hence, due the complexity of the reach back architecture and the observed degraded performance, the author believes the GBS model approaches the upper bound of Extend limitations. This limitation caused the author to simplify the model significantly (after the reach back channel transmissions) and also caused a less rigorous data analysis function to be implemented. Thus, any improvements to the GBS Extend model have to be done in a piecemeal fashion in order to avoid program memory limitations. More granular studies (any model requiring greater than 50 Mb) should be done with more powerful communications modeling tools such as OPNET Radio Modeler (by *MIL3*) and COMNET III (by *CACI Products, Inc.*). This limitation does not mean Extend cannot be used for very granular studies. Detailed studies may still be done using Extend, but the system has to be small. Some specific limitations of Extend are listed in Table 1.

Blocks in a model	2 billion
Output connectors in a model (nodes)	2 billion
Connectors per block	255
Dialog items in a block	1024
Blocks in a library	200
Libraries open at one time	30
Steps in a simulation run	2 billion
# of attributes for discrete event item	100
Number of simulations in a multiple run	32K

Table 1. Example Extend Limitations [EXTEND]

B. METHODOLOGY

The design portion of this project was conducted in six steps: modeling tool selection, network characterization, logical model development, simulation and data collection, data analysis, and conclusions (summary of findings). The first five steps are discussed in this chapter and the summary of findings are presented in the next chapter. Further model application (specifically for GBS IDM process development) and validation is left as an area for further study.

1. Modeling Tool Selection

There are numerous computer-based modeling and simulation tools available to conduct network modeling. Three tools (COMNET III, OPNET and Extend) available at the research site (NPS) were considered for use by the author. The author chose to use Extend, Version 4, for reasons discussed below.

Extend is an advanced simulation tool designed for decision support. Although the program is not designed specifically for communications modeling, the basic blocks and the user-friendly GUI (graphic user interface) environment allow for fast development of models. Likewise, the ability to build any process from basic blocks make Extend ideal for analyzing high-level models in which hardware and data do not exist. Given that GBS is relatively new and the project involved time constraints, the selection of Extend became a logical choice. Additional detailed models can be derived from this project's model to conduct more thorough analysis. It should be noted, however, to be useful for the TIM, a relatively inexpensive COTS program like Extend may be best to understand the GBS data flow (given time constraints and the need to look at information flow at a high level).

The model in this project was tailored to look at the latency of message request-to-product receipt as traffic loading increases. In addition, simulation of the model provides the ability to assess the limits each reach back channel places on user throughput. A study on throughput is left as an area for future study.

The GBS model is also characterized by hundreds of user inputs (which can be organized in a single Extend notebook). Inputs such as message rate, message attributes (i.e., sizes, classification, source/user priority, port priority, node identification, unit identification), maximum transmission units, overhead, data rate, segmentation and reassembly rate (SAR), bandwidth, communication system status, and equation algorithms (i.e., congestion control cost for ADNS) are just a few examples of how the model can be tailored. If one realizes that the inputs just described only affect one node (of six) on one of thirteen platforms, then it can be seen that the model variations are endless. Appendix G lists some of these inputs. As a result, the model can be used to conduct focused studies based on specific reach back channels, users, or other groupings of interest. Time constraints of this project limit analysis to basic measures of timeliness.

Once the model is built, verification and debugging can be done to observe performance. A very useful Extend functionality is the ability to animate simulations. Physically seeing items move through the model is helpful in troubleshooting. However, using the animation takes up a significant amount of system memory and significantly increases simulation time. Once debugged, the data collection can begin. First, however, it is helpful for users to identify what is to be measured. As already mentioned, throughput and timeliness are two important measures of performance that can be easily studied with the incorporation of plotters, timers and time stamp attributes. Finally, simulation runs are conducted to collect, tabulate and present data in a fashion easily interpreted.

2. Network Characterization and Model CONOPS Description

Characterization: The three scenarios originally envisioned included a carrier battle group (CVBG) in transit, an amphibious readiness group/marine expeditionary unit (ARG/MEU) in a small scale contingency (SSC) operation, and a joint coalition force involved in a major theater war (MTW). These three scenarios were chosen because they are indicative of normal and heavy traffic load conditions and provided the opportunity to assess various reach back channels on a variety of users. Nevertheless, due to the time constraints, the enormous complexity of a MTW, and the complexity of the GBS configurations, only one of the three scenarios was built. The same variation in traffic loading can be studied by taking one model and varying the message rate inputs.

DISA D82 is planning to build upon their recent modeling assessment of the PACOM DISN (using COMNET III). They plan to analyze the DISN again with GBS implemented. [Berry] Additionally, follow-on NPS work will research integration solutions for the "stove-piped" Service SATCOM-DISN entry sites.

As discussed, the modeled network in this project is a highly asymmetric network. The network uses the GBS as the primary system for information delivery and seven existing or planned (near term) military and commercial communications systems as back channels. Obviously, the common communications system for all users in the model is the GBS. However, each user has its own mixture of back channels.

The GBS users are various Naval forces in an imaginary CVBG. The seven back channels modeled are SHF, commercial wideband (Challenge Athena and Inmarsat B) and narrowband (Iridium), HF, UHF DAMA (demand assigned multiple access), and EHF LDR (low data rate). Detailed discussions of the reach back channels and model assumptions are provided later in Section 3b (Methodology). Some broad model characteristics and assumptions are provided in Table 2.

Characteristic	Assumption
Time Frame	Around Year 2000
Location	Western Pacific (within 500nm of nearest HF station)
Units	One CVBG
CVBG Composition	1 CVN, 2 CGs, 2 DDGs, 2 DDs, 2 FFGs, 3 SSNs, 1 AOE
Message Rates	See Appendix I
Ship Subnets	Fast Ethernet
Ship Backbones	CVs, CGs, DDGs & SSNs with ATM; other units with FDDI
Reach Back Channels	Fully Connected Users; see Appendix H for unit capabilities
GBS Channel Allocation	15 Mbps for all IP (variable) data

Table 2. Summary of Model Assumptions

As indicated in Table 2, each of the thirteen ships in the CVBG GBS reach back model are built with back channel capabilities representative (though optimistic) of that unit type in the year 2000 (see Appendix G, FYDP Future Bandwidth). Appendix C (Topology of Users) in the [IBS ORD] was also used to identify unit RB capabilities. The CVBG composition and bandwidth allocations are derived from the Navy FRD (Functional Requirements Database) and ERDB (Emerging Requirements Data Base). Appendix H indicates the force composition for the models and for Fiscal Year Defense Plan (FYDP) and 2010. Appendix H also provides the bandwidth assignments for the models and the requirements for FY98/99 implementation, FYDP (2003), and 2010. Rather than use numbers to match the estimated unit bandwidth requirements, the author incorporates unit allocations based on what can be expected presently and in the near future. One significant model drawback is characterization of the bandwidth allocations to fit actual availability of the channels for GBS reach back traffic. This deficiency can be overcome by increasing the message rates of the subnet users (nodes) that do not initiate return products. These users are implemented into the model to provide traffic loading in addition to the reach back requests.

As already mentioned, the model takes into account many factors that can be varied. The reader is reminded that the GBS Extend model is a discrete event model and as such, the approach to modeling the GBS reach back architecture is to simplify the system into object-oriented sections starting from a user on a ship. Divisions quickly became apparent. The users themselves are complex and it was decided to incorporate them into a fast Ethernet (using CSMA/CD, Carrier Sense Multiple Access with Collision Detection) subnet, which aggregated the entire ship's network to this one subnet (with six end users). The subnet then interfaced with a simplified ATM or FDDI backbone. The ATM and FDDI backbone blocks are not fully developed, but incorporate delays based on MTU, SAR and capacity inputs. For additional simplification, the model did not incorporate real time voice and video. One can easily integrate voice and video (e.g., VTC) users into the ship's backbone. Previous NPS research incorporated VTC in an IT-21 model (ATM backbone) using both Extend and OPNET (see Rieffer). The GBS Extend model simplifications in this project helped reduce the development requirements and also alleviated the processing demand on the computer hosting the simulation. More detailed user characterization is discussed in the section on logical model development.

Model CONOPS Description: A top level view of the model is provided in Figure 9.

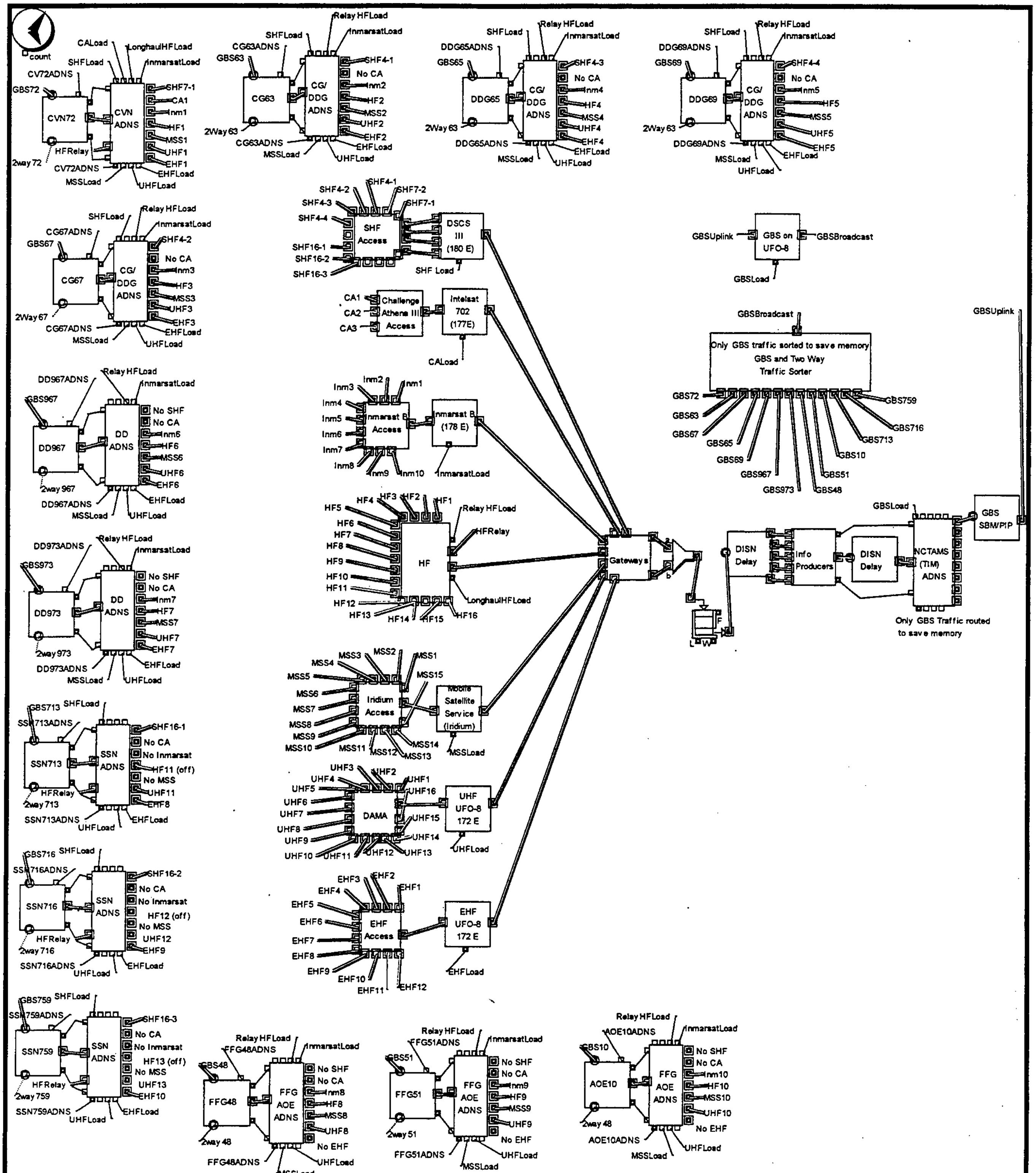


Figure 9. GBS Reach Back Top Level View

General model flow goes from left to right. Once items reach the right side of the model, they are transported back to the original users (via the forward communications channel, normally GBS). Basic flow goes from (1) one of thirteen ships (2) to one of seven back channel systems (via each ship's ADNS) (3) to the gateways (4) to the DISN (5) to the information producers (6) back to the DISN (7) to the NCTAMS/TIM ADNS (8) to the GBS SBM (9) to the GBS satellite (10) and back to the originating ship's RBM (11). The following paragraph provides further explanation of the model CONOPS by stepping through an example user pull operation. It should be noted that the actual GBS flow goes from the DISN to the SBM/TIM and then to the information producers (to return back to the SBM). The actual information flow was not developed in order to simplify the model. Nevertheless, the ability for users to communicate directly with information producers gives them better access. An in depth discussion on the issue of user access and TIM control is beyond the scope of this document, but is briefly addressed in the Section IV-B3-C (Role of the TIM).

The following description describes an example user pull flow for the model. A CVN end user on a ship sends a WWW browsing (HTTP) request for a document on the SIPRNET. The request message travels outside the six-node subnet (fast Ethernet) to the ship's ATM backbone to the ADNS router. The CVN's ADNS senses the channel that has the least congestion cost (based dynamically on system bandwidth, unit bandwidth and current system and unit use) and sends the message packets via that route. A message's packets may travel on different paths to get to its destination because ADNS senses channel availability for each packet and not for each message. The packets will be delayed based on transmission, propagation and processing characteristics associated with the specific reach back channel. At the entry site (i.e., NCTAMS), the request message packets are further routed on to the SIPRNET/DISN (ATM) for delivery to the information producer. Upon receiving the request, the information server sends the requested document to the Theater Information Management (TIM). The TIM sees all information destined for the SBM and audits the flow. After TIM validation, the requested product is routed (via ADNS) to the GBS Satellite Broadcast Manager (SBM) for broadcast scheduling. The TIM (recommended to be co-located at a communications hub such as NCTAMS) also incorporates an ADNS switch that decides what forward channel to send the document. If GBS (which normally will be the case) is the best distribution path, the document will be sent to the SBM to wait in a queue until placed on the Secret IP broadcast channel. Once selected for GBS broadcast, the document IP packets are multiplexed into the DVB (digital video broadcast) waveform where it travels the GBS space segment. During the GBS space segment the packets experience delay due to transmission, propagation and satellite processing. The CVN receives the broadcast via the Secret Receive Broadcast Manager (RBM) PC. The document packets are then routed from the Secret RBM to the ship's ATM backbone. From the backbone, it goes back to the original fast Ethernet hub. Normally, the hub would send the packets to the originating node, but the model sends all received packets to a data analysis node for easier data collection.

Although not modeled, an example smart (TIM) push flow is described for the reader's reference and future incorporation into the model. The TIM approves an image produced by NIMA (National Imagery and Mapping Agency) to be broadcast by GBS on the Secret IP data channel. The approval is based on user requirements and CINC priorities. The approved broadcast image is scheduled to be transmitted by the SBM. The image waits in a queue until it is placed on the Secret IP broadcast channel. Once placed on the GBS broadcast, the image IP packets are multiplexed into the DVB waveform where it travels the GBS space segment. During the GBS space segment the packets experience delay due to transmission, propagation and satellite processing. The CVN receives the broadcast via the Secret RBM PC, assuming the RBM has the filter to accept the image (and the current user's filter is stored at the SBM). The image packets are then routed from the Secret RBM to the ship's ATM backbone. From the backbone, the image packets go to the end users (via the Ethernet subnet) that are filtered to accept the image. It was the author's intention to provide the smart push path flow into the model. Due to model limitations and time constraints the smart push development is left to the researcher that is interested in studying the GBS IDM process and seeks to answer the question of "What is the right mix of smart push and user pull?" The modeled ships are designed, however, to receive push products.

3. Logical Model Development

Models are first sketched on paper from the highest level view. Verbal descriptions of the sketched nodes and discrete event item flow are also put on paper.

Once comfortable with the flow of the model, the model is built from left to right. Consequently, the user transmit portion on the left also becomes the receive portion once a packet has reached the right end of the model. At the right end, the packets are "thrown" back to the users on the left via the GBS satellite, a traffic sorter block and "named" connectors.

As described in the model CONOPS, the user in a ship generates request messages, which are transmitted to an entry site via ADNS and the back channel system. The entry site forwards the requests to the information producers. Upon receiving requests, the producers send information products to the TIM. The TIM passes the information (once validated) to the SBM. The SBM processes the products and transmits them to the original user via the GBS. Another ADNS switch is incorporated with the TIM to give the product the ability to go back via the back channel if it is less "costly" than the GBS (e.g., the weather is bad and GBS service is severely degraded). More detailed discussion of users, reach back channels, TIM, and the SBM are provided in the following sections.

a. Identifying the Users and Their Requirements

Users must be able to interact with the GBS. The model allows users to request information much like in the real world when a user must query for additional information on a reported entity or archived database. An alternative approach to the user's query is the smart pushing of pre-determined data. In the GBS system, to effectively implement smart push, the users must forward their information requirements to the CINC TIM/SBM in order to activate and set the user's filter (by geography or activity) at the SBM. As already mentioned, this project's model provides the means for information delivery via the former approach and does not model smart push.

There are two types of tactical users: small (highly mobile) or large (fixed or mobile). [IBS] The CVN in the model can be considered as large and mobile while all other ships are small and highly mobile. In addition, end users on each ship are assigned priorities which correspond with the SATCOM priorities listed in CJCSI Draft 6250.01. Note that Priority Zero is not used unless in an emergency. Table 3 indicates the standard composition of priorities assigned to each message. Appendix I further defines the SATCOM priorities. It should be noted that these priorities in combination with the "NodeID" attribute are equated to the user's IP address (or source). This prioritization becomes important for datagram routing by ADNS. The user priority has precedence over all other priorities (e.g., port priority).

As already mentioned, the Ethernet message generator in Figure 10 takes message rate inputs (messages per hour) to produce items (messages) with an exponential arrival interval (Poisson arrival rate). The unit default message rates are derived from the predicted numbers of computers for IT-21 implementation (see Figure 11).

The total default message rates in messages per hour are 12000 for Email, 2200 for message traffic, 22000 for HTTP, 2200 for FTP, 1200 for imagery requests, and 1200 for tactical requests. These totals are divided and apportioned to the ships based on the total number of computers per unit relative to other units.

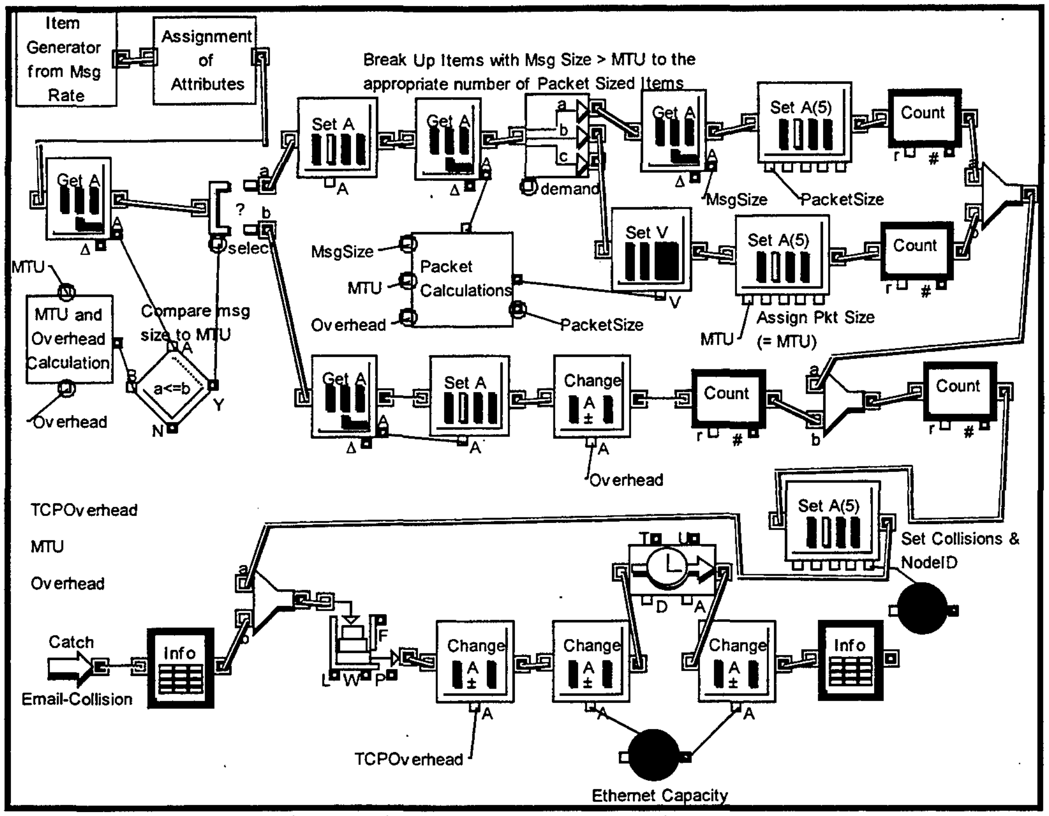


Figure 10. Ethernet Message Generator

Appendix G provides the message rate inputs for each unit. In the assignment of attributes block, message sizes are generated using a normally distributed random number generator in which the mean and standard deviation is determined by user inputs. Appendix G also provides the message sizes and deviations for each unit. Likewise, each item generated is given other attributes to be later used in the model (e.g., the ADNS section). These attributes include priority of user (see Table 3), classification (see Table 4), priority of application (see Table 5) and product request (see Table 6). Other attributes assigned in the Ethernet generator include collisions and node identification. The number of collisions is set to zero initially. If the packet experiences a collision in the Ethernet hub, the number of collisions is incremented by one. The packet is then sent back to the Ethernet generator catch block for retransmission (after a back-off period determined from the number of collisions the packet has experienced and the current use of the network by other nodes). This process is consistent with carrier sense multiple access/collision detection (CSMA/CD) in Ethernet networks. [Stallings]

Common Capabilities: 5/25 kHz DAMA, GCCS-M and GCSS-M, 128 KBPS (Except FFG/ CM/MHC/AOE/AS: 64 KBPS)

	RF Mgmt	Wideband	Narrowband	LAN	Class PC		Unclass PC
CV(N)	ADNS2	SHF (Dual)/GBS/CWSP EHF MDR*	EHF LDR	ATM	CV(N)	450	615
LCC/AGF	ADNS2	SHF (Dual)/GBS/CWSP DWTS/EHF MDR*	EHF LDR	ATM	LCC AGF	118 100	160 108
LHA/LHD	ADNS2	SHF (Dual)/GBS/CWSP DWTS/ EHF MDR*	EHF LDR	ATM	LHA LHD	161 172	216 232
LSD/LPD	ADNS2	SHF/EHF MDR DWTS/GBS	EHF LDR	ATM	LSD LPD	49 63	65 80
CG/DDG	ADNS2	SHF/EHF MDR GBS	EHF LDR	ATM	CG DDG	63 50	78 63
DD	ADNS2	INMARSAT B (Dual) EHF MDR/GBS	EHF LDR	Most Cost Effec	DD	54	70
SSN/SSBN	ADNS2	EHF MDR/GBS 128Kbps Global Solution Required	EHF LDR	ATM	SSN # SSBN #	27 30	29 33
FFG/MCM/MHC	ADNS2	INMARSAT B/GBS		Most Cost Effec	FFG MCM MHC	30 16 10	32 17 10
AOE/AS/AO/ARS	ADNS2	INMARSAT B/GBS		Most Cost Effec	AOE AS ARS	128 240 24	144 280 27
			End-To-End Capability	Total		19,017	23,785

* Post-FY02 Installation
# Laptops for SSN/SSBN

Figure 11. IT-21 Unit Capabilities [Mayo]

Value	Probability
0 Assigned only by NCA/Joint Staff for emergent contingencies	0
1 Strategic Order (Essential to National Survival)	.05
2 Warfighting Requirements	.05
3 Essential Support	.25
4 Training	.40
5 VIP Support	.10
6 RDT&E (including quality of life initiatives)	.10
7 Miscellaneous	.05

Table 3. Default User Priority Assignments

Value	Probability
1 (Top Secret)	.20
2 (Secret)	.40
3 (Unclassified)	.40

Table 4. Default Message Classification Assignments

Value	Probability
1 (equivalent to Higher Applications)	.40
2 (equivalent to FTP)	.20
3 (equivalent to HTTP)	.20
4 (equivalent to Email)	.20

Table 5. Default Port Priority Assignments

Item Number	Product	Mean Size
1	Tactical Data	8 kbits (std dev 1.5 kbits)
2	Imagery	90 Mbits (std dev 15Mbits)
3	Word Docs/.ppt briefs	60Mbits (std dev 10Mbits)
4	Video/Audio	120 Mbits (std dev 20Mbits)
5	FTP	120 kbits (std dev 20kbits)
6	HTTP	280 kbits (std dev 60kbits)
7	Message Traffic	60 kbits (std dev 10kbits)
8	Email	12 kbits (std dev 2.5kbits)

Table 6. Default Product Request Assignments

The messages are broken up (if required) based on the inputs for MTU (maximum transmission unit) and overhead. Thus,. the message item becomes a packet item or a number of packet items. Another attribute is assigned to signify the packet size.

The default MTU and overhead inputs for the model are 1500 bytes (12000 bits) and 20 bytes (160 bits), respectively. Hence, the Ethernet generator breaks messages into 1500-byte packets or less with an overhead of 20 bytes. The IP header is included within the overhead. The MTU and IP overhead inputs can be changed in the appropriate constant block dialog box or the Extend notebook. Different inputs may be required to reflect individual systems and protocols.The model assumes TCP/IP communication, hence 20 bytes of TCP overhead (including header) is added to the packet size. Finally, the model generator delays the packets based on the input user data rate (default input is 100 Mbps), which affects the time it takes for the packet to be transmitted. The six message generators (Email, Message Traffic, HTTP, FTP, Product Requests, and Tactical Order Wire) sent packets into the subnet shown in Figure 12.

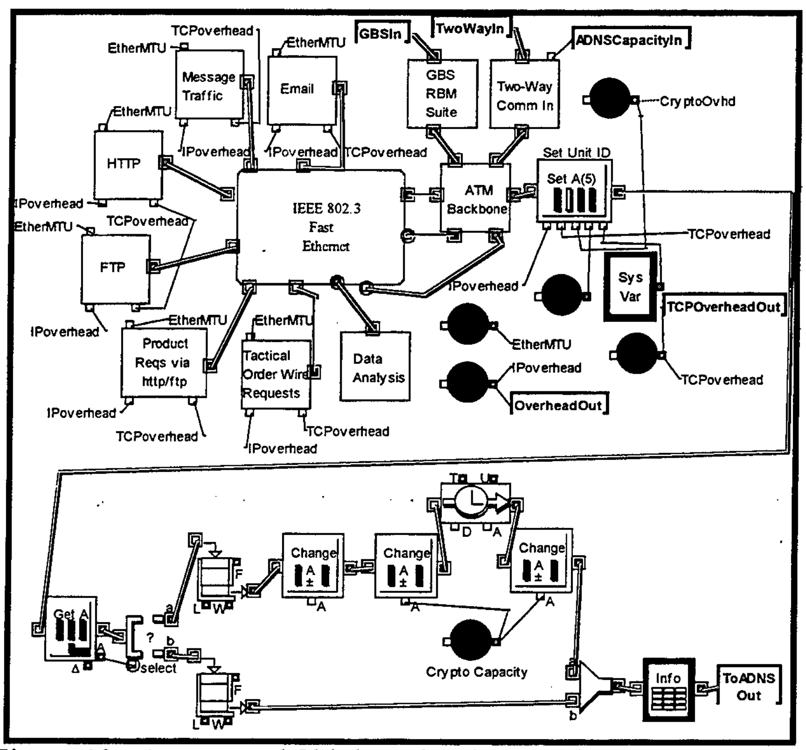


Figure 12. Aggregated Shipboard Subnet within an ATM LAN

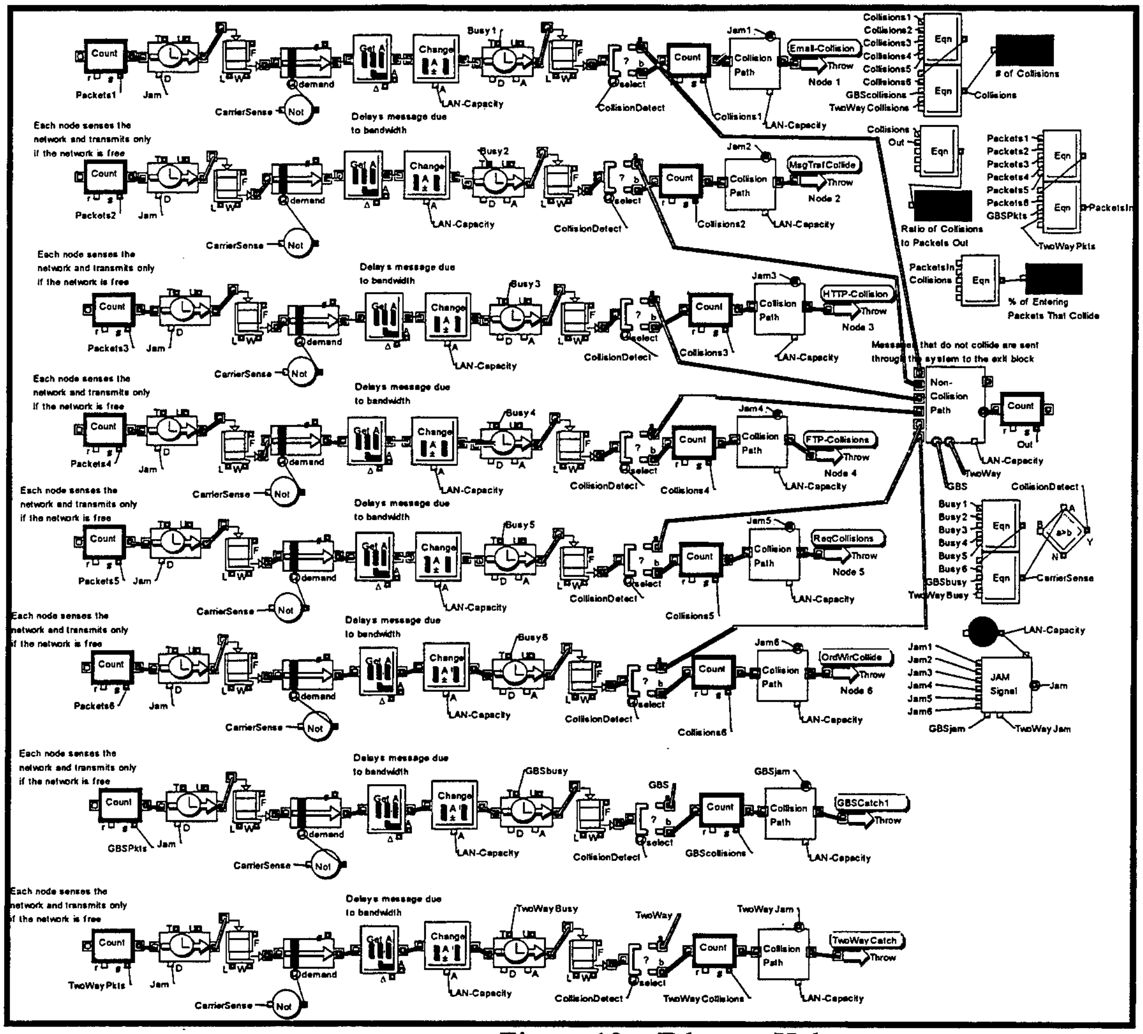


Figure 13. Ethernet Hub

Figure 13 above shows the CSMA/CD structure of the Ethernet subnet's hub. The reader is referred to Stallings and Stevens for a detailed discussion of CSMA/CD. From the subnet, packets enter the asynchronous transfer mode (ATM) backbone and experience cell conversion and ATM delay. From the ATM backbone, the packets enter the ship's ADNS (which is handling IP packets vice ATM cells). Once products return based on the generated requests, they enter via the GBS RBM or the two-way block (which simulates returning via the ship's ADNS CAPs). The products subsequently enter the ATM backbone and the Ethernet subnet. After the subnet the packets are sent to the data analysis block. In reality, the packets are sent back to the six generators, but a single block was used to receive all packets in order to simplify data analysis. The data analysis block is explained later in this chapter in Section 5.

b. Identifying Model Back Channels and Traffic Routing Scheme

Specific commercial wideband channels modeled include Challenge Athena and Inmarsat B. Teledesic was not modeled, but can be added as another channel or as a replacement to Challenge Athena. Likewise, the model uses Iridium as the commercial narrowband back channel, but another narrow band MSS (Mobile Satellite System) could also be used (e.g., Globalstar and ICO). Figure 14 illustrates the SATCOM satellites possibly available to units in the year 2003.

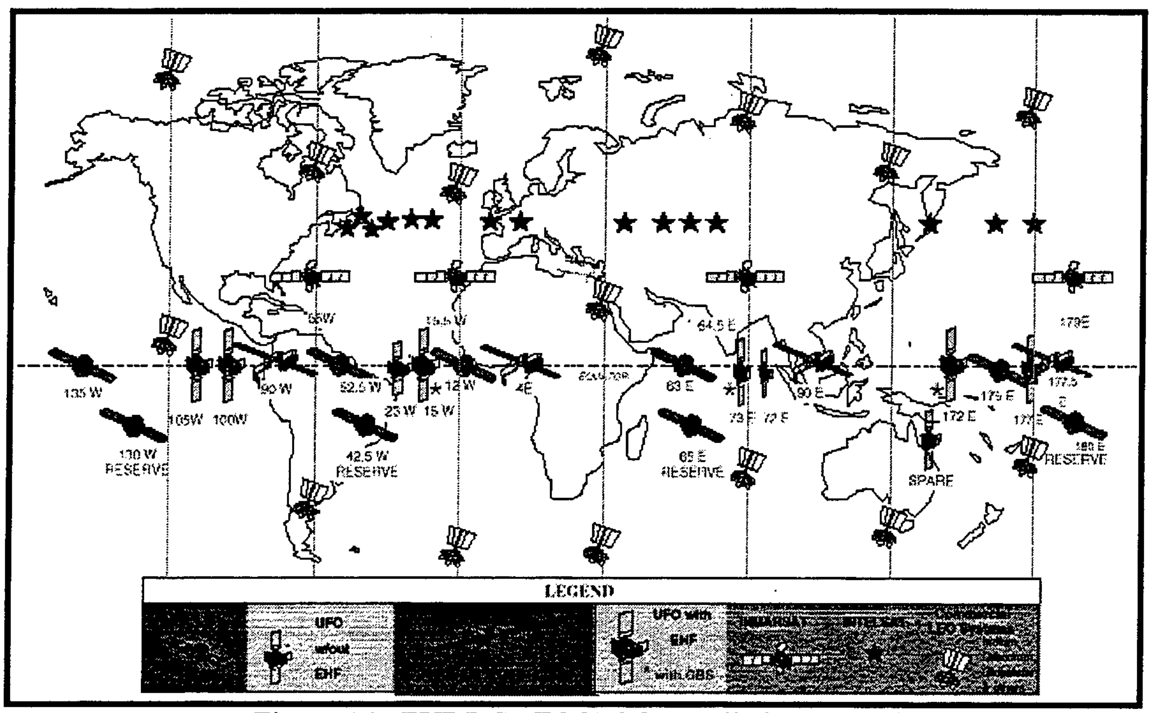


Figure 14. FYDP SATCOM Constellations [Boyd]

The following subsections discuss the reach back channel model assumptions and system description. Commercial systems other than Inmarsat B are not described in depth and the reader is referred to the research of others and the official documents of the commercial companies themselves. The discussions are focused to address the five SATCOM key performance parameters (KPPs) as mentioned in the *Advanced Satellite Communications Capstone Requirement Document.* The KPPs include coverage, capacity, protection, access and control, and interoperability. [SPACECOM] In addition, the reader is referred to [Powers] for an in depth assessment of using commercial systems for military communications. Likewise, a study on *Teledesic* for military use can be found in [Wickline].

1) Super High Frequency

Model: Assumptions include the use of DSCS III; a 40W channel for forces in each scenario; 1.9Mbps total SHF system capacity (divided among a maximum of 14 ships using TDMA); afloat users equipped with AN/WSC-6 variant terminals; SHF availability to the CVN via a 7 ft antenna; to CGs and DDGs via a 4 ft antenna; to SSNs via 16 inch antennas. CVN nominal throughput is 768 kbps; CG/DDG throughput is 256 kbps and SSN throughput is 64 kbps.

System Description: SHF systems support worldwide users ashore and afloat. The DSCS III satellite constellation consists of five satellites with six independent transponder channels each. The DSCS III SLEP program will extend naval communications from the sharing of only one 50W channel (currently channel 1) to having one dedicated 50W channel and sharing another (channel 3 and 1 respectively). Each spacecraft has two 19 element (single beam) antennas and one 33" diameter steerable parabolic downlink antenna; there are also 2 downlink earth coverage horns. Shore SHF uplinks/downlinks for the Navy consists of GSC-39/52 and FSC-78 medium and heavy earth terminals located at the three NCTAMS worldwide. The AN/WSC-6 (V) 1-6 is the standard shipboard terminal in 4 and 7-foot diameters. For GMF missions the AN/TSC-93B is the standard SHF SATCOM terminal with an 8-foot diameter dish. [NTP2]

SHF SATCOM is a joint asset whose wide bandwidth and high data rate characteristics provide the additional satellite capacity required by all of the Services. The Navy's early access supported afloat Numbered Fleet Commanders using the jam-resistant (spread-spectrum/code-division multiple access [SSMA/CDMA]) mode of operation that provides a 4.8 kpbs maximum aggregate, full-duplex capability, and Surveillance Towed Array Sensor System (SURTASS) asymmetrical frequency-division multiple access (FDMA) mode of operation. The afloat Numbered Fleet Commander capability was limited to a few medium data rate (1.2-2.4 kbps) circuits with most of the C4I direct connectivity provided via low data rate (LDR) channels. Navy C4I requirements increased significantly during Operation Desert Shield/Storm, which saturated all available satellite assets. The bandwidth and high data rate characteristics of DSCS/SHF SATCOM emerged as the best solution to provide additional satellite capacity. Current Navy SHF SATCOM networks provide afloat units with high capacity telecommunications trunks that are terminated at NCTAMS STEP facilities.

Coverage: DSCS SHF worldwide coverage extends from 70° N to 70° S. There are two series of DSCS III satellites: A-series and B-series. A-series are the first-generation DSCS III satellites. The newer B-series have received upgrades to various support subsystems and the communications system.

Satellite Ocean Area	DSCS III Satellite Model	Longitude (Degrees)
East Pacific Primary	B-14	135W
East Pacific Reserve	A-1	130W
West Atlantic Primary	B-7	52.5W
West Atlantic Reserve	B-4	42.5W
East Atlantic Primary	B-12	12W
Indian Ocean Primary	B-10	60E
Indian Ocean Reserve	A-2	57E
West Pacific Primary	B-9	175E
West Pacific Reserve	B-5	180E

Table 7. DSCS III Satellite Positions [FAS]

The communications subsystem may simultaneously employ various modes of transmission and reception: full Earth coverage, area coverage, and narrow coverage. Using multiple beam antenna (MBA), the capability exists to provide narrow coverage, area coverage, or selectively shaped area coverage by combining multiple, simultaneous narrow coverage patterns. A high gain, narrow transmit coverage capability is provided by the gimbaled dish antenna (GDA). The receive and transmit MBAs have the ability to simultaneously cover multiple areas, thereby maximizing link gain between terminals in the illuminated areas and reducing the effect of off beam jamming signals. This capability is not normally used during naval operations, but may be employed as directed for contingencies. [Lindberg]

Capacity: There are currently 62 commanders afloat and ashore using SHF SATCOM. Under the current configuration of only one channel per satellite, not all ships capable of coming up on SHF can be active at the same time. [Lindberg] Those ships capable of SHF access have either two 7-foot antennas, two 4-foot antennas or one 16-inch antenna. The 16-inch submarine SHF antenna is rarely utilized due to the amount of power required for transmission.

Currently as of FY98 the CV/CVN SHF bandwidth is 512-768 kbps up to 1.5 Mbps using a WSC-6 (V) 5. The CG SHF bandwidth is 256 kbps. The DDG SHF bandwidth is 256 kbps. The LHD/LHD bandwidth is 512-768 kbps up to 1.5 Mbps maximum using a WSC-6 (V) 5. The LCC/AGF SHF bandwidth is 512-768 kbps up to 3.0 Mbps maximum using a WSC-6 (V) 5. Submarine SHF bandwidth is 64 kbps. [IT21]

The last four DSCS III satellites scheduled for launch (B-8, B-11, B-6, and A-3) will receive performance upgrades through the DSCS SLEP. Responding to the Services' need for more capacity, the original DSCS III SLEP has been revised. The revised SLEP provides improved satellite capability for the next four DSCS satellites to be launched with the first scheduled in July 1999 and the fourth in fiscal year (FY) 2003 (a fifth satellite is currently unfunded). Major revised SLEP upgrades to the DSCS III satellite include increased transponder bandwidth and 50-watt TWTA in all six channels. The 50-watt TWTA and bandwidth addition is predicted to provide a 700 percent increase in tactical communications capacity. Furthermore, upgrades to the low noise amplifiers (LNA) is estimated to provide an approximately 30 percent increase in data rates for smaller terminals. The increased power capability in all channels on SLEP DSCS III satellites will allow shifting of nontactical users on channels 2 through 4 to channels 5 and 6 by using bandwidth-efficient modulation techniques. This compression technique provides greater bandwidth utilization but, in the past, was not feasible due to the increased power-per-bit requirement. SLEP will increase the mean mission duration (MMD) from 7.5 to 10 years per satellite. [Lindberg]

Protection: DSCS SHF security components include KG-194's for bulk encryption and KG-84's for single channel encryption. Currently there are a wide variety of modems and multiplexers in use. The configuration depends on the type of terminals connected to the circuits.

Access and Control: DSCS DAMA as proposed by DISA will be supported by FDMA single channel per carrier (SCPC) circuits and will offer a broad range of messaging, director, port in-network, and billing services. It will support semi-permanent fixed bandwidth and bandwidth-on-demand through user recognition. DAMA Network Control Terminals (NCT) will be given a certain amount of bandwidth and power to manage. These allocations may not be confined to a single transponder and may not be contiguous within a given transponder. The majority of terminals in the net will be multicarrier capable. It should be noted that the acronym DAMA when used as the implementation standard in SHF DSCS is misleading and would be better named FDMA

Network Management System (FNMS). FNMS is defined as a control system to monitor and control links using standard FDMA modems (OM-73, EFD-8650, and CQM-248). [FAS] FNMS will eventually replace the Interim Tactical Orderwire System (ITOS)/Ground Mobile Force (GMF) orderwires (O/ W). The system capabilities include: login/ logout, O/ W services, FDMA link setup and characterization, FDMA link maintenance and teardown, NCT handover, remote NCT operations, and control circuit transmission security (TRANSEC) (CCT) protection. Eventually, the FNMS will replace the Automatic FDMA Power Control and Link performance reporting functions and be able to control links on leased commercial communications satellite transponders. [Lindberg]

Each transponder channel is capable of relaying, with minimal performance degradation, time-division multiplexer (TDM)/FDMA, CDMA, and time-division multiple access (TDMA) signals. When relaying FDMA signals, the transponder HPA must operate in an essentially linear mode. CDMA and TDMA signals permit operation in a near-saturated mode. The gain of the transponder is controlled prior to the TWTA/ HESSA to ensure the desired degree of TWT saturation for varying input levels. Input variations depend on the number of uplink signals and the EIRP of the Earth terminals. [Lindberg]

The DSCS III Communications Subsystem includes six independent RF channels, jammer location electronics (JLE), one receive 61-beam MBA, two receive ECHs (E1R and E2R), two transmit 19-beam EC/ narrow coverage (NC) MBAs (M1X and M2X), one transmit GDA, and two transmit ECHs (E1X and E2X). Channels 1 and 2 are designated as power channels and each operates with a 40-watt TWTA. Channels 3 to 6, the low power channels operate with a combination of 10-watt TWTAs/ high efficiency solid-state amplifiers (HESSA), and linear solid-state amplifiers (LSSA). [Lindberg]

Interoperability: End user applications supported through SHF SATCOM systems fall in four general categories: command and control, mission planning/support, nontactical initiatives, and SURTASS. SHF future applications envisioned by the Copernicus Architecture are affected by the major restructuring of Navy C4I to put the warfighter at the center of the command and control universe. The Joint Maritime Communications Strategy (JMCOMS) provides the technical and implementation strategy for the communications portion of Copernicus. JMCOMS technical thrusts are designed to introduce systems that facilitate the collection, correlation, and fusion of data to produce and efficiently disseminate information that is required by joint task force (JTF) and joint task group (JTG) commanders in a format that can be readily used. The major components of Copernicus are the CINC Command Complex (CCC) ashore, the Tactical Command Centers (TCC) afloat, the Global Information Exchange System (GLOBIXS), Tactical Data Information Exchange System (TADIXS), and Battle Cube Information Exchange System (BCIXS). The Navy SHF SATCOM architecture will support Copernicus by providing additional/supplemental media for the TADIXS and BCIXS networks. The Automated Digital Networking System (ADNS) is the primary

JMCOMS technical thrust for integrating the Navy's SHF SATCOM assets into Copernicus. [JMCOMS]

DSCS SHF has as a future capability to be compatible with ADNS. As of November 1997 SHF DSCS was incompatible with ADNS. Navy SHF packages has very rigid COMMPLANs, which could be controlled via ADNS. The ADNS capability is being built into the future DSCS SHF SLEP program that begins launching in 1999 through 2003. [JMCOMS]

Latency: SHF has a nominal 240 millisecond geosynchronous delay. The circuits are currently dedicated to a certain bandwidth without any flexibility. The significant latency delays are between the earth stations and the satellites. None of the satellites have or are planned to have on board processing; they are all in bent-pipe configurations.

2) Commercial High Data Rate (HDR) Wide Band (Challenge Athena)

Model: Assumptions include the use of Challenge Athena III (Intelsat 702); 2.4 Mbps total system capacity (divided among a maximum of 3 ships using TDMA); afloat users equipped with C-band 9-foot antennas; CA available to the CVN with a nominal throughput of 768Kbps. No other platforms have CA other than command ships and big deck amphibious assault ships (LHD/LHA).

System Description: Challenge Athena, as discussed in the Background, answers the fleets call for additional bandwidth. CA uses leased lines and Earth stations to integrate into the DISN. For PACOM, the entry site is at Steele Valley, California.

This site is connected to NCTS San Diego via three T1 lines. From the NCTS, the military traffic is connected to other nodes in the DISN such as NCTAMS EASTPAC in Hawaii. The satellites have geostationary positions of 76 W, 21.3 W, 177 E, 1 W and 177E. The constellation provides near worldwide coverage. There is gapped coverage in the Indian Ocean region, but triple coverage in the Atlantic, European and Middle East regions. The satellite transponders are also leased. A typical Intelsat VII satellite (e.g., Intelsat 702) is capable of providing 42 channels of C-band and 20 channels of Ku-band transmission. The latest Intelsat VIII versions can provide 64 and 12, respectively. One of the biggest drawbacks of CA is the size of the terminals. The terminals weigh 1840 pounds. The 9 foot antennas are housed in a radome that is 13.5 feet in height. Understandably, CA is only available to big deck Navy ships.

3) Commercial Medium Data Rate (MDR) Wide Band (Inmarsat B)

Model: Assumptions include the use of Inmarsat B (HSD); 1.2 Mbps total system capacity (divided among a maximum of 10 ships) for F3 satellite; Inmarsat is available for all units except SSNs. Nominal unit throughput is 64 Kbps.

System Description: Inmarsat-B High Speed Data (HSD) was launched in 1993 as the digital successor to Inmarsat-A. Inmarsat-B (HSD) provides a global satellite-based extension of the terrestrial ISDN network to users who would otherwise be unable to access ISDN. Three features make Inmarsat-B (HSD) unique when compared to other satellite communications service providers: (1) On-demand satellite capacity, (2) seamless worldwide coverage, and (3) Direct dial access to the global ISDN network.

[Inmarsat]

Coverage: Four geostationary satellites (178 E, 54 W, 15.5 W, and 64 E) provide continuous worldwide coverage.

Capacity: Using robust file transfer protocols such as TCP/IP, average throughputs of 60 kbps on a 64 kbps channel along with full error correction and data recovery is possible using Inmarsat-B (HSD). Although the Inmarsat-B (HSD) is best suited to operate in environments where a 56/64 kbps terrestrial connection is available at the Land-Earth Station (LES), the service can still function without the terrestrial connection, however the LES will be limited only to mobile-to-mobile service. Therefore, the growth and demand of Inmarsat-B HSD is clearly linked to the availability and growth of ISDN. Inmarsat-B (HSD) also supports medium speed data service that provides a 9.6 kbps circuit through the terrestrial PSTN to normal dial-up modems. Some of the typical HSD applications include multiplexed voice, data, and fax, audio uplinks, store and forward video, videoconferencing, and LAN interconnections. Each Inmarsat-B (HSD) multiplexed voice, data and fax channel provides a duplex 64 kbps data channel that may be multiplexed to carry 2 to 10 users. Audio applications use 7.5 or 15 kHz audio codecs to provide broadcast-quality audio from remote locations. Under the video store and forward concept, each HSD channel transfers data at a much lower rate than video applications require. Therefore, the video is captured at rates ranging from 512 kbps to 3 Mbps and then is transferred using the 56/64 kbps HSD channel. Once at the final destination, the video is then stored and played back at the original rate.

LAN interconnections, such as (but not limited to) those supported by TCP/IP-based protocols are also supported by Inmarsat-B HSD.

Access: The preferred multiplexing technique for most efficient use of the fixed bandwidth channels is statistical multiplexing (Demand Assignment). DAMA is used by both the remote and terrestrial links. For mobile-to-fixed calling, LES selection is made by the Mobile Earth Station (MES) either using the default code programmed into the MES or by the user entering an LES code while dialing. For fixed-to-mobile calling, the system requires the telephone service provider recognize the correct region called and the type of service to be provided for correct LES routing. For mobile-to-mobile calling (which is consistent with those areas not offering terrestrial 56/64 kbps connections), there is an additional delay introduced due to the double satellite hop which will reduce throughput in most applications.

Interoperability: Inmarsat-B HSD land-mobile terminals typically cost $30-40 K US dollars. This is about half the price of VSAT that runs $50-100 K US dollars depending on the antenna size and system (C-band or Ku band). Size of the Inmarsat system is a particularly attractive element for mobile maritime applications. The Inmarsat-B (HSD) system typically weighs approximately 18-30 kgs and has an antenna size of about 1 meter. It can easily be transported in a small aircraft (COD) or helicopter. Untrained personnel can do deployment and setup in a matter of minutes, with permanent installations taking only a few hours. [Inmarsat]

Latency: Channel delays from the satellite link vary with the LES but are typically on the order of 250 ms. For mobile-to-mobile communications, the delays may approach 2 seconds.

4) High Frequency

Model: Assumptions include the use of ground wave HF with HF fleet radio, the RF-3261E, which can deliver 2.4 kbps at a range of 500 nautical miles(nm). For simplicity, one radio was assigned per ship, but multiple radios could be added. In addition, the CVN was configured to conduct long-haul HF communications at 2.4 kbps but the other twelve ships were configured to use HF relay at 64 kbps. The HF relay allows users to send data to the carrier to subsequently be sent out the CVN's SHF or Challenge Athena. The relay concept is similar to the UHF relay envisioned in the Digital Wideband Transmission System (DWTS) for amphibious forces. DWTS can provide up to 2.048 Mbps of additional bandwidth for the littoral region. [IT21]

System Description: High frequency (HF) communications have been employed (especially by the United States Navy) since the beginning days of wireless radio. Traditionally, the HF spectrum used by the Navy ranges from 2 to 30 MHz. The deployment of modern communication satellites ended the Navy's reliance on long-range (greater than 500 nm) HF communications. In addition, the Navy turned away from sky wave HF and began to develop ground wave HF. Tests have shown that ground wave waveforms are less likely to be affected by fading and scintillation. [Pinck] However, ground wave HF does not provide as much range (on the Earth's surface) as sky wave HF due to the extended propagation field of view provided by the atmosphere.

Capacity: The current HF fleet radio, the RF-3261E can deliver 2.4 kbps at a range of 500 miles. Many initiatives have sought to increase the available data rate provided by the RF-3261E. A test conducted at SPASYSCEN San Diego CA for the NAVCOASYSSTA Panama City, Florida demonstrated the feasibility of using HF beyond the line-of-sight (BLOS) to support a communications link between a semi-submersible mine hunter and it's parent vessel. At ranges of less then 25 nautical miles the system supported data rates varying from 56k to 75 kbps. [Pinck]

HF data rate depends on the environmental conditions. To combat poor environmental conditions or fading one has to use a combination of bandwidth efficient modulation techniques and forward error correction coding. The reader is referred to Rappaport for an in depth discussion on the interrelationships between data rate, fading, modulation and forward error correction coding.

A brief discussion to reduce environmental effects and optimize HF data rate follows. As a communications signal propagates from the transmitter to the receiver, energy is lost due to scattering, reflection, and diffraction. These effects are characterized as fading, which includes both large and small scale fading. For a ship that moves over distances that are large compared to the wavelength, fluctuations in receiver signal strength are characterized as large scale fading. Large scale fading represents the loss introduced by the channel. In contrast, small scale fading, or simply fading, occurs when a ship's motion is short compared to the wavelength. Small scale fading causes the received signal to induce inefficiency by causing rapid changes in the signal's amplitude and phase.

Likewise, when transmitting in unguided mediums (i.e., the atmosphere) a signal can arrive at the receiver via multiple paths. These multiple paths can be due to obstructions, ground reflections, or scattering within the channel. The receiver sums the multipath contributions; but since the multipath components vary widely in phase, the signal at the receiver can also fluctuate. Subsequently, the sum of the multipath components can be either constructive or destructive. Nevertheless, multipath in the channel creates small scale fading effects. The three most important effects are (1) rapid changes in received signal strength over distances short compared to a wavelength, (2) random frequency modulation due to varying Doppler shifts on different multipath signals, and (3) time dispersion caused by multipath propagation delays. [Rappaport]

In addition to reducing the fading just discussed, the proper selection of modulation can optimize channel performance. Choices for modulation include M-ary phase shift keying (MPSK) and M-ary frequency-shift keying (MFSK), PSK (BPSK) and QPSK. A modulation technique that maintains the highest performance and spectral efficiency as possible should be chosen. If satisfactory performance for the link is defined as a probability of bit error smaller than 10^{-5} for a given SNR of twelve dB, the appropriate choice for modulation is QPSK. Calculations using equations from Rappaport support this conclusion.

Given the effects of a fading channel, the use of forward error correction (FEC) is one way to improve performance (by detecting and/or correcting errors). The additional bits improve the system's performance (i.e., probability of bit error) without increasing SNR. Unfortunately, an unavoidable consequence of using FEC is data rate reduction by a factor equal to the code rate. This means that the cost of coding gain leads to either an increase in bandwidth or a reduction in bit rate. Likewise, the greatest disadvantage to using FEC is the additional bandwidth required by the code. This additional bandwidth lowers the potential system data rate. However, without the additional coding gain provided by FEC, the forward link cannot meet the probability of bit error performance requirement of 10^{-5}. [Rappaport]

It can be shown that a combination of soft decision decoding and concatenated FEC coding improves system performance. For example, a test conducted between USS Coronado and USS Cleveland during RIMPAC-98 successfully demonstrated a HF data link at a maximum range of 147 nm and a nominal range of 110 nm [Pinck]. The test concluded that a quadrature phase shift keyed signal using a concatenated forward error correction code supported a data rate varying from 56k to 75 kbps. At a range of 50 nm or less the system was able to deliver a data rate of 75 kbps; at 110 nm 64 kbps; at 147 nm 56kbps, and at 500 nm, the RF-3261E is capable of 2.4 kbps.

Clearly, a QPSK concatenated system significantly increases the date rate of each RF-3261E. Nevertheless, to deliver higher data rates to support the larger volumes of data required for wireless Internet operations, the implementation of a mulitcarrier system is recommended (assuming that the limiting factor is the channel coherence bandwidth). In a multicarrier system, the data stream is broken up into as many as m bit streams that are individually transmitted on up to m different frequencies $(f_1, f_2, \ldots f_m)$, where the subscript $i = 1,2,3,\ldots,m$ uniquely identifies the carrier frequency. For QPSK, a single carrier system provides a data rate equal to the bit rate. For a multicarrier system having the same bit rate, each of the m multicarrier system frequencies will provide a data rate equal to $R_{b_i} = \frac{R_b}{m}$. Therefore, the bandwidth of each multicarrier frequency is 1/m times smaller than that of the single carrier system. As a result, if a Ticonderoga cruiser uses three RF-3261E radios at a range of 110 nm, the ship could increase HF data rate from 64 kbps to 192 kbps.

Additional means can also improve the available HF bandwidth. Current communications doctrine assigns each HF user with a set of frequencies. If the Navy abandoned this FDMA approach and allowed dynamic allocation, the HF bandwidth data rates would be maximized more, while preventing distortion. In addition, the master controller (MC) could dynamically assign different FEC types and constraint lengths, thereby providing enough coding gain to maintain the desired link margin and minimizing the use of code that unduly burdens the available data rate.

5) Commercial Mobile Satellite Service (MSS)

Model: Assumptions include a single handset per ship, 2.4 kbps unit throughput, TDMA transponder access with ten active users; cross-link time is 2 msec; satellite altitudes are 787 km.

System Description: Sixty six cross-link capable low earth orbit (LEO) satellites in six planes provide global coverage. The system can support up to 3840 simultaneous users per satellite. Multiple access is provided via TDMA. The system utilizes a QPSK modulation scheme. Current capability does not provide dual mode (cellular and satellite) use but will. [Hampton] Handsets cost approximately $3000 each and typical service costs are advertised to be $3.00 per minute. Additional crypto sleeves add approximately $2,000. Thus, in addition to the PSTN, connectivity is provided with DRSN and DSN. In January 1998 the U.S. military purchased a gateway ($14.5 million), which is co-located in the same building as the GBS SBM in Wahiawa, Hawaii. [Yee] This fixed DoD gateway will provide additional security for military users. The gateway will support up to 120,000 users. The latency of 5 milliseconds is low compared to the geosynchronous satellites.

6) Ultra High Frequency DAMA

Model: Assumptions include use of UFO-8, 25 khz UHF-DAMA protocol, four users per system channel; all units UHF capable.

System Description: UHF systems support thousands of users ashore and afloat. The UHF follow-on satellite system (UFO) is replacing the Fleet Satellite Communications (FLTSATCOM) and the Leased Satellites (LEASAT), which provide links between naval aircraft, ships, submarines and ground stations. The UFO satellites offer increased communications channel capacity over the same frequency spectrum as the current systems. Each spacecraft has 11 UHF amplifiers and 39 UHF channels with a total 555 kHz bandwidth. These frequencies consist of 21 narrowband channels at 5 kHz each and 17 relay channels at 25 kHz. In comparison, FLTSATCOM offers 22 channels.

The F1 through F7 spacecraft include an SHF subsystem, which provides redundant command and ranging capabilities when the satellite is on station as well as the secure uplink for Fleet Broadcast service, which is downlinked at UHF. [Shumadine]

The UFO satellites will improve UHF protection against electronic threats as well as host the interim GBS capability onboard F8 through F10 as previously discussed. Satellites F4 through F10 also have a MILSTAR-compatible EHF package with enhanced anti-jam communication capabilities. This addition includes 11 EHF channels distributed between an earth coverage beam and a steerable 5-degree spot beam. Beginning with satellite F7, the EHF package has been enhanced to provide 20 channels through the use of advanced digital integrated circuit technology. For network control purposes, Demand Assigned Multiple Access (DAMA) controllers will maximize use of 5- and 25-kHz channels to meet user needs.

Coverage: UHF SATCOM theoretically provides excellent near worldwide coverage from 65° N to 65° S. The coverage does not appear to fully extend across the United States and excludes a portion of the eastern Pacific Ocean from about 80° W to 105° W. [Shumadine]

Capacity: The typical maximum number of simultaneous TCP/IP users that the ADNS UHF DAMA channel access protocol (CAP) can support is four. [Arthur] The 25 kHz UHF DAMA system was originally designed to support point-to-point, conference, and network calls. Its associated data rates are 75 bps – 16 kbps. The 5 kHz UHF DAMA system was originally designed to provide short data messages, low speed data circuits, and limited secure voice capability. Its associated data rates are 75 bps – 4.8 kbps. In order to utilize (TCP/IP), the UHF DAMA system has to be analyzed within the framework of an interface to the protocol. An interface that can be used is the Automated Digital Network System (ADNS). In this context, the typical mode of operation for ADNS and UHF DAMA for the Navy is the assignment of a 2.4 kbps slot on a 25-kHz DAMA channel.

Protection: Security for the UHF SATCOM system is largely dependent upon the user's terminal. All terminals employ security measures. Of the three main terminals, AN/WSC-3, LST-5D, and AN/ARC-187, only the LST-5D has embedded security. The other two terminals utilize external security features. The AN/WSC-3 is the standard shipboard terminal. The level of security for the reach back channel over UHF DAMA would be comparable to the UHF MILSATCOM Fleet Broadcast.

Access: UHF demand assigned multiple access (DAMA) satellite communications is the most widely available long haul system to members of the armed services. Often, it may be the only communications capability. As such, it is a prime candidate to provide a reach back path for GBS. When UHF DAMA is the primary means of long haul communications, manual retransmit request will be utilized. [Arthur]

There are currently two different UHF DAMA SATCOM waveforms, one for operation over 5-kilohertz (kHz) channels, and one for operation over 25-kHz channels. The Navy has focused on the development of the 25-kHz DAMA controllers and terminals for both ships and aircraft, while the Air Force has concentrated on the 5-

kHz DAMA controllers and terminals.

The two modes of operation for channel assignment is distributed control (DC) and automatic control (AC). The DC mode involves centralized assignment of time slots within the channel. The control site determines how the DAMA slots are allocated and distributes the assignments. In the DC mode, there is no dynamic reallocation of bandwidth. In the AC mode, a time slot is requested from a central controller, assigned to a terminal, and released back to the controller once the terminal has completed using it. An additional capability when operating in the AC mode is called demand assigned single access (DASA). The DASA mode allows a single user access to an entire channel without having to share the bandwidth. The request for a DASA channel is made via the user's UHF DAMA channel. In the DASA mode of operation, once the channel has been assigned to a user, it is operated in the dedicated UHF SATCOM mode. The user retains access of the DASA channel until the channel is voluntarily released and the user logs back onto his home channel or the timer expires. DASA channels cannot be preempted. [Arthur]

Latency: When using UHF DAMA as a GBS reach back channel there is a substantial time delay associated with the DAMA protocol itself. In fact, UHF DAMA may represent a worst case scenario for timing delays. For the 25 kHz version, the minimum time to request and access a time slot is three frames. Each frame delay is approximately 1.4 seconds. A typical time would then be 3 frames plus two satellite hop delays, approximately 4.6 seconds total. For the 5 kHz version, the entire frame is 8.96

seconds in duration, but the lengths of the time slots assigned for circuit use within the frame vary with the type of data, modulation, and code rate. The minimum time to set up a channel is also 3 frame cycles or almost 27 seconds and could be longer if more, higher priority users are competing for the channel. Once the circuit is established the worst case delay would be at most two frames which makes full duplex data communications difficult, and voice communications even more difficult. Due to the difference in delays, the 25 kHz channel is the preferred method for communications. Table 8 provides an indication of UHF DAMA total time to complete a reach back session (time from first synchronization [SYNC] sent from the RDM until the final ACK is received to close out the TCP session). Likewise, it should be noted that a significant amount of this time was attributed to ACK times. For example, average times for first ACK for four users no load, 25% load and 50% load are 17.24, 26.77 and 41.32 seconds, respectively. [Arthur]

	Direct Con.	2 User	4 User No Load	4 User 25% Load	4 User 50% Load
Attempts/Successful	10/10	10/10	10/10	10/13	0/14
Percent Successful	100%	100%	100%	76.9%	0%
Mean Time	1.356	78.76	79.31	112.01	NA
Standard Deviation	0.079	2.95	3.21	5.58	NA

Table 8. Total Time to Complete UHF DAMA Reach Back [Arthur]

A 5-kHz DASA circuit may be set up using a 25-kHz channel or a 5-kHz channel to request the circuit. The use of a 25-kHz channel greatly decreases the setup time. In the DASA mode of operation once the channel has been assigned there are no framing delays, only the satellite delay. However, the inflexibility of the DASA channels for preemption does not make it a good candidate for reach back.

Interoperability: UHF DAMA cannot support a direct connection between two computers without a third party system to govern data access to the channel or time slot. The system that can perform this task for UHF DAMA is the ADNS UHF DAMA CAP (Channel Access Protocol). The normal configuration for a UHF DAMA SATCOM data connection is from the ship to a regional Naval Computer and Telecommunications Master Station (NCTAMS) where the information can be sent forward via a terrestrial SIPRNET connection.

The main ingredient for TCP/IP over DAMA for ADNS is the CAP Router Interface Unit (CRIU). Since the channel has a relatively high latency, it is likely that the originating computer will have generated duplicate packets in establishing the TCP session due to the retransmission timer. The ADNS CRIU removes these duplicate packets rather than sending them over an already bandwidth limited link. The CRIU is responsible for policing the link and developing its own pseudo-retransmission timer based on channel latency to determine when a packet may have been lost. The ADNS channel access method is less efficient at lower loads, but more efficient as the net becomes congested.

7) Extra High Frequency

Model: Assumptions include use of UFO-8 (i.e., MILSTAR and the Interim Polar EHF System are not considered), TDMA access among EHF capable units, 2.4 kbps nominal data rate for users, satellite processing adds 20 milliseconds of delay, all units EHF capable except FFGs and AOE.

System Description: The extremely high frequency (EHF) secure communications links provides the Navy with anti-jam (AJ), low probability of intercept (LPI), and low probability of detection (LPD) capability for command and control of the fleet. The LPI/LPD features of EHF could allow transmissions during EMCON. In terms of MILSATCOM architecture, EHF comprises the protected segment. This is due largely to the wider bandwidths at EHF, narrow antenna beamwidth, spread spectrum techniques, and advanced signal processing at the satellite. Four available systems now provide EHF communications links to the military: the Fleet satellite EHF Package (FEP), the UHF follow-On / EHF Package (UFO/E), MILSTAR and the Interim Polar EHF System. The FEP consists of two operational satellites; FEP-7 over CONUS at 100 W (December 1986), and FEP-8 over the Atlantic ocean at 23 W (September, 1989). [Hedges] These two operational satellites are the primary UHF fleet satellites with installed EHF payloads. [Hedges]

Coverage: The FEP does not provide worldwide coverage since only two geosynchronous satellites exist in the western longitudes (060 E to 180 E not covered). However, the UFO/E and the UFO/EE together provide excellent worldwide coverage that extends from 70° N to 70° S. The UFO/E system currently has three operational satellites (UFO/E-4 through UFO/E-6). An Enhanced UFO/E Package (UFO/EE), part of the UFO/E satellite system, has two satellites flying (UFO/EE-7, 8) with plans to have UFO/EE-9 operational in November of 1998 and UFO/EE-10 operational in April of 1999. [Hedges]

Capacity: These two operational satellites can accommodate 26 low data rate (LDR) channels that can be mapped to either beam. Uplink (U/L) and downlink (D/L) frequencies are 44 and 20 GHz respectively. The primary data rates per channel are 75, 1200 and 2400 bps. The secondary data rates per channel are 75, 150 and 300 bps. The difference in throughput represents the tradeoff with secure communications, i.e., as the level of encryption and forward error correction (FEC) encoding rises, for the same bandwidth, the information throughput is reduced. TDMA is used to support multiple users from the terminals. Four terminal channels can be multiplexed to achieve a 9.6 kbps throughput. The downlink frequency is SHF only and no crosslinks are available for this system. Antenna beams used are earth coverage (EC) and spot beams (no agile beams). FEP links to submarines are only supported during research, development, testing and evaluation (RDT&E). This is due to a complete payload reconfiguration required to use this capability, which would deny support to other EHF users until returned to original configuration. This system does not support UHF broadcasts. [Hedges]

The enhanced version of EHF includes balanced U/L and D/L hops and 20 channels, while the original system only provides hops on 11 U/L channels. Antenna beams used are earth coverage (EC) and spot beams (no agile beams). The primary and secondary data rates are identical to the FEP. Also, TDMA is used to support multiple users. However, the UFO/E and UFO/EE are EHF-UHF crossbanded at 75, 1200, 2400, 4800, and 9600 bps. [Hedges]

Access: Four channels per terminal are available to the user with throughput available up to 2400 bps per channel. The network control terminal defines the network ID, priority, data rate, beams, D/L modes, etc., which then sends an activation request to the payload. An onboard resource controller checks for available channels. If the resources are available, the payload assigns them and sends the ground station an 'ack.' If resources are unavailable the payload checks channel use priority and preempts lower priority channels to make resources available. If resources cannot be made available, the payload sends back an 'ack' that denies network activation. [Hedges]

Latency: EHF communications links have additional delays for two reasons. First, the satellites are not bent pipes. The payload performs advanced signal processing before transmitting the signal back to earth. This signal processing includes demodulating, de-interleaving and decoding at the receive-end, and encoding, interleaving and modulating at the transmit-end. Second, there is also FEC encoding, which provides reduced bit error rates but at the expense of information throughput. FEC encoding also increases the probability that the message sent is received. [Hedges]

b. Implementing ADNS for Radio-WAN Management

ADNS can be thought of as a "black box" for RF management that dynamically chooses the best "cost" path for a packet to be routed. ADNS can manage RF channels by integrating all available transmissions systems for a unit (i.e., ship) into one system. [Rehard] The integration is accomplished with the use of a system CAP (Channel Access Protocol). The model incorporates an ADNS "black box" aboard all ships and at the NCTAMS (Naval Computer and Telecommunications Command). The number of CAPs that a ship has depends on the ship's communications capabilities (or number of available reach back channels).

Just like ADNS, the model has the capability to prioritize packets by source users (via IP addresses) and application (e.g., FTP and Email) if more than one packet is waiting to be routed. The source prioritizing is done within the ADNS' CRIU (Channel Access Protocol, CAP, to Router Interface Unit). If two or more packets are waiting in the CRIU queue, the packet with the lowest number priority is sent first. See Table 3 for the default assignment of these priorities. After the CRIU, the packets are sent to an ADNS CAP (e.g., SHF). The CAP queue prioritizes packets based on an application's port number. Thus, the CAP allows an FTP packet to have precedence over an Email packet since the FTP packet has a lower port priority number. See Table 5 for the default assignment of port priorities. Other model priority schemes are incorporated based on packet attributes such as node identification, classification and product request. Classification and product request default values are listed in Tables 4 and 6, respectively. These additional priorities are implemented at the CAP queue, but are lower in precedence than the port priority.

When the CRIU receives IP packets from the ADNS IP router, the CRIU forwards the packet to the best "cost" path based on a congestion control algorithm. This algorithm determines the best path based on the initial RF system bandwidth, the current system use, the unit's bandwidth allocation and the unit's current use of that system.

Any RF system that has an ADNS CAP can be selected as the path for transmission. In the model, the queue lengths provide an indication of channel use for both the unit channel and the overall system channel. The cost is dynamically computed for each RF channel and compared to all other channels. The channel with the lowest calculated "cost" is chosen as the transmission path. ADNS also includes the ability to conduct load balancing across similarly sized radio links. For example, if the "congestion cost" for SHF and CA are equal, then

ADNS will send every other packet to each channel. The Extend model incorporates this feature, but can load balance only when system capacities are set to be equal. Otherwise the congestion cost algorithm will never compute equal costs.

As discussed, many functions of ADNS, including port and IP address prioritization, open shortest path first (OSPF) type routing, and load balancing are incorporated into the model. Figure 15 shows a typical ADNS model block. A packet can be transmitted on any of the seven reach back channels. To route the packet, ADNS takes into account the available system bandwidth (and it's current use or queue size) and the unit's bandwidth (and it's current use). Every possible path is compared before sending the packet to a back channel. Likewise, if any channels have equal costs, the subsequent packets will be "load shared" equally between the channels. Figure 16 shows the actual ADNS (Build 2) structure (see Rehard for more a more in depth discussion on ADNS).

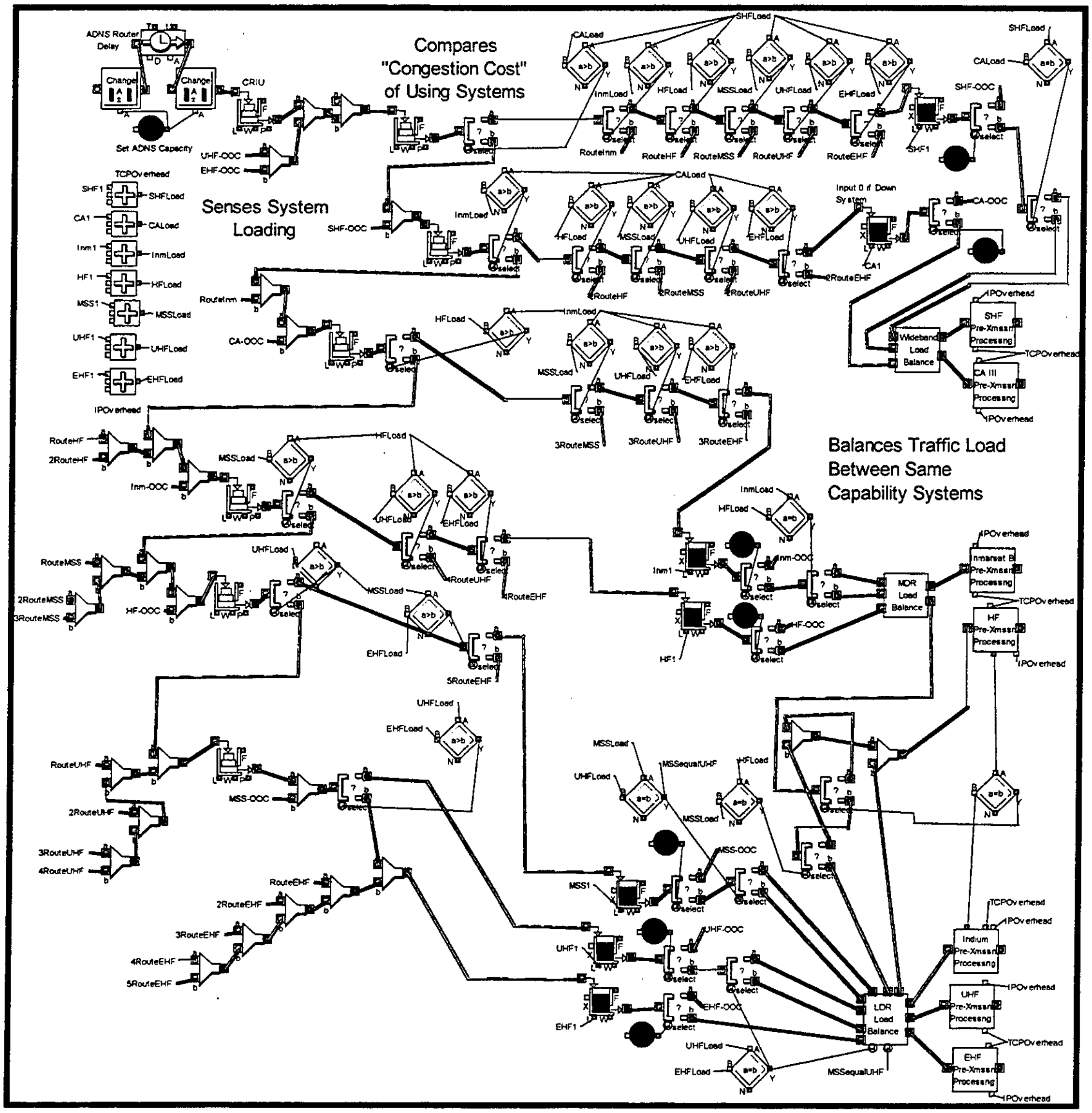


Figure 15. ADNS Block for CVN

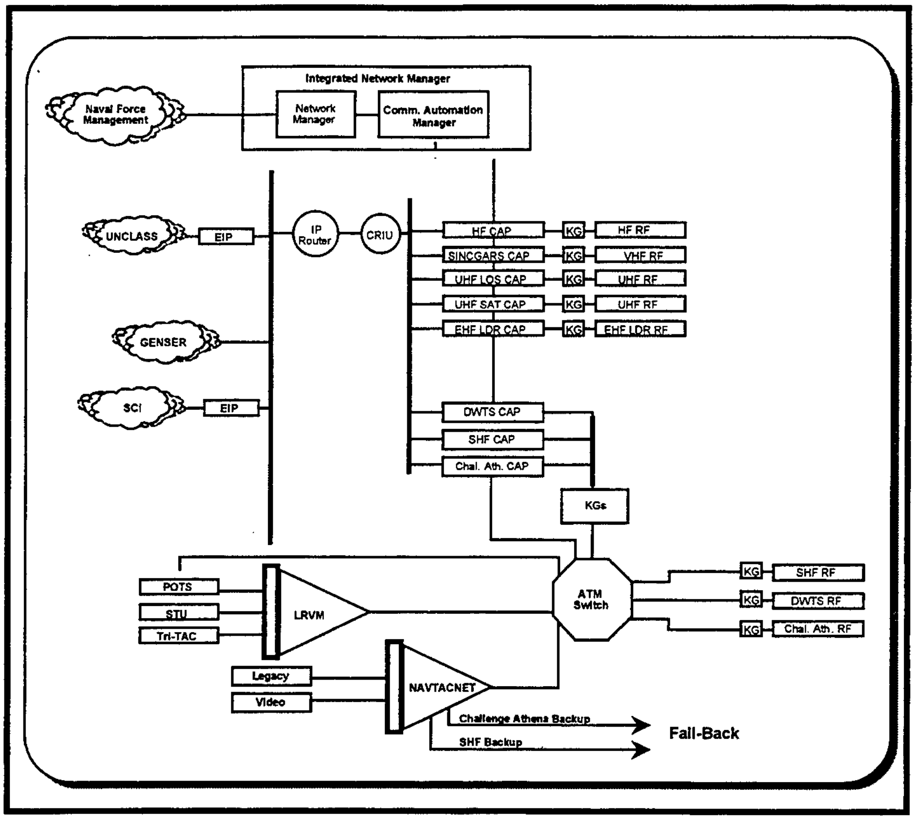


Figure 16. ADNS Build 2 [JMCOMS]

c. Identifying the Role of the Information Managers and Commanders

The CINC or JTF commander is responsible for providing a composite priorities list for the theater to resolve priority conflicts in their AOR. This guidance, along with GBS user profile inputs, is used to build the SBM profiles and the broadcast schedule. The TIM serves to execute the responsibilities of the CINC. Thus, the TIM verifies and validates user requests before the request is routed to the information producer.

The model has a slightly different implementation. It is built to allow requests to go directly to information producers. If implemented in the real world, this functionality assumes that the TIM has coordinated with all information producers beforehand, to give them guidance on who is and isn't allowed to access information. This process keeps the responsibility on the information producer to produce quality intelligence and provide the storage and meta-data necessary for extremely user-friendly operatoions. Likewise, placing most of the burden on the "expert" intelligence producers (who already have personnel and resources) reduces the management requirement on the GBS SBM/TIM and reduces GBS caching requirements.

Nevertheless, the model does implement the TIM by building an "TIM ADNS switch". The ADNS serves to push products to the GBS only when the GBS is the best cost path (which will almost always be the case if the GBS is operating and environmental conditions are not severely degrading the broadcast). It is the author's opinion that this TIM ADNS switch ideally should be placed at a NCTAMS-like facility. Of course, the facility should be joint and not "stovepiped" like the existing Service SATCOM entry sites. Clearly, the TIM functionality goes well beyond the GBS system and should strive to encompass and integrate all DoD RF communications systems.

d. Identifying the Information Producers and Products

For simplicity, the model uses one entry point/site to enter the DISN for all reach back channels except Challenge Athena. CA uses the Naval Computer and Telecommunications Station (NCTS) San Diego to access the DISN. Eight types of products that varied in size were able to be requested (see Table 6). However, actual requests only came from two of the six nodes shown in Figure 12. One of the nodes represented users that request products (via HTTP and FTP) such as imagery, maps, briefs and documents. The second node represented users requesting tactical (e.g., order wire) data that would be similar to tactical intelligence provided by the Integrated Broadcast Service (IBS). The other four nodes simply are placed in the model to provide "background" traffic. Hence, Email generators receive the same packets that it sends; likewise for the message traffic node, FTP node and HTTP node.

In reality, it should be noted that multiple producers can simultaneously input into the broadcast and expand on the input of other providers. Some examples of providers include the users themselves (possible via a TIP) or anyone with access to the NIPRNET, SIPRNET or JWICS. [IBS] Again for simplicity, the model did not incorporate TIP injection and provided only single unicast PIP injection.

Information products should be tagged with unique reference numbers to allow producers and users to correlate the products. Thus, the user can readily identify what information is directly from the producers/sensors, what information is correlated/deconflicted and the source of the correlation/deconfliction. [IBS] An example 24 Mbps configuration for one transponder is shown below in Table 9.

Information Product	Channel	Bandwidth (Mbps)
Program Guide and Catalog	1	1
CNN	2	3
AFRTS	3	3
Unclassified Data	4	6
Classified Data	5	9
Unused Bandwidth	--	2

Table 9. Example Single Transponder Broadcast Allocation [PACOM]

Data examples include imagery, weather, maps, ATO (Air Tasking Order), and the MDU (Mission Data Update). Video examples include UAV video and virtual video-teleconferencing. Appendix J provides a thorough list of possible GBS products.

e. Implementing the GBS SBM

The GBS SBM serves to carry out the policies from the TIM/CINC in order to provide the best service to users. See Chapter III CONOPS for more detailed explanations of SBM responsibilities. In building the program guide and scheduling the broadcast, the SBM relies on having updated profiles. It is very critical that users keep the SBM/TIM appraised of their latest information needs. This is especially important when dealing with smart push products. The model connected the SBM to the DISN via the SIPRNET and D-ATM (DISN-ATM). The model total connectivity for Wahiawa is 40 Mbps for classified data and 14 Mbps for unclassified data. Table 10 shows actual predicted data rates for the three GBS SBMs.

	Wahiawa	Norfolk	Italy
Secret	40	45	40
Unclass	14	25	14
Total	54	70	54

Table 10. SBM Port Data Rates (Mbps) for GBS-DISN Access [Combs]

In addition, Figure 17 shows the actual layout of the PACOM SBM in Hawaii. Building 261 provides actual connectivity to the DISN and Building 108 houses the SBM and MSS gateway equipment. From building 108, the broadcast signal is sent to the PIP for transmit. Due to the focus of this study (on reach back channels), limitations of the modeling program and time constraints, the SBM was not modeled in as much detail as the users (ships), the reach channels and the communication systems.

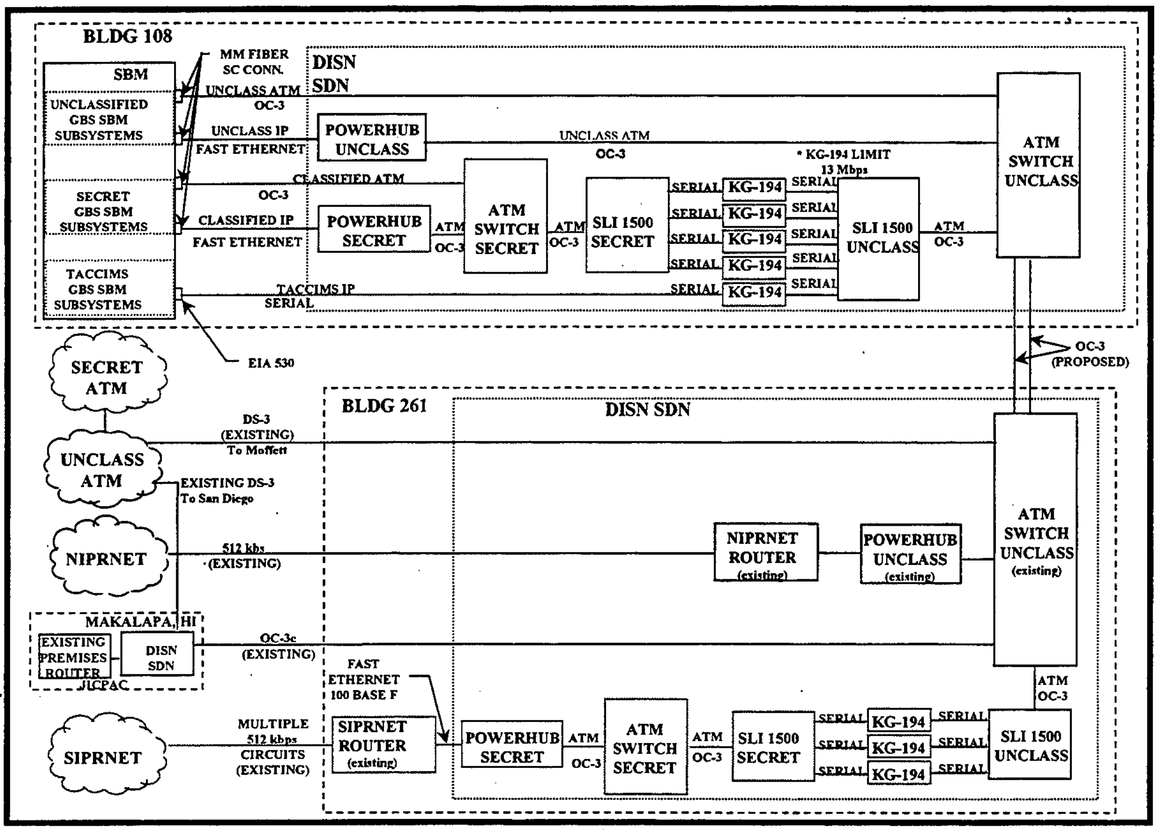


Figure 17. GBS Block Diagram – Wahiawa, HI
[Combs]

4. Simulation and Data Collection

After and during model development, an analysis plan must be decided upon. To correctly optimize a model, only one factor should be looked at. More than one can be analyzed if the factors are dependent on each other. The model in this thesis focuses on the timeliness of the messages. Placing time stamp attributes at various sections of the model allows the evaluation of timeliness for the architecture. A similar technique can be done for throughput analysis. As already mentioned, Extend's use of plotters, timers and "get attributes" blocks take up considerable memory (See Appendix F). One "original" data analysis block as seen in Figure 12 used twelve Mbytes of memory. If one considers that the thirteen ships and the four major category of information requests each have this data analysis node, the model becomes 208 Mbytes (not including the rest of the model). Figures 18 to 20 show the internal blocks of a data analysis block. It can be seen that there are unlimited data areas to analyze. However, analysis has to be done piecemeal (based on the program limitations) unless the model is completely rebuilt to streamline and reduce model size. It should be noted that these blocks had to be changed near the end of the project in order to save memory. The consequence is less thorough data collection and less attribute and group break downs for later detailed analysis.

Again, this project concentrated on the latency of the request-to-receipt cycle for the reach back channels modeled without an in depth look at each channel. As such, thorough model variation and simulation and subsequent sensitivity analysis was beyond the scope of this project. Nevertheless, a follow-on researcher can use the model to concentrate on one or more reach back channels to obtain more detailed performance results, e.g., other areas such as throughput and channel utilization can be looked at.

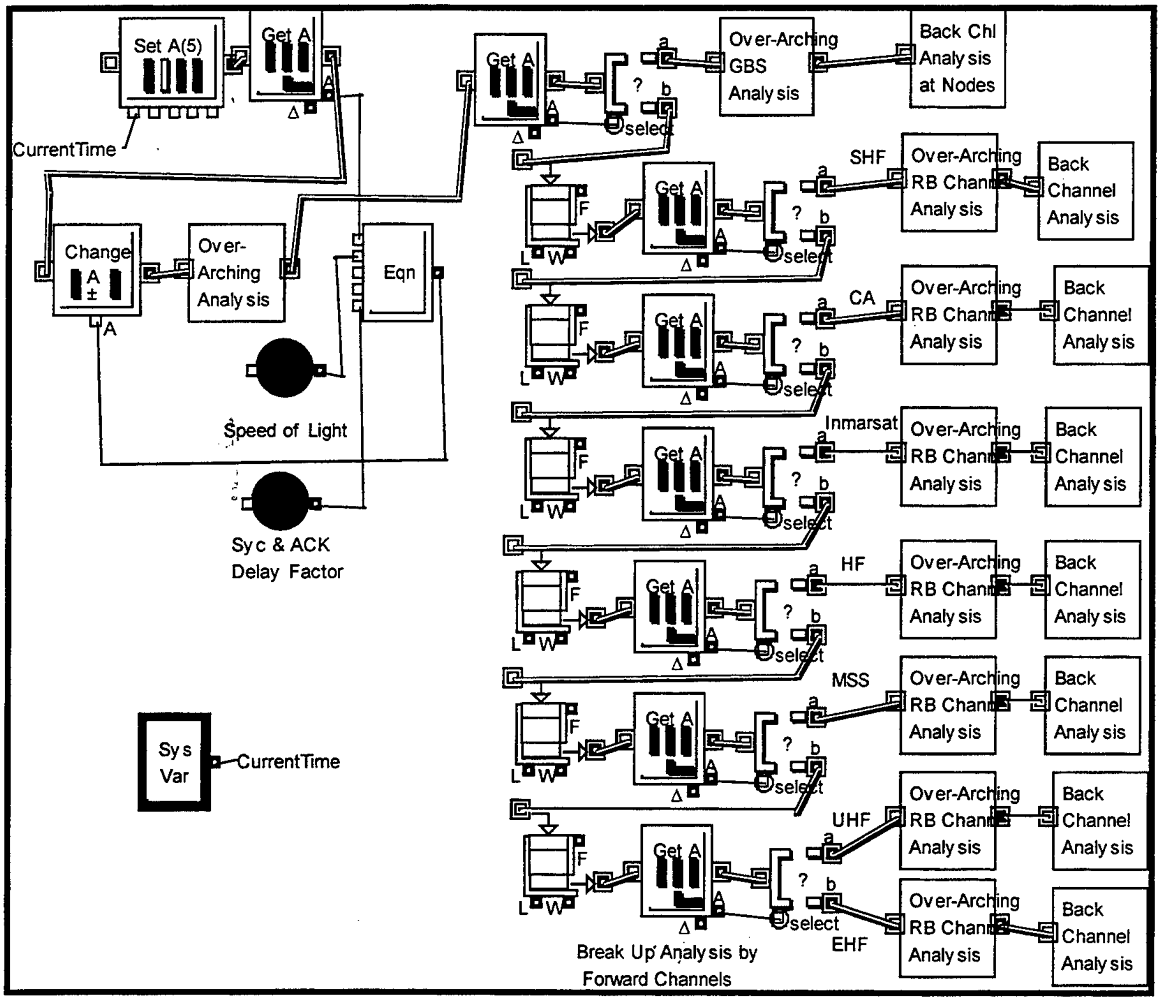


Figure 18. Forward Channel Analysis

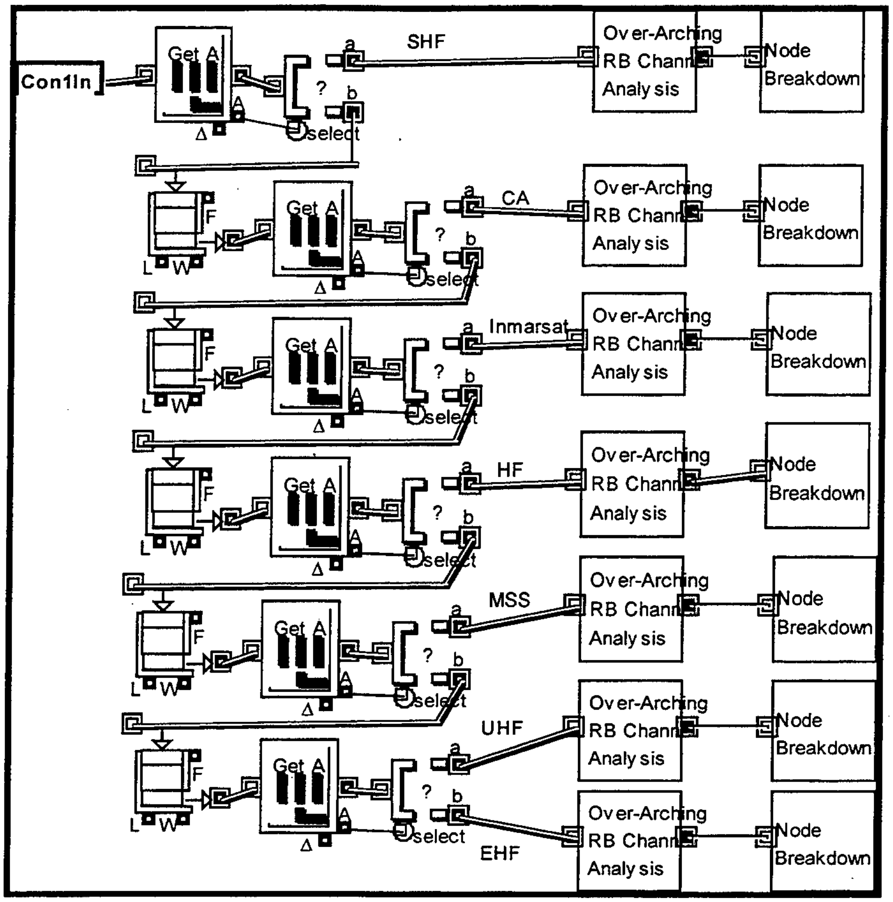


Figure 19. Reach Back Channel Analysis

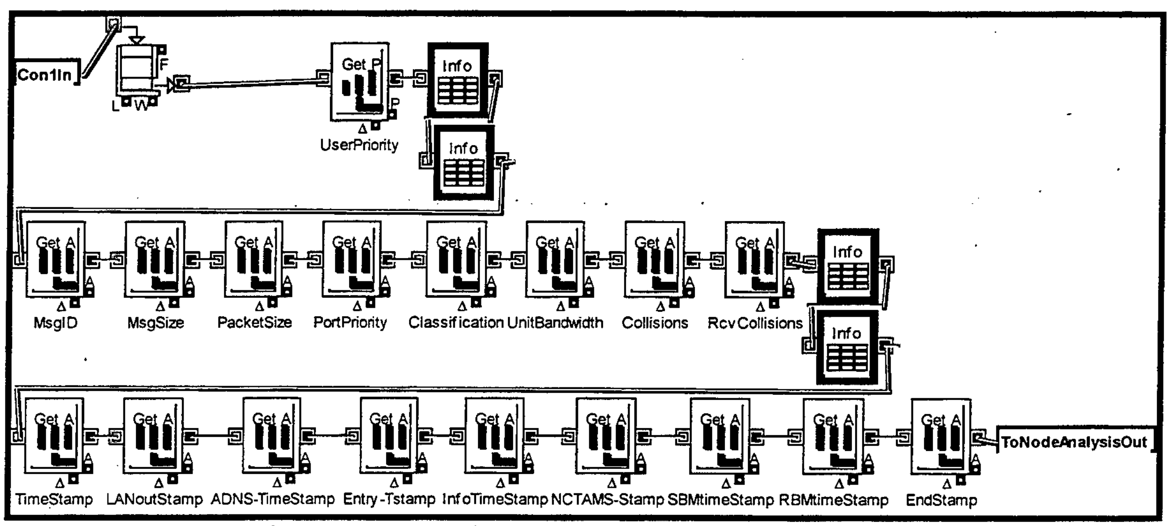


Figure 20. Sample Attribute Analysis Break Down

Some examples of sensitivity analysis include changing the inputs for message rates and changing MTUs for the seven reach back channels. Another recommended approach or tool to do sensitivity and optimization analyses with this model is the orthogonal array. Orthogonal arrays provide a means for conducting trade and system optimization studies. The primary steps in the methodology include:

- Brainstorming to define factors and states
- Determining the objective function and how to measure it
- Setting Up the Appropriate Orthogonal Matrix
- Running the Simulations
- Analyzing the results [Roy]

As seen in the data analysis figures, data can be collected on each of the thirteen ships, for each of its seven reach back channels, for each of its eight forward channels, and for each of the six nodes on the subnet. Figure 20 shows the useful attributes that can be plotted or tabulated in a table. In a detailed analysis, plotters would be strategically placed in the data analysis blocks to look specifically at certain aspects of the communications channel or architecture model.

This project collected the information for the various time stamps in Figure 20 to calculate request-to-receipt times. It should be noted that to account for SYN and ACK delays, the cumulative propagation distance was multiplied by a factor of 1.5 and then divided by the speed of propagation (light). The result is added to the model end-to-end times. The SYN and ACK delay was added twice (from user to information producer and from information producer back to the user). The cumulative propagation distances were zeroed at the information producers. Thus, the actual compensation for SYN and ACK is three times the total propagation distance. Table 11 provides a summary of the data collected from one simulation (65 seconds). Appendix K has a thorough list of all attributes and time stamp values. The times in Table 11 are not actual time stamp values as indicated in Appendix K, but are relative values from time zero. Hence, the times for the last two columns give an indication of how long it took for and information producer to receive a request and how long it took for the entire request-to-receipt cycle. Due to time constraints and severe program limitations, some ships were not analyzed and even some that were analyzed yielded no data.

(seconds)	Start Time Stamp	Info Producer	End Time Stamp
CV72	0	6.7430	31.7495
CG 63	0	11.1477	40.6999
CG67	0	Not Measured	Not Measured
DDG65	0	2.0491	14.0334
DDG69	0	Not Measured	Not Measured
DD967	0	No Data	No Data
DD973	0	Not Measured	Not Measured
FFG48	0	Not Data	No Data
FFG51	0	Not Measured	Not Measured
AOE10	0	No Data	No Data
SSN713	0	7.5431	33.8458
SSN716	0	Not Measured	Not Measured
SSN759	0	Not Measured	Not Measured
Tactical Data	0	3.3601	24.2962
Imagery	0	7.0223	27.422
Word/PowrPt	0	.0578	.7819
Video/Audio	0	3.4930	23.5802

Table 11. Time Stamps (Relative Mean) for GBS RB Model

5. Data Analysis

As mentioned, the key parameter analyzed is timeliness. This parameter is only one (albeit a very important one) of many that should be taken into consideration when developing a subsequent GBS IDM process. Throughput, channel utilization and information relevance are some other key parameters. Information relevance is a parameter that is subjective in nature and would not be an easy parameter to model. Instead, information relevance should be analyzed through qualitative research of past operations and exercises and associated lessons learned. In addition, any real world data from initial GBS operations should be studied closely.

As discussed, timeliness can be studied easily with different techniques in Extend. This project chose to use time stamp attributes to consolidate analysis of the information flow to the very end of the model. However, the drawback to this approach is a significant increase in model size. Other Extend approaches include the insertion of plotters and timers at focused sections of the model. In addition, the sensitivity analysis feature in Extend allows a user to vary certain parameters automatically for multiple simulation runs. Tables 12 to 14 further summarize the table from the previous section and Appendix K and were intended to provide timeliness for the reach back channels modeled. Unfortunately, the program limitations at the end of the project significantly curtailed data collection.

(seconds)	Total Mean Time	Standard Deviation
Tactical Data	24.2962	N/A
Imagery/Mapping	27.422	15.0935
Word / PowerPoint	0.7819	0.1672
Video/Audio Files	23.5802	N/A

Table 12. Round Trip Times for GBS RB Products

	Total Mean Time	Standard Deviation
CV72	31.7495	10.7288
CG 63	40.6999	20.2200
CG67	Not Measured	N/A
DDG65	14.0334	13.9618
DDG69	Not Measured	N/A
DD967	No Data	N/A
DD973	Not Measured	N/A
FFG48	No Data	N/A
FFG51	Not Measured	N/A
AOE10	No Data	N/A
SSN713	33.8458	N/A
SSN716, SSN 759	Not Measured	N/A

Table 13. Ship Round Trip Times for GBS RB Model

	Total Mean Time	Std. Deviation
SHF Tactical Data	24.2962	N/A
SHF Imagery	27.422	15.0935
SHF Word / PowerPoint Files	-	-
SHF Video/Audio Files	23.5802	N/A
CA Tactical Data	-	-
CA Imagery	-	-
CA Word / PowerPoint Files	-	-
CA Video/Audio Files	-	-
Inmarsat Tactical Data	-	-
Inmarsat Imagery	-	-
Inmarsat Word / PowerPoint Files	-	-
Inmarsat Video/Audio Files	-	-
HF Tactical Data	-	-
HF Imagery	-	-
HF Word / PowerPoint Files	.7819	.1672
HF Video/Audio Files	-	-
MSS Tactical Data	-	-
MSS Imagery	-	-
MSS Word / PowerPoint Files	-	-
MSS Video/Audio Files	-	-
UHF Tactical Data	-	-
UHF Imagery	-	-
UHF Word / PowerPoint Files	-	-
UHF Video/Audio Files	-	-
EHF Tactical Data	-	-
EHF Imagery	-	-
EHF Word / PowerPoint Files	-	-
EHF Video/Audio Files	-	-

Table 14. Round Trip Times for All Back Channels for GBS Delivered Products

V. CONCLUSIONS

A. SUMMARY

The ideal GBS IDM architecture should work like the IBS vision: GBS should be "an integrated, interactive dissemination system which provides producers and information sources the means to disseminate strategic, operational and tactical intelligence and information to the warfighter via multiple transmission paths with dynamic, user generated dissemination priorities." [IBS] Thus it "incorporates dynamic user defined prioritization to make the greatest use of available communications bandwidth and obtain the best operational utility." [IBS]

This vision was kept in mind throughout the model design process. As such, the model strives to make information dissemination via GBS as transparent as possible to the user. Implementing reach back ensures the user uses information in the same manner as the growing number of Internet users. Furthermore, incorporating ADNS at both the unit level and at the communications hub (NCTAMS) makes the model architecture extremely flexible and robust. Likewise, incorporating a GBS CAP at the communications hub provides another alternative and automatic means of pushing information to users. This seamless integration of GBS (using reach back and ADNS) is significant to the CINC TIM and SBM's information management problem. Therefore, a one-way system virtually works as a two-way system and the GBS bandwidth is maximized along with all other available communications channels.

With these implementations, the GBS architecture can get away from the smart push and user pull paradigm. Instead, all broadcasts can emulate a "smart pull" concept. In smart pull, the information can be considered either "pushed" or "pulled". If pushed, the user interactively selects from a menu of pre-identified GBS broadcast products (at the TIM or SBM home page). The action of selecting a product sends a back channel request to the information source. The information provider provides the product (assuming that the TIM has told the provider who can and cannot receive their information) to the GBS SBM via the TIM ADNS (located at NCTAMS). If there is any unusual delay or unapproved requests, the GBS SBM provides the user feedback via the TIM ADNS and non-GBS communications channels. Otherwise, the information is placed on the GBS broadcast queue. If pulled, the only difference is that the user interactively selects from the actual information producer's home page vice the TIM/SBM home page. Again, a significant advantage of this latter method is the decreased management requirements for the TIM.

Hence, the "smart pull" concept combines the two types of information dissemination into one mechanism in which the information is always interactively requested by the end user via some back channel method. Hopefully the method is automated, even for users that are not fully connected. These disadvantaged users could use a relay approach similar to the HF relay in the model. The smart pull simplifies the need to balance smart push and user pull because the user is "interactively" requesting products, regardless of whether the product is a push or pull item.

In support of the smart pull concept, this thesis has demonstrated the feasibility of the reach back mechanisms in an environment of multiple users with different and multiple reach back channels. The following sections summarize the advantages and disadvantages of GBS reach back and highlight the usefulness and performance of each of the reach back channels modeled.

1. General Advantages of Reach Back for User Pull Products

Using GBS for delivery of information that previously was disseminated over the limited-throughput tactical links reduces the overall burden on the tactical channels even though additional traffic is generated by reach back requests. Often times these tactical links are the only means of feedback communication for users. An example of a limited tactical link is UHF SATCOM, a communication channel that many lower echelon users must rely on for long-haul communications. Thus with RB, the lower echelon users have increased access to more types of information (when policy allows) because they are no longer using the limited tactical channel as the delivery path, but rather the GBS.

As mentioned previously, reach back makes GBS an end-to-end system and allows users to participate interactively in broadcast scheduling. The ability to make GBS work end-to-end is critical to end-users because the users cannot provide real-time feedback on information requirements without RB (this is especially true for the disadvantaged users). In general a disadvantaged user is one who is limited in the ability to use large antennas and is often highly mobile. If users have reach back, they can inform information producers and broadcast managers that they need old information to be rebroadcast or that they need new information not originally broadcast. As a result, GBS reach back allows users to tailor the broadcast information to meet dynamic mission requirements.

Additionally, with reach back an end user is more likely to get relevant information because the user is interactively requesting the information. This decreases the risk of information overload. For example, how often do people miss a good television show because they were too busy doing day-to-day activities? For the warrior, the term is "too busy putting out fires." It is not a situation where people did not want to watch the TV show or the warrior did not need the information, but it's a case of forgetting or not knowing the information is available. Reach back inherently ensures a higher probability of information relevancy to the end user because the action of requesting information serves as a near real-time reminder to look for that information.

Direct reach back to information producers also assists in reducing the SBM caching requirements. Information is sent to the SBM only if the GBS pipe is available and the information producers are responsible for the storage of products.

Furthermore, reach back can be monitored and audited to help identify user information tendencies. Thus, the RB audit assists in scheduling future smart push products which further reduces the burden of information management on the TIMs and IMEs (Information Management Elements). As the broadcast schedule becomes populated with more smart push products, use of the GBS bandwidth becomes more efficient.

A similar consequence of providing more bandwidth for a variable IP data channel to deliver RB-user pull products is the reduction of TIM and SBM requirements for scheduling and managing the GBS broadcast. Using a GBS IP data channel for RB-WWW browsing on a military network (via the DISN) capitalizes on the interactive nature of requesting and getting information. It should be noted that the author disagrees with the notion that web browsing occurs when a user selects a "smart push" product (i.e., Email mailing lists, news broadcasts, consumer sale notifications, etc.). "True" web browsing occurs when the user gets real time responses to inputs into the keyboard (e.g., TCP/IP applications such as FTP [file transfer protocol] and TELNET). When mailing lists, news broadcasts or sale notifications are delivered to a user's Email program or web browser, the user may or may not look at it based on the user's schedule at that time. User pull IP data channels are desirable to the user because it fits better with the "nature" of information users. Moreover, the technology advancements of the web (e.g., IP switching) are revolutionizing (in months) how people share information. RB user pull IP channels provide the best position to leverage off the commercial technology advancements.

Lastly, even though reach back tends to decentralize GBS information flow, commanders still have resource control if "information dissemination by negation" is used. A decentralized, "IDM by negation concept" harnesses the full power of technology and lets the users have access to everything that their allocated bandwidth permits. Commanders can restrict user access based on the latest mission priorities and subsequent resource allocations. The centralized approach of giving users access (only when requested and approved) adds delay in verification and validation. This delay may prevent users from getting relevant and timely information.

2. General Disadvantages of Reach Back for User Pull Products

Reach back for user pull is an inefficient use of the GBS bandwidth if the CINC has a priori knowledge of the end users' information needs. In the ideal situation, exactly the right information is identified for smart push and all the users get exactly what they need and only what they need. However, in accordance with the GBS Joint CONOPS, "the user, more so than anyone else, knows their information requirements," thus it is unrealistic to assume the CINC has a priori knowledge of all user information requirements. Nevertheless, given that generally "user pull" is less efficient than "smart push," the goal should be to maximize the smart push portion of the GBS broadcast, constrained by the requirement to satisfy the user's changing needs. Thus, a user pull portion should always be available for end users to access a broad range of information based on their latest requirements.

Updated user profiles help the CINC have a priori knowledge. Hence, if the users are responsible in dynamically updating their profiles, the TIMs aggressive in their collection of profiles, and the SBMs efficient in building and disseminating the profiles, the need for user pull via reach back is minimized (possibly to extinction). It is a significant assumption, however, to assume that user profiles and filters will dynamically be kept up to date.

Large volumes of reach back requests from many users cause broadcast queue delays at the SBM due to scaling problems associated with TCP/IP. Just like the Internet, the GBS asymmetric network can accommodate a finite number of users before it experiences excessive congestion and delay. An in-depth analysis of this scalability problem is required to fully assess how the users' effective throughput changes with increases in the number of GBS users. The model in this thesis provides a first look at this problem.

During times of heavy use of tactical links, there is a danger of saturating the already oversubscribed military communications channels with too many reach back requests. As a result, these channels may not be able to cope with even small amounts of RB requests. A solution to this problem is already inherent in the request for information (RFI) procedures. Priorities and policy prevent RB from using bandwidth that is needed for critical communications. The model in this project incorporates the use of ADNS and priorities to ensure highest priority messages get transmitted first.

Lastly, reach back decentralizes control of communication and information resources away from commanders and broadcast managers. In accordance with the USACOM (United States Atlantic Command) GBS CONOPS (draft), the "USACOM staff and the in-theater commander are in the best positions to determine warfighter information needs" therefore the TIM is the central coordination point for the apportionment and use of GBS resources. This viewpoint definitely contradicts a decentralized reach back environment where users have access to information producers (without directly going through the TIM).

3. Reach Back Channel Findings

From the model, subjective and objective conclusions can be made based on the model default parameters and the actual back channel performances. The relative weighting of parameters is subjective, but the timeliness measures are objective (except when data is declared inconclusive). The following discussions provide overall conclusions for the reach back channels modeled.

SHF: Currently the SHF communications plans are extremely rigid, however they do have slack times that can be utilized via ADNS. Likewise, the SHF packages currently have little or no extra room for additional channels. In this sense, SHF is not an ideal reach back channel and other less utilized mediums would make better back channels. However, as implemented in the model, if an ADNS RF management system could integrate the entire SHF allocation, it's shared use will lead to overall improved information dissemination. The model showed that a large portion of the traffic was routed through SHF because of its large relative bandwidth and the way the model's ADNS calculated congestion cost. However, no improved timeliness for SHF routed data was noted.

Challenge Athena: Just as in SHF, allocation of bandwidth is also a limitation for using CA for reach back. Yet, just as it is prudent to set aside significant bandwidth for GBS variable IP channels, it is also prudent to do the same for SHF and CA. Subsequently, by incorporating a CA and SHF CAP into ADNS, the large bandwidth of these systems can be utilized. CA should have also captured a large percentage of the model message traffic, but did not. More analysis and troubleshooting is needed to determine the cause.

Inmarsat B (HSD): Overall, Inmarsat-B (HSD) is a good candidate for GBS reach back channel implementation. Although its data throughput does not approach that of some other high data rate satellite systems such as VSAT, it provides "modest" high data rates for many applications (including video) with worldwide seamless coverage. Additionally, its cost is relatively low; it is easy to employ, and it is extremely portable (weighing only a fraction of other high data rate satellite systems). Its main drawbacks is that it cannot provide real time video due to the 64 kbps channel restriction, but must rely on a store and forward implementation of video transmission. As a result, approximately 30 minutes of delay is expected from live video to remote broadcast. Additionally, its most efficient use relies on implementation of a terrestrial ISDN (or Switched-56) link. Without the terrestrial link, Inmarsat-B (HSD) is reduced to only mobile-to-mobile communications which significantly reduce throughput and application potential. The model surprisingly showed that Inmarsat-B is a very capable back channel. It was probably second to SHF in being the most used RB channel. Likewise, the total time for the request to receipt cycle was not significantly different from higher bandwidth systems such as SHF.

HF: Even though the Internet can provide a wealth of information to the warfighter at delivery speeds greater than ever before, the limiting factor is still access.

As such, the Chief of Naval Operations directed that all USN ships have full Internet and Email capability by the year 2000. Yet, where does all this capability come from? Existing SATCOM is already oversubscribed and future systems are surely to be insufficient compared to the exponentially increasing bandwidth requirements. Using GBS as the forward link and HF communications as the back channel for an "Internet architecture at sea" was worth researching in order to relieve the oversubscribed satellite systems.

A HF link can provide sufficient data rates for a GBS back reach channel. The link is greatly affected by fading, but performance greater then 10^{-5} can be maintained through the use of spectrally efficient and high performance modulation techniques. But modulation techniques alone will not provide enough performance to maintain a probability of bit errorless than 10^{-5}. There must also be some form of error correction coding. FECs provide additional coding gain that allows sufficient link margin to meet performance requirements.

The cost of additional coding gain is a reduction in available bandwidth or data rate. Using greater convolutional constraint lengths or concatenated codes will provide greater coding gain, but will also increase circuit complexity and lower bandwidth. Experimental tests have confirmed HF can deliver a data rate ranging form 2.4 to 75 kbps at a range of 500 to less the 50 nm respectively. As discussed earlier, three possible methods can be employed to increase these bit rates.

- Using multicarrier techniques.

- Develop an MC with the capability to test the channel, assign available HF radios, and dynamically allocate the HF bandwidth.
- Allow the MC to dynamically assign different FEC types and constraint lengths. Thus, there will be enough coding gain to maintain the desired link margin while minimizing the impact on the available data rate.

Therefore, with no alterations to the current shipboard systems, HF can provide a GBS reach back channel with medium data capability. With minimum alterations, the shipboard system data rates can be improved. HF is by not a total solution to the GBS reach back problem, but can help reduce the current demands on SHF links.

Likewise, the model effectively showed that HF provides minimum latency due to the relative short link distances. The use of HF relay was a great path for smaller, disadvantaged ships to transmit reach back requests. It was also observed that the use of HF relay was a significant factor in keeping the more disadvantaged ships from tying up their UHF and EHF channels. The carrier had no problem processing the other ship's HF relays. The HF channels actually were the third most used RB channel in the model. In many cases the HF RB was easily identified by it's quick delivery to the information producer.

MSS (Iridium): Iridium brings another exciting opportunity to leverage commercial satellite technology. As a reach back channel for GBS, the obvious advantage of the system is it's low latency cross-linked LEO satellites. However, system data rate (2.4 kbps) limits the ability to handle large-sized requests. The model showed that a small percentage of the reach back traffic passed through the system, however the datagrams that did get routed through Iridium had improved timeliness over other channels of same capacity.

UHF: UHF DAMA gets the high marks as a back channel due to its coverage and accessibility. However, it ranks average for throughput (up to 16 kbps for 25 kHz and 4.8 kbps for 5 kHz), capacity, and security. The biggest problem in using UHF DAMA for a back channel is its long latency (averaging 4.6 seconds for 25kHz and 27 seconds for 5 kHz UHF DAMA). This large delay problem is pointed out in [Arthur], but it also can be alleviated through the CRIU in ADNS. The model severely underutilized the UHF RB. Further analysis and troubleshooting is required to find the problem.

EHF: Using EHF as a reach back channel in the GBS architecture is favorable for many reasons. EHF has the obvious advantages in security. Also, because EHF is transmitted using LPI/LPD spread spectrum techniques, it becomes even more critical and advantageous to use during wartime. Additionally, because the payload processes the incoming signals, any anti-jam (AJ) is filtered out before transmitting back to earth, making EHF communications links very AJ resistance. The narrow beamwidth at these frequencies also makes jamming more difficult. This channel was not required because the other model channels were able to handle the default settings for message rates. Further analysis is required to assess the effectiveness of EHF LDR as a reach back channel. The model showed that EHF was a superb RB channel for its capacity. No significant delays were noticed for products that were requested by EHF.

B. RECOMMENDATIONS AND AREAS FOR FURTHER STUDY

The concept of "smart push" is understandably the most natural way to use the GBS. Yet, to rely on a majority of "smart push" dangerously gets into an increased risk of information overload. For this project, this overload situation can be represented by increased congestion and collisions in the subnet. This project did not inject (push) information to user subnets unless the users requested the information; however, one can imagine what happens when introducing a large amount of data into the user subnets. If this data was not "recently" asked for, but rather placed in an "acceptance profile" days, weeks or months before, information saturation can occur quickly. Even without smart push, the model's percentage of entering packets that experienced collisions was around 30%.

As such, unless there's a priori knowledge of needs and the user has a complete understanding of the products being disseminated, data never transforms into information. As discussed previously, implementing reach back and ADNS into the GBS architecture provides an opportunity to better manage the system if one uses the concept of "information dissemination by negation." In this concept, the TIM still maintains control and audits all GBS information; however, no direct intervention and additional personnel is needed to ensure the maximum use of scarce resources. By reallocating more GBS bandwidth to variable IP channels, the TIM has the ability to best satisfy users while minimizing the intensive challenges of theater information management.

1. Recommendations

The following list is a summary of recommendations based on this project:

- Improve and implement reach back (asymmetric networks) into the GBS architecture to improve user access to information. "The ability to win the Information War is dependent on the ability to provide critical information to combatant commands. There is an asymmetric flow of information in that deployed units normally require more information for mission performance than is required for return transmission." [IBS] Lessons learned indicated commanders have historically had access to information but not the end users. As such, the priority of users should always be kept in mind. GBS should not be another system to enhance upper echelon users; it should be used first to provide critical information to disadvantaged users.
- Continue to improve the information on military networks. Reach back addresses the connectivity to get information, but a problem that RB does not solve is information content on military. Although true for the Internet, the military networks (e.g., NIPRNET, SIPRNET, Intelink, and NSANET) have significant problems with poor search capabilities, unorganized data and old information. The producers of information must be accountable for keeping web pages up to date to make GBS reach back useful. Otherwise, the "smart push" approach is

the best method in organizing the information on military networks. As pointed out in this thesis, however, the responsibility to provide good information should not be placed on CINC planners and users, but the information producers.

- Incorporate "smart pull" concepts and "information dissemination by negation." Initially, the GBS pipe will be underutilized, as was the case for JBS. This period is the time to test out these concepts.
- Advertise GBS more and train users. One reason the GBS pipe will be underutilized is that commanders and users are not fully cognizant of GBS capabilities. Thus, advertising on the capabilities of the GBS must be given high priority, as well as user training. Of course, the GBS system (like most new technologies) is ahead of doctrine, therefore it is critical to ensure the lessons learned from operations, exercises (such as JWID) and research are shared with all GBS users.
- Implement ADNS as a part of the reach back. Dynamic allocation of RF channels is a natural way to maximize bandwidth. It is projected that ADNS can provide a four-fold increase in throughput during peak traffic times. [Rehard] Other advantages of ADNS include the removal of humans from the communication loop, the ability to load share between channels (ideal for naval vessels who often maintain at least two operational channels), and the ability of units with

uncommon communication channels to maintain communications. [Rehard]

- Incorporate the use of reach back relays. The relays are considerably important for less capable platforms to maintain connectivity with the rest of the fleet.
- Expand the role of HF as a back channel. Refer to pages 70 – 74 of this document.

2. Areas for Future Study

The biggest shortfall of this project was the underestimation of hardware and software limitations. This problem caused frequent rework due to abrupt error messages and program shut down. Program failure became noticeable when the model size was greater than 40 Mb, and it made programming impractical after 50 Mb. Beyond 70 Mb, the program would accept few changes, if any, before it abruptly shut down. As such, an "on the job" lesson was to rebuild the model to be less than 50 Mb. This limitation severely limited the analysis that could be performed and the granularity of the "right" side of the model. A compromise was made near the end of the project to scale down the internal composition of the thirteen ships by removing the data analysis blocks (5 Mb each). By luck the author was able to incorporate a data analysis block in each ship type, however, this caused the program to act very sluggishly. The net size of the model became 102 Mb. At this size, a 50-second simulation would take almost an hour.

Due to the problems associated with this project. Numerous areas of study can be looked at. Specifically, the program problem may not be in the software itself. Interesting research would observe how the model operates on a 128Mb RAM machine. Furthermore, an analysis on the impact of ADNS was not done due to time constraints. A simple method to study ADNS would be to equalize the "cost congestion" algorithm so that all channels have the same chance of carrying traffic. In the default model, the bigger channels get a majority of the traffic due to their bandwidth.

Some other areas for future study are highlighted as follows:

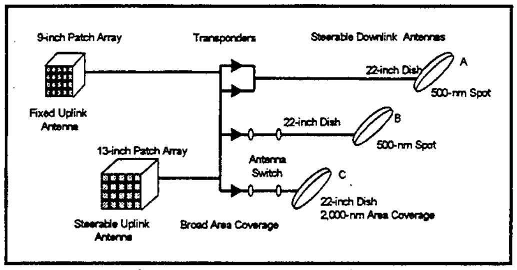
- Validate and improve the model based on the latest lessons learned and technology advancements. For example, the actual GBS flow goes from the entry sites to the SBM/TIM and then back to the SBM. This information flow was not developed to simplify the model but could be done as future research. Likewise, it was the author's intention to provide the smart push path flow into the model. Due to time constraints the development of users (ships) was built to accept push data, but no node was built to inject the data.
- Integrate real time or near real time voice and video (e.g., VTC) users into the ships. Previous NPS research incorporated VTC in an IT-21 model using both Extend and OPNET (see Rieffer).
- Continue detailed model analysis. The model in this project is very robust and many variations of numerous parameters were beyond the scope of this project. Focused studies based on specific reach back

channels, users, or other groupings of interest can be done as follow-on projects.

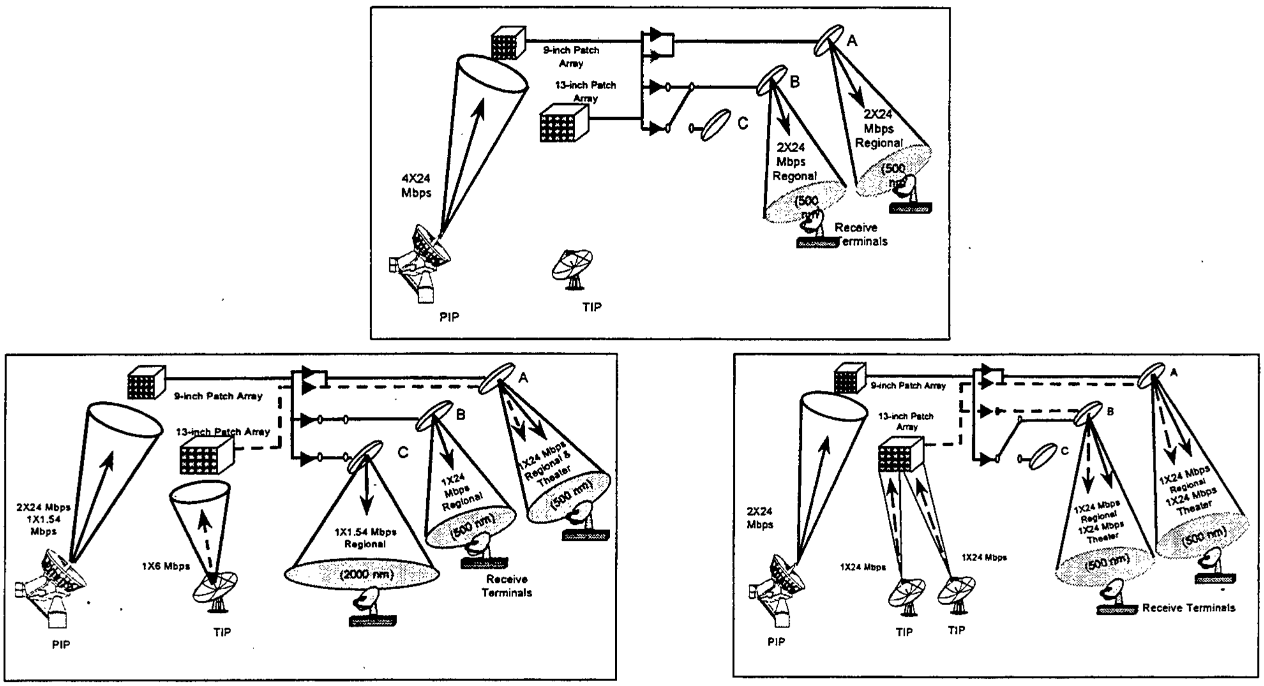
- Conduct studies on other measures of effectiveness/measures of performance (MOEs/MOPs), e.g., throughput and channel utilization.
- Conduct detailed comparisons on the GBS performance based on existing and developing protocols. One recommended study could look at the effects of path MTU on timeliness and effective throughput. See Appendix I for default MTU settings.
- Conduct a similar study involving other AORs and possibly include a MTW. In addition, the study could build a second model which involves an Amphibious Readiness Group (ARG) and a Marine Expeditionary Unit (MEU) conducting an military operation other-than-war (MOOTW) in the Pacific AOR. The scenario can replace the carrier with an amphibious assault ship (LHD), add one LPD, LSD and MEU ashore (with wireless LAN) and keep two DDGs. Recent NPS work uses Extend to model a wireless LAN in an Operational Maneuver From the Sea (OMFTS) network [Smith].
- Develop a GBS IDM process template to incorporate actual IBS architecture visions by applying the model in this project. This work would include how to determine the best mix of smart push and user pull by comparing the results of model variations. Specifically, the

variations involving different amounts of user pull (reach back) implementations (e.g., no user pull, 25% user pull, 75% user pull and 100% user pull). Likewise, a study on variable allocations of GBS IP channel could be done. For instance, this model used 15 Mbps as a default value; what happens if this value is more or less?

APPENDIX A. GBS PHASE II CONFIGURATIONS [ACOM]



Phase II GBS Payload



PIP-Only Configuration, PIP and TIP Configuration, PIP and Two TIP Configuration

APPENDIX B. REACH BACK CONNECTIVITY MODES [GBS]

1. User Pull empowers users to deal directly with information producers using existing procedures to request information. The mode used to make the request depends on the user's GBS receive suite connectivity capabilities and the user's access to existing information systems. Use of receive suite feedback from terminals which are either fully or partially connected to provide quality of service feedback to the SBM will improve broadcast efficiencies, even if only a few representative terminals can act as proxies for others in the area of broadcast beams.

a. **Receive Only (RO) Mode.** In this mode, the receive suite can only receive the GBS broadcast. There is no manual or automatic communications channel available. In this case, the user has no means to request products to initiate User Pull.

b. **Manually Connected (MC) Mode.** In this mode, the receive suite can receive the GBS broadcast and the end user has access to some type of manual communications system. A human-in-the-loop is required for submitting user pull requests or requesting the rebroadcast of data products. In other words, the user calls in a request using whatever existing communications capability is available.

c. **Partially Connected (PC) Mode.** In this mode, the receive suite can receive the GBS broadcast and provide a means to transmit using standard protocols and applications, user pull or rebroadcast requests. The rebroadcast requests are automatically generated; however, full virtual duplex connectivity is not achieved and user pull is not automatically generated. The users must still request their products from the source by whatever means are available to them. The likelihood that the users are connected to some existing network is high and they will make their user pull requests via the various applications programs they have access to (e.g., SIPRNET and INTELINK).

d. **Fully Connected (FC) Mode.** In this mode, the receive suite can receive the GBS broadcast and a "return" channel exists over which rebroadcast requests are transmitted on a packet-per-packet basis using split protocols. The requests are automatically generated by the RBM and a virtual full-duplex connectivity is achieved. However, user pull is not automatically generated. The users must still request their products from the source by whatever means are available to them. The likelihood that the users are connected to some existing network is high and they will make their user pull requests via the various applications programs they have access to (e.g., SIPRNET and INTELINK).

2. In the future, we hope a more automated user pull network might be accessible to all users over GCCS or some other standard application that will simplify the user pull process.

APPENDIX C. IDM SERVICES [IDM, Mowerey]

This appendix discusses the IDM services of information awareness, information access, information delivery, and information dissemination support services and presents an architectural framework for providing the services. The roles of information sources, commanders, and users are not distinct; e.g., commanders are also information users.

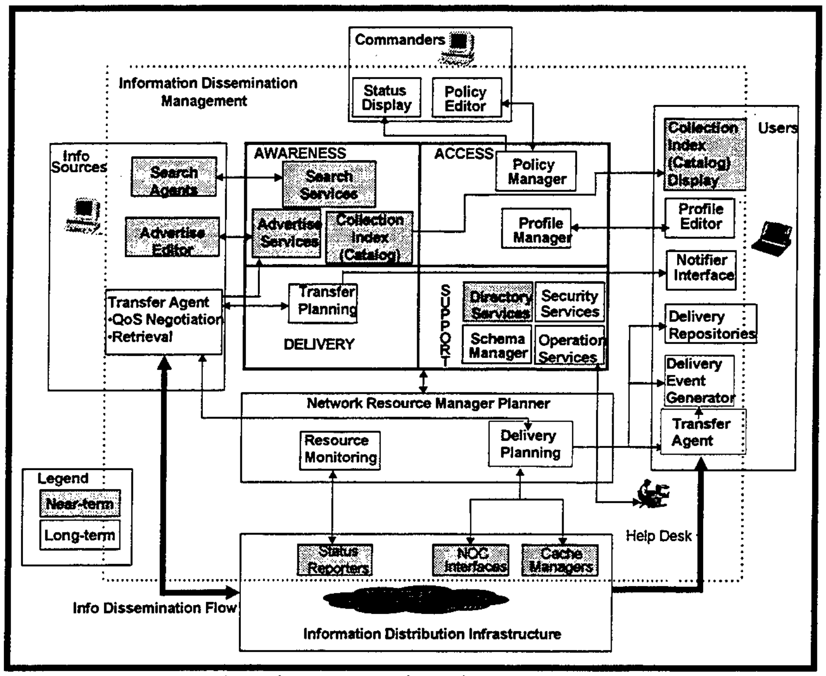
Information Awareness	**Information Access**
• *Indexing and Advertising* services for Information producers • *Catalog* services to make relevant information known • *Search* services to find operationally relevant information	• Automated repetitive information retrieval *(Smart User Pull)* • Aggregation of User *profiles* to improve information and communications resource usage
Information Delivery	**Info Dissemination Support**
• *Delivery planning* service to optimize use of infrastructure • *Commanders' Policy* service to implement policies on user profiles and infrastructure resource usage	• Common *directories* for sources, commanders, and users • Integration with DII *security* management • *Schema* interoperability across source, catalog, and user domains

Information awareness interacts with sources to populate a catalog of relevant information, and makes the catalog available to users in accordance with commanders' policies. The catalog is populated by either advertising entries or by search and discovery, as determined by the capabilities and procedures of the associated sources. The entries in the catalog are built upon a common schema structure that is understood across source and user domains. The catalog is published and delivered to users with visibility to entries in accordance with commanders' policies. The catalog is accessible by either a user display or by electronic access directly from user mission applications.

Information access interacts with commanders for expression of their policies on user access to information and the allocation of infrastructure resources, with sources who enable access, and with users to input their information requirement profiles. The status of the information distribution infrastructure (communications and storage) is available to assist commanders in dynamic priority adjustments during mission execution. User expression of information requirements (profiles) is either through an interactive user interface or by direct electronic interface from user mission applications. Overlaps among profiles are processed by aggregation of similar requirements to minimize dissemination of duplicate information. User profiles will also be provided to sources to assist in focusing their resources on specified user requirements and priorities.

Information delivery interacts with sources to support the retrieval of information in accordance with validated profiles, with the information distribution infrastructure to optimize information transfer in accordance with commanders' policies, and with users in the delivery of information. The retrieval process includes translation of queries and data formats (mediation) if required to accommodate inconsistencies between source and user systems. Delivery processes located at sources, at intermediate waypoints within the infrastructure, and at user sites collaborate to develop dynamic path selection plans. Monitoring of the status of resources within the infrastructure provides feedback to commanders in making priority adjustments, and is used to tune and optimize delivery plan execution based on changing operational conditions. The delivery path may differ depending on factors such as direction and amount of data (e.g., requests for imagery may go through a low-bandwidth channel, and the imagery itself may be broadcast via GBS). The infrastructure should support mechanisms to optimize the use of bandwidth (e.g., multicasting).

Information dissemination support provides the necessary interfaces to directory, security, operations, and schema management functions within the DII to support the other functions of IDM.



IDM Services Functional Decomposition

An architectural framework for the IDM services is shown above. Each of the shaded boxes represents a software module that provides one or more of the functions. These modules will be deployed to one or more locations within the DII. Some modules, particularly those that provide local IDM interfaces, must be collocated with the sources, commanders, users, and infrastructure components to provide acceptable performance. Other modules, particularly those in the center of the figure will provide IDM support within an AOR from a small number of regional, component, and/or task-force locations. The arrows represent interactions between the common modules and the local IDM interface modules; internal interactions between the common modules are not shown.

Many of the IDM functions discussed above are at least partially addressed by commercially available products and from the BADD ACTD, BC2A, and other programs.

APPENDIX D. CINC GBS CONOPS (DRAFTS) [PACOM, ACOM, EUCOM]

CINCs are responsible for their own GBS CONOPS in order to tailor the GBS system to their specific AOR requirements, CINC policies, apportionment, etc. The following sections are provided for reader reference and outline the USPACOM, USACOM and USEUCOM GBS CONOPS (Drafts) as they apply to this thesis. The reader is reminded that the outlines contain direct content from each draft CONOPS and is merely organized by the author for the reader's reference.

United States Pacific Command (USPACOM): It is the author's opinion that the USPACOM's view is to implement a more decentralized control of the GBS which allow users to use the bandwidth as it's available. The TIM will attempt to use existing RFI procedures to remedy any conflicts. The USPACOM's CONOPS focuses primarily on GBS Phase II (scheduled to last until FY 2009).

a. What must the PACOM GBS do?

- Connect into the existing and future communications architecture through established DISN gateways (when practicable). It should be noted that GBS is not a primary means for distributing critical command and control information.
- Provide the communications "pipe" to support the asymmetric flow of large volumes of video and data from national and theater information sources to fixed, in-transit, and deployed forces.
- Conform sensor-to-shooter information dissemination to "smart push" and "user pull" principles in order to prevent user saturation from information overload.

b. How does the PACOM GBS provide information?

- Uses an end-to-end information loop, beginning at the information source, ending at the GBS user, and returning from the user to the information source via user pull information requests.
- Pre-determines smart push products based on inputs to the TIM from HQ USCINCPAC, its component and subordinate commands, the Services, and other unified CINCs.
- Broadcasts user pull products in response to ad hoc requests from GBS users at all levels of command and force size.
- Broadcasts both Smart Push and User Pull products. During routine operations, the TIM and SBM will coordinate with information producers to receive and broadcast previously determined Smart Push products. The SBM will develop and broadcast a catalog of these information products to GBS users, who may then subscribe via alternate communications systems to receive, or "pull" selected products. The TIM and SBM will also support User Pull by coordinating with information producers and users to broadcast information not in the product catalog. The SBM will develop a program guide to inform users when Smart Push and User Pull information will be broadcast.
- Receives information products via the DISN at the SBMs, for SBM processing and transmission via the PIPs to the satellites.
- Implements TIM guidance in building and transmitting the GBS broadcast on a daily basis via the SBM and PIP.

c. What are some key PACOM GBS requirements?

- Co-location of the Primary Injection Point (PIP) and Satellite Broadcast Management (SBM). Personnel working in the SBM/PIP facility are responsible for collecting, packaging, and transmitting GBS information to the space segment. SBM and PIP operations comply with HQ USCINCPAC Theater Information Management (TIM) guidance and direction.
- Capability to transmit a single level end-to-end bulk encrypted signal from inject terminal to receive terminal. In order to transmit and receive information at different levels of security and releasability, user organizations must add additional cryptographic equipment at the front and back ends of the inject and receive terminals.
- Capability of the steerable uplink antenna to receive GBS information from up to three TIPs at a time. When using multiple TIPs, each TIP must be assigned a separate transponder and must be within a 350 nm diameter of each other.
- Capability of the UFO GBS payload to receive and broadcast signals from up to four inject terminals simultaneously. In the default configuration, the UFO GBS payload broadcasts information from only the PIP and one TIP at any given time.
- Different receive suites configurations fielded, depending on user requirements.
- Connection of GBS receive suites to local area workstations and networks in order to provide GBS information directly to the end user's workplace.

d. What are some key PACOM GBS elements for successful implementation?

- Development of GBS CONOPS for respective subordinate commands (USFK, United States Forces Japan (USFJ), ALCOM, and Special Operations Command Pacific, SOCPAC).
- Modification of information and broadcast management processes based on operational experience and advances in commercial technology. Subordinate commands also forward Smart Push information requirements to the HQ USCINCPAC TIM.
- Consolidation and forwarding of user profiles to the HQ USCINCPAC TIM and SBM. Subordinate commands also coordinate directly with information producers to receive new information products.
- Compliance with the DoD MILSATCOM Architecture, Joint Chiefs of Staff Memorandum Of Policy (MOP) 37, "Military Satellite Communications Systems," dated 14 May 92, for satellite resource apportionment and allocation."
- Organization of TIM functions within USPACOM by the CINC (i.e., providing direction, guidance, and policy for the operation of the apportioned GBS resources). No one person or organization has the expertise, authority, and manning to accomplish all the TIM functions required. Since procedures and systems currently exist within USPACOM to request and provide information to appropriate users, USCINCPAC will fulfill its TIM responsibilities by using existing processes and forming a GBS TIM working group co-chaired by the J2 and J3 directorates and composed of members from the staff directorates. Working Group members represent their directorates' functional disciplines in advocating users' requirements, resolving cross-functional issues, and determining Smart Push information products. The TIM will provide overall policy, priorities, and operational requirements, guidance, and direction to ensure a smooth flow of information across GBS. Guidance and policy will be promulgated by the J6 directorate. Direction will include managing apportioned

resources; directing spot beam pointing; and approving the broadcast schedule and information contents in support of all users, including supporting CINCs, allies, and coalition partners under the UFO 8 FOV. As such, the TIM will prioritize and adjudicate between competing requirements from all CINCs, Services, U.S. agencies, and subordinate commands.

- Identification of USPACOM GBS TIM Working Group responsibilities. These responsibilities include development of rationale for GBS employment, guidance and direction for the GBS broadcast (i.e., prevent GBS "log-jams" and abuse of user pull), and approval of restrictions on users' access (as required). In addition the TIM reviews and approves information products (for inclusion in the GBS broadcast catalog), determines priorities for information transmitted over GBS, and reprioritizes information and users based on mission needs. Likewise, the TIM must determine what data to remove from the broadcast if demand for GBS resources exceeds bandwidth allocation. The establishment of priorities by the TIM will dictate which users will be serviced first, which products will be transmitted first, and which areas will receive coverage first. Also, the TIM will resolve conflicts between competing users and supporting CINCs, coordinate user pull procedures, coordinate user profiles and user access, determine releasability to coalition partners, prioritize TIP access to UFO 8 (in the event of multiple TIPs requiring broadcast over UFO 8), determine USPACOM requirements for UFO 10 GBS resources, and resolve conflicts between competing users and other CINCs. Initial broadcasts consist of regularly scheduled smart push products (as determined and coordinated in advance by the HQ USCINCPAC TIM). As users become familiar with GBS capabilities and the information products catalog (developed and distributed by the SBM), User Pull products will begin populating the broadcast. Users will make requests directly to the information producers subject to HQ USCINCPAC policy. Again, GBS will rely on the existing DISN, such as voice, record, and electronic mail systems, for User Pull requests.
- Assistance from the HQ USCINCPAC staff and SBM (to find products and coordinate with information sources) for the delivery and broadcast of information from the PIP.
- Number of downlink antenna movements per day dependent on operational requirements and the geographic dispersion of GBS users.
- Location of the UFO 8 SBM in Building 108 at NCTAMS Pacific. The SBM is manned 24 hours a day with approximately 5 persons per shift, and responsible for day-to-day GBS system operation.
- Reliance on existing (non-GBS) communications systems (e.g., secure and nonsecure telephone/facsimile/electronic mail, voice radio, Automatic Digital Information Network (AUTODIN) messages, and Joint Worldwide Intelligence Communications System (JWICS), Secure Internet Protocol Router Network (SIPRNET), etc.) for users to "reach back" and request User Pull products to be broadcast.

United States Atlantic Command (USACOM): It is the author's opinion that both USACOM and USEUCOM exert more control over GBS broadcasts through the use of the TIM (than USPACOM). To these two commands, the TIM plays the critical role in ensuring the GBS delivers the information required.

a. What must the GBS do?

- Act as an adjunct to the MILSATCOM system, which is under the purview of Joint Chiefs of Staff (JCS) and the associated Integrated Communications

Database (ICDB) process. CINCUSACOM validates user requirements in accordance with the ICDB process for GBS services and monitors access to the USACOM AOR broadcast.

- Recent operational experience in Southwest Asia, Haiti, and Bosnia has proven that no single command, control, communications, computers, and intelligence (C4I) system or service can satisfy all of the joint or combined C4I requirements of the modern tactical warfighter.
- Mobile forces are thereby freed from restrictive, large, fixed terminals and can now receive information products formerly delivered only to command centers."

b. How does the GBS provide information?

- The TIM is a central feature of major importance to USACOM. It is within the TIM that the dissemination of information to USACOM forces via GBS is coordinated. Direct interfaces with numerous information repositories are maintained in order to produce specific information products tailored to meet warfighter requirements using both Smart Push and User Pull methodology. This process of information management by the warfighter for the warfighter ensures that theater GBS subscribers have access to tailored information that best supports their mission.
- Dissemination of these products will use a dynamic mix of "Smart Push" and "User Pull" to satisfy warfighter information requirements most expeditiously....The Smart Push approach, which will constitute the major portion of USACOM's GBS support, will optimize the use of those GBS broadcast resources apportioned to the command through efficient broadcast scheduling geared to meet warfighter information utility and timeliness requirements across the AOR. User Pull services will enable deployed warfighters to request and receive specific information products needed to meet ad hoc operational requirements.
- The broadcast management process will be based on the use of subscriber information profiles for Smart Push in combination with User Pull responses to specific requests for information (RFI) from deployed warfighters.
- It places specific information products from each of the CINC's TIMs in broadcast time slots according to established priorities. The broadcast schedule is based on the broadcast capacity apportioned to each CINC and the priority of the various information products to be broadcast. The initial apportionment of UFO 9 GBS resources for Phase 2 GBS, has USACOM and U.S. Southern Command (USSOUTHCOM) sharing one 500-nm spot beam capable of 48 Mbps and one 500-nm spot beam capable of 24 Mbps. The 2,000-nm 1.544-Mbps area coverage beam is apportioned to USEUCOM.
- Within the USACOM AOR, there are two types of GBS broadcasts, regional and theater, that originate from the SBM/PIP and the TIP, respectively....In addition, a separate CONUS regional broadcast using a leased commercial Ku transponder will originate from the NCTAMS LANT Detachment Hampton Roads SBM serving forces belonging to all CONUS CINCs.
- Also, close coordination is required between the TIP and the SBM/PIP to deconflict competing broadcasts and ensure interference-free operations.
- GBS will have two major classes of service: Smart Push and User Pull. Smart Push is the process by which information products such as intelligence, bulk imagery, TOMAHAWK MDUs, operations updates, software enhancements, etc., are placed on the broadcast in accordance with a prearranged schedule or as

updated information becomes available. The USACOM TIM will work directly with theater users to determine what video and data products they require.. The TIM will accommodate user needs to the maximum extent possible in accordance with established USACOM/CJTF priorities while matching available resources with demand. The primary goal of Smart Push is to meet the majority of the predictable information needs of the users within the USACOM AOR through this class of service. Management of Smart Push services will be handled by the existing chain of command as part of the deliberate planning process using the user profiles within the GRAT. The Smart Push approach optimizes the employment of shared GBS resources by allowing the SBM to construct a predictable broadcast schedule by integrating the Smart Push requirements from each CINC's TIM being supported by the broadcast. User Pull is designed to give authorized users in the theater direct access to information both inside and outside the theater....This method allows the user to request a certain information product through a reachback process....This class of service will help satisfy the remaining information requirements that could not be met through Smart Push. Management of User Pull within the USACOM AOR involves creating an environment in which users and providers interact based on user access, privileges, and priorities assigned by the USACOM TIM. This approach uses existing communications means, in concert with GBS, to create a virtual two-way network for interaction. User Pull is not intended to replace existing collection management processes. In many instances, RFI and information product request procedures are already established within existing doctrine and policy. For GBS purposes, these procedures should be modified as necessary to ensure that the USACOM TIM is advised of all RFI to be satisfied using the GBS User Pull process.

- There are two primary types of broadcast information products: video and data. Assured delivery of data products is not possible with a one-way broadcast such as GBS; however, GBS Phase 2 broadcasts will be very high quality (bit error rate (BER) of 10^{-10}).
- Reachback connectivity, via other communications means that GBS can provide specific product access by users. This reachback capability allows a user to request specific and timely information from the TIM. The TIM will have a dial-in and a SATCOM link interface capability to allow users to access the TIM gateway server. After gaining access to the server, users can browse through the TIM homepage or the menus of the SIPRNET or Nonsecure Internet Protocol Routing Network (NIPRNET). When an information product is located, the user will select a broadcast-delivery option to determine whether a single user or multiple users will receive the product.
- The high bandwidth of GBS allows for the transmission of many information products. Therefore, a method is being developed to screen out unwanted information products, using filtering and buffering mechanisms.
- Since the USACOM staff and the in-theater commander are in the best positions to determine warfighter information needs, coordination of AOR GBS support by the TIM enables the CINC or in-theater commander to tailor information services and optimize the flow of information available for broadcast to the users within the AOR.
- The TIM will maximize the effectiveness of GBS resources within the AOR by using the system primarily to deliver high-volume information products by the Smart Push distribution process. This will enable the off-loading of high-volume information products from other LDR, two-way, C2, SATCOM

systems. The TIM will also coordinate with information producers about dissemination of information products developed in response to ad hoc user RFIs under the User Pull provisions of GBS.

- To take advantage of the high-speed, high-bandwidth properties of GBS, the TIM uses the following factors as the basis for deciding which information products are and are not best suited for dissemination via GBS: size of the product, new or existing product, number of intended recipients, location of recipients, delivery timeliness requirements (precedence), current means of delivery (GBS or other), availability of GBS-apportioned resources, & ability of recipients to accept GBS delivery.
- The overarching role of the TIM is to establish and monitor USACOM's policies and procedures for GBS information flow within the AOR. The USACOM TIM is the hub for managing the distribution of information products to meet established GBS user information profiles and the dissemination of data and video products in response to user ad hoc RFIs.
- For GBS to function successfully as a tool for theater warfighters, it must be controlled by the warfighter.
- The TIM balances user demands in order to optimize the use of apportioned GBS resources. In cases where demand exceeds the availability of resources, the TIM will reprioritize information, reallocate bandwidth, and remove low priority information products from the broadcast. In addition, the affected users are notified of reprioritization decisions. When requirements call for additional GBS resources beyond the USACOM apportionment, the TIM can request the use of any unused resources from the SBM or negotiate with another CINC's TIM (i.e., USEUCOM) to borrow GBS resources.
- Due to the limited number of resources in the GBS Phase 2 architecture, there will always be more CINCs and forces requiring support than available GBS resources. The SBM will consolidate these requirements with requirements received from the other CINC TIMs and produce an overall broadcast schedule.
- If the hot spots become a crisis, the TIM may allocate more resources to the CJTF and his supporting forces.
- The GRAT will provide the TIM with the capability to view current allocations and usage of GBS resources and the means for monitoring and operational control of GBS resource utilization throughout the AOR.
- The USACOM TIM will develop and maintain catalogues to inform users of new information product availability.
- Supported by SBM traffic analysis, the USACOM TIM will audit the request process used for User Pull to preclude abuse and logjams. For this purpose, the TIM must be included as an information addressee on all GBS User Pull RFIs. This will enable the TIM to revise decisions concerning user access and Smart Push GBS content.
- Establishment of a TIM homepage will enable remote users to efficiently access, browse, and request information. The TIM homepage will be tailored to provide relevant information for forces conducting operations within the USACOM AOR. Through the use of search engines on the homepage, users will be able to locate specific items of interest scattered throughout various disparate information repositories more quickly. TIM personnel will regularly update the resource database.
- The TIM structure supports both the Smart Push preplanned dissemination process and the response to ad hoc User Pull requests for information products....This broadcast schedule is developed based on user information

profiles (Smart Push) and specific information product requests (User Pull).

- Within the USACOM AOR, the TIM will be an addressee on all requests for GBS information products from USACOM forces and will attend to their satisfaction in accordance within established priorities.
- It is envisioned that during normal peacetime operations within the USACOM AOR, the TIM will employ the Smart Push approach for the majority of GBS. For routine delivery of high-volume products that are best suited for high capacity broadcast delivery, GBS users will include specified products on their GBS user profiles and will request the producer organization to use GBS as the delivery medium. As such, the TIM will have approval authority over all GBS use by units operating in the USACOM AOR. Therefore, information producers desiring to disseminate their product via GBS will need TIM concurrence.
- On occasion the TIM may have to directly interface with various information sources to extract data and build tailored information products in response to one-time RFIs from GBS subscribers (i.e., User Pull) as dictated by the operational/tactical situation. However, with adequate planning and development of comprehensive GBS subscriber information profiles, this situation should rarely happen, most probably only during a rapidly developing crisis.
- Through the TIM, USACOM personnel will regularly search information sources and acquire the most useful information products.
- To facilitate the User Pull information request for those situations where users have requirements for high volume/wide dissemination of unique information products not contained in their user information profile, the TIM will maintain a system of product catalogues in addition to maintaining the virtual information resource database...Users will submit User Pull RFIs via other two-way/reachback communications media.
- The cornerstone to integrating GBS operations is the consolidated broadcast schedule....To construct the Atlantic regional GBS broadcast, the SBM will coordinate with the various producer organizations and repositories to facilitate delivery of the required data and video products to the SBM for insertion into the broadcast stream....The broadcast stream will be built from staged information based on direction received from each CINC's TIM that identifies the products and schedule for their portion of the broadcast....While it is possible that files may be corrupted in transmission, the GBS system BER of 10^{-10} should make this occurrence extremely rare.
- To ensure important file products are not missed following payload configuration changes, hand-offs between TIPs and the PIP, or spot beam reorientation, the SBM will transmit a broadcast synchronization signal and delay the transmission of information to the new coverage area for a period of time to enable users to acquire and synchronize with the broadcast downlink.

c. What are some key GBS requirements?

- Since only three UFO satellites will be equipped with the GBS Ka-band payloads, the continued lease of commercial satellite services in the Ku-band will be required to augment UFO GBS coverage over the continental United States where coverage gaps exist.
- Multiplexing equipment at the PIP will allow various data streams to be uplinked on various channels to support dynamic requests and multiple users.
- For GBS Phase 2, only one TIP will be capable of uplinking data to the GBS

satellite at any one time....USACOM or the designated CJTF will deconflict TIP operations when multiple TIPs are deployed within the GBS footprint area by assigning specific time slots to each in-theater TIP....Although use of the TIP can offer some significant advantages, its use takes a dedicated transponder away from the regional PIP broadcast and use of the TIP near front lines may subject the uplink to enemy jamming.

- The PIP is capable of uplinking four 24-Mbps video/data streams while the TIP is limited to a 6-Mbps uplink capability.
- It is important to note that reconfiguration of the GBS transponders to uplink and downlink antennas is not directly controlled by the SBM since it requires use of satellite control telemetry, tracking and commanding (TT&C) resources controlled by the Air Force and Navy satellite control systems....Likewise, while spot and area coverage beams can be repointed under TIM direction and SBM control to direct the broadcast streams to dispersed users throughout the satellite FOV, the process is not instantaneous and can take up to 10 minutes for each beam movement.
- The SBM will have the capability to remotely enable or disable receive suite access to the broadcast.
- The SBM will maintain end user profiles (description of user receive configuration, product requirements, location, CINC priorities, etc.) to enable development of Smart Push and access control.
- The SBM will use this information to perform traffic analysis and provide each of the supported CINC's TIM with an assessment of overall broadcast utilization and how well information is flowing over their apportioned GBS resources.
- Most RBM functions will be resident in the receive suite, but some may be located with end user equipment.

d. What are some key GBS elements for successful implementation?

- In the Atlantic area the SBM is located at Naval Computer and Telecommunications Area Master Station Atlantic (NCTAMS LANT) Detachment Hampton Roads, VA.
- The GBS user base is expected to grow rapidly once deployment of the system begins and users realize the potential benefits available to them.The BADD system is being developed to achieve new levels in managing information access and flow.
- Tactical information on air, sea or land units is available for COP construction in context with other source information now available to the warfighter. Raw information enters the database through automated channels for some systems and is manually entered for others.

United States European Command (USEUCOM): It is the author's opinion that the USEUCOM CONOPS (draft) is nearly identical to the USPACOM CONOPS (draft). As such the following outline will only include selected sections that varied from the USACOM CONOPS. It's not surprising that the two CONOPS are very similar given the fact that they will have to share the use of the UFO-9 satellite. Nevertheless, the author also notes that USEUCOM has adopted similar TIM functions and implementations as USPACOM.

a. What must the GBS do?

- The TIM and SBM uses subscriber information profiles to manage Smart Push and anticipate User Pull. User Pull (RFI) from deployed warfighters. GBS is a one-way broadcast that only distributes information, requests for information (RFIs) User Pull must be made via other communications means.

- The GBS is a multicast system. Multicast allows simultaneous broadcast of a variety of data and video products. The system can provide these products to all users, a small subset of users, or, in some cases, a single user depending on how the information is addressed and/or routed.

- This request link uses any existing Service-unique, low-bandwidth communications system available to the user which employs Transmission Control Protocol (TCP) and Internet Protocol (IP) routing protocols.

- Since the USEUCOM staff and the in-theater commander determines warfighter information needs, coordination of AOR GBS support by the TIM enables the CINC or in-theater commander to tailor information services and optimize the flow of information available for broadcast to the users within the AOR.

b. How does the GBS provide information?

- The Smart Push approach, constitutes the major portion of USEUCOM's GBS support, optimizes use of GBS broadcast resources apportioned to the command through broadcast scheduling geared for warfighter information utility and timeliness requirements.
- Within the USEUCOM AOR, the TIM is an addressee, or the lead on all requests for GBS information products from USEUCOM forces and will attend to their satisfaction in accordance within established priorities. Bottom line, the CINCs priorities will drive the scheduling of product delivery.
- USEUCOM fulfills all USEUCOM GBS information management responsibilities through the HQ USEUCOM GBS Information Management Board (GIMB), co-chaired by the J2, J3 and J6 and composed of members from the staff directorates. As GIMB co-chairs, the J2, J3 and J6 are responsible for operational requirements, guidance, and direction in managing USEUCOM GBS operations. Working Group members will represent their directorates' functional disciplines in advocating users' requirements, resolving cross-functional issues, and determining Smart Push information products.

c. What are some key GBS requirements?

- Additionally, to support JTF, NAVEUR, and MARFOREUR, GBS also requires an interface with the Joint Maritime Command Information System (JMCIS).
- Remember, this is a broadcast service and does not insure delivery.
- The TIP and PIP DON'T multiplex on the satellite. The TIP completely uses one of the transponders on the satellite.

d. What are some key GBS elements for successful implementation?

- Since GBS enables the storage, retrieval, and dissemination of huge information files that quickly exceed the capability of most mobile users, the tailoring of the Smart Push and User Pull dissemination architecture for GBS is a significant challenge (see section 2.3.2).
- The 500 nm spot beams and the 2000 nm Broad beam on UFO 9 will be shared by TRANSCOM, SOCOM, STRATCOM SPACOM, USEUCOM, USSOUTHCOM, and USACOM.
- USEUCOM J6 will send out a questionnaire on the products that are wanted by the users.
- USEUCOM plans on updating the AOR GBS broadcast schedule at least every three days. USEUCOM will modify it in response to operational changes throughout the AOR and the availability of GBS resources apportioned to USEUCOM. The SBM will broadcast a consolidated schedule from USEUCOM's, USACOM's, USPACOM's, and USCENTCOM's TIM.
- USACOM oversees SBM operations for UFO 9 and USEUCOM oversees SBM operations for UFO 10 for Joint Staff.
- The USEUCOM SBM will be funded and operated by the Navy at Sigonella, Italy.

Other CINCs: CONOPS were not available from any other CINCs prior to this publication.

APPENDIX E. GROUND RECEIVE SUITE FIELDING AND CONFIGURATIONS [ORD, Chappell]

1. Army: A total of 504 receive suites will be fielded to Force Packages I, II, and III, and Force Support Packages I and II.
2. Navy: Total of 166 receive suites, of which, 50 will be manpackable receive suites. All shore requirements shall be met by 2004.
3. Air Force: 300. The Air Force may require additional receive suites pending the outcome of their current receive suites fielding analysis.
4. USMC: Estimated total of 70 receive suites.

**The number of required receive suites may change (increase or decrease) pending the outcome of fielding analysis. All ship and submarine requirements should be equipped by FY 2004. The services' initial plan is to acquire 1,406 ashore, afloat, and subsurface receive suites.

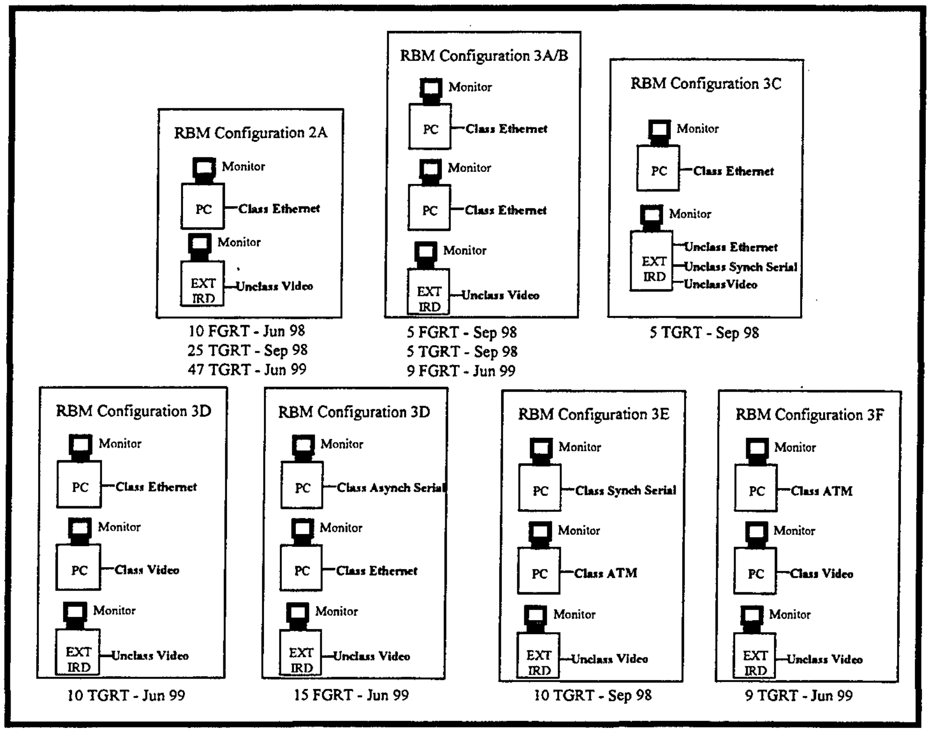
FIXED	Quantity Required
NCTAMS	10
NCTS	18
COMMDET	4
MAST	7
MICFAC	5
TSC	15
MOC	9
CINC CCC	4
TOTAL	72

TRANSPORTABLE MANPACKABLE *	Quantity Required
SPECWAR *	50
EODGRU	20
TACGRU	10
BEACHGRU	10
CINC-MOBILE	4
TOTAL	94

SHIP CLASS	Quantity Required	SHIP CLASS	Quantity Required	SHIP CLASS	Quantity Required	SHIP CLASS	Quantity Required
CVN	10	CG	27	MCS	1	TAE	8
CV	3	DDG	50	MCM	10	TAFS	8
AGF	2	DDG993	4	MHC	11	TAGOS	8
LCC	2	DD	31	AOE	8	TAH	2
LHA	5	FFG	20	AO	5	TAO	12
LHD	7	FFG NRF	10	ARS	4	TATF	5
LPD	12	SSN	52	AS	3	ISEA	1
LSD	17	SSBN	14	PC	13	TRAINER	1
						TOTAL	**366**

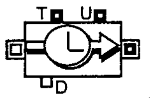
Unit Total	Quantity Required		Total
SJTF	1		1
MARFORPAC/MARFORLANT	1 ea		2
MEF Command Element	2 ea		6
Marine Division Command Element	2 ea		6
Marine Division Infantry/Artillery Regt	1 ea		10
MAW Command Element	2 ea		6
MAW MAG/Support Group	1 ea		13
FSSG Command Element	2 ea		6
FSSG Standing CSSD	1 ea		6
MEU	1 ea		7
MCCES	2		2
Marine Reserve	5		5
		Total	70

Ground Receive Suite Configurations and Allocation:

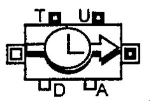


Location	AOR	Jun 98	Sep 98	Jun 99
Bahrain	CENTCOM		1 FGRS 1 TGRS	1 FGRS 1 TGRS
Germany	EUCOM		3 TGRS	5 TGRS
Iceland	ACOM			1 FGRS
Italy	EUCOM		5 TGRS	2 FGRS
Japan	PACOM			2 FGRS
Saudi Arabia	CENTCOM			1 FGRS 1 TGRS
Korea	PACOM	7 FGRS		3 FGRS 10 TGRS
Spain	EUCOM		1 TGRS	1 FGRS
Turkey	EUCOM			1 FGRS
UK	EUCOM			1 FGRS
USA	ALL		5 FGRS 9 TGRS	3 FGRS 13 TGRS
USA	CENTCOM		6 TGRS	4 TGRS
USA	EUCOM			7 TGRS
USA	PACOM	1 FGRS	1 TGRS	2 FGRS 13 TGRS
USA	SOCOM		5 TGRS	2 FGRS
USA	SOUTHCOM		4 TGRS	2 TGRS
	Joint Staff		4 TGRS	1 TGRS
	Misc	2 FGRS	1 TGRS	2 TGRS

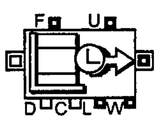
APPENDIX F. EXTEND BLOCK DEFINITIONS [EXTEND]



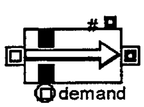
Activity, Delay Block. Holds an item for a specified amount of delay time, then releases it. The delay time is the value in the dialog or, if connected, the value at the D connector when the item is received (the connector overrides the dialog). This block can be used for any kind of service delay. For example, you can use this block to represent red lights in traffic, the time it takes a clerk to wait on a customer, or multitasking CPU time.



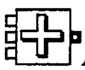
Activity, Delay (Attributes). Works the same as the Activity Delay block except it interacts with an item's attributes. You can use the attribute value as the delay and/or modify the attribute value. The delay time is (in order of decreasing priority): • D (delay) connector (if it is connected); • the value of the chosen attribute (if that option is selected in the dialog); • the delay (time units) value specified in the dialog. If you are using an attribute value as the delay, you can specify whether the first attribute's value or a named attribute's value is used. You may also have the block modify an attribute value (of either the first or a named attribute). The options for this modification include subtracting the delay used from the chosen attribute, increasing the attribute value by a percentage, or adding a specified value to the attribute. The A connector overrides the percentage or value for modifying the attribute. By subtracting the actual delay time from an attribute, you can later determine how long an item has been delayed. For example, you can use this block to process (delay) an order for the time specified by its attribute, then subtract the delay from the attribute value to show that the item has been processed. Or you could process an item, then add an amount to an item's attribute to track processing costs. The number of items which have arrived in the block and the number that have departed from the block are displayed.

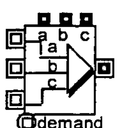


Activity, Multiple. Holds many items and passes them out based on the delay and arrival time for each item. The item with the smallest delay and earliest arrival time is passed out first. The delay time for each item is set through the D connector or, if nothing is connected there, can be specified in the dialog. For example, this block can be used to represent a supermarket where customers arrive at different times and take a varying amount of time to shop. Customers who arrive earlier or only shop a little will leave first; customers who arrive later or shop a long time will leave last.

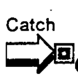


Activity, Service. Passes an item only when the demand connector is connected and certain conditions exist at the demand input (either demand's value is true [greater than 0.5] or it pulls in an item). Depending on the type of output connector (item or value) attached to demand, this block passes single items or passes a specified number of items. This block allows service on demand. You can think of this block as a path with a gate that opens on demand, where demand can accumulate. If an item output connector is attached to the demand connector, the block accumulates the value of the items coming into it and passes that many items through (item values can be set by other blocks, for example the Set Value block). For example, if an item with a value of 4 is passed to the demand connector, the block will pass four items through before closing its "gate." The block accumulates demand: two items at the demand connector with values of 4 and 3 will cause this block to accumulate a demand for 7 items at its item input connector. If required items are not immediately available, the block will remember the demand amount and decrement it only as items become available and are pulled in. If a value output connector is attached to the demand connector, items will pass through as long as the value at demand is greater than 0.5. For example, a value of 4 from a value connector will cause items to pass through the block as long as the gate is open. The 4 does not affect the number of items passed, it only serves to keep the gate open. If the value at the value connector changes to 0, the gate will close. This block serves as a conditional wait. Examples are: multiple food orders, customers waiting in line, flight arrivals. Warning: When using the Activity Service block it is possible to prematurely halt the flow of events in a simulation. This can occur if you have a resource block (for example, the Resource block from the Discrete Event library, or Stock or Bin from Manufacturing library) connected to an Activity Service block, and the Activity Service block is controlled by an Input Data block. If the first number output by the Input Data block is a zero, and there is no other source of events in the model (such as a Generator or Program block), the Executive block will set the time clock to the end of the simulation and the simulation will end. A simple work-around in this situation would be to use a Program block to control the Activity Service block because the Program block generates its own events.

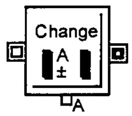

Add. This block adds the three inputs on the left of the block and outputs the total.



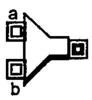
Batch. Allows items from several sources to be joined as a single item. This is useful for synchronizing resources and combining various parts of a job ("kitting"). In the dialog, you specify the number of items from each of the inputs that is required to produce one output item (one "kit"). You can also specify that items at one or more inputs will not be brought into the block until one or more of the other inputs has its requirements filled. The block can either let all items waiting to be batched into the block whenever they arrive (the default mode), or can force the items at specified inputs to wait outside the block. Each input for which "Delay kit at..." is selected will have its items wait outside until all required items for the unselected inputs are in the block. For example, if only the "Delay kit at a" option is selected, items at the b and c inputs are pulled in until the quantities required at each are filled, then the a items are immediately pulled in. At least one of the "Delay kit at..." choices in the dialog must be left unselected. By default, the highest priority that was on any of the input items is transferred to the output item, and all of the input items' attributes are combined in the output. If you select Preserve uniqueness in this block and in the corresponding Unbatch block, the batched item will unbatch into items with their original properties (attributes and priorities). However, the Preserve uniqueness option uses more computer memory and it must be specified in both blocks. If the demand connector is connected, the block will pull in items for batching only when demand is activated (if an item is present at demand or if the value at that connector is greater than 0.5). If an item output connector is attached to the demand connector, the block accumulates the value of the items coming into it and passes that many batched items out; if a value output connector is attached to the demand connector, items will be batched as long as the value at demand is greater than 0.5. This works similarly to the demand connector on the Activity Service block.



Catch. This block "catches" items sent by Throw blocks even though the blocks aren't connected by connection lines. Any number of Throw blocks can send items to a Catch block. The connection between the blocks is made at the Throw block by specifying in its dialog the label and block number of the Catch block. You could use the Throw and Catch blocks instead of using Combine blocks, even from inside one hierarchical block to inside another one.

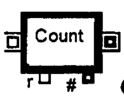


Change Attribute. Changes an item's attribute value then passes the items through. You specify the name of the attribute to change, an operation to use in the change, and a modifier value to change with. The operations are: increment, decrement, multiply; divide; The values you can use as modifiers are: a constant; the value from another attribute; the value from the A connector.

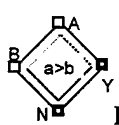


Combine. Combines the items from two different sources into a single stream of items. This is different from the batch blocks which join items from several sources into one item. The items in the Combine block retain their separate identities and are not batched together. Examples of use are: merging traffic, customers coming from two entrances to form a single line.

Constant. Generates a constant value at each step. You specify the constant value in the dialog (the default constant is 1). If the input is connected, the input value is added to the constant in the dialog. This block is typically used for setting the value for the inputs to other blocks. For example, you can use it for a steady flow of fluid, cash, or a delay time value. Note: If the Constant value field is left blank in the dialog, this block will output a Novalue. Outputting a Novalue is useful in some situations because most blocks will ignore NoValues. For example, when you want to start a Mean and Variance calculation only after a certain amount of simulation time has passed; send NoValues to the Mean and Variance block until you want calculations to occur. If you had input zeros into the Mean & Varience block, its sample size would grow, whereas NoValues will be ignored.

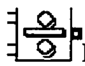


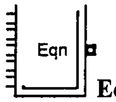
Count. Passes items through and reports the total number of items passed in its dialog and at the # connector. Item values are usually but not always 1. If you have item values other than 1, and do not want to increment the count by item values, and instead want the count to increment by only 1 when an item with a value greater than 1 passes by, choose Count by 1 only. A value greater than 0.5 at the r connector will cause the count to be reset back to zero.



Decision. This block makes a decision based on the inputs and internal logic you define. The dialog lets you perform the following tests comparing A to B: greater than, greater than or equal to, equal to, less than, less than or equal to, and not equal. You can also test for A being an invalid number (noValue). The block compares the two inputs (A and B). If only the A input is connected, the block compares that value to the B value in the dialog. If the selected test is true: the Y connector outputs 1 and the N connector outputs 0. If the test is false: the Y connector outputs 0 and the N connector outputs 1. The block can also use hysteresis. If this choice is selected, the block outputs a 1 or 0 value depending on the specified test and the value for B, but the value does not change until the A input crosses the relaxation threshold. For example, assume you select the Use hysteresis option and the > option, and set B to 9 and

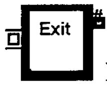
Relax to 7. The Y connector will be 0 until A > 9, at which point it will become 1. The Y connector will stay 1 while A>7. As soon as A is <= 7, the output goes to 0. Examples of using the Decision block are contingency planning, pass/fail tests, and routing.


Divide. Divides the top input by the bottom input. You can choose whether a bottom input of 0 yields an output of noValue or stops the simulation with an error message.

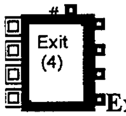


Equation. Outputs the results of an equation entered in the dialog. The equation must be of the form "Result = formula;". You can use Extend's built-in operators and functions, and some or all of the input values as part of the equation. Extend's operators are: +, -, *, /, ^ (exponentiation), MOD or % (modulus), AND or &&, OR or ||, NOT or !, == (equals), != or <> (not equal), <, <=, >, >= . The Functions buttons in the dialog display a list of all built-in functions and procedures, including placeholders to remind you of which arguments are required. You can copy functions from the listing to your equation with the Copy and Paste commands. You must replace the placeholders with the real arguments, and separate arguments with a comma (,). The parentheses are required to show where the arguments begin and end. User-defined functions are not allowed. Each input must be named in the dialog in order to use it in the equation. You can use the default input value names (Var1, Var2, etc.) or specify new names. Extend will warn you if an input is used in the equation but it is not connected. The Equation block is discussed fully in the Extend manual; refer to the manual for more information.

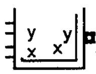
Executive. This block is the heart of each discrete event model and must be placed to the left of all other blocks in the model. It allows the duration of the simulation to be controlled by the end time or by another number specified in the dialog. Generally you will have no reason to change the default values in the dialog. You can specify in the dialog that the simulation end at the end time (the default choice) or after a specific count has been reached or a number of events have occured. There are two ways to use the count or number of events choice. If you enter a number in the dialog and do not connect to the count connector, the simulation will stop when the specified number of events have occured. If you do connect to the count connector, the simulation will stop whenever the value at count has reached the value set in the dialog. The count connector compares its value to the dialog value count or number of events, if that choice is selected. When the value at count equals the dialog amount, the simulation is stopped. For example, the count connector could be connected to the # connector of an Exit block to count the number of items exiting at that block. (Other possible connections would be to the L connector on a Queue, or the Status connector on the Status block). The "Item rows allocated" field displays the number of rows of data that the Executive block has allocated for items to travel through the simulation. When Extend runs out of available item rows, this will be increased by the number specified in the "Allocate additional items in groups of_____" dialog item. For an aproximate estimate of the amount of memory occupied by the item information, multiply the number displayed in the "Item rows allocated" field by .31 for models without a Timer block, and by .56 for models with one or more Timers. This calculation will give you the memory required in K. Dividing this number by 1000 will give you the number of megabytes. NOTE: If you are using custom DE blocks and you get an error message when running your model, try selecting the Use attribute string (backwards compatible): checkbox. Do not use this unless you are using custom programmed DE blocks developed in Extend version 3.2 or earlier. If you are using custom DE blocks and you get an error message when running your model, try selecting this checkbox.



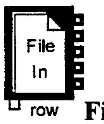
Exit. Passes items out of the simulation. The total number of items absorbed by this block is reported in its dialog and at the # connector.



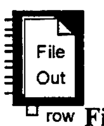
Exit (4). Passes items out of the simulation from many inputs. The total number of items absorbed by this block is reported in its dialog and at the # connector. The number absorbed for each input is reported in the dialog and at the value connectors on the right of the block.



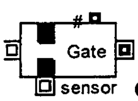
Exponent. Raises the bottom input (x) to the power of the top input (y). You can specify y either through the connector or dialog. The connector overrides the dialog value.



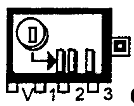
File Input. Reads data from a text file and writes it into the block's table. Once the data is in the table, you can use it in your model. You select the file to be read by typing its path name, or you can leave the name blank so Extend prompt's you and fills in the path name. You can create the text file using Extend's text file features, in a word processor, or a spreadsheet application. The file can have up to five columns of real data that are separated by tabs, spaces, or a character such as a comma. The file can have as many rows as you want, but you must specify the maximum number of rows that you want to read from the file in the dialog. Note that specifying a higher number of rows causes the block to allocate more memory. To choose which row from the table will be output into the model, you can: * use the row connector to specify the row numbers, with 0 being the first row; * select run number in the dialog (each simulation run will cause the next row of data to be output to the model); * select step number in the dialog (each simulation step will cause the next row of data to be output to the model). This block can be used to control parameters for many blocks in a model or many runs of the model.



File Output. Writes data from the block to a text file. You can type or paste data into the block, or model data can be input through the input connectors during the simulation. You select the file either by typing its path name or you can leave the name blank so Extend prompts you and fills in the path name. The file will have up to five columns of real data that are separated by tabs, spaces, or a character such as a comma. You can write as many rows as you want, but you must specify the maximum number of rows that you will write in the dialog. Note that specifying a higher number of rows causes the block to allocate more memory. To choose which row data will be input to during the simulation, you can: * use the row connector to specify the row numbers, with 0 being the first row; * select run number in the dialog (each simulation run will cause data to be input into the next row); * select step number in the dialog (each simulation step will cause data to be input into the next row). You specify in the dialog whether the file is written at the end of the simulation or when you click the Write button in the dialog.

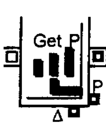


Gate. Allows only a specified number of items to be in a section of the model (the restricted section). Use this block to restrict the passing of items into a system that can only have a specific number of items in the system at a time. You specifiy in the dialog the number of items which can be in the restricted section at one time. The first items to arrive are allowed through, up to the number specified. New items are only allowed to pass through the block when one or more of those original items have left the restricted section. The block determines that an item has left the restricted section when the sensor connector views an input from the output of the last block in the section. (The sensor connector does not accept items, but only notes their presence). Thus the last block in the section has its output connected in parallel: it is connected both to whichever block follows it and to the sensor input. How you connect this block in your model determines the restricted section. This block is the first block in the restricted section. The block whose item output is connected to the Gate block's sensor input is the last block in the restricted section. To use this block in a model, connect from the item output of the last block in the restricted system to the sensor connector. This tells the Gate block that an item has gone out of the restricted area, so it can release the next item. You must also connect in parallel from the last block's output to the next block in the model. For example, the following feedback loop can be used. (This is similar to the way the Timer block feedback works.) Warning: Only one viewing type connector (sensor, or status block input) can be connected to a given output connector in a model. Other viewing connectors may not get any information, and thus may not function properly.

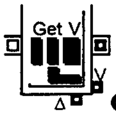


Generator. Provides items for a discrete event simulation at specified interarrival times. Choose either a distribution on the left, or choose the empirical distribution and enter probabilities in the table. Items can be created with a random distribution or at a constant rate of arrival. You can also specify the number of items output at each event in the dialog or at the V connector. This block provides items at specified interarrival rates. Since it always pushes items, this block should usually be followed by a Queue or Resource block when used to provide items for the model. Otherwise, you may lose some items that are generated. If an arrival rate of 0 or less occurs, items are generated immediately (at the time the 0 or less value occurs). The parameters for the distribution arrival times are set in the dialog. The random distributions include: beta, binomial, constant, empirical, Erlang, exponential, gamma, hyperexponential, log normal, normal, Pearson type V, Pearson type VI, Poisson, Triangular, uniform integer, uniform real, and Weibull. The empirical distribution may have up to 20 points and may be interpreted as a discrete, stepped, or interpolated distribution. The input connectors 1, 2, and 3 allow you to change the parameters of the random distribution as the simulation progresses.

Get Attribute. Displays and/or removes attributes on items, then passes the items through. The attribute value is shown in the dialog and output at the A connector. You can also use this block to clone the item based on the number in an attribute. As items are passed through the block, the block can either read or remove an attribute, and that attribute can be specified as the first attribute in the list or a named attribute. If the attribute is found, its value is reported in the dialog and sent through the A connector. You can specify whether to output a 0 or noValue at A if the attribute is not found. There is also a choice in the dialog to change the value of the item to the value of the attribute (clone the item into multiples). The D connector outputs 1 if the attribute value has changed since the last value was read in.

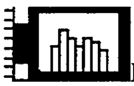


Get Priority. Reads the priority of items then passes them through. The priority is shown in the dialog and output at the P connector. The priority number is usually used to route items. The D connector outputs 1 if the priority value has changed since the last item was read in.

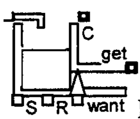


Get Value. Reads the value of items then passes them through. The value is shown in the dialog and output at the V connector. The D connector outputs 1 if the value has changed since the last item was read in.

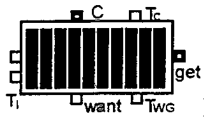
Help. Shows help text. You can use this block to document your models. Include information about what the model does, what impact specific blocks or parameters have on the model, authorship, cross-references to other models, and so on. You are limited to 255 characters per box in the dialog. If you type over the limit in a box, you are alerted with a sound. There are four text entry boxes in this block.



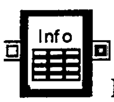
Histogram. Creates a histogram of all the values it receives. May be used in both continuous and discrete event models. This block separates data into bins based on a specified number of bins and a total range of values. Each bin counts the number of data values that fall within its range. The number of bins and the minimum and maximum range values for the plotter are specified in the dialog (the plotter uses these numbers to calculate the range for each bin). The maximum and minimum can be the entire range for the data received or specified numbers. Values which fall outside the specified range will not be plotted but will show in the data table. You can specify in the dialog whether to plot the data from each step/event or, if you run multiple simulations, to plot the final values of each run. The dialog also displays the number of points received that fall within the range. Note: When using a specified range, the histogram can be open during the simulation, wheras using the max/min, it will remain closed until the end, and then open if the show plot during simulation checkbox is checked. Note: The 'Don't preserve data' option will prevent the plotter from preserving all the data points collected during the previous run. This can be a large memory savings if the plotter is accumulating large amounts of data, but it is incompatible with the option of using the min and max values from the entire range.



Holding Tank. Accumulates the total of the input values, allows you to request an amount to be removed, and outputs that requested amount, if it is available. The Holding Tank block is similar to the Accumulate block except that it allows you to request an amount to be removed at each step or event. The amount to be removed is specified at the want connector; the amount is actually output at the get connector, up to the amount available. You can choose to allow output that would make the contents go negative (such as an overdraft); the default is not to allow withdrawals that make the contents go negative. The Holding Tank block can serve many different uses: As a bank: The Holding Tank block holds the money in your bank account. The input connector receives money. The C connector shows the balance in the bank account. The want connector requests money be withdrawn from the bank and the get connector is the money you actually withdrew from the bank. Allowing the contents to go negative represents an overdraft. As a waiting line: The Holding Tank bank holds the number of people in line. New people enter the line at the input connector. The C connector tells how many people are in line at a particular time. The want connector tells how many people are supposed to leave the line at each step. The get connector shows how many people actually left the line. Note that you would not want the contents to go negative in this situation. As a reservoir: The Holding Tank block holds the water in the reservoir. The input connector receives the amount of water entering the reservoir. The C connector shows the current level of the reservoir. The want connector specifies the amount of water to withdraw from the reservoir at each step. The get connector gives the actual amount of water withdrawn. Note that you would not want the contents to go negative in this situation.

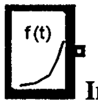


Holding Tank (Indexed). This block represents a series of holding tanks. It accumulates input values, allows the current contents to be reduced by a certain amount, and reports the contents for the tanks. The specific tank used is controlled by its toggle connector. The Holding Tank (Indexed) differs from a Holding Tank in that it contains a series of holding tanks. The active tank is controlled by input connectors which specify the index of the tank to be used. Up to 100 holding tanks can be referenced. Only one of the tanks is available at any input or output connector. The "T" (toggle) connectors control which one of the indexed holding tanks is being used for a connector at that time step or event. The use of the "T" connectors is as follows: Tc - This connector controls which holding tank is referenced by the "C" or contents connector. Ti - This connector controls which holding tank will get the input. Twg - This connector controls which holding tank is referenced by the "want" and "get" connectors. You can think of each of these connectors like a switch. They allow you to choose which of the indexed holding tanks will be used for the corresponding input/output connector. At each time step or event, you can only access one holding tank within the Holding Tank (Indexed) block per input or output connector. You could, however, access different holding tanks for the input, contents or get connectors. Note that the get and want connectors use the same toggle connector.



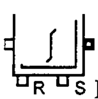
Information. Views and displays information about the items that pass through it. The first column in the table in the dialog is the time the item arrived in the block, the second is the priority of the item, and the remaining columns are attribute values for the named attributes. You must specify the names of attributes you wish to view. If an attribute is not found, its value is blank.

Input Data. Generates a curve of data over time from a table of values and acts as a lookup table. This block is the same as the Conversion Table block except that the variable is always the current time of the simulation. This block contains a table of values (Time and Y Output) which are used to calculate what the y output value would be for the current simulation time. The table defines a curve; the output is calculated based on where current simulation time occurs on the curve. The table may be typed into the dialog, imported from a file, or pasted from the Clipboard using the commands in the Edit menu. The values in the table do not need to be in sorted order. The calculations may also be a repeated series with the time units between repeats set in the dialog. You can specify that the simulation should stop or that a 0 be output if the simulation start time or end time is out of the range of the values in the table. It is important that the time range specified in the table at least covers the time range specified in the Simulation Setup dialog. For example, if you enter 0 through 20 as the Time values in the table, and the end time of the simulation is 40, the block will not be able to calculate values for times 21-40. In this case, depending on the choices made for "simulation time is outside of table range", Extend will stop the simulation and give you an error message or will output zeroes. This table may have as many rows of values as required (up to 500) to define the function, but it must have at least two rows. The output may be interpolated from the data or given a stepped distribution. You can use this block to represent items which change over time, such as traffic volume, sales volume, production, and so on.

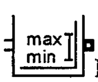


Input Function. Generates a function over time. This works the same as the Conversion Function block except that the variable is always the time in the simulation. A delay parameter is included for most functions so the output may be delayed for a specified length of time. In addition to the functions in the Conversion Function block, this block also includes impulse, ramp, and repeated pulse functions, however it does not contain the modulo and multiplier functions. The functions that you can select from the dialog are: absolute value, arccosine, arcsine, arctangent, ceiling, cosine, cosh, exponential, floor, impulse, lognormal, log base 10, nearest integer, pulse, pulse repeated, ramp, sine, sinh, square root, step, tangent, tanh, and user defined. You can also specify constants to be used in an equation with the function. The constants are: a, b, and wi. For most functions, the equation is output = a*function(b*(time-delay)). For example, if you choose the log10 function, the output will be a*log10(b*(time-delay)). The exceptions to this rule are: 1) impulse: In this function, b is not applicable and the output is a/deltatime on the first time step (modified by delay) and 0 for all other time values. 2) pulse: Instead of b, the second constant is wi, and the equation is output = a for 0 □time-delay □wi. 3) pulse, repeated: Uses wi instead of b, and repeat instead of delay as constants. This function is the same as the pulse function above, except the pulse is repeated every repeat time units. 4) ramp: In this function, b is not applicable and the equation is output = a*(time - delay). 5) step: In this function, b is not applicable and the equation is: output = a if (time-delay) < 0 otherwise output = a . 6) user defined: Instead of a, the first constant is XLo; instead of b the second constant is XHi. XLo and XHi are the minimum and maximum values which define the range for the user defined function. You can define your own function by drawing a curve or entering values in a table. To do this: select the user defined choice and set a minimum x value (XLo) and a maximum x value (XHi) for the time range. Then click Draw Function. In the window that appears, use the pencil tool to draw a curve which specifies the relationship of the output to time. Alternately, you can type values into the data table to specify the curve. Note that for most purposes, XLo and XHi should be the same as the simulation start and end times, respectively. If XLo and XHi are out of range (for example if XHi is less than simulation end time), you will get an error message.

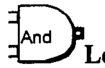
Input Random Number. Generates random integers or real numbers based on the selected distribution. You can use the dialog or the three inputs, 1, 2, and three to specify arguments for the distributions. You can select the type of distribution: Uniform (integer or real), Beta, Binomial, Erlang, Exponential, Gamma, Geometric, HyperExponential, LogLogistic, LogNormal, Neg. Binomial, Normal, Pearson type V, Pearson type VI, Poisson, Triangular, Weibull, and Empirical. The Empirical distribution uses a table of up to 50 values to generate a discrete, stepped, or interpolated empirical distribution.



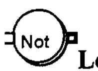
Integrate. Integrates the input over time. If present, a starting value is added to the outputs. This block may be used in a discrete event model.



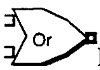
Limits. Allows you to limit the output value to a range of values. The range is specified by the maximum and minimum set in the dialog. The block passes the input through to the output unless the input exceeds the given maximum limit or falls below the given minimum limit, in which case the output is that limit. You can use the block to specify volume ranges, salary draw, temperature tolerances, and so on.



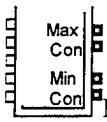
Logical AND. Performs logical AND operation on the inputs. If each of the two inputs is greater than 0.5, the output is 1; if none or only one of the inputs is greater than 0.5, the output is 0.



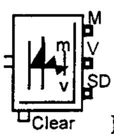
Logical NOT. Performs logical NOT operation on the inputs. If the input is greater than 0.5, the output is 0; otherwise the output is 1.



Logical OR. Performs logical OR operation on the inputs. If either of the inputs is greater than 0.5, the output is 1; if neither of the inputs is greater than 0.5, the output is 0.



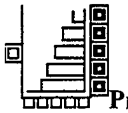
Max and Min. Determines the maximum and minimum values from among the five values input. The dialog shows the maximum and minimum values and the input connectors they came from. The block outputs the maximum and minimum values and their respective connector numbers.



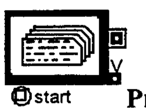
Mean and Variance. Calculates the mean, variance, and standard deviation of the values input during the simulation. If an input is a noValue, it is ignored and does not affect the statistics. Depending on the choice in the dialog, the variance is computed as: Sum of (valid inputs - mean)^2 ÷ (number of inputs) or Sum of (valid inputs - mean)^2 ÷ (number of inputs - 1) The variance is computed using 1/(N-1) as an averaging factor.


Multiply. This block multiplies the inputs.

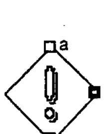

Plotter, Discrete Event. This plotter is to be used only in discrete event models. It is used to plot values such as information about items (queue length, attribute values, number of items exited, etc). Both the value and the time the value was recorded (event time) are shown in the data table for each input. You can specify in the dialog whether to plot values only when they change (the default) or to plot all values (this last choice plots slower and uses more memory). NOTE: The DE plotter defaults to drawing trace lines with the stepped format. We don't recommend using the DE plotters with the trace lines drawn as interpolated lines. There are several problems with doing this. For one, the combination of the plot important data option in the dialog box and the interpolated mode can cause the interpolation to be done wrong. The reason for this is that the plot important data option causes points that have the same value as the previous point to be ignored, and therefore the interpolation will be drawn from the first of the points with a given y value, rather then the last. The other potential problem with interpolation has to do with the nature of discrete event simulation. Discrete event simulations will output points at arbitrary time intervals, and an interpolated line drawn between two of these points is not necessarily an accurate reflection of the actual data.



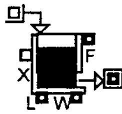
Prioritizer. Prioritizes the outputs, allowing items to be sent into parallel process activities based on a user-defined priority. Items arrive through the item input connector. They are made available at one of the five item output connectors based on two things: the specified priorities, and whether or not the items are needed at the output. In order of its priority, each output will be checked to see if an item is needed. The item will leave through the highest available prioritized output. If two or more outputs have the same highest priority, the output closest to the top will be checked first to see if the item is needed; if it isn't needed there, the next lower output with that same priority will be checked. Note that this block differs from the Set Priority block which assigns priorities to the items. In the Prioritizer block, the priorities are assigned to the outputs; no priority attaches to the items. This block also differs from the Select DE Output block in that the item will go through the block to the highest available prioritized output, whereas in the Select block, the item will only go through if the specific path chosen can take an item. The Priorities are specified in the dialog, or can be modified through the five value input connectors, overriding the dialog values. The value input on the left corresponds to the priority for the top output connector; the value input on the right corresponds to the priority for the bottom output connector. Priorities are specified as real numbers, with the lowest number (including negative numbers) representing the highest priority. For example, assume the first three outputs (a, b, and c) are connected and are assigned the priorities 2, 1, and 3, respectively. When an item arrives, the block will check output b first, to see if it needs an item. If b needs the item, the item is output there. If not, output a will be checked, then output c.



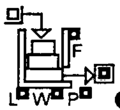
Program. Provides items by scheduling many items to be output into the model. This is similar to the Generator block, except the arrival times of the items are scheduled rather than random. Also, you can assign a value, a priority, and attributes to each item generated. These items (with a given output time, item value, priority, attribute name, and attribute value) may repeat on a regular basis. This block is useful for repetitive or timed needs. Up to 500 events can be generated before repeating a sequence. The block provides items only at the specified times. Since this block always pushes items, when you use it to provide items in a simulation, it should usually be followed by a queue or resource block. Otherwise, you may lose items. If you use this block to activate a universal connector, you do not need to connect to a queue or resource first: you would connect directly to the universal input. If the start connector is not connected, the timing of the program entered in the dialog is in absolute simulation time. For example, an Output Time of 2 in the Program dialog will occur at simulation time 2, as long as simulation time 2 actually occurs (it would not occur if the simulation starting time is later than 2). If the start connector is used, the Output Time entered in the dialog is relative to when the start connector is activated. For example, if Output Time is 2 and start is activated at simulation time 1, the program will start at time 3 (1+2). The start connector is activated whenever it receives an item or a true value (a value > 0.5). If there are no additional arrivals specified, the start connector will restart the program. The first row of the Program block must be filled in. Attributes are only output if an attribute name is given. The program ends at the first blank row.



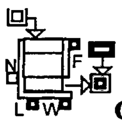
Prompt. Prompts for a value to output if the inputs meet a test. Until the test is met, the block outputs a value specified in the dialog. When the test is met, the block prompts for a new output value, then outputs that value.You select one of two tests, both comparing input a to the value b (b is specified in the dialog, or by the b connector, which overrides). The first test is if a is greater than b, the second is if a is less than or equal to b. You can specify that you should be prompted only the first time the test is met (in which case that prompt value will be output for the remainder of the simulation), or to wait a period of time before testing the condition again. You may enter your own prompt message in the dialog by typing over the default prompt message. If you click the cancel button in the prompt, the simulation is stopped. Note that the output of this block can be any value, whereas the Decision block outputs only 1 or 0. You would use this block to pause a simulation, request a value from the user, then continue the simulation using the new value.



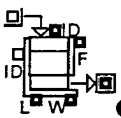
Queue, Attributes. A queue where items with a particular attribute have a higher priority than other items. If there are no attributes to prioritize, this becomes a simple FIFO queue. Any items that do not have the attribute at all, will fall to the back of the queue. Up to four different attribute names may be listed in the dialog. If the A connector is not connected, the attribute named at the top of the list has the highest priority and the other attributes listed are ignored. If connected, the value at the A connector selects which of the four named attribute has the priority. The top attribute is selected by an X value of 1, the bottom attribute by an X value of 4. By default, only the presence or absence of the attribute is considered. If the "Sort by attribute value" option is chosen, the items will be further sorted by the value of the attributes. The default sort order is Highest value first, meaning from highest value (including negative numbers) to lowest.



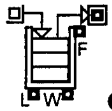
Queue, FIFO. A first-in-first-out (FIFO) queue. The maximum length, which determines how many items the queue can hold, can be set in the dialog. You can specify that the simulation should stop when the queue is full (reaches the maximum length). You can also see the average queue length, average wait time, and utilization of the queue in the dialog.



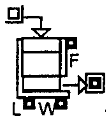
Queue, LIFO. A last-in-first-out (LIFO) queue. The maximum length, which determines how many items the queue can hold, can be set in the dialog. You can specify that the simulation should stop when the queue reaches the maximum length (is full). You can also see the average queue length, average wait time, and utilization of the queue in the dialog.



Queue, Matching. A queue in which items are released only if they have the specified attribute and the attribute's value matches the value at the ID connector. The block searches an item entering the queue to find the attribute named in the dialog. If the attribute's value matches the value at the ID connector, the item is released. If there is more than one item with that attribute name and value, only the first one that entered the block is released unless the "Release multiple items" option in the dialog is selected. You can vary the value at the ID connector so that all items with the named attribute are released. Note that items which don't have the named attribute will never be released from the queue. This block is useful for being sure that items in a simulation have a particular characteristic at a particular time.

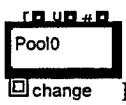


Queue, Priority. A queue that releases items by priority. The item in the queue with the lowest numerical value for its priority will be released first. If the items in the queue all have the same priority, it becomes a first-in-first-out (FIFO) queue. The maximum length, which determines how many items the queue can hold, can be set in the dialog. You can specify that the simulation should stop when the queue is full (reaches the maximum length).

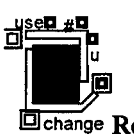


Queue, Resource Pool. A queue for resource pool units. Items wait until the specified number of resource pool units become available. The order of items in the queue is determined by the ranking rule in the dialog of the Resource Pool block. The maximum length, which determines how many items the queue can hold, can be set in the dialog. You can also see the average queue length, average wait time, and utilization of the queue in the dialog.

ReadOut. Displays the value at the input connector at each simulation step. This block comes to the front of the screen during a simulation run if the "Open dialog" option is selected, even in front of any plotters you may have open. This is useful for debugging models and scripts because you can see the value of another block's value output connector at any time. The NTicks field in the dialog allows you to set a delay in ticks (60ths of a second) for the block to pause while displaying each number.



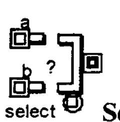
Release Resource Pool. Releases a resource pool as the item passes through. This pool of resource units can be released by either: 1) - Choosing the "Release Resource Pool by name" radio button and entering the name of the Resource Pool block and the number of units to be released. 2) - Choosing the "Release resource pool by attribute" radio button and specifying an attribute which has been set by a Queue, Resource Pool block. The Resource Pool is immediately released and will check its list of items requesting the resource pool to see if it can be allocated to a different item. Note: The order in which the item goes to the release blocks specifies the order in which the Resource Pool blocks are activated to check for waiting items. In situations where the resource allocation is complex (multiple resource pools are being allocated at once and different items will require different resource pools), it is generally recommended to release the Resource Pool which is expected to have the highest utilization first. This will give this resource an opportunity to allocate itself before other resource pools.



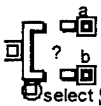
Resource. This block holds and provides items (cars, workers, orders, etc) to be used in a simulation. It can be used as part of an open or closed system. Unlike the Generator and Program blocks, this block does not push items. If you use it in place of a Generator or Program block to provide items for the simulation, be sure that there are sufficient items in initial number to satisfy item requirements for the duration of the simulation. This block is similar to a queue. Items can be pulled from the resource through the item output connector as long as they are available. If the block's contents become negative, the block will not output any values until the contents become a positive number. The change connector modifies the number of items stored in the resource by the value of the item at change. (The main difference between the regular item input and the change input is that the input at change may be negative, reducing the number of items available in the block.) You can add attributes and priorities to items passing through the block or strip attributes from them. If you use this block as part of a closed system and you strip attributes, the default attributes will become the items' attributes. If you do not strip attributes (such as in an open system), the default attributes are added to the items' attributes.

Resource Pool. This block holds resource pool units to be used in a simulation. These units limit the capacity of a section of a model. For example, this could be used to represent a limited number of tables at a restaurant. Unlike the Resource block, the resource pool units are not items. They are variables which indicate how much of a constraining factor is available. The Resource Pool block works with the Queue, Resource Pool to allocate the pool of resources to items and it works with the Release Resource Pool block to release the pool of resources. Items can wait for a resource pool from any number of Queue, Resource Pool blocks. The Resource Pool block determines the order in which the resource pool units are allocated. Units can be allocated to either the item which arrived first in the Queue, Resource Pool block or the item with the highest priority (the lowest numerical priority value). If the Only allocate to the highest ranked item option is checked, only one item will be considered when the resource pool allocation is attempted. If this is not checked, the pool will look through all of the items waiting until it finds both the first item which can leave the Queue, Resource Pool block and a sufficient number of available resource pool units. The change connector modifies the number of resource pool units available by the value of the item at change. (The main difference between the regular item input and the change input is that the input at change may be negative, reducing the number of units available in the block.)

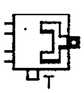
Retain. Outputs the initial value set in its dialog until the T connector is TRUE (greater than 0.5), then outputs the value of its input while T is TRUE. This block retains the current value at its input when T becomes FALSE. While T is FALSE, the retained value is output. If T becomes TRUE again, the block outputs and retains the current value at its input. The initial value must be specified in the dialog (the default initial value is 0). The value retained and output is changed to the value of the input only when the value at the T connector is TRUE (greater than 0.5).



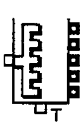
Select DE Input. Selects one input to be output based on a decision. The item that is present at the selected input is passed through the output. The dialog has options for choosing based on the top priority, changing which input is selected after a given number of items have passed, or choosing based on the select connector. For example, you can use this block to represent traffic signals at an intersection, candidate selection, CPU interrupt access, and so on. If the select connector is not used, you can have one out of a specified number of items come from the bottom connector, or you can choose based on priority. If you choose based on priority, the input with the highest priority is selected for output. If both inputs have the same priority, the top input is output. The first input will be taken from the top connector when one of every N items are coming from the bottom. If the select connector is used, the dialog has options for toggling (choosing the inputs sequentially each time select is activated) or choosing the input based on the value at the select connector. • If you choose to toggle the inputs based on the select connector value, the block will choose the input sequentially each time select is activated (each time select pulls in an item or sees a value > 0.5). If select is not activated (for instance, if it sees a value of 0) and there is an item available for output, the item will come from the last input that was selected. If an item is connected to the select connector, the output will be changed each time an item arrives to the select connector. • If you choose to have the input selected based on the value at the select connector, each valid value at select will choose an input based on the input connector's assigned number. The number corresponding to the top input connector is set in the dialog; the bottom input is 1 more than the number for the top input. Invalid values at select are values which do not correspond to the numbers assigned to the inputs. You can choose whether invalid values at select cause Extend to choose the top input connector or to not pull in an item until the select connector has a valid input. If an item is connected to the select connector, the value of the item is used to determine which output will be used. If the select connector is connected to one or more Get blocks (such as Get Attribute, Get Priority), then you should be careful to avoid putting the following types of blocks in between the select and the Get blocks: Set blocks (Set Attribute, Set Priority,) activities, and queues. These blocks can alter the value that you use for the select input.



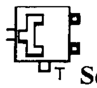
Select DE Output. Selects the input item to be output at one of two output connectors based on a decision. The item at the input is passed through the selected output. The dialog has options for changing the outputs after a given number of items have passed and selecting based on the select connector. If the select connector is not used, you can have 1 out of every specified number of items go to the bottom connector. If the select connector is used, the dialog has options for toggling (choosing the outputs sequentially each time select is activated) or choosing the output based on the value at the select connector. The first input will be sent to the top connector when one of every N items are going to the bottom. 1) • If you choose to toggle the outputs based on the select connector value, the block will choose the top and the bottom outputs sequentially each time select is activated (each time select sees a value > 0.5). If select is not activated and there is an item available for output, the item will go to the last output that was selected. If an item output connector is attached to the select connector and you choose toggle, the select block will switch outputs each time an item arrives to the select connector. 2)• If you choose to have the output selected based on the value at the select connector, each valid value at select will choose an output based on the output connector's assigned number. The number corresponding to the top output connector is set in the dialog, the number of the bottom output is 1 more than the top output. Invalid values at select are values which do not correspond to the numbers assigned to the outputs. You can choose whether invalid values at select cause Extend to output the item at the top output connector, at the bottom output connector, or to not pull in an item until the select connector has a valid input. If an item output connector is attached to the select connector, the select block will choose the connector corresponding to the value of the item arriving to the connector. If the select connector is connected to one or more Get blocks (such as Get Attribute, Get Priority), then you should be careful to avoid putting the following types of blocks in between the select and the Get blocks: Set blocks (Set Attribute, Set Priority,) activities, and queues. These blocks can alter the value that you use for the select input.



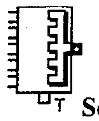
Select Input. Selects its output to be either of two input values based on a threshold test. The block acts like a switch. The value to be output is determined by comparing the value of the T connector to a critical value set in the dialog. When the value of the T connector is less than the critical value, the top input is used; when the value of the T connector is greater than or equal to the critical value, the bottom input is used. This block is useful for any sorting procedure. The default for the critical value, 0.5, works well for boolean logic since Extend booleans have true equal to 1 and false equal to 0.



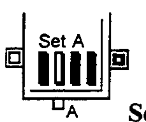
Select Input (5). Selects its output to be one of five inputs according to the value of the T connector. The top input is selected if the T connector is 1, and the bottom input is selected if the T connector is 5. The dialog also lets you specify an output value of either noValue or 0 if the value at T is out of the range of 1 to 5 .



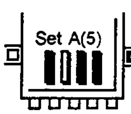
Select Output. Passes the input value to one of two output connectors based on a threshold test. The output connector is selected by comparing the value of the T connector to a critical value specified in the dialog. When the value of the T connector is less than the critical value, the top output connector is used; when the value of the T connector is greater than or equal to the critical value, the bottom output connector is used. For the unselected output connector, the dialog lets you specify an output value of either noValue, 0, or a repeat of the last value it output. The default for the critical value, 0.5, works well for boolean logic since Extend booleans have true equal to 1 and false equal to 0.



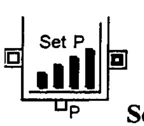
Select Output (5). Passes the input value to one of five outputs according to the value of the T connector. The top output is selected if the T connector is 1 and the bottom output is selected if it is 5. For connectors that are not selected, the dialog lets you specify an output value of either noValue, 0, or a repeat of the last value they output.



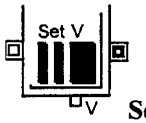
Set Attribute. Sets the attributes of items passing through the block. Up to seven attribute names and values may be assigned to an item with each Set Attribute block. The attributes may add to or replace existing item attributes. You can specify the value of one of the attributes with the A connector. The value at the A connector overrides the corresponding value in the dialog. If the attribute name is already present on the item passing through, the old value will be stripped off, and the new value will be substituted for it.



Set Attribute (5). Sets the attributes of items passing through the block. Up to five attribute names and values may be assigned to an item with this block. The attributes may add to or replace existing item attributes. You can specify the value of each of the attributes with the value input connectors; these connectors override values set in the dialog. This works similarly to the Set Attribute block except that you can use the value input connectors to set the value for each of the five attributes rather than for just one. If the attribute name is already present on the item passing through, the old value will be stripped off, and the new value will be substituted for it.

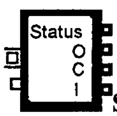


Set Priority. Assigns a priority to items that pass through. The priority value may be set at the P connector or, if no connection is made there, in the dialog. Note that the lowest value (including negative numbers) has the top priority.



Set Value. Assigns a value to items. This is used to change an item's initial value of 1 to a different value. Items originally have a value of 1 unless the value is changed by the Set Value, Generator, Get Attribute, Program, or Schedule blocks. You would use this to have one item represent a group of items as it travels through the simulation, or to have an item with a value greater than 1 to cause a demand at the Activity Service block. Note: queues split items with a value greater than one into clones. For example, if you set a value of 5 on an item, when it goes into a queue, it will become five distinct items.

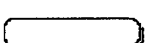
Show Times. Displays when the next event will occur for each block in the model. The block displays the requested next event times and their index numbers. To see events as they are posted, leave this block's dialog open when running a simulation. You can specify in the dialog how long the block should pause before updating the display. The index number of event-posting blocks is based on the simulation order. For example, index number 0 will be the first event-posting block in the model. You can calculate the index value of a block by counting the number of event posting blocks in the simulation order before the block you are interested in. The Executive block initializes the time array to blanks. This means those blocks not requesting events will not show any values in the data table in the Show Times dialog. If your model has more than 2000 blocks posting events, the table will show only the first 2000. The Show Times block will not blank out old events, but will save them in the table until updated by a block. This block must be placed to the right of all blocks to display events from all blocks.



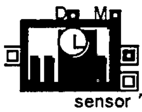
Status. Views and displays information about an item or values. For items: Connect the Status block's item input to any block's item output connection to view the items moving through the connection. The Status block's dialog lists a great deal of information about the items at that connector, including: • number present at the beginning of the simulation step (available at onset) • number currently at the output connector (available currently) • total number of items that came into the block (total input) • interval between arrival times of items (interval) • priority • attributes By default, the block views items (does not remove them from the model). The block can also be set to absorb items and thus be used like the Exit block (use this choice with caution).

Subtract. Subtracts the bottom input from the top input.

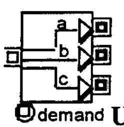
System Variable. Allows you to regulate some aspect of the model based on the status of the simulation. It is usually used in conjunction with a decision-type block, for example, to halt a process after current time reaches a certain value. The variables you can use are: current run number, current step, current time, end time, number of runs, number of steps, start time, and time step.



Throw. This block "throws" items to a Catch block without using an output connector or connection lines. Any number of Throw blocks can send items to a single Catch block. The connection between the blocks is made by specifying the label and block number of the Catch block in the Throw block's dialog. You could use the Throw and Catch blocks instead of using Combine blocks, even from inside one hierarchical block to inside another one. Choose either a specific Catch block to throw to or a Catch block based on an attribute value.



Timer. Displays the time that it takes an item to pass between two parts of the model. The block adds a time tag to an item passing through and records it in a list in the dialog. You can find how long it takes for the item to get from this block to another one (the target block) by attaching the sensor connector to the output of the target block. You can also specify to time only items with a particular attribute. The data table displays the time each item leaves this block. It also displays the delay time (the time it takes for the item to travel to the target block once it leaves the Timer). If you want the delay time to also include the time items wait to be pulled into the next block, you should follow the Timer block with a FIFO queue so that the item waits in the queue (and that wait time will be counted). Since the data table is limited to the Maximum number of items timed at once, items beyond that number write over the first item. Thus items cycle through the data table. If the maximum number of items is unknown or if the items need to be timed over multiple paths, attributes can be used to record the timing information. Assign an attribute to the current time (the System Variable block in the Generic library will return the current simulation time) when the item arrives. At the point where the item is finished processing, get the value of the attribute (Get Attribute block) and subtract this from the current time. How you connect this block in the model determines the section in which the item will be timed. The Timer is the first block in the timing section; the target block is the last block in the timing section. The output of the target block should connected in parallel with the Timer and the block after the target. Thus the last block in the section has its output connected in parallel, that is, connected to both the block that follows it and to the sensor input. Warning: Only one viewing type connector (sensor or status block input) can be connected to a given output connector in a model. Subsequent connectors may not get any information and so may not function properly.



Unbatch. Produces several items from a single input item. The number of items produced at each output are specified in the dialog. By default, this block holds its inputs until its outputs are used or another demand occurs at the connector. The attributes and priorities of the input item are copied to each output. If you selected preserve uniqueness in the Batch block and here, items will be output with their original properties (attributes and priorities) restored. This block can be used to break a message packet into component messages, route the same message to several places, or distribute copies of invoices. Items are pulled in continuously or upon demand if the demand connector is used. If the demand connector is connected, items are only pulled in if demand is activated (if an item is present at demand or if the value at that connector is greater than 0.5). • If an item input connector is attached to the demand connector, the block accumulates the value of the items coming into demand and pulls in that many items. • If a value output connector is attached to the demand connector, items will pass through as long as the value at demand is greater than 0.5. This works similarly to the demand connector on the Activity Service block. Since the Unbatch block has no storage capability, all of the outputs must be pulled from the block before another item may be pulled in. Note that each non-zero value for Output at... in the dialog must have its corresponding output connected.

APPENDIX G. MODEL BANDWIDTH AND FUTURE REQUIREMENTS

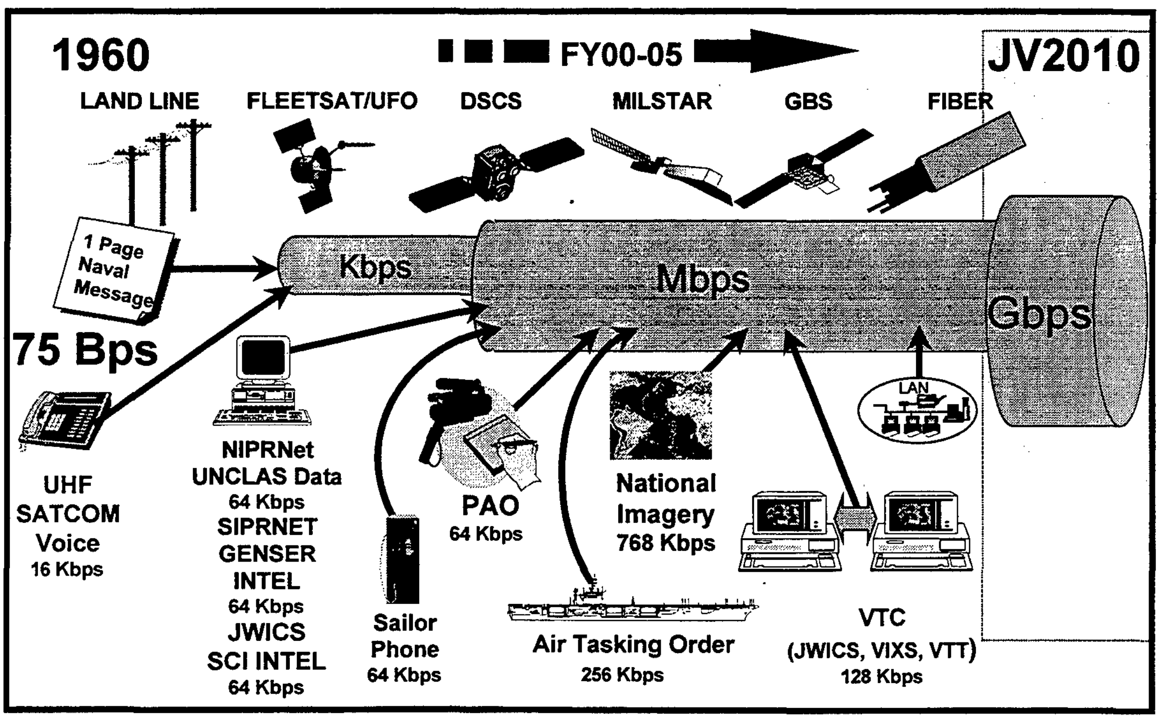
[Boyd, Mayo, IT21, FRD, ERDB]

Model Bandwidth (See Appendix I for Unit and System Bandwidth)

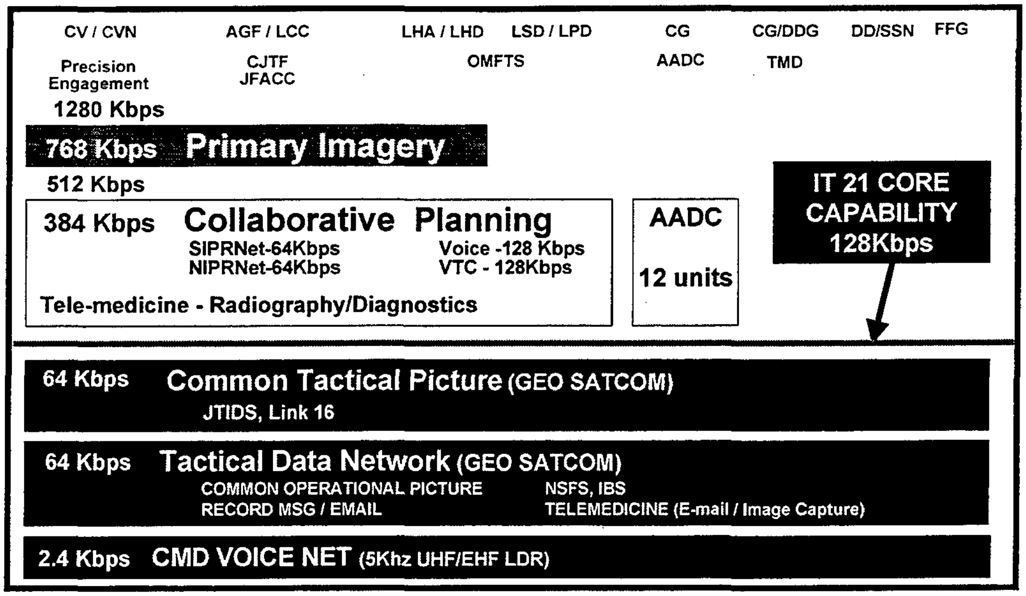
User Group	Back Channel	IP (Variable) Data Rqmts
CVBG	SHF	1.792 Mbps
CVBG	Challenge Athena	768 kbps
CVBG	Inmarsat B	640 kbps
CVBG	Iridium	24 kbps
CVBG	HF	578.4 kbps
CVBG	UHF DAMA	31.2 kbps
CVBG	EHF	24 kbps

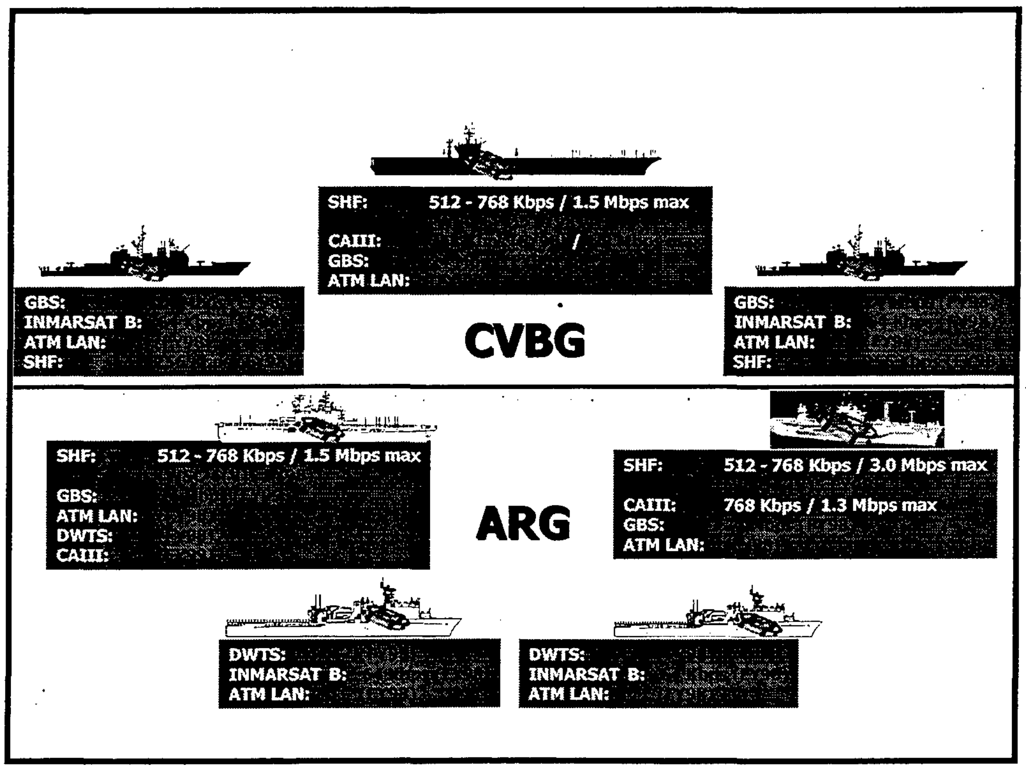
CVBG in Extend Model = 1 CVN + 2 CG + 2 DDG + 2 DD + 2 FFG + 3 SSN + 1 AOE
Extend Model CVBG SHF = 768k + 2(256k) + 2 (256k) + 0 + 3(0) + 3(128K) + 0 = 1.792 Mbps
Extend Model CVBG Comm. WB (Challenge Athena) = 768k + 2(0) + 3(0) + 3(0) + 0 = 768 kbps
Extend Model CVBG Comm. WB (Inmarsat) = 64k + 2(64k) + 2(64k) + 2(64k) + 2(64k) + 3(0) + 64k = 640 kbps
Extend Model CVBG Comm. NB (Iridium) = 2.4k + 2(2.4k) + 2(2.4k) + 2(2.4k) + 2(2.4k) + 3(0) + 2.4k = 24 kbps
Extend Model CVBG HF = 2.4k + 2(64k) + 2(64k) + 2(64k) + 2(64k) + 3(0) + 64k = 578.4 kbps
Extend Model CVBG UHF DAMA = 2.4k + 2(2.4k) + 2(2.4k) + 2(2.4k) + 2(2.4k) + 3(2.4k) + 2.4k = 31.2 kbps
Extend Model CVBG LDR EHF = 2.4k + 2(2.4k) + 2(2.4k) + 2(2.4k) + 2(2.4k) + 3(0) + 2.4k = 24 kbps
Extend Model Total Allocation for CVBG = 3.8576 Mbps

Chronology of Bandwidth Requirements

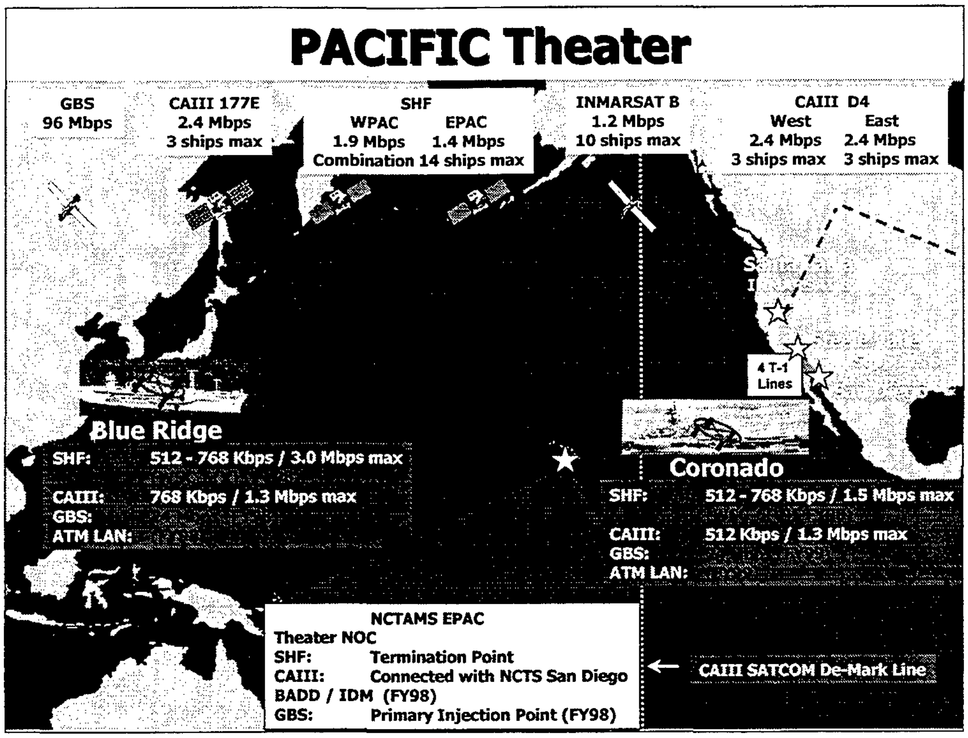


Current Bandwidth Requirements (FY 98/99 IT-21 Implementation)



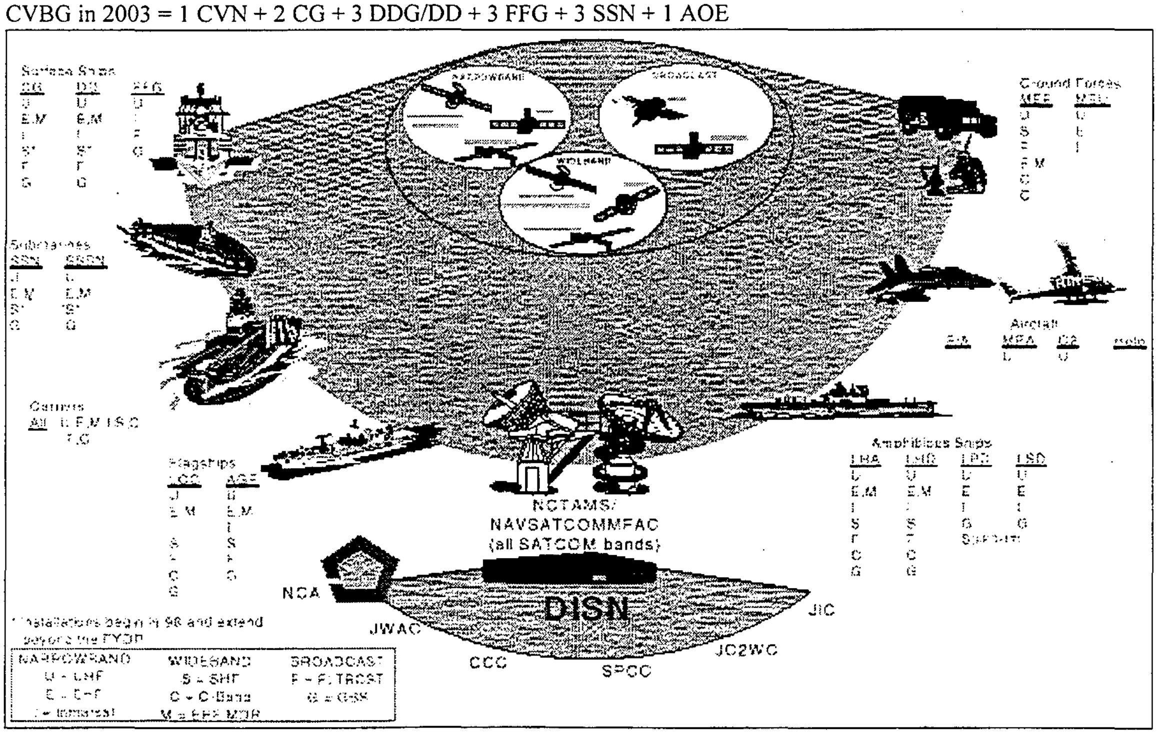


Current Bandwidth Requirements (continued)



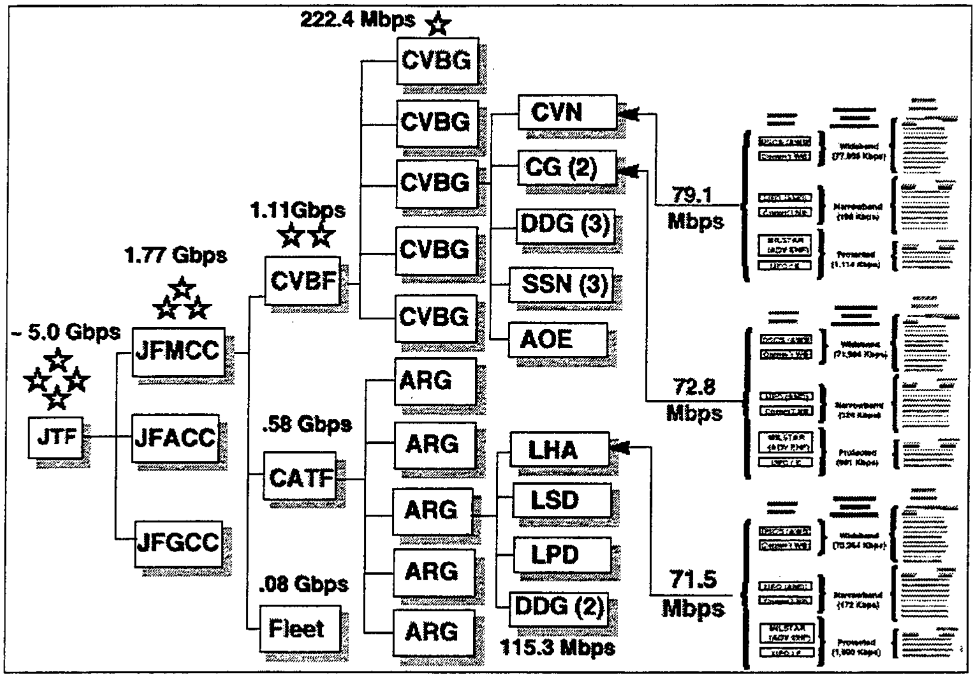
Future Bandwidth (FYDP, 2003)

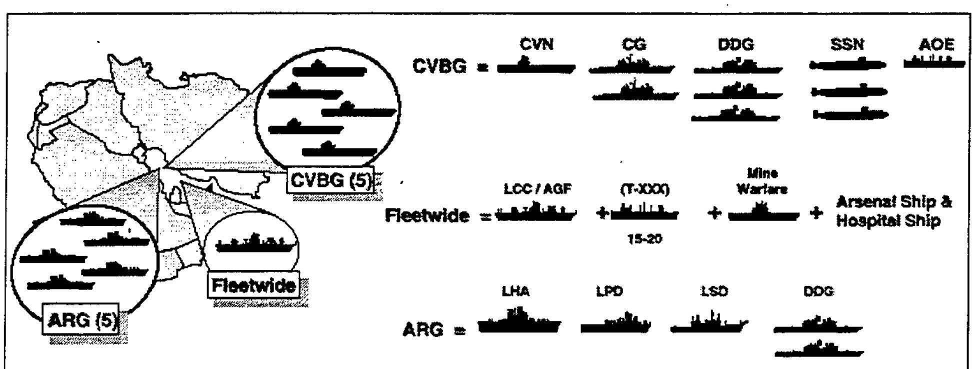
CVBG in 2003 = 1 CVN + 2 CG + 3 DDG/DD + 3 FFG + 3 SSN + 1 AOE



Future Bandwidth (2010 for JTF, SW Asia MTW, CVN, CG, LHD/LHA) [ERDB]

CVBG in 2010 = 1 CVN + 2 CG + 3 DDG + 3 SSN + 1 AOE



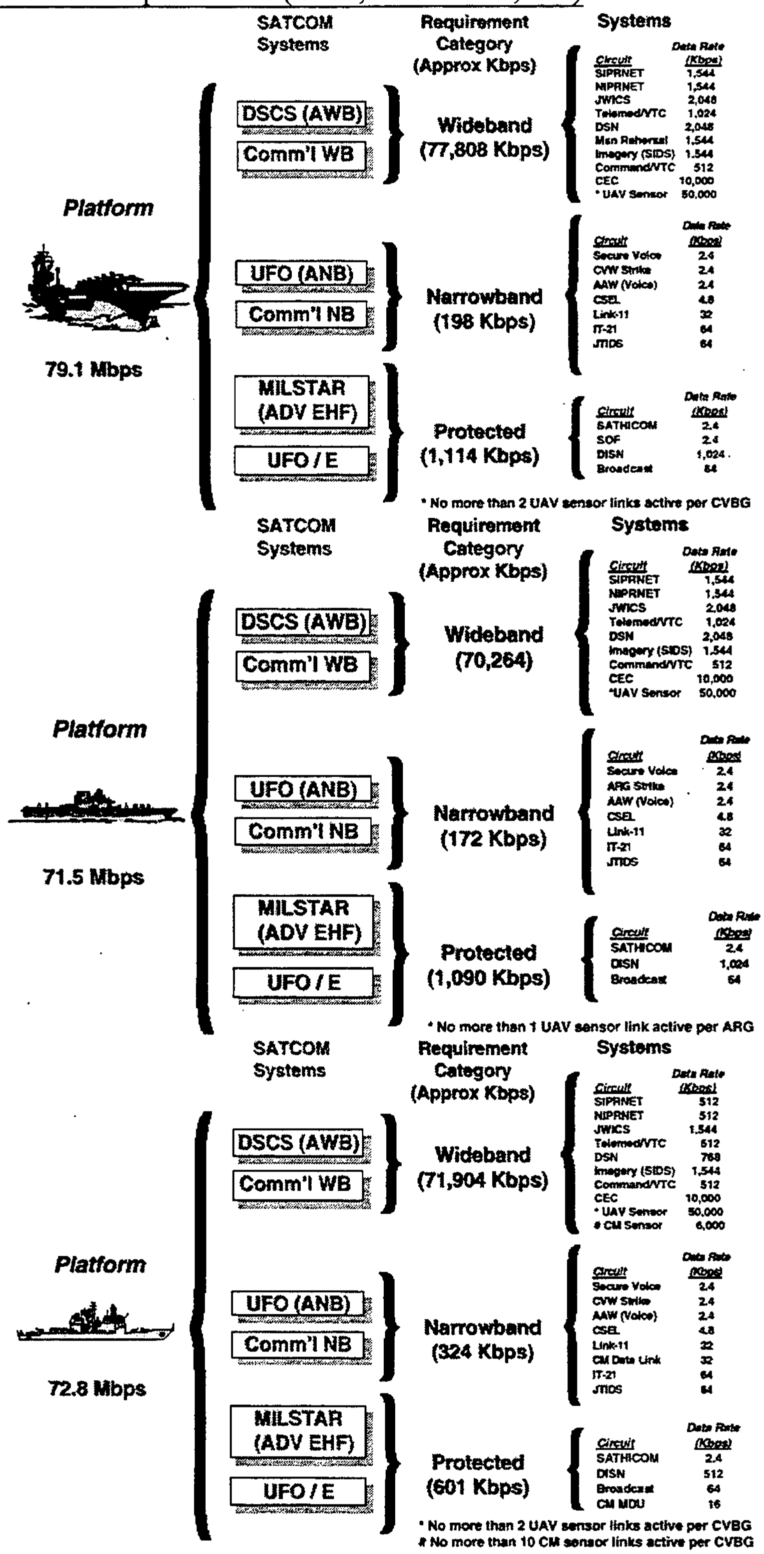


Naval Battle Force Requirements (Kbps)

	Wide Band	Narrow Band	Prot	Total	Groups Deployed	Total Ships	Sub Total
CVBG	218,856	1,035	2,527	222,418	5	50	1,112,090
ARG	111,456	737	3,116	115,309	5	25	576,545
Fleet	69,560	3,218	4,788	77,566	1	24	77,566
					Total	99	*1,766,201*

(*) Actual amount of forces deployed is *scenario dependent*

2010 Unit Bandwidth Requirements (CVN, LHD/LHA, CG)



APPENDIX H. SATCOM PRIORITY TABLE [CJCSI]

PRIORITY	USER CATEGORY
PRIORITY 0	*ASSIGNED ONLY BY NCA/JOINT STAFF FOR EMERGENT CRITICAL CONTINGENCY SUPPORT*
PRIORITY I.	*STRATEGIC ORDER (ESSENTIAL TO NATIONAL SURVIVAL)*

1A System Control/Orderwire
1B National Command Authorities
  - *1B1* Presidential Support
  - *1B2* Secretary Of Defense Support
  - *1B3* Envoy/Emissary Support

1C Strategic Warning/Intelligence
  - *1C1* CINCSTRAT Force Direction
  - *1C2* PAC/LANT/EUR Force Direction
  - *1C3* USCINCSTRAT Airborne Resources

1D SIOP REQUIREMENTS
  - *1D1* USCINCSTRAT Force Element

REPORT BACK

  - *1D2* PAC/LANT/EUR Report Back
  - *1D3* Comm Between SIOP and CINCs

PRIORITY II. *WARFIGHTING REQUIREMENTS*

2A Department Of State Diplomatic Negotiations
2B CJCS Support
2C CINC (CINCs Will Rank Requirements Within (Each Priority Category)
2D JTF/CTF
2E Component Support (Theater Forces)
2F Tactical Warning/Intelligence
2G CJCS-Sponsored Select Exercises
2H Counter-Narcotics Operations

PRIORITY III. ESSENTIAL SUPPORT

3A Other Intelligence (e.g., Technical, Economic)
3B Weather
3C Logistics
3D MIJI Support
3E Diplomatic Post Support
3F Space Vehicle Support (Minimum Circuits For TT&C From Space Vehicles and Primary Circuits for Manned Space Flights)
3G Other Service Support

PRIORITY IV. TRAINING

4A CJCS Sponsored
4B CINC Sponsored (CINCs Prioritize Trng Reqmts.)
4C MAJCOM/MACOM/Echelon 2 Sponsored
4D Unit Sponsored

PRIORITY V. VIP SUPPORT

5A Service Secretaries
5B Service Chiefs (CNO/CMC/CSA/CSAF)
5C CINC Travel
5D Other Travel

PRIORITY VI. RDT&E and GENERAL

6A DoD Sponsored Testing
6B DoD Sponsored Demonstrations
6C Administrative Support
6D Quality Of Live Initiatives

PRIORITY VII. MISCELLANEOUS

7A DoD Support To Law Enforcement
7B Other Non-DoD Support
7C Non-Us Support As Approved By CINCs
7D Other

APPENDIX I. EXTEND DEFAULT NOTEBOOK SETTINGS

Message Rate (messages per hour)

	CVN72	CG63	CG67	DDG65	DDG69	DD967	DD973	FFG48	FFG51	AOE10	SSN713	SSN716	SSN759
Email	5000	720	720	600	600	600	600	360	360	1320	240	240	240
Msgs	1000	132	132	110	110	110	110	66	66	242	44	44	44
HTTP	10000	1320	1320	1100	1100	1100	1100	660	660	2420	440	440	440
FTP	1000	132	132	110	110	110	110	66	66	242	44	44	44
Imagy	500	72	72	60	60	60	60	36	36	132	24	24	24
Tact.	500	72	72	60	60	60	60	36	36	132	24	24	24

Message Size (bits)

	CVN72	CG63	CG67	DDG65	DDG69	DD967	DD973	FFG48	FFG51	AOE10	SSN713	SSN716	SSN759
Email	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000
Msgs	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
HTTP	280k	280k	280k	280k	280k	280k	280k	280k	280k	280k	280k	280k	280k
FTP	120k	120k	120k	120k	120k	120k	120k	120k	120k	120k	120k	120k	120k
Imagy	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000
Tact.	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000

Standard Deviation of Message Size (bits)

	CVN72	CG63	CG67	DDG65	DDG69	DD967	DD973	FFG48	FFG51	AOE10	SSN713	SSN716	SSN759
Email	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
Msgs	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
HTTP	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
FTP	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Imagy	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Tact.	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500

Bandwidth Capabilities (bps)

	SHF	CA	Inmarsat B	HF	Iridium	UHF	EHF	GBS Chl
RB System	1.9M	2.4M	64k	Variable	2400	2400	2400	N/A
CVN72	768k	768k	64k	2400	2400	2400	2400	15M
CG63	256k	N/A	64k	64k	2400	2400	2400	15M
CG67	256k	N/A	64k	64k	2400	2400	2400	15M
DDG65	256k	N/A	64k	64k	2400	2400	2400	15M
DDG69	256k	N/A	64k	64k	2400	2400	2400	15M
DD966	N/A	N/A	64k	64k	2400	2400	2400	15M
DD973	N/A	N/A	64k	64k	2400	2400	2400	15M
FFG48	N/A	N/A	64k	64k	2400	2400	N/A	15M
FFG51	N/A	N/A	64k	64k	2400	2400	N/A	15M
AOE10	N/A	N/A	64k	64k	2400	2400	N/A	15M
SSN713	64k	N/A	N/A	OFF	OFF	2400	2400	15M
SSN716	64k	N/A	N/A	OFF	OFF	2400	2400	15M
SSN759	64k	N/A	N/A	OFF	OFF	2400	2400	15M

RB system

	MTU	Alt. (km)
SHF	2368	35786
CA	2368	35786
Inmarsat	2368	35786
HF	4608	N/A
Iridium	4608	787
UHF	840	35786
EHF	4608	35786

Protocols

	Overhead	MTU
IP	160	12000
TCP	160	See RB syst
FDDI	6	N/A
ATM	40	424
UDP	64	See RB syst

User Requests

Prod Reqs	Tact. Reqs
50% Imag.	60% Tact.
25% Word	30% Image
25% Video	5% Word
	5% Video

APPENDIX J. GBS PRODUCTS [Arthur]

	Information Product	Data		Class	Pt. Of Origin	SBM	End User HW/SW Rqmts
		Data	A/V			Source	
1	MAPPING, CHARTING AND GEODESY ((GGIS))	X		S	NIMA -St. Louis	SIPRNET	Browser Applications
2	METEOROLOGICAL AND OCEANOGRAPHIC (METOC)	X		S	NPMOC	SIPRNET	Browser, MPEG viewer
3	ARMY NOTICES OF AMMUNITION RECLASSIFICATION (NARS)	X		U	HQ, JOC	AUTODIN	AMHS
4	MISSILE NOTICE OF AMMUNITION RECLASSIFICATION (NARS)	X		U	HQ, MICOM	AUTODIN	AMHS
5	OVERHEAD FIRE SUPPLEMENTAL NOTICES	X		U	HQ, JOC	AUTODIN	AMHS
6	TPFDL	X		S	CINCPAC J3/4/5	GCCS	GCCS RDA
7	COMMON TACTICAL PICTURE	X		S	J3 (GCCS/JMCIS)	GCCS	GCCS 3.0
8	TOMAHAWK LND CRUISE MISSILE ATK MSN SUPPORT	X		TS	CMSA (CRUISE MISSILE SUPPORT, PACOM & ACOM)	CP SMITH B/20	7AF=MDS , Ships=Fire Control Sys
9	ATO	X		S	7 AF	OSAN	CTAPS
10	SOFTWARE UPDATES/PATCHES	X		TSC	MULTIPLE SOURCES	JICPAC et al	?
11	MEDICAL INTELLIGENCE	X	X	U	AFMIC, WHO, JTF	ArMedSurvActy	WALTER REED
12	GTN (ITV, JTAV/JTAD)	X	X	U,S	USTRANSCOM	?	BROWSER
13	SARSS-O/RF/	X		?	?	?	?
14	INTEGRATED BROADCAST SERVICE (IBS)	X		S	NSA/NRO/AIA (JICPAC)	UHF via landline	CTT/MATT=>JTT
15	USE/LOCATION OF WMD	X		S	JTF, JICPAC	SIPRNET	Browser Applications
16	INTEL IMAGERY	X		S	JICPAC	SIPRNET	HTML, 5D, IPL client
17	DAILY INTELLIGENCE BULLETIN (DIB)	X		TSC	JICPAC	TSC Feed	HTML, FrameReader, Adobe Acrobat
18	DAILY INTEL SUMMARY (DISUM)	X		S	JICPAC	SIPRNET	Browser Applications
19	COUNTRY FACT SHEETS	X		S	JICPAC	SIPRNET	HTML, FrameReader, Adobe Acrobat
20	DEFENSE INTELLIGENCE WARNING SYSTEM	X		S	JICPAC	SIPRNET	Browser Applications
21	HULTEC DATABASE MESSAGE	X		S	JICPAC	SIPRNET	Browser Applications
22	POL-MIL AND TACTICAL ADVISORIES	X		S	JICPAC	SIPRNET	Browser Applications
23	TACMILINTSUM AND SI-TACMILINTSUM	X		TSC	JICPAC	TSC Feed	Browser Applications
24	EXPEDITIONARY SUPPORT PACKAGE	X		S	JICPAC	SIPRNET	Browser Applications
25	FEASIBILITY ASSESSMENT SUPPORT	X		S	JICPAC	SIPRNET	Browser Applications
26	MILITARY CAPABILITIES STUDY (MCS)	X		S	JICPAC	SIPRNET	HTML, FrameReader, Adobe Acrobat
27	JICPAC SPECIAL REPORT	X		S	JICPAC	SIPRNET	Same as Above
28	TARGET SYSTEM ANALYSIS	X		S	JICPAC	SIPRNET	Same as Above
29	LINES OF COMMUNICATIONS ROUTE STUDY	X		S	JICPAC	SIPRNET	Browser Applications

30	OPERATIONAL TARGET GRAPHIC (OTG)	X		S	JICPAC	SIPRNET	Browser Applications
31	BASIC TARGET GRAPHIC (BTG)	X		S	JICPAC	SIPRNET	Browser Applications
32	QUICK RESPONSE GRAPHICS (QRG)	X		S	JICPAC	SIPRNET	Browser Applications
33	TARGET INTELLIGENCE PACKAGE (TIP)	X		S	JICPAC	SIPRNET	Browser Applications
34	IMAGERY INTERPRETATION REPORT	X		S	JICPAC	SIPRNET	Browser Applications
35	MODERNIZED INTEGRATED DATABASE (MIDB)	X		S	JICPAC	SIPRNET	Browser Applications
36	CONTINGENCY EXPED./SOF PRODUCT (CESP)	X		S	JICPAC	SIPRNET	Browser Applications
37	*NEO DATABASE *Not listed in message	X		S	JICPAC	SIPRNET	Browser Applications
38	CURRENT INTELLIGENCE BRIEF		X	TSC	JICPAC	JWICS	Monitor
39	J2 CHALLENGES BRIEF		X	TSC	JICPAC	JWICS	Monitor
40	CNN		X	U	CABLE TV (BRDCST STATION)	OCEANIC CABLE	Television
41	AFRTS		X	U	MARCH AFB, CA (BRDCST STATION)	INTELSAT 177W	Television
42	UAV/HUD VIDEO DOWNLINK		X		PLATFORM BASE STATION	BASE STATION	Monitor
43	COMMAND INFORMATION		X	TSC	JTF	JTF	Monitor
44	BDA	X	X	S	JICPAC	Browser, JWICS	HTML, Monitor
45	PSYCHOLOGICAL OPERATIONS PRODUCTS	X	X		JPOTF		Television
46	PREVENTIVE MEDICINE ORIENTATION AND TRAINING	X	X	U	SVCS, COMPONENTS (NAVY EPMU'S)	NAVY EPMU'S	Monitor
47	MEDICAL SIGNIFICANT TRAINING	X	X	U	SRVCS (ECHELON III UNITS, MEDICAL TEACHING FACIL.)	CONUS	Monitor+H63
48	*NEO SUPPORT *Not listed in message	X	X	?	PACOM, NEO CENTERS	?	
49	EMERGENCY ACTION MESSAGES (EAM)	X		S	COMUSKOREA	SIPRNET	
50	CINC FORCE DIRECTION MESSAGES (FDM)	X		S	USFK (CINCUNC/CFC & USFK)	SIPRNET	
51	SITUATION REPORTS (SITREPS)	X		S	USFK (CINCUNC/CFC & USFK)	SIPRNET	
52	FRIENDLY ORDER OF BATTLE (FOB) DATA	X		S	USFK (CFC FIELD UNITS & SUPPRTNG ORGS/ ELEMENTS)	SIPRNET	
53	ENEMY ORDER OF BATTLE (EOB) DATA	X		S	SAME AS ABOVE	SIPRNET	
54	INTEGRATED TARGETING ORDER (ITO)	X		S	USFK COMPONENTS (COMPONENT COMMANDS)	SIPRNET	
55	TARGET NOMINATION DATA	X		S	USFK (CINCCFC, JICPAC, TARGET NOMINATION BOARDS,	SIPRNET	

					COMPONENT COMMANDS)		
56	COLLECTION MANAGEMENT (RFIS)	X		S	USFK (CP TANGO, OSAN AND CAMP HUMPHREYS, JICPAC)	SIPRNET	
57	HUMINT	X		S	USFK (YONGSAN, CP TANGO, OSAN, HUMPHREYS)	SIPRNET	
58	GRAPHIC INTSUMS (Intel Summaries)	X			USFK (YONGSAN IN ARMISTICE, CP TANGO, CAMP HUMPHREYS, OSAN)	SIPRNET	ASAS/WARLORD
59	INTELLIGENCE ESTIMATE PRODUCTS	X		S	USFK C2 (CFC C2)	SIPRNET	
60	KOREA TACTICS, TECHNIQUES AND PROCEDURES (KTTP)	X		S	USFK C2 (CFC C2)	SIPRNET	
61	SIMULATIONS	X		S	USFK, USCP (YONGSAN, OSAN, TAEGU, CP TANGO, SUWON, PACOM)	SIPRNET	
62	THEATER MISSILE DEFENSE INTEL PREPARATION OF THE BATTLEFIELD (TMD IPB)	X		S	USFK (YONGSAN, OSAN, CP TANGO, HUMPHREYS)	SIPRNET	
63	SIGNALS INTELLIGENCE (SIGINT)	X		S	USFK (YONGSAN, OSAN, CP TANGO, K-50, HUMPHREYS)	SIPRNET	
64	JSTARS	X		?	JSTARS MGSM (WARTIME MGSM LOCATIONS)		2D Imagery
65	VIDEO TELECONFERENCE (VTC) BROADCASTS		X	?	USFK (CINCCFC/USFK AND VARIOUS PENINSULA COMMAND CENTERS)	PAC VTC?	VTC
66	DISTANCE LEARNING	X	X	U	USFK (ALL U.S. MILITARY POSTS AND CAMPS IN ARMISTICE. YONGSAN, OSAN, HUMPHREYS, TAEGU,J12 CHINHAE, POHANG, AS A MIN.)	?	VTC, PASS-K
67	NONCOMBATANT EVACUATION OPERATION (NEO) SUPPORT	X	X	S	USCP, NEP CTRS (PACOM, NEO CENTERS)	?	

APPENDIX K. GBS MODEL DATA TABLES

The following pages of data tables were tabulated from Extend-collected data during one 65-second simulation. The Extend data was incorporated into Excel™ spreadsheets to make it easier to read and better organized. Page 170 provides the request-to-information time stamps for product requests (tactical data, imagery, documents, and video). Page 171 shows the attributes associated with the items on page 170. Pages 172-175 provide the complete time stamps for the entire request-to-receipt cycle. These pages are organized by ships (the CVN is first). Lastly, pages 176-179 provide the attributes that are associated with the same numbered items in the time stamp sections.

Tactical Data Results (Time Stamps in seconds)- Simulation One													
Item#	StartTime	LANOutTime	ADNS-Time	Entry-Time	Info-Time	NCTAMS-Time	SBM-Time	RBM-Time	End Time	TimeforRequest	TimetoDeliver	Total Time	
	(of Reqst)				(Rqst Rcved)				(Delivery)				
1	0	0.000184979	1.217215703	19.11356683	19.48700557					19.48700557			
2	0	1.85E-04	1.224530823	19.35230533	19.71915007					19.71915007			
3	0	0.000184979	1.224530823	19.59104382	19.96956331					19.96956331			
4	0	0.000184979	1.224530823	19.82978231	20.20329834					20.20329834			
5	0	0.000201733	3.127123657	42.74867776	43.11521555					43.11521555			
6	0	0.000201733	3.129325559	42.98741625	43.3709392					43.3709392			
7	0	0.000201733	3.129325559	43.22615475	43.59299949					43.59299949			
8	0	0.000201733	3.129325559	43.46489324	43.84341273					43.84341273			
9	0	0.000201733	3.129325559	43.70363174	44.07381212					44.07381212			
Imagery Results (Time Stamps in seconds)- Simulation One													
1	0	0.001994453	0.016544849	4.789257179	5.164130662					5.164130662			
2	0	0.001994453	0.017253545	5.027995673	5.408182982					5.408182982			
3	0	0.001994453	0.017253545	5.266734167	5.640250194					5.640250194			
4	0	0.001994453	0.017253545	5.505472662	5.882324329					5.882324329			
5	0	0.001994453	0.017253545	5.744211156	6.124398464					6.124398464			
6	0	0.003130847	0.075349388	15.53248942	15.90262918					15.90262918			
7	0	0.003130847	0.08348096	15.77122791	16.14641176					16.14641176			
8	0	0.003130847	0.08348096	16.00996641	16.3884859					16.3884859			
9	0	0.003130847	0.08348096	16.2487049	16.61554965					16.61554965			
10	0	0.003130847	0.08348096	16.4874434	16.86095942					16.86095942			
11	0	0.003130847	0.08348096	16.72618189	17.10136574					17.10136574			
12	0	0.000185816	0.000269761	30.81175305	31.18660468					31.18660468			
13	0	0.000185816	2.163133743	31.05049154	31.42233975					31.42233975			
14	0	0.000185816	2.163133743	31.28923004	31.66441388					31.66441388			
15	0	0.000185816	2.163133743	31.52796853	31.90815584					31.90815584			
16	0	0.000185816	2.163133743	31.76670703	32.15022997					32.15022997			
17	0	0.000227349	5.049255506	63.54018659	63.92967661					63.92967661			
18	0	0.000227349	5.108422751	64.01766358	64.40409256					64.40409256			
19	0	0.000227349	5.108422751	64.25640207	64.64783451					64.64783451			
20	0	0.000227349	5.108422751	64.49514057	64.89824775					64.89824775			
Word/PowerPoint Results (Time Stamps in seconds)- Simulation One													
1	0	0.00187577	0.002120154	0.038456965	0.057823028					0.057823028			
2	0	0.00187577	0.035788452	0.109381965	0.122495104					0.122495104			
3	0	0.00187577	0.035788452	0.112050478	0.125830745					0.125830745			
4	0	0.000420131	3.138361496	43.94237023	44.31741963					44.31741963			
5	0	0.000420131	3.144404241	44.18110872	44.55796039					44.55796039			
6	0	0.000420131	3.144404241	44.41984722	44.79503107					44.79503107			
7	0	0.000420131	3.144404241	44.65858571	45.03043392					45.03043392			
8	0	0.000420131	3.144404241	44.89732421	45.27417587					45.27417587			
Video/Audio Results (Time Stamps in seconds)- Simulation One													
1	0	0.000195141	0.01364228	3.11808772	3.492956085					3.492956085			
2	0	0.000195141	0.015654445	7.65411911	8.030970777					8.030970777			
3	0	0.000195141	0.015654445	7.892857604	8.271377092					8.271377092			
4	0	0.000195141	0.015654445	8.131596098	8.506779945					8.506779945			
5	0	0.000195141	0.015654445	8.370334592	8.742182798					8.742182798			
6	0	0.002388284	2.434699826	32.50418234	32.89669538					32.89669538			
7	0	0.002388284	2.461228765	32.74292084	33.13751587					33.13751587			
8	0	0.002388284	2.461228765	32.98165933	33.37625437					33.37625437			

Item#	UnitID	NodeID	HFRelay	RB-ID	UnitBandwidth	Priority	Port Priority	Classific.	PropagDistance	#Collisions	#Collisions	FwdChl-ID	ProductID	MsgID	MsgSize	PktSize
	(Ship)	(1-6)	(1 if yes)	(1-7)	(bps)	(0-7)	(1-4)	(1-3)	(km)	(ReqsOut)	(ProductsIn)	(0-7)	(1-8)	(Varies)	(bits)	(bits)
Tactical Data Requests (Attributes) - Simulation One																
1	67	1		1	256000	1	4	2	72572	0			1	0	7597.870561	1809.071
2	67	1		1	256000	1	4	2	72572	0			1	0	7597.870561	2249.6
3	67	1		1	256000	1	4	2	73572	0			1	0	7597.870561	2249.6
4	67	1		1	256000	1	4	2	72572	0			1	0	7597.870561	2249.6
5	69	1		1	256000	2	4	2	72572	0			1	0	8218.486849	500.0868
6	69	1		1	256000	2	4	2	74572	0			1	0	8218.486849	2249.6
7	69	1		1	256000	2	4	2	72572	0			1	0	8218.486849	2249.6
8	69	1		1	256000	2	4	2	73572	0			1	0	8218.486849	2249.6
9	69	1		1	256000	2	4	2	72572	0			1	0	8218.486849	2249.6
Imagery Requests (Attributes) - Simulation One																
1	72	2		1	768000	4	2	2	73572	5			2	0	7399.078484	480.6785
2	72	2		1	768000	4	2	2	74572	5			2	0	7399.078484	2249.6
3	72	2		1	768000	4	2	2	72572	5			2	0	7399.078484	2249.6
4	72	2		1	768000	4	2	2	74572	5			2	0	7399.078484	2249.6
5	72	2		1	768000	4	2	2	74572	5			2	0	7399.078484	2249.6
6	63	2		1	256000	5	3	2	72572	7			2	0	10546.08243	2018.082
7	63	2		1	256000	5	3	2	73572	7			2	0	10546.08243	2249.6
8	63	2		1	256000	5	3	2	73572	7			2	0	10546.08243	2249.6
9	63	2		1	256000	5	3	2	72572	7			2	0	10546.08243	2249.6
10	63	2		1	256000	5	3	2	72572	7			2	0	10546.08243	2249.6
11	63	2		1	256000	5	3	2	73572	7			2	0	10546.08243	2249.6
12	65	1		1	256000	3	4	2	73572	0			2	0	8074.518009	356.118
13	65	1		1	256000	3	4	2	73572	0			2	0	8074.518009	2249.6
14	65	1		1	256000	3	4	2	73572	0			2	0	8074.518009	2249.6
15	65	1		1	256000	3	4	2	74572	0			2	0	8074.518009	2249.6
16	65	1		1	256000	3	4	2	74572	0			2	0	8074.518009	2249.6
17	967	1		3	64000	4	4	1	74572	0			2	0	7256.303631	1467.504
18	967	1		3	64000	4	4	1	72572	0			2	0	7256.303631	2249.6
19	967	1		3	64000	4	4	1	73572	0			2	0	7256.303631	2249.6
20	967	1		3	64000	4	4	1	74572	0			2	0	7256.303631	2249.6
Word/PowerPoint Requests (Attributes)- Simulation One																
1	65	2		4	64000	2	3	2	1800	4			3	0	9468.371122	1993.171
2	65	2		4	64000	2	3	2	1800	4			3	0	9468.371122	4377.6
3	65	2		4	64000	2	3	2	1800	4			3	0	9468.371122	4377.6
4	69	2		1	256000	4	2	2	73572	0			3	0	9201.742547	1483.343
5	69	2		1	256000	4	2	2	74572	0			3	0	9201.742547	2249.6
6	69	2		1	256000	4	2	2	73572	0			3	0	9201.742547	2249.6
7	69	2		1	256000	4	2	2	73572	0			3	0	9201.742547	2249.6
8	69	2		1	256000	4	2	2	74572	0			3	0	9201.742547	2249.6
Video/Audio Requests (Attributes) - Simulation One																
1	63	1		1	256000	3	4	2	73572	0			4	0	8169.914203	451.5142
2	63	1		1	256000	3	4	2	74572	0			4	0	8169.914203	2249.6
3	63	1		1	256000	3	4	2	73572	0			4	0	8169.914203	2249.6
4	63	1		1	256000	3	4	2	73572	0			4	0	8169.914203	2249.6
5	63	1		1	256000	3	4	2	73572	0			4	0	8169.914203	2249.6
6	67	2		3	64000	4	3	3	73572	7			4	0	4373.452124	1634.252
	67	2		3	64000	4	3	3	73572	7			4	0	4373.452124	2249.6
	67	2		3	64000	4	3	3	73572	7			4	0	4373.452124	2249.6

CVN 72 Results (Time Stamps in seconds)- Simulation One											
Item#	StartTime	LANOutTime	ADNS-Time	Entry-Time	Info-Time	NCTAMS-Time	SBM-Time	RBM-Time	End Time	TimeforRequest	TimetoDeliver	Total Time
	(of Reqst)				(Rqst Rcved)				(Delivery)			
1	0	0.000577516	0.001550316	0.253225789	0.266480339	0.268154884	0.2682275	3.404031389	3.767321013	0.266480339	3.500840674	3.767321013
2	0	2.83E-03	0.002908971	0.274485622	0.296911904	0.302135897	0.302303	4.59772386	4.963416779	0.296911904	4.666504875	4.963416779
3	0	0.002833903	0.025747128	0.513224116	0.544378717	0.546399447	0.5466461	8.656278262	9.021989581	0.544378717	8.477610864	9.021989581
4	0	0.000577516	0.004487295	0.730702777	0.754858914	0.756533551	0.7566071	12.47609417	12.84188907	0.754858914	12.08703016	12.84188907
5	0	2.83E-03	0.025747128	0.75196261	0.775280388	0.780636758	0.7808834	12.71483266	13.08054398	0.775280388	12.3052636	13.08054398
6	0	0.000577516	0.004487295	0.969441272	0.973001767	0.974860155	0.9749337	16.53464857	16.89794174	0.973001767	15.92493998	16.89794174
7	0	0.002833903	0.025747128	0.990701105	1.020690164	1.026046534	1.0262931	17.25086405	17.61657537	1.020690164	16.59588521	17.61657537
8	0	0.000577516	0.004487295	1.208179766	1.211740262	1.213414899	1.2134885	18.44455652	18.8078497	1.211740262	17.59610944	18.8078497
9	0	0.000942316	0.061890878	1.229439599	1.258748491	1.263758676	1.2638313	18.68329502	19.04658464	1.258748491	17.78783615	19.04658464
10	0	0.000577516	0.004487295	1.44691826	1.450478756	1.455489034	1.4555626	19.16077201	19.52406518	1.450478756	18.07358642	19.52406518
11	0	0.000942316	0.097134628	1.468178093	1.494658465	1.499668743	1.4997423	19.3995105	19.76280367	1.494658465	18.26814521	19.76280367
12	0	0.000577516	0.004487295	1.685656754	1.68921725	1.690891887	1.6909655	19.638249	20.00154217	1.68921725	18.31232492	20.00154217
13	0	0.000942316	0.097134628	1.706916587	1.733396959	1.735071596	1.7351452	19.87698749	20.24028066	1.733396959	18.5068837	20.24028066
14	0	0.001721434	0.007499274	1.924395248	1.928044819	1.931658969	1.9318609	20.11572598	20.4764235	1.928044819	18.54837868	20.4764235
15	0	0.000942316	0.097134628	1.945655082	1.968799812	1.973810091	1.9738837	20.59320297	20.95399441	1.968799812	18.9851946	20.95399441
16	0	0.001721434	0.009888078	2.163133743	2.173538567	2.178894937	2.1791415	20.83194147	21.19765279	2.173538567	19.02411422	21.19765279
17	0	0.000942316	0.097134628	2.184393576	2.214209589	2.219219867	2.2192934	21.07067996	21.4314714	2.214209589	19.21726181	21.4314714
18	0	0.001721434	0.009888078	2.401872237	2.412277061	2.41429779	2.4145444	21.54815695	21.91386827	2.412277061	19.50159121	21.91386827
19	0	0.000942316	0.097134628	2.42313207	2.446276801	2.451287079	2.4513606	21.78689544	22.14768689	2.446276801	19.70141008	22.14768689
20	0	0.001813323	0.012900058	2.640610731	2.647359325	2.65243165	2.6525076	22.02563394	22.38880404	2.647359325	19.74144472	22.38880404
21	0	0.001063916	0.133278378	2.661870564	2.684508174	2.687850539	2.6879232	22.26437243	22.62516033	2.684508174	19.94065215	22.62516033
22	1.155915	1.15656433	1.15826673	2.780268576	2.790645707	2.795658357	2.7957562	22.50311093	22.86899671	1.634731145	20.07835101	21.71308215
23	0	0.001063916	0.168522128	2.900609058	2.930425071	2.932099708	2.9321733	22.98058791	23.34137936	2.930425071	20.41095429	23.34137936
24	0	0.001063916	0.168522128	3.139347553	3.165827925	3.169170382	3.1692439	23.4580649	23.82135808	3.165827925	20.65553015	23.82135808
25	0	0.001813323	0.01353287	3.356826214	3.360559756	3.364248306	3.3644949	23.93554189	24.29624975	3.360559756	20.93568999	24.29624975
26	0	0.001063916	0.168522128	3.378086047	3.401230778	3.404573235	3.4046468	24.17428039	24.53507183	3.401230778	21.13384105	24.53507183
27	0	0.001813323	0.01353287	3.595564708	3.59929825	3.6029868	3.6032334	24.41301888	24.7787302	3.59929825	21.17943195	24.7787302
28	0	0.001063916	0.168522128	3.616824541	3.643304913	3.646647371	3.6467209	24.65175737	25.01755228	3.643304913	21.37424736	25.01755228
29	0	0.001813323	0.01353287	3.834303202	3.841372385	3.846728756	3.8469754	24.89049587	25.25620719	3.841372385	21.4148348	25.25620719
30	0	0.001063916	0.168522128	3.855563035	3.882043407	3.887053685	3.8871273	25.12923436	25.49502927	3.882043407	21.61298586	25.49502927
31	0	0.001813323	0.01353287	4.073041696	4.080110879	4.08546725	4.0857139	25.36797286	25.73368418	4.080110879	21.6535733	25.73368418
32	0	0.002158316	0.204665878	4.094301529	4.123610421	4.128620607	4.1286932	25.60671135	25.96749924	4.123610421	21.84388882	25.96749924
33	0	0.001813323	0.01353287	4.311780191	4.318849374	4.320870103	4.3211167	25.84544985	26.2061577	4.318849374	21.88730833	26.2061577
34	0	0.002158316	0.239909628	4.333040024	4.356184755	4.357859392	4.357933	26.08418834	26.44998324	4.356184755	22.09379849	26.44998324
35	0	0.001813323	0.01353287	4.550518685	4.554252227	4.556272956	4.5565196	26.32292683	26.68363469	4.554252227	22.12938246	26.68363469
36	0	0.002158316	0.239909628	4.571778518	4.59825889	4.601601347	4.6016749	26.56166533	26.9249585	4.59825889	22.32669961	26.9249585
37	1.155915	1.15656433	2.777600064	4.67160191	4.675372079	4.677050138	4.6771587	26.80040382	27.16632983	3.519457517	22.49095775	26.01041526
38	1.155915	1.15656433	2.777600064	4.674270423	4.67870772	4.683721419	4.68383	27.03914232	27.40506832	3.522793158	22.7263606	26.24915376
39	0	0.001994453	0.016544849	4.789257179	5.164130662	4.801378236	4.8016155	27.5166193	27.88232845	5.164130662	22.71819779	27.88232845
40	0	0.001994453	0.016544849	4.789257179	5.164130662	4.807151767	4.8083238	27.7553578	28.12128326	5.164130662	22.9571526	28.12128326
41	0	0.002158316	0.239909628	4.810517012	4.833661743	4.838672021	4.8387456	27.99409629	28.35488774	4.833661743	23.52122599	28.35488774
42	0	0.002158316	0.239909628	5.049255506	5.079071519	5.080746156	5.0808197	28.47157328	28.83236472	5.079071519	23.7532932	28.83236472
43	0	0.002158316	0.239909628	5.287994001	5.317810013	5.321152471	5.321226	28.71031178	29.07610668	5.317810013	23.75829667	29.07610668
44	0	0.002401516	0.276053378	5.526732495	5.552705746	5.556048111	5.5561207	28.94905027	29.30983816	5.552705746	23.75713242	29.30983816
45	0	0.002401516	0.311297128	5.765470989	5.791951361	5.793625998	5.7936996	29.18778876	29.55358367	5.791951361	23.76163231	29.55358367
46	0	0.00242158	0.020265524	5.98294965	5.986390675	5.988152232	5.9882432	29.42652726	29.79220255	5.986390675	23.80581188	29.79220255
47	0	0.002401516	0.311297128	6.004209483	6.030689855	6.035700133	6.0357737	29.66526575	30.03106066	6.030689855	24.0003708	30.03106066
48	0	0.00242158	0.02110667	6.221688144	6.232092968	6.235781518	6.2360281	29.90400425	30.2647121	6.232092968	24.03261914	30.2647121
49	0	0.002401516	0.311297128	6.242947977	6.266092708	6.271102987	6.2711766	30.14274274	30.50353418	6.266092708	24.23744147	30.50353418
50	1.155915	1.15668593	4.668933397	6.290935243	6.294641092	6.299653741	6.2997516	30.38148124	30.74486529	5.138726529	24.4502242	29.58895073
51	0	0.00242158	0.02110667	6.460426639	6.46416018	6.469516551	6.4697632	31.09769672	31.45840458	6.46416018	24.9942444	31.45840458
52	0	0.002401516	0.311297128	6.481686472	6.504831203	6.509841481	6.509915	31.33643521	31.70223012	6.504831203	25.19739891	31.70223012
53	0	0.00242158	0.02110667	6.699165133	6.702898675	6.706587225	6.7068338	31.57517371	31.94088503	6.702898675	25.23798635	31.94088503
54	0	0.002401516	0.311297128	6.720424966	6.750240979	6.751915616	6.7519892	31.8139122	32.1797071	6.750240979	25.42946613	32.1797071
55	0	0.00242158	0.02110667	6.937903627	6.941637169	6.943657898	6.9439045	32.05265069	32.41586028	6.941637169	25.47422311	32.41586028
56	0	0.002887916	0.347440878	6.95916346	6.985136711	6.988479076	6.9885517	32.29138919	32.65718054	6.985136711	25.67204383	32.65718054
57	0	0.00242158	0.02110667	7.176642121	7.183711304	7.185732034	7.1859786	32.53012768	32.895839	7.183711304	25.7121277	32.895839
58	0	0.002887916	0.382684628	7.197901954	7.224382326	7.226056963	7.2261305	32.76886618	33.12965762	7.224382326	25.90527529	33.12965762
59	0	0.00242158	0.02110667	7.415380615	7.422449798	7.424470528	7.4247171	33.00760467	33.37092471	7.422449798	25.94847491	33.37092471
60	0	0.002887916	0.382684628	7.436640448	7.459785179	7.463127637	7.4632012	33.24634317	33.60963634	7.459785179	26.14985116	33.60963634
61	0	0.002887916	0.382684628	7.675378943	7.705194956	7.710205234	7.7102788	33.72382015	34.08711333	7.705194956	26.38191837	34.08711333
62	0	0.002887916	0.382684628	7.914117437	7.940597809	7.943940266	7.9440138	33.96255865	34.32335009	7.940597809	26.38275228	34.32335009
63	0	0.002887916	0.382684628	8.152855931	8.179336303	8.182678761	8.1827523	34.44003564	34.80583054	8.179336303	26.62649424	34.80583054
64	1.155915	1.15668593	6.28826673	8.182268576	8.192710028	8.197723727	8.1978323	34.67877413	35.03969667	7.036795466	26.84698665	33.88378211
65	1.155915	1.15668593	6.28826673	8.184937089	8.202716951	8.20773065	8.2078392	34.91751263	35.27843517	7.046802388	27.07571822	34.12252061
66	0	0.003380973	0.418828378	8.391594425	8.405323435	8.410330776	8.4103743	35.15625112	35.51692999	8.405323435	27.11160656	35.51692999
67	0	0.00266478	0.024118649	8.609073086	8.612514112	8.61761131	8.6177022	35.39498961	35.76066491	8.612514112	27.1481508	35.76066491
68	0	0.003380973	0.426422128	8.63033292	8.660148932	8.665159211	8.6652328	35.63372811	35.99702128	8.660148932	27.33687235	35.99702128
69	0	0.00266478	0.024959795	8.847811581	8.858216405	8.863572775	8.8638194	36.1112051	36.47441469	8.858216405	27.61619828	36.47441469
70	0	0.003380973	0.426422128	8.869071414	8.898887427	8.902229884	8.9023035	36.34994359	36.71323676	8.898887427	27.81434934	36.71323676
71	0	0.00266478	0.024959795	9.086550075	9.096954899	9.100643449	9.1008901	36.58868208	36.9543934	9.096954899	27.85743851	36.9543934
72	0	0.003380973	0.426422128	9.107809908	9.130954639	9.134297097	9.1343707	36.82742058	37.19071375	9.130954639	28.05975911	37.19071375
73	0	0.001671916	0.006439826	9.290633705	9.301010835	9.302687844	9.3027857	37.06615907	37.42954313	9.301010835	28.12853229	37.42954313
74	0	0.00266478	0.024959795	9.325288569	9.335693393	9.337714122	9.3379607	37.30489757	37.67060889	9.335693393	28.33491549	37.67060889
75	0	0.003380973	0.426422128	9.346548402	9.369693133	9.37136777	9.3714413	37.54363606	37.9044275	9.369693133	28.53473437	37.9044275

76	0	0.00266478	0.024959795	9.564027063	9.574431887	9.578120437	9.578367	38.02111305	38.38182091	9.574431887	28.80738902	38.38182091
77	0	0.003380973	0.426422128	9.585286896	9.608431627	9.613441906	9.6135155	38.25985154	38.62314472	9.608431627	29.01471309	38.62314472
78	1.155915	1.15680753	8.179600064	9.80160191	9.805307758	9.810320408	9.8104182	38.49859004	38.86447583	8.649393196	29.05916807	37.70856126
79	0	0.00266478	0.024959795	9.802765558	9.808816445	9.812161275	9.8124079	38.73732853	39.10303985	9.808816445	29.29422341	39.10303985
80	0	0.003380973	0.426422128	9.824025391	9.853841403	9.858851682	9.8589252	38.97606703	39.3393602	9.853841403	29.4855188	39.3393602
81	0	0.00266478	0.024959795	10.04150405	10.04857323	10.05059396	10.050841	39.21480552	39.57801511	10.04857323	29.52944188	39.57801511
82	0	0.003996973	0.462565878	10.06276388	10.06982161	10.07316113	10.073205	39.45354402	39.81922635	10.06982161	29.74940474	39.81922635
83	0	0.003996973	0.470159628	10.30150238	10.33131839	10.33466085	10.334734	39.931021	40.29431418	10.33131839	29.96299578	40.29431418
84	0	0.001307116	0.027971774	10.51898104	10.52253586	10.52587823	10.525951	40.1697595	40.53555085	10.52253586	30.01301499	40.53555085
85	0	0.003996973	0.470159628	10.54024087	10.5633856	10.56839588	10.568469	40.40849799	40.76928943	10.5633856	30.20590383	40.76928943
86	0	0.001307116	0.030908754	10.75771953	10.76461567	10.76795813	10.768032	40.64723649	41.01303139	10.76461567	30.24841572	41.01303139
87	0	0.003996973	0.470159628	10.77897937	10.8021241	10.80546656	10.80554	40.88597498	41.24926815	10.8021241	30.44714405	41.24926815
88	0	0.001307116	0.030908754	10.99645803	11.00001852	11.0050288	11.005102	41.12471347	41.49050838	11.00001852	30.49048985	41.49050838
89	0	0.003996973	0.470159628	11.01771786	11.04753387	11.05087633	11.05095	41.36345197	41.72424341	11.04753387	30.67670954	41.72424341
90	0	0.001307116	0.030908754	11.23519652	11.23875702	11.24209948	11.242173	41.84092896	42.20672386	11.23875702	30.96796684	42.20672386
91	0	0.003996973	0.470159628	11.25645636	11.28627237	11.28794701	11.288021	42.07966745	42.44296062	11.28627237	31.15668826	42.44296062
92	0	0.001307116	0.030908754	11.47393502	11.48416679	11.48750925	11.487583	42.55714444	42.92043761	11.48416679	31.43627082	42.92043761
93	0	0.003996973	0.470159628	11.49519485	11.52501086	11.53002114	11.530095	42.79588293	43.16167784	11.52501086	31.63666697	43.16167784
94	1.155915	1.15680753	9.798933397	11.69293524	11.70004105	11.70505475	11.705163	43.03462143	43.3980457	10.54412649	31.69800465	42.24213114
95	1.155915	1.15680753	9.798933397	11.69560376	11.71004798	11.71506168	11.71517	43.27335992	43.63928593	10.55413341	31.92923795	42.48337137
96	0	0.001307116	0.030908754	11.71267351	11.71623401	11.72124429	11.721318	43.51209842	43.87539159	11.71623401	32.15915758	43.87539159
97	0	0.001185516	0.00412718	10.20010842	11.75918716	11.76419981	11.764298	43.75083691	44.11171924	11.75918716	32.35253208	44.11171924
98	1.155915	1.15705073	11.69026673	13.31226858	13.31597442	13.31765143	13.317749	48.04812981	48.41401559	12.16005986	35.09804117	47.25810103
99	1.155915	1.15705073	13.30960006	15.20360191	15.20737208	15.21238578	15.212494	52.5841612	52.94508374	14.05145752	37.73771166	51.78916918
100	1.155915	1.15705073	13.30960006	15.20627042	15.217379	15.21905706	15.219166	52.82289969	53.18632397	14.06146444	37.96894496	52.0304094
101	1.155915	1.15753713	15.2009334	16.82293524	16.82997673	16.83498938	16.835087	55.44902313	55.80990545	15.67406217	38.97992872	54.65399089
102	1.155915	1.15753713	16.82026673	18.71426858	18.71803875	18.72138462	18.721493	59.74631602	60.1097403	17.56212418	41.39170155	58.95382574
103	1.155915	1.15753713	16.82026673	18.71693709	18.72804567	18.72972373	18.729832	59.98505452	60.35098052	17.57213111	41.62293485	59.19506596
104	1.155915	1.15778033	18.71160006	20.33360191	20.34397904	20.34899169	20.34909	63.08865494	63.45454073	19.18806448	43.11056169	62.29862617

CG63 Results (Time Stamps in seconds)- Simulation One

Item#	StartTime (of Reqst)	LANOutTime	ADNS-Time	Entry-Time	Info-Time (Rqst Rcved)	NCTAMS-Time	SBM-Time	RBM-Time	End Time (Delivery)	TimeforRequest	TimetoDeliver	Total Time
1	0	0.001038466	0.001160066	0.064553579	0.068545951	0.074131647	0.074516	0.777907952	1.138647686	0.068545951	1.070101736	1.138647686
2	0	0.001038466	0.061885066	0.135478579	0.139585487	0.143604843	0.1440502	1.255384941	1.61613878	0.139585487	1.476553293	1.61613878
3	0	0.001038466	0.061885066	0.138147092	0.146256769	0.151943945	0.1523893	1.494123435	1.857379005	0.146256769	1.711122236	1.857379005
4	0	0.001284866	0.132810066	0.196203579	0.200195951	0.204113826	0.2044982	2.449077412	2.812318876	0.200195951	2.612122926	2.812318876
5	0	0.001284866	0.193535066	0.267128579	0.271235487	0.275254843	0.2757002	3.642769883	4.003523722	0.271235487	3.732288236	4.003523722
6	0	0.001284866	0.193535066	0.269797092	0.277906769	0.281926125	0.2823714	3.881508377	4.247265678	0.277906769	3.969358909	4.247265678
7	0	0.001406466	0.264460066	0.327853579	0.335181592	0.337431647	0.337816	5.075200848	5.438480335	0.335181592	5.103298743	5.438480335
8	0	0.001406466	0.325185066	0.398778579	0.402885487	0.409157716	0.409603	6.030154825	6.393410395	0.402885487	5.990524908	6.393410395
9	0	0.001406466	0.325185066	0.401447092	0.406221128	0.414161177	0.4146065	6.268893319	6.63465062	0.406221128	6.228429492	6.63465062
10	0	0.001899266	0.396110066	0.459503579	0.469880709	0.471557718	0.4716556	7.223847296	7.589733083	0.469880709	7.119852374	7.589733083
11	0	3.15E-05	4.46E-05	0.491964283	0.498868394	0.504078508	0.5042373	7.701324285	8.064513544	0.498868394	7.565645151	8.064513544
12	0	0.001899266	0.456835066	0.530428579	0.54087003	0.542548089	0.5426567	8.417539767	8.780964041	0.54087003	8.240094011	8.780964041
13	0	0.001899266	0.456835066	0.533097092	0.550876953	0.555890653	0.5559992	8.895016756	9.260942761	0.550876953	8.710065807	9.260942761
14	0	0.002290531	0.527760066	0.596153579	0.603226598	0.608239763	0.6083429	9.849970733	10.21587623	0.603226598	9.612649636	10.21587623
15	0	0.002290531	0.593485066	0.667078579	0.670848748	0.674194627	0.6743032	10.80492471	11.16584725	0.670848748	10.4949985	11.16584725
16	0	0.002290531	0.593485066	0.669747092	0.680855671	0.68253373	0.6826423	11.0436632	11.40708748	0.680855671	10.72623181	11.40708748
17	0	0.002763266	0.664410066	0.727803579	0.734845068	0.738189898	0.7382877	11.99861718	12.36450297	0.734845068	11.6296579	12.36450297
18	0	0.002763266	0.725135066	0.798728579	0.805834389	0.809180268	0.8092888	13.43104815	13.79697415	0.805834389	12.99113976	13.79697415
19	0	0.002763266	0.725135066	0.801397092	0.815841312	0.820855012	0.8209636	13.66978664	14.03070918	0.815841312	13.21486787	14.03070918
20	0	0.003254466	0.796060066	0.859453579	0.866495068	0.869839898	0.8699377	14.62474062	14.98562294	0.866495068	14.11912787	14.98562294
21	0	0.003254466	0.856785066	0.930378579	0.94082003	0.944165909	0.9442745	15.57969459	15.9456206	0.94082003	15.00480057	15.9456206
22	0	0.003254466	0.856785066	0.933047092	0.950826953	0.952505012	0.9526136	15.81843309	16.17935563	0.950826953	15.22852868	16.17935563
23	0	0.003992324	0.927710066	0.993603579	1.003996474	1.009009381	1.0091098	17.01212556	17.37301774	1.003996474	16.36902127	17.37301774
24	0	0.003992324	0.990935066	1.064528579	1.07497003	1.076648089	1.0767567	17.96707954	18.32800208	1.07497003	17.25303205	18.32800208
25	0	0.003992324	0.990935066	1.067197092	1.078305671	1.07998373	1.0800923	18.20581803	18.56674057	1.078305671	17.4884349	18.56674057
26	0	0.001179873	0.002508866	1.93724736	1.944304615	1.947649701	1.9477502	20.35446448	20.72036012	1.944304615	18.77605551	20.72036012
27	0	5.31E-05	0.005405381	2.879349225	2.886225207	2.887899516	2.8879697	22.74184942	23.10512999	2.886225207	20.21890478	23.10512999
28	0	0.000195141	0.01364228	3.11808772	3.492956085	3.12815271	3.129115	23.21932641	23.58019987	3.492956085	20.08724379	23.58019987
29	0	0.001528066	0.001766466	1.636607021	3.199307923	3.201557978	3.2019423	23.6968034	24.05754313	3.199307923	20.85823521	24.05754313
30	0	0.00030616	0.024690382	10.28024255	10.28718088	10.28908567	10.289263	39.69228251	40.05797771	10.28718088	29.77079684	40.05797771
31	0	0.001179873	1.688508866	11.07935251	11.08979396	11.09313984	11.093248	41.60219046	41.96561474	11.08979396	30.87582078	41.96561474
32	0	0.001179873	1.688508866	11.318091	11.32853246	11.33021051	11.330319	42.31840595	42.68183022	11.32853246	31.35329776	42.68183022
33	0	0.000550466	0.000754579	11.73393334	11.7693627	11.77137447	11.771616	43.98957541	44.35028202	11.7693627	32.58091932	44.35028202
34	0	0.00030616	0.030813097	11.95141201	11.96181683	11.96383756	11.964084	44.46705239	44.83276371	11.96181683	32.87094688	44.83276371
35	0	0.000550466	1.006141548	11.97267184	12.0026609	12.00468163	12.004928	44.70579089	45.06900048	12.0026609	33.06633958	45.06900048
36	0	0.00030616	0.030813097	12.1901505	12.20055532	12.20257605	12.202823	45.18326788	45.54647747	12.20055532	33.34592214	45.54647747
37	0	0.000550466	1.006141548	12.21141033	12.24139939	12.24675576	12.247002	45.42200637	45.78271423	12.24139939	33.54131484	45.78271423
38	0	0.00030616	0.030813097	12.42888899	12.43262254	12.43464327	12.43489	45.66074486	46.02395445	12.43262254	33.59133192	46.02395445
39	0	0.000550466	1.006141548	12.45014883	12.47680225	12.4804908	12.480737	45.89948336	46.26269295	12.47680225	33.7858907	46.26269295
40	0	0.00030616	0.030813097	12.66762749	12.67469667	12.6767174	12.676964	46.13822185	46.50143144	12.67469667	33.82673477	46.50143144
41	0	0.000550466	1.006141548	12.68888732	12.7122051	12.71756147	12.717808	46.37696035	46.74267167	12.7122051	34.03046657	46.74267167
42	0	0.00030616	0.030813097	12.90636598	12.91343517	12.91879154	12.919038	46.85443734	47.21514519	12.91343517	34.30171003	47.21514519
43	0	0.000550466	1.006141548	12.92762582	12.95094359	12.95296432	12.953211	47.09317583	47.45638542	12.95094359	34.50544183	47.45638542
44	0	0.000428866	0.039849034	13.14510448	13.15549919	13.16084661	13.161088	47.33191432	47.6976244	13.15549919	34.54212521	47.6976244
45	0	0.000672066	1.042285298	13.16636431	13.18917054	13.19118231	13.191424	47.57065282	47.93636289	13.18917054	34.74719236	47.93636289

46	0	0.000428866	0.048659972	13.38384297	13.39424779	13.39960417	13.399851	48.2868683	48.65257962	13.39424779	35.25833183	48.65257962
47	0	0.000672066	1.077529048	13.4051028	13.42842058	13.43210913	13.432356	48.5256068	48.88881638	13.42842058	35.4603958	48.88881638
48	0	0.001528066	1.6210998	11.4501694	13.58358822	13.58927539	13.589721	48.76434529	49.13010259	13.58358822	35.54651437	49.13010259
49	0	0.000428866	0.048659972	13.62258146	13.62631501	13.63000356	13.63025	49.00308378	49.36629337	13.62631501	35.73997837	49.36629337
50	0	0.000672066	1.077529048	13.6438413	13.67383036	13.67751891	13.677766	49.24182228	49.6075336	13.67383036	35.93370324	49.6075336
51	0	0.000428866	0.048659972	13.86131996	13.8650535	13.86707423	13.867321	49.71929927	50.08250886	13.8650535	36.21745535	50.08250886
52	0	0.000672066	1.077529048	13.88257979	13.91256885	13.9162574	13.916504	49.95803776	50.31874562	13.91256885	36.40617677	50.31874562
53	0	0.000428866	0.048659972	14.10005845	14.11046328	14.11581965	14.116066	50.19677625	50.56248757	14.11046328	36.4520243	50.56248757
54	0	0.000672066	1.077529048	14.12131829	14.1479717	14.14999243	14.150239	50.43551475	50.79872434	14.1479717	36.65075263	50.79872434
55	0	0.000428866	0.048659972	14.33879695	14.34920177	14.35455814	14.354805	50.67425324	51.03746283	14.34920177	36.68826106	51.03746283
56	0	0.000672066	1.077529048	14.36005678	14.38337456	14.38706311	14.38731	50.91299174	51.27870306	14.38337456	36.8953285	51.27870306
57	0	0.000181492	0.057695909	14.57753544	14.58442103	14.58609549	14.586167	51.15173023	51.51751854	14.58442103	36.93309751	51.51751854
58	0	0.000793666	1.113672798	14.59879527	14.62810417	14.63311435	14.633187	51.39046873	51.75125662	14.62810417	37.12315245	51.75125662
59	0	0.000181492	0.06631345	14.81627394	14.82650571	14.82818035	14.828254	51.62920722	51.98999866	14.82650571	37.16349295	51.98999866
60	0	0.000793666	1.148916548	14.83753377	14.86734978	14.87069224	14.870766	51.86794571	52.22873716	14.86734978	37.36138737	52.22873716
61	0	0.000181492	0.06631345	15.05501243	15.06190857	15.06525102	15.065325	52.10668421	52.46997738	15.06190857	37.40806881	52.46997738
62	0	0.000793666	1.148916548	15.07627226	16.09941699	15.10442727	15.104501	52.3454227	52.71121761	15.09941699	37.61180061	52.71121761
63	0	0.000181492	0.06631345	15.29375092	15.29731142	15.3023217	15.302395	53.06163819	53.42493136	15.29731142	38.12761994	53.42493136
64	0	0.000793666	1.148916548	15.31501076	15.34149113	15.34650141	15.346575	53.30037668	53.66617158	15.34149113	38.32468045	53.66617158
65	0	0.001528066	1.6210998	11.75214567	15.40758822	15.40993975	15.410385	53.53911517	53.89986901	15.40758822	38.4922808	53.89986901
66	0	0.003130847	0.075349388	15.53248942	15.90262918	15.54269453	15.543581	53.77785367	54.143713	15.90262918	38.24108381	54.143713
67	0	0.000793666	1.148916548	15.55374925	15.58022962	15.58190426	15.581978	54.01659216	54.3773836	15.58022962	38.79715398	54.3773836
68	0	0.000793666	1.148916548	15.79248775	15.81563248	15.82064276	15.820716	54.25533066	54.62112556	15.81563248	38.80549308	54.62112556
69	0	0.001776066	1.185060298	16.03122624	16.05719949	16.06054186	16.060614	54.49406915	54.85986051	16.05719949	38.80266101	54.85986051
70	0	0.001776066	1.220304048	16.26996473	16.29644511	16.29978756	16.299861	54.73280765	55.09359909	16.29644511	38.79715398	55.09359909
71	0	0.001776066	1.220304048	16.50870323	16.5351836	16.53852606	16.5386	54.97154614	55.33233758	16.5351836	38.79715398	55.33233758
72	0	0.001776066	1.220304048	16.74744172	16.77392209	16.77893237	16.779006	55.21028463	55.57607954	16.77392209	38.80215744	55.57607954
73	0	0.002145666	0.092516897	16.96492038	16.97181085	16.97515321	16.975226	55.68776162	56.05105125	16.97181085	39.0792404	56.05105125
74	0	0.001776066	1.220304048	16.98618022	17.01599623	17.02100651	17.02108	55.92650012	56.29229502	17.01599623	39.27629879	56.29229502
75	0	0.002145666	0.101327835	17.20365888	17.20721937	17.21222965	17.212303	56.16523861	56.53103351	17.20721937	39.32381414	56.53103351
76	0	0.001776066	1.220304048	17.22491871	17.25139908	17.25307372	17.253147	56.6427156	57.00600877	17.25139908	39.75460969	57.00600877
77	0	0.002145666	0.101327835	17.44239737	17.44595787	17.45096815	17.451042	56.88145409	57.247249	17.44595787	39.80129113	57.247249
78	0	0.002270466	1.256447798	17.46365721	17.48963046	17.491305	17.491378	57.12019259	57.48098048	17.48963046	39.99135002	57.48098048
79	0	0.002145666	0.101327835	17.68113587	17.688032	17.68970664	17.68978	57.35893108	57.72222425	17.688032	40.03419225	57.72222425
80	0	0.002270466	1.291691548	17.7023957	17.73221171	17.73388635	17.73396	57.59766958	57.96346448	17.73221171	40.23125277	57.96346448
81	0	0.002145666	0.101327835	17.91987436	17.93010614	17.93511642	17.93519	57.83640807	58.19970124	17.93010614	40.2695951	58.19970124
82	0	0.002270466	1.291691548	17.94113419	17.96427892	17.96595356	17.966027	58.07514656	58.43593801	17.96427892	40.47165908	58.43593801
83	0	0.002145666	0.101327835	18.15861286	18.16884463	18.17051927	18.170593	58.31388506	58.67967996	18.16884463	40.51083533	58.67967996
84	0	0.002270466	1.291691548	18.17987269	18.2096887	18.21303116	18.213105	58.55262355	58.91341499	18.2096887	40.70372629	58.91341499
85	0	0.002270466	1.291691548	18.41861118	18.44175591	18.44676619	18.44684	59.03010054	59.39089198	18.44175591	40.94913607	59.39089198
86	0	0.002270466	1.291691548	18.65734968	18.68716569	18.68884033	18.688914	59.50757753	59.8708707	18.68716569	41.18370501	59.8708707
87	0	0.002641666	1.327835298	18.89608817	18.92539706	18.92873943	18.928812	60.46253151	60.8233194	18.92539706	41.89792234	60.8233194
88	0	0.002641666	1.363079048	19.13482667	19.16130704	19.16631732	19.166391	61.41748548	61.78328039	19.16130704	42.62197335	61.78328039
89	0	0.002641666	1.363079048	19.37356516	19.40338117	19.40839145	19.408465	61.65622398	62.02201888	19.40338117	42.61863771	62.02201888
90	0	0.002641666	1.363079048	19.61230365	19.64211967	19.6437943	19.643868	61.89496247	62.25825564	19.64211967	42.61613598	62.25825564
91	0	0.002641666	1.363079048	19.85104215	19.87752252	19.88086498	19.880939	62.13370097	62.49699414	19.87752252	42.61947162	62.49699414
92	0	0.002641666	1.363079048	20.08978064	20.11626101	20.12127129	20.121345	62.61117795	62.97447113	20.11626101	42.85821011	62.97447113
93	0	0.003170976	1.399222798	20.32851914	20.35398596	20.35899408	20.359045	63.32739344	63.69060361	20.35398596	43.33661765	63.69060361
94	0	0.003170976	1.414316548	20.56725763	20.593738	20.59708046	20.597154	63.80487043	64.17066533	20.593738	43.57692733	64.17066533
95	0	0.003170976	1.414316548	20.80599612	20.83581214	20.83748677	20.83756	64.28234741	64.64814232	20.83581214	43.81233018	64.64814232
96	0	0.003170976	1.414316548	21.04473462	21.06787935	21.07288963	21.072963	64.9985629	65.36185607	21.06787935	44.29397672	65.36185607

DDG65 Results (Time Stamps in seconds)- Simulation One

Item#	StartTime	LANOutTime	ADNS-Time	Entry-Time	Info-Time	NCTAMS-Time	SBM-Time	RBM-Time	End Time	TimeforRequest	TimetoDeliver	Total Time
	(of Reqst)				(Rqst Rcved)				(Delivery)			
1	0	0.00187577	0.002120154	0.038456965	0.057823028	0.051087948	0.0514632	0.300430964	0.663670319	0.057823028	0.605847291	0.663670319
2	0	0.00187577	0.002120154	0.038456965	0.057823028	0.05341214	0.0545841	0.539169458	0.900091457	0.057823028	0.842268429	0.900091457
3	0	0.001915934	0.106713452	0.175106965	0.185826764	0.191462205	0.1918764	2.210338918	2.576089027	0.185826764	2.390262264	2.576089027
4	0	0.001915934	0.172438452	0.246031965	0.250138873	0.252490408	0.2529357	2.9265544	3.28730824	0.250138873	3.037169367	3.28730824
5	0	0.001915934	0.172438452	0.248700478	0.260145796	0.262497331	0.2629426	3.165292895	3.531050195	0.260145796	3.270904399	3.531050195
6	0	0.00201747	0.243363452	0.306756965	0.314084978	0.318002853	0.3183872	4.836462354	5.202205549	0.314084978	4.888120572	5.202205549
7	0	0.00201747	0.304088452	0.377681965	0.388460155	0.394147331	0.3945926	5.552677837	5.913431676	0.388460155	5.524971521	5.913431676
8	0	0.00201747	0.304088452	0.380350478	0.398467078	0.404154254	0.4045996	5.791416331	6.154671901	0.398467078	5.756204823	6.154671901
9	0	0.00275507	0.375013452	0.438406965	0.442399337	0.446317212	0.4467016	6.985108802	7.348350267	0.442399337	6.90595093	7.348350267
10	0	0.00275507	0.435738452	0.509331965	0.516774514	0.52246169	0.522907	7.940062779	8.303318349	0.516774514	7.786543835	8.303318349
11	0	0.00275507	0.435738452	0.512000478	0.526781437	0.529132972	0.5295783	8.178801273	8.544558574	0.526781437	8.017777137	8.544558574
12	0	0.00311987	0.506663452	0.570056965	0.580720619	0.586306315	0.5866907	9.611232238	9.974473703	0.580720619	9.393753084	9.974473703
13	0	0.00311987	0.567388452	0.640981965	0.651760155	0.65411169	0.654557	10.32744772	10.69320502	0.651760155	10.04144487	10.69320502
14	0	0.00311987	0.567388452	0.643650478	0.658431437	0.660782972	0.6612283	10.56618622	10.92694005	0.658431437	10.26850862	10.92694005
15	0	0.00140787	0.638313452	0.701706965	0.705412814	0.707089823	0.7071877	11.75987869	12.12326274	0.705412814	11.41784993	12.12326274
16	0	0.00140787	0.699038452	0.772631965	0.785114264	0.786792323	0.7869009	12.95357116	13.31949716	0.785114264	12.5343829	13.31949716
17	0	0.00140787	0.699038452	0.775300478	0.791785546	0.796799246	0.7969078	13.19230965	13.55823566	0.791785546	12.76645011	13.55823566
18	0	0.004100927	0.769963452	0.835856965	0.84321305	0.848823619	0.8492229	14.38600212	14.74924704	0.84321305	13.90603399	14.74924704
19	0	0.004100927	0.833188452	0.906781965	0.917560155	0.921579511	0.9220248	15.10221761	15.46797491	0.917560155	14.55041475	15.46797491
20	0	0.004100927	0.833188452	0.909450478	0.924231437	0.928250793	0.9286961	15.3409561	15.7067134	0.924231437	14.78248196	15.7067134
21	0	0.004593727	0.904113452	0.970006965	0.976636239	0.980578987	0.9809783	16.77338706	17.13413026	0.976636239	16.15749402	17.13413026
22	0	0.004593727	0.967338452	1.040931965	1.051710155	1.055729511	1.0561748	17.48960255	17.85035639	1.051710155	16.79864623	17.85035639
23	0	0.004593727	0.967338452	1.043600478	1.058381437	1.064068613	1.0645139	17.72834104	18.09409834	1.058381437	17.03571691	18.09409834

24	0	0.00079987	0.002609754	3.188644269	6.301312374	6.306325023	6.3064229	30.62021973	30.98110206	6.301312374	24.67978968	30.98110206
25	0	0.00092147	0.003099354	12.74816297	12.75520446	12.76021711	12.760315	46.61569884	46.97658117	12.75520446	34.22137671	46.97658117
26	0	0.00079987	3.065833333	17.22414567	20.87591584	20.8775939	20.877702	64.52108591	64.88701191	20.87591584	44.01109608	64.88701191
DD967 Results (Time Stamps in seconds)- Simulation One												
Item#	StartTime	LANOutTime	ADNS-Time	Entry-Time	Info-Time	NCTAMS-Time	SBM-Time	RBM-Time	End Time	TimeforRequest	TimetoDeliver	Total Time
	(of Reqst)				(Rqst Rcved)				(Delivery)			
			NO AVAILABLE DATA DUE TO EITHER UNKNOWN MODEL ERROR OR SHORT SIMULATION DURATION									
SSN713 Results (Time Stamps in seconds)- Simulation One												
1	0	0.000673509	0.000799397	7.535729449	7.543057461	7.546975337	7.5473597	33.48508166	33.84583866	7.543057461	26.3027812	33.84583866
FFG48 Results (Time Stamps in seconds)- Simulation One												
			NO AVAILABLE DATA DUE TO EITHER UNKNOWN MODEL ERROR OR SHORT SIMULATION DURATION									
AOE10 Results (Time Stamps in seconds)- Simulation One												
			NO AVAILABLE DATA DUE TO EITHER UNKNOWN MODEL ERROR OR SHORT SIMULATION DURATION									

CVN 72 Results (Attributes) - Simulation One																
Item#	UnitID	NodeID	HFRelay	RB-ID	UnitBandwidth	Priority	Port Priority	Classific.	PropagDistance	#Collisions	#Collisions	FwdChl-ID	ProductID	MsgID	MsgSize	PktSize
	(Ship)	(1-6)	(1 if yes)	(1-7)	(bps)	(0-7)	(1-4)	(1-3)	(km)	(ReqsOut)	(ProductsIn)	(0-7)	(1-8)	(Varies)	(bits)	(bits)
1	72	3		1	768000	4	2	3	72582	0	0	0	5	0	127096.166	2032
2	72	5		3	64000	4	1	2	73082	3	0	0	7	0	54066.84201	1238.042
3	72	5		3	64000	4	1	2	73082	3	0	0	7	0	54066.84201	2089.6
4	72	3		1	768000	4	2	3	73082	0	0	0	5	0	127096.166	2089.6
5	72	5		3	64000	4	1	2	73082	3	0	0	7	0	54066.84201	2089.6
6	72	3		1	768000	4	2	3	72582	0	0	0	5	0	127096.166	2089.6
7	72	5		3	64000	4	1	2	73082	3	0	0	7	0	54066.84201	2089.6
8	72	3		1	768000	4	2	3	72582	0	0	0	5	0	127096.166	2089.6
9	72	3		3	64000	4	2	3	72582	0	0	0	5	0	127096.166	2032
10	72	3		1	768000	4	2	3	72582	0	0	0	5	0	127096.166	2089.6
11	72	3		3	64000	4	2	3	72582	0	0	0	5	0	127096.166	2089.6
12	72	3		1	768000	4	2	3	72582	0	0	0	5	0	127096.166	2089.6
13	72	3		3	64000	4	2	3	72582	0	0	0	5	0	127096.166	2089.6
14	72	6		1	768000	2	4	2	72082	6	0	0	8	0	16510.20194	1611.002
15	72	3		3	64000	4	2	3	72082	0	0	0	5	0	127096.166	2089.6
16	72	6		1	768000	2	4	2	73082	6	0	0	8	0	16510.20194	2089.6
17	72	3		3	64000	4	2	3	72082	0	0	0	5	0	127096.166	2089.6
18	72	6		1	768000	2	4	2	73082	6	0	0	8	0	16510.20194	2089.6
19	72	3		3	64000	4	2	3	72082	0	0	0	5	0	127096.166	2089.6
20	72	5		1	768000	4	1	2	72582	1	0	0	7	0	54066.84201	262.4
21	72	3		3	64000	4	2	3	72082	0	0	0	5	0	127096.166	2032
22	72	4		4	2400	3	3	3	73082	0	0	0	6	7676	179181.8343	3564.8
23	72	3		3	64000	4	2	3	72082	0	0	0	5	0	127096.166	2089.6
24	72	3		3	64000	4	2	3	72582	0	0	0	5	0	127096.166	2089.6
25	72	5		1	768000	4	1	2	72082	1	0	0	0	0	54066.84201	2089.6
26	72	3		3	64000	4	2	3	72082	0	0	0	5	0	127096.166	2089.6
27	72	5		1	768000	4	1	2	73082	1	0	0	7	0	54066.84201	2089.6
28	72	3		3	64000	4	2	3	73082	0	0	0	5	0	127096.166	2089.6
29	72	5		1	768000	4	1	2	73082	1	0	0	7	0	54066.84201	2089.6
30	72	3		3	64000	4	2	3	73082	0	0	0	5	0	127096.166	2089.6
31	72	5		1	768000	4	1	2	73082	1	0	0	7	0	54066.84201	2089.6
32	72	4		3	64000	3	3	3	72082	0	0	0	6	0	261176.8469	2032
33	72	5		1	768000	4	1	2	72082	1	0	0	7	0	54066.84201	2089.6
34	72	4		3	64000	3	3	3	73082	0	0	0	6	0	261176.8469	2089.6
35	72	5		1	768000	4	1	2	72082	1	0	0	7	0	54066.84201	2089.6
36	72	4		3	64000	3	3	3	72582	0	0	0	6	0	261176.8469	2089.6
37	72	4		4	2400	3	3	3	73082	0	0	0	6	7676	179181.8343	4217.6
38	72	4		4	2400	3	3	3	73082	0	0	0	6	7676	179181.8343	4217.6
39	72	2		1	768000	4	2	2	73082	5	0	0	2	13167	13669.09711	1989.097
40	72	2		1	768000	4	2	2	73082	5	0	0	2	13167	13669.09711	12000
41	72	4		3	64000	3	3	3	72082	0	0	0	6	0	261176.8469	2089.6
42	72	4		3	64000	3	3	3	72082	0	0	0	6	0	261176.8469	2089.6
43	72	4		3	64000	3	3	3	73082	0	0	0	6	0	261176.8469	2089.6
44	72	4		3	64000	3	3	3	72082	0	0	0	6	0	261176.8469	2032
45	72	4		3	64000	3	3	3	73082	0	0	0	6	0	261176.8469	2089.6
46	72	5		1	768000	4	1	2	73082	2	0	0	7	0	54066.84201	422.4
47	72	4		3	64000	3	3	3	73082	0	0	0	6	0	261176.8469	2089.6
48	72	5		1	768000	4	1	2	72082	2	0	0	7	0	54066.84201	2089.6
49	72	4		3	64000	3	3	3	72082	0	0	0	6	0	261176.8469	2089.6
50	72	4		4	2400	3	3	3	72582	0	0	0	6	7676	179181.8343	3564.8
51	72	5		1	768000	4	1	2	72082	2	0	0	7	0	54066.84201	2089.6
52	72	4		3	64000	3	3	3	73082	0	0	0	6	0	261176.8469	2089.6
53	72	5		1	768000	4	1	2	73082	2	0	0	7	0	54066.84201	2089.6
54	72	4		3	64000	3	3	3	73082	0	0	0	6	0	261176.8469	2089.6
55	72	5		1	768000	4	1	2	72582	2	0	0	7	0	54066.84201	2089.6
56	72	4		3	64000	3	3	3	73082	0	0	0	6	0	261176.8469	2032
57	72	5		1	768000	4	1	2	73082	2	0	0	7	0	54066.84201	2089.6
58	72	4		3	64000	3	3	3	72082	0	0	0	6	0	261176.8469	2089.6
59	72	5		1	768000	4	1	2	72582	2	0	0	7	0	54066.84201	2089.6
60	72	4		3	64000	3	3	3	72582	0	0	0	6	0	261176.8469	2089.6
61	72	4		3	64000	3	3	3	72582	0	0	0	6	0	261176.8469	2089.6
62	72	4		3	64000	3	3	3	72082	0	0	0	6	0	261176.8469	2089.6
63	72	4		3	64000	3	3	3	73082	0	0	0	6	0	261176.8469	2089.6
64	72	4		4	2400	3	3	3	72082	0	0	0	6	7676	179181.8343	4217.6
65	72	4		4	2400	3	3	3	72082	0	0	0	6	7676	179181.8343	4217.6
66	72	4		3	64000	3	3	3	72082	1	0	0	6	0	261176.8469	262.4
67	72	5		1	768000	4	1	2	73082	2	0	0	7	0	54066.84201	422.4
68	72	4		3	64000	3	3	3	72582	1	0	0	6	0	261176.8469	2089.6
69	72	5		1	768000	4	1	2	72582	2	0	0	7	0	54066.84201	2089.6
70	72	4		3	64000	3	3	3	72582	1	0	0	6	0	261176.8469	2089.6
71	72	5		1	768000	4	1	2	73082	2	0	0	7	0	54066.84201	2089.6
72	72	4		3	64000	3	3	3	72582	1	0	0	6	0	261176.8469	2089.6
73	72	4		7	2400	3	3	3	72582	0	0	0	6	0	261176.8469	3564.8
74	72	5		1	768000	4	1	2	73082	2	0	0	7	0	54066.84201	2089.6
75	72	4		3	64000	3	3	3	72082	1	0	0	6	0	261176.8469	2089.6

76	72	5		1	768000	4	1	2	72082	2	0	0	7	0	54066.84201	2089.6
77	72	4		3	64000	3	3	3	72582	1	0	0	6	0	261176.8469	2089.6
78	72	4		4	2400	3	3	3	73082	0	0	0	6	7676	179181.8343	3564.8
79	72	5		1	768000	4	1	2	73082	2	0	0	7	0	54066.84201	2089.6
80	72	4		3	64000	3	3	3	72582	1	0	0	6	0	261176.8469	2089.6
81	72	5		1	768000	4	1	2	72582	2	0	0	7	0	54066.84201	2089.6
82	72	4		3	64000	3	3	3	73082	1	0	0	6	0	261176.8469	262.4
83	72	4		3	64000	3	3	3	72582	1	0	0	6	0	261176.8469	2089.6
84	72	3		1	768000	4	2	3	73082	0	0	0	5	0	127096.166	2032
85	72	4		3	64000	3	3	3	72082	1	0	0	6	0	261176.8469	2089.6
86	72	3		1	768000	4	2	3	73082	0	0	0	5	0	127096.166	2089.6
87	72	4		3	64000	3	3	3	72582	1	0	0	6	0	261176.8469	2089.6
88	72	3		1	768000	4	2	3	73082	0	0	0	5	0	127096.166	2089.6
89	72	4		3	64000	3	3	3	72082	1	0	0	6	0	261176.8469	2089.6
90	72	3		1	768000	4	2	3	73082	0	0	0	5	0	127096.166	2089.6
91	72	4		3	64000	3	3	3	72582	1	0	0	6	0	261176.8469	2089.6
92	72	3		1	768000	4	2	3	72582	0	0	0	5	0	127096.166	2089.6
93	72	4		3	64000	3	3	3	73082	1	0	0	6	0	261176.8469	2089.6
94	72	4		4	2400	3	3	3	72582	0	0	0	6	7676	179181.8343	4217.6
95	72	4		4	2400	3	3	3	73082	0	0	0	6	7676	179181.8343	4217.6
96	72	3		1	768000	4	2	3	72582	0	0	0	5	0	127096.166	2089.6
97	72	3		5	2400	4	2	3	72082	0	0	0	5	0	127096.166	3564.8
98	72	4		4	2400	3	3	3	73082	0	0	0	6	7676	179181.8343	3564.8
99	72	4		4	2400	3	3	3	72082	0	0	0	6	7676	179181.8343	4217.6
100	72	4		4	2400	3	3	3	72582	0	0	0	6	7676	179181.8343	4217.6
101	72	4		4	2400	3	3	3	72082	0	0	0	6	7676	179181.8343	3564.8
102	72	4		4	2400	3	3	3	72582	0	0	0	6	7676	179181.8343	4217.6
103	72	4		4	2400	3	3	3	73082	0	0	0	6	7676	179181.8343	4217.6
104	72	4		4	2400	3	3	3	73082	0	0	0	6	7676	179181.8343	3564.8

CG63 Results (Attributes) - Simulation One

Item#	UnitID (Ship)	NodeID (1-6)	HFRelay (1 if yes)	RB-ID (1-7)	UnitBandwidth (bps)	Priority (0-7)	Port Priority (1-4)	Classific. (1-3)	PropagDistance (km)	#Collisions (ReqsOut)	#Collisions (ProductsIn)	FwdChl-ID (0-7)	ProductID (1-8)	MsgID (Varies)	MsgSize (bits)	PktSize (bits)
1	63	3		4	64000	4	2	2	72082	0	0	0	5	0	141391.8149	3564.8
2	63	3		4	64000	4	2	2	72082	0	0	0	5	0	141391.8149	4217.6
3	63	3		4	64000	4	2	2	72582	0	0	0	5	0	141391.8149	4217.6
4	63	3		4	64000	4	2	2	72582	0	0	0	5	0	141391.8149	3564.8
5	63	3		4	64000	4	2	2	72082	0	0	0	5	0	141391.8149	4217.6
6	63	3		4	64000	4	2	2	73082	0	0	0	5	0	141391.8149	4217.6
7	63	3		4	64000	4	2	2	72582	0	0	0	5	0	141391.8149	3564.8
8	63	3		4	64000	4	2	2	72582	0	0	0	5	0	141391.8149	4217.6
9	63	3		4	64000	4	2	2	73082	0	0	0	5	0	141391.8149	4217.6
10	63	4		4	64000	4	3	3	73082	0	0	0	6	0	297725.046	3564.8
11	63	6		1	256000	7	4	1	72582	0	0	0	8	0	12828.76844	1148.768
12	63	4		4	64000	4	3	3	72582	0	0	0	6	0	297725.046	4217.6
13	63	4		4	64000	4	3	3	73082	0	0	0	6	0	297725.046	4217.6
14	63	5		4	64000	4	2	3	73082	2	0	0	7	0	55291.29053	3884.8
15	63	5		4	64000	4	2	3	72082	2	0	0	7	0	55291.29053	4217.6
16	63	5		4	64000	4	2	3	72582	2	0	0	7	0	55291.29053	4217.6
17	63	4		4	64000	4	3	3	73082	0	0	0	6	0	297725.046	3564.8
18	63	4		4	64000	4	3	3	73082	0	0	0	6	0	297725.046	4217.6
19	63	4		4	64000	4	3	3	72082	0	0	0	6	0	297725.046	4217.6
20	63	4		4	64000	4	3	3	72082	0	0	0	6	0	297725.046	3564.8
21	63	4		4	64000	4	3	3	73082	0	0	0	6	0	297725.046	4217.6
22	63	4		4	64000	4	3	3	72082	0	0	0	6	0	297725.046	4217.6
23	63	4		4	64000	4	3	3	72082	1	0	0	6	0	297725.046	3724.8
24	63	4		4	64000	4	3	3	72082	1	0	0	6	0	297725.046	4217.6
25	63	4		4	64000	4	3	3	72082	1	0	0	6	0	297725.046	4217.6
26	63	5		7	2400	4	2	3	73082	1	0	0	7	0	55291.29053	3724.8
27	63	4		1	256000	4	3	3	72582	0	0	0	6	0	297725.046	1885.046
28	63	1		1	256000	3	4	2	72082	0	0	0	4	10870	9593.751515	9753.752
29	63	3		5	2400	4	2	2	72082	0	0	0	5	0	141391.8149	3564.8
30	63	3		1	256000	4	2	2	73082	0	0	0	5	0	141391.8149	1343.815
31	63	5		7	2400	4	2	3	72582	1	0	0	7	0	55291.29053	4217.6
32	63	5		7	2400	4	2	3	72582	1	0	0	7	0	55291.29053	4217.6
33	63	3		3	64000	4	2	2	72082	0	0	0	5	0	141391.8149	2032
34	63	3		1	256000	4	2	2	73082	0	0	0	5	0	141391.8149	2089.6
35	63	3		3	64000	4	2	2	72582	0	0	0	5	0	141391.8149	2089.6
36	63	3		1	256000	4	2	2	72582	0	0	0	5	0	141391.8149	2089.6
37	63	3		3	64000	4	2	2	72082	0	0	0	5	0	141391.8149	2089.6
38	63	3		1	256000	4	2	2	72582	0	0	0	5	0	141391.8149	2089.6
39	63	3		3	64000	4	2	2	72582	0	0	0	5	0	141391.8149	2089.6
40	63	3		1	256000	4	2	2	72582	0	0	0	5	0	141391.8149	2089.6
41	63	3		3	64000	4	2	2	73082	0	0	0	5	0	141391.8149	2089.6
42	63	3		1	256000	4	2	2	72082	0	0	0	5	0	141391.8149	2089.6
43	63	3		3	64000	4	2	2	72582	0	0	0	5	0	141391.8149	2089.6
44	63	3		1	256000	4	2	2	73082	0	0	0	5	0	141391.8149	2032
45	63	3		3	64000	4	2	2	73082	0	0	0	5	0	141391.8149	2032

46	63	3		1	256000	4	2	2	73082	0	0	0	5	0	141391.8149	2089.6
47	63	3		3	64000	4	2	2	72582	0	0	0	5	0	141391.8149	2089.6
48	63	3		5	2400	4	2	2	73082	0	0	0	5	0	141391.8149	4217.6
49	63	3		1	256000	4	2	2	72582	0	0	0	5	0	141391.8149	2089.6
50	63	3		3	64000	4	2	2	73082	0	0	0	5	0	141391.8149	2089.6
51	63	3		1	256000	4	2	2	72582	0	0	0	5	0	141391.8149	2089.6
52	63	3		3	64000	4	2	2	72082	0	0	0	5	0	141391.8149	2089.6
53	63	3		1	256000	4	2	2	73082	0	0	0	5	0	141391.8149	2089.6
54	63	3		3	64000	4	2	2	72582	0	0	0	5	0	141391.8149	2089.6
55	63	3		1	256000	4	2	2	72582	0	0	0	5	0	141391.8149	2089.6
56	63	3		3	64000	4	2	2	73082	0	0	0	5	0	141391.8149	2089.6
57	63	5		1	256000	4	2	3	73082	0	0	0	7	0	55291.29053	1982.491
58	63	4		3	64000	4	3	3	72082	0	0	0	6	0	297725.046	2032
59	63	5		1	256000	4	2	3	72082	0	0	0	7	0	55291.29053	2089.6
60	63	4		3	64000	4	3	3	72082	0	0	0	6	0	297725.046	2089.6
61	63	5		1	256000	4	2	3	72582	0	0	0	7	0	55291.29053	2089.6
62	63	4		3	64000	4	3	3	73082	0	0	0	6	0	297725.046	2089.6
63	63	5		1	256000	4	2	3	72582	0	0	0	7	0	55291.29053	2089.6
64	63	4		3	64000	4	3	3	73082	0	0	0	6	0	297725.046	2089.6
65	63	3		5	2400	4	2	2	72082	0	0	0	5	0	141391.8149	4217.6
66	63	2		1	256000	5	3	2	73082	7	0	0	2	24610	8779.414966	8939.415
67	63	4		3	64000	4	3	3	72082	0	0	0	6	0	297725.046	2089.6
68	63	4		3	64000	4	3	3	73082	0	0	0	6	0	297725.046	2089.6
69	63	4		3	64000	4	3	3	73082	0	0	0	6	0	297725.046	2032
70	63	4		3	64000	4	3	3	72082	0	0	0	6	0	297725.046	2089.6
71	63	4		3	64000	4	3	3	72082	0	0	0	6	0	297725.046	2089.6
72	63	4		3	64000	4	3	3	73082	0	0	0	6	0	297725.046	2089.6
73	63	4		1	256000	4	3	3	72582	0	0	0	6	0	297725.046	2032
74	63	4		3	64000	4	3	3	73082	0	0	0	6	0	297725.046	2089.6
75	63	4		1	256000	4	3	3	73082	0	0	0	6	0	297725.046	2089.6
76	63	4		3	64000	4	3	3	72582	0	0	0	6	0	297725.046	2089.6
77	63	4		1	256000	4	3	3	73082	0	0	0	6	0	297725.046	2089.6
78	63	4		3	64000	4	3	3	72082	0	0	0	6	0	297725.046	2032
79	63	4		1	256000	4	3	3	72582	0	0	0	6	0	297725.046	2089.6
80	63	4		3	64000	4	3	3	73082	0	0	0	6	0	297725.046	2089.6
81	63	4		1	256000	4	3	3	72582	0	0	0	6	0	297725.046	2089.6
82	63	4		3	64000	4	3	3	72082	0	0	0	6	0	297725.046	2089.6
83	63	4		1	256000	4	3	3	73082	0	0	0	6	0	297725.046	2089.6
84	63	4		3	64000	4	3	3	72082	0	0	0	6	0	297725.046	2089.6
85	63	4		3	64000	4	3	3	72082	0	0	0	6	0	297725.046	2089.6
86	63	4		3	64000	4	3	3	72582	0	0	0	6	0	297725.046	2089.6
87	63	4		3	64000	4	3	3	72082	0	0	0	6	0	297725.046	2032
88	63	4		3	64000	4	3	3	73082	0	0	0	6	0	297725.046	2089.6
89	63	4		3	64000	4	3	3	73082	0	0	0	6	0	297725.046	2089.6
90	63	4		3	64000	4	3	3	72582	0	0	0	6	0	297725.046	2089.6
91	63	4		3	64000	4	3	3	72582	0	0	0	6	0	297725.046	2089.6
92	63	4		3	64000	4	3	3	72582	0	0	0	6	0	297725.046	2089.6
93	63	5		3	64000	4	2	3	72582	4	0	0	7	0	55291.29053	742.4
94	63	5		3	64000	4	2	3	73082	4	0	0	7	0	55291.29053	2089.6
95	63	5		3	64000	4	2	3	73082	4	0	0	7	0	55291.29053	2089.6
96	63	5		3	64000	4	2	3	72582	4	0	0	7	0	55291.29053	2089.6

DDG65 Results (Attributes) - Simulation One

Item#	UnitID (Ship)	NodeID (1-6)	HFRelay (1 if yes)	RB-ID (1-7)	UnitBandwidth (bps)	Priority (0-7)	Port Priority (1-4)	Classific. (1-3)	PropagDistance (km)	#Collisions (ReqsOut)	#Collisions (ProductsIn)	FwdChl-ID (0-7)	ProductID (1-8)	MsgID (Varies)	MsgSize (bits)	PktSize (bits)
1	65	2		4	64000	2	3	2	72582	4	0	0	3	5153	15147.17624	3467.176
2	65	2		4	64000	2	3	2	72082	4	0	0	3	5153	15147.17624	12000
3	65	5		4	64000	6	2	2	73082	2	0	0	7	0	55781.44279	3884.8
4	65	5		4	64000	6	2	2	72082	2	0	0	7	0	55781.44279	4217.6
5	65	5		4	64000	6	2	2	73082	2	0	0	7	0	55781.44279	4217.6
6	65	4		4	64000	3	3	2	73082	0	0	0	6	0	305691.9907	3564.8
7	65	4		4	64000	3	3	2	72082	0	0	0	6	0	305691.9907	4217.6
8	65	4		4	64000	3	3	2	72582	0	0	0	6	0	305691.9907	4217.6
9	65	4		4	64000	3	3	2	72582	0	0	0	6	0	305691.9907	3564.8
10	65	4		4	64000	3	3	2	72582	0	0	0	6	0	305691.9907	4217.6
11	65	4		4	64000	3	3	2	73082	0	0	0	6	0	305691.9907	4217.6
12	65	4		4	64000	3	3	2	72582	0	0	0	6	0	305691.9907	3564.8
13	65	4		4	64000	3	3	2	73082	0	0	0	6	0	305691.9907	4217.6
14	65	4		4	64000	3	3	2	72082	0	0	0	6	0	305691.9907	4217.6
15	65	3		4	64000	4	2	3	72582	0	0	0	5	0	134178.7471	3564.8
16	65	3		4	64000	4	2	3	73082	0	0	0	5	0	134178.7471	4217.6
17	65	3		4	64000	4	2	3	73082	0	0	0	5	0	134178.7471	4217.6
18	65	4		4	64000	3	3	2	72582	1	0	0	6	0	305691.9907	3724.8
19	65	4		4	64000	3	3	2	73082	1	0	0	6	0	305691.9907	4217.6
20	65	4		4	64000	3	3	2	73082	1	0	0	6	0	305691.9907	4217.6
21	65	4		4	64000	3	3	2	72082	1	0	0	6	0	305691.9907	3724.8
22	65	4		4	64000	3	3	2	72082	1	0	0	6	0	305691.9907	4217.6
23	65	4		4	64000	3	3	2	73082	1	0	0	6	0	305691.9907	4217.6

24	65	3		5	2400	4	2	3	72082	0	0	0	5	0	134178.7471	3564.8
25	65	3		7	2400	4	2	3	72082	0	0	0	5	0	134178.7471	3564.8
26	65	3		5	2400	4	2	3	73082	0	0	0	5	0	134178.7471	4217.6
DD967 Results (Attributes) - Simulation One																
Item#	UnitID (Ship)	NodeID (1-6)	HFRelay (1 if yes)	RB-ID (1-7)	UnitBandwidth (bps)	Priority (0-7)	Port Priority (1-4)	Classific. (1-3)	PropagDistance (km)	#Collisions (ReqsOut)	#Collisions (ProductsIn)	FwdChl-ID (0-7)	ProductID (1-8)	MsgID (Varies)	MsgSize (bits)	PktSize (bits)
					NO AVAILABLE DATA DUE TO EITHER UNKNOWN MODEL ERROR OR SHORT SIMULATION DURATION											
SSN713 Results (Attributes) - Simulation One																
1	713	3		7	2400	5	2	2	72082	0	0	0	5	0	125805.0392	3564.8
FFG48 Results (Attributes) - Simulation One																
					NO AVAILABLE DATA DUE TO EITHER UNKNOWN MODEL ERROR OR SHORT SIMULATION DURATION											
AOE10 Results (Attributes) - Simulation One																
					NO AVAILABLE DATA DUE TO EITHER UNKNOWN MODEL ERROR OR SHORT SIMULATION DURATION											

APPENDIX L. GLOSSARY [GBS, IBS]

1. **Airborne Receive Terminal (ART)** - A GBS receive terminal installed on airborne platforms, to include fixed and rotary wing aircraft. This receiver will receive while on the move.
2. **Broadcast Stream** - The aggregation of video and data products into a continuous digital stream to be transmitted to the space segment. Broadcast streams are created by the Satellite Broadcast Manager, processed and transmitted to the space segment by the injection terminal, and received and processed by the receive suite (receive terminal, cryptographic equipment and Receive Broadcast Manager) for subsequent dissemination to end user systems.
3. **Broadcast Management** - The set of functions, processes, and systems required to collect, assemble, prioritize, transmit, encrypt or decrypt, and disseminate information provided from information producers to end user systems. Divided into two parts: transmit broadcast management and receive broadcast management.
4. **Broadcast satellites** - Satellites with high-power transponders capable of broadcasting data at rates up to 24 megabits per second.
5. **Broadcast services** - Delivery of information products by the GBS system which users employ to improve their combat effectiveness.
6. **Defense Information Infrastructure (DII)** - Resources identified by the Defense Information Systems Agency (DISA) as critical for the flow of information within the Department of Defense. Interoperability and multi-path technologies are being applied to the DII to make it as flexible as possible. DISA and NSA are also working on a multi-level security capability for the DII.
7. **Defense Information Systems Network (DISN)** - A network of communications paths that support information transfer within the DOD.
8. **Direct satellite broadcasting** - A commercially developed system of satellites, equipped with high-power transponders, and small receivers and antennas, which deliver broadcast television and data services to commercial users.
9. **End User** - The ultimate recipient and/or user of the information products broadcast by the GBS.
10. **End User System** - An end user owned and operated system that uses information provided via the GBS.
11. **File** - A discrete or fixed size information product. Imagery, weather information, maps, and Air Tasking Orders (ATO) are examples of file products.
12. **Fixed** - Not intended to be moved.
13. **Fixed Ground Receive Terminal (FGRT)** - A GBS receive terminal installed in a fixed location. This receiver will not receive while on the move.
14. **Fully Connected (FC) Mode** - In this mode, the receive suite can receive the GBS broadcast and a "return" channel exists over which rebroadcast requests are transmitted on a packet-per-packet basis using split protocols. The requests are automatically generated by the RBM and a virtual full-duplex connectivity is achieved. However, user pull is not automatically generated. The users must still request their products from the source by whatever means are available to them. The likelihood that the users are connected to some existing network is high and they will make their user pull requests via the various applications programs they have access to (e.g., SIPRNET and INTELINK).
15. **Global Broadcast Service (GBS)** - An Acquisition Category (ACAT) ID DOD program providing a system of satellites and commercially developed receivers used by a CINC-responsive or -directed broadcast management structure to support the flow of national and theater level generated information products to forces deployed, on the move (in transit), or in garrison.
16. **GBS Receive Terminal** - A small satellite antenna and receive equipment that will receive and convert the downlink GBS radio frequency (RF) signal into a broadcast stream.
17. **GBS Resource Allocation Tool (GRAT)** - A software tool providing a means of operational control over what, when, and to whom information is disseminated in a particular AOR via GBS

18. **Global Coverage** - For GBS, 90 o North to 65 o South latitude, 180 o West to 180 o East longitude.
19. **Ground Mobile Receive Terminal (GMRT)** - A GBS receive terminal which is capable of receiving and processing the GBS downlink while on the move.
20. **Hyperlinks** - A method for information producers to connect one information file to another. This is common technique used when exploring the Internet.
21. **Information Dissemination Management (IDM)** - The function of providing the right information to the right place at the right time in accordance with commanders' policies and optimizing the use of information infrastructure resources. IDM is " content aware" in that it provides access to information, may integrate information from multiple sources, archives products, and may format some information for transmission on the selected media. It involves the safeguarding, compilation, cataloging, caching, distribution, and retrieval of data; manages the flow of information to users; and enables the execution of commanders' information policy
22. **Information Management** - Information management enables warfighting decision makers to collaborate with information producers to get relevant information, generate knowledge and understanding about the Battlespace, and empower successful decision making.
23. **Information Producer** - A provider of file or stream information products. Information producers are categorized as national and theater.
24. **Information Products** - File and stream products from national and theater information producers to be delivered to end users by the GBS system.
25. **Injection Points** - Hardware and software that implements the functions necessary to transmit broadcast streams to the space segment. Injection points are categorized as Primary Injection Points and Theater Injection Points.
26. **Metadata** - A quick synopsis of a file. An example might be file name, classification, when the file was created, how large the file is, who created the file, and a brief description of the contents (i.e., image of target x, map of area y, and ATO for day z). Additional information might also be included. It is usually attached as a header to the file.
27. **Manpackable Receive Terminal (MRT)** - A manpackable GBS receive terminal suitable for special operations.
28. **Manually Connected (MC) Mode** - In this mode, the receive suite can receive the GBS broadcast and the end user has access to some type of manual communications system. A human-in-the-loop is required for submitting user pull requests or requesting the rebroadcast of data products. In other words, the user calls in a request using whatever existing communications capability is available.
29. **Mobile** - Capable of communicating while moving.
30. **Near-Real-Time Dissemination (NRTD)**: NRTD is a tool for the dissemination of time critical intelligence information to the Warfighter and supporting elements. NRTD takes inputs from SIGINT and other intelligence sources, sanitizes the information to the appropriate user specific classification level, and provides the information via existing
31. Client Server (CS) and Broadcast dissemination means. NRTD provides a graphically displayed combined, correlated and deconflicted picture of the battlefield. NRTD provides various interactive channels, segregated by security level, for operational and technical support. The Producer Multi-level Interaction Net (PMIN) provides the ability to interface and exchange information with other users, as well as the NRTD 24-hour Watch, across multiple security levels.
32. **Near Worldwide Coverage** - An area 65 o North latitude to 65 o South latitude, with longitude coverage limited by the UHF Follow-On satellite footprint.
33. **Operational Control** - For the purpose of this CONOPS, operational control focuses on the CINC's ability to control GBS as an information system. The elements which this concept includes are the management functions (SBM and TIM) and the GBS payload. The TIM functions are the tools available to the CINC to exercise this operational control over information resources which are only a part of the entire payload on any one GBS satellite. The SBM functions are the execution elements of the CINC's operational control.
34. **Partially Connected (PC) Mode** - In this mode, the receive suite can receive the GBS broadcast and

provide a means to transmit using standard protocols and applications, user pull or rebroadcast requests. The rebroadcast requests are automatically generated; however, full virtual duplex connectivity is not achieved and user pull is not automatically generated. The users must still request their products from the source by whatever means are available to them. The likelihood that the users are connected to some existing network is high and they will make their user pull requests via the various applications programs they have access to (e.g., SIPRNET and INTELINK)

35. **Primary Injection Point (PIP)** - A fixed injection system that provides the primary uplink of the broadcast streams from the broadcast management segment to the space segment.
36. **Receive Broadcast Management** - The set of functions, processes, and systems associated with receiving and disseminating the file and stream information contained within the broadcast to end users. Receive broadcast management functions include interfacing on the physical layer between the receive suite and the end user system; enabling remote commanding and tuning; filtering and routing information; identifying missing or damaged files; enabling user profiling; decoding and displaying program guides, product catalogs and schedules; and providing anti-virus defense.
37. **Receive Only (RO) Mode** - In this mode, the receive suite can only receive the GBS broadcast. There is no manual or automatic communications channel available. In this case, the user has no means to request products to initiate User Pull.
38. **Receive Site** - A location capable of receiving the GBS downlink directly from the satellite. Receive sites will be fixed, transportable, and mobile.
39. **Receive Suite** - The receive terminal, cryptographic equipment, and receive broadcast management hardware and software required to support an end user's information delivery and dissemination requirements.
40. **Receive Terminal** - The hardware and software that implements the functions necessary to receive the downlink broadcast streams and convert them to data streams for subsequent processing and dissemination by the receive broadcast management hardware and software. Receive terminals are categorized as ground, airborne, shipboard and submarine.
41. **Satellite Broadcast Management** - The set of functions, processes, and systems associated with collecting information products, assembling broadcast streams, and transmitting these streams to the injection point for uplink to the space segment. Satellite broadcast management functions include building the schedule and program guide, coordinating information products, conducting traffic analysis, constructing and transmitting the broadcast stream, providing for protection of the data, technically controlling the GBS broadcast, controlling remote enabling/disabling, and establishing and maintaining the user profile data base.
42. **Scalable Architecture** - The capability of the GBS system architecture to support an array of capabilities and terminal configurations required to meet the end users' operational needs. For example, the transmit and receive data rates will vary dynamically with the capabilities of the injection and receive terminals. The capability of the receive suite will vary depending on whether the equipment will be used in a stand-alone or networked configurations.
43. **Shipboard Receive Terminal (SRT)** - A GBS receive terminal that is installed on ship-board platforms. This receiver will receive while on the move.
44. **Smart Push** - The capability for the end user to define information requirements in advance so that the GBS system can tailor broadcast services without regard to specific user requests.
45. **Space Segment** - The space-borne elements of the GBS system, consisting of the broadcast satellite packages and satellite command and control systems.
46. **Stream** - A continuous or variable duration information product that originates from a national or theater source. Real time video is an example of a stream product.
47. **Sub-surface Receive Terminal (SSRT)** - A GBS receive terminal that is installed on submarine platforms. This receiver will receive while on the move at periscope depth.
48. **Tactical Data Information Exchange Subsystem (TADIXS)-B**: The TADIXS-B broadcast distributes National generated data to operational forces and commanders worldwide. The information delivered directly to tactical users can be used to support I & W, surveillance data, targeting (to

include Over the Horizon Targeting (OTH-T)), maneuver, execution, and battle damage assessment.

49. **Tactical Information Broadcast Service (TIBS)**: IBS provides near real time situation awareness information from an open network of interactive participants using multiple sensors and sources. The TIBS broadcast uses UHF SATCOM assets for network operation and for the relay of out-of-theater specific information into the tactical users area of operations. TIBS participants include a wide variety of national, airborne, surface, and subsurface platforms. (TIBS ORD, approved 9 Dec 96.)
50. **Tactical Related Applications (TRAP) Data Dissemination System (TDDS)**: The TDDS broadcast provides global surveillance information in time for sensor cueing, and I & W. Data is forwarded from sensor to communications gateway/relay for dissemination to worldwide military users via geosynchronous UHF satellite links. TDDS data sources include national and tactical sensor systems. (TRAP ORD, approved 6 Jun 93; Draft TDDS ORD, draft as of Feb 96)
51. **Tactical Reconnaissance Intelligence Exchange System (TRIXS)**: TRIXS provides high accuracy targeting data to multi-service/Joint Services Command Control and Intelligence (C2I) users. The TRIXS network supports full-duplex data and half-duplex voice connectivity between user terminals and is designed to provide in time intelligence reports focused on high pay off ground threat to joint forces battle managers at all echelons to support maneuver, threat avoidance, targeting, mission planning, and sensor cueing. The TRIXS network can support up to five intelligence producers including the Army Guardrail Common Sensor (GRCS), Air Force Contingency Airborne Reconnaissance System (CARS), the Navy Story Teller System, and the Airborne Reconnaissance Low (ARL). (TRIXS is capable of operating at both the Secret and TS/SCI levels. The TRIXS LOS SCI capability will be retained until the IBS has fully incorporated multi-level security.) (GRCS ROC, approved 24 Apr 92.)
52. **Theater Injection Point (TIP)** - A transportable injection system that provides the capability for theater commanders to transmit information directly from within a theater to the space segment. A TIP incorporates the necessary TIM and SBM functions needed to carry out its mission.
53. **Theater Information Management (TIM)** - The set of functions, processes, and systems associated with control and management of GBS that provides individual CINCs with the control essential for delivery of the correct information products to their forces worldwide. TIM functions include directing GBS operations, coordinating the broadcast schedule, managing apportioned resources, identifying new products, reviewing and validating the user profile data base, and auditing User Pull.
54. **Transportable** - Capable of being moved from one location to another and communicating from a fixed location (not while on the move).
55. **Transportable Ground Receive Terminal (TGRT)** - A GBS receive terminal packaged to provide portable capability. This receiver will not receive while on the move.
56. **User Profile** - A record of information which identifies a specific user, his information needs, address, accesses, and other selected data that can be helpful to the user and to information managers in ensuring the user receives complete support from GBS.
57. **User Pull** - The capability for end users to define specific information to be broadcast on demand in response to operational circumstances, or the actual end user request for specific information to be broadcast on demand. "User Pull" requests are made via a backchannel.
58. **Virtual Injection** - The process of utilizing organic communications paths (non-satellite) to transmit in-theater generated information to a Primary Injection Point for broadcast to users in theater.
59. **Wrapper** - An electronic header added to file products containing metadata which allows the SBM to schedule dissemination. Receive suites can use the wrapper to ascertain addressing and then filter and process products.
60. **Worldwide Coverage** - An area 65 o North latitude to 65 o South latitude, 180 o West to 180o East longitude.

APPENDIX M. ACRONYMS [GBS, IBS]

1. A&T - Acquisition and Technology
2. ACAT - Acquisition Category
3. ACTD - Advanced Concept Technology Demonstration
4. AE - Acquisition Executive
5. AF - Air Force
6. AFFOR - Air Force Forces
7. AFOTEC - Air Force Operational Test and Evaluation Center
8. AFRTS - Armed Forces Radio and Television System
9. AIS - Automated Information System
10. AO - Area of Operations
11. AOR - Area of Responsibility
12. ARFOR Readiness Group
13. ARL - Air- Army Forces
14. ARG – Amphibious borne Reconnaissance Low
15. ART - Airborne Receive Terminal
16. ASD - Assistant Secretary of Defense
17. ATM – Asynchronous Transfer Mode
18. ATO - Air Tasking Order
19. BADD - Battlefield Awareness and Data Dissemination
20. BC2A - Bosnia Command and Control Augmentation
21. BDA - Bomb Damage Assessment
22. BER - Bit Error Rate
23. BIT - Build-in Test
24. BM - Broadcast Management
25. C2 - Command and Control
26. C2I - Command, Control and Intelligence
27. C3I - Command, Control, Communication and Intelligence
28. C4I - Command, Control, Communication, Computers and Intelligence
29. CARS - Contingency Airborne Reconnaissance System
30. CASS - Consolidated Automated Support System
31. CIBS-M - Common Integrated Broadcast System Module
32. CINC - Commander-in-Chief
33. CJCS - Chairman, Joint Chiefs of Staff
34. CJCSM - Chairman Joint Chiefs of Staff Memo
35. CJTF - Commander Joint Task Force
36. CMSA - Cruise Missile Support Activity
37. CNN - Cable News Network
38. CNO - Chief of Naval Operations
39. COE - Common Operating Environment
40. COMSEC - Communications Security
41. CONOPS - Concept of Operations
42. CONUS - Continental United States
43. COP - Common Operating Picture
44. COTS - Commercial Off-the-Shelf
45. CS - Client Server
46. CTAPS - Contingency Theater Automated Planning System
47. CTT - Commanders Tactical Terminal

48. DAMA - Demand Assign Multiple Access
49. DARPA - Defense Advanced Research Projects Agency
50. DBS - Direct Broadcast Service
51. DED - Data Element Dictionary
52. DGIAP - Defense General Intelligence Applications Program
53. DIA - Defense Intelligence Agency
54. DII - Defense Information Infrastructure
55. DISA - Defense Information System Agency
56. DISN - Defense Information System Network
57. DMS - Defense Message System
58. DOD - Department of Defense
59. DSCS - Defense Satellite Communications System
60. DTD - Dated
61. EHF - Extremely-High Frequency
62. EKMS - Electronic Key Management System
63. EMP - Electromagnetic Pulse
64. EOB - Electronic Order of Battle/Enemy Order of Battle
65. ERDB - Emerging Requirements Database
66. ETIE - Expanded Tactical Information Element
67. EW - Electronic Warfare
68. FC - Fully Connected
69. FGRT - Fixed Ground Receive Terminal
70. FOC - Full Operational Capability
71. FOV - Field of View
72. FSSG - Force Service Support Group
73. FY - Fiscal Year
74. GBS - Global Broadcast Service
75. GCCS - Global Command and Control System
76. GCSS - Global Combat Support System
77. GMF - Ground Mobile Forces
78. GMRT - Ground Mobile Receive Terminal
79. GOSC - General Officer Steering Committee
80. GOTS - Government Off-the-Shelf
81. GPS - NAVSTAR Global Positioning System
82. GRAT - GBS Resource Allocation Tool
83. GRCS - Guardrail Common Sensor
84. GRT - Ground Receive Terminal
85. HDR - High Data Rate
86. HEMP - High-altitude electromagnetic pulse
87. HQ - Headquarters
88. HSFB - High Speed Fleet Broadcast
89. HUMINT - Human Intelligence
90. I & W - Indications and Warning
91. IBS - Integrated Broadcast Service
92. ICDB – Integrated Communications Database
93. IDM - Information Dissemination Management
94. IME - Information Management Element
95. IMINT - Imagery Intelligence
96. INFOSEC - Information Security
97. IOC - Initial Operational Capability
98. IP - Internet Protocol

99. IRD - Integrated Receiver/Decoder
100.IRINT - Infrared Intelligence
101.IRS - Interface Requirements Specification
102.IW - Information Warfare
103.JAC - Joint Analysis Center
104.JBS - Joint Broadcast Service
105.JCIT - Joint Combat Information Terminal
106.JCS - Joint Chiefs of Staff
107.JDISS - Joint Deployable Intelligence Support System
108.JIBSG - Joint Integrated Broadcast Steering Group
109.JIC - Joint Intelligence Center
110.JITI - Joint In-Theater Injection
111.JMCIS - Joint Maritime Command Information System
112.JMIP - Joint Military Intelligence Program
113.JORD - Joint Operational Requirements Document
114.JPD - Joint Potential Designator
115.JPO - Joint Program Office
116.JS - Joint Staff
117.JSOTF - Joint Special Operations Task Force
118.JTA - Joint Technical Architecture
119.JTF - Joint Task Force
120.JTIDS - Joint Tactical Information Distribution System
121.JTT - Joint Tactical Terminal
122.JV2010 - Joint Vision 2010
123.JWCA - Joint Warfighter Capability Assessment
124.JWICS - Joint Worldwide Intelligence Communications System
125.JWID - Joint Warrior Interoperability Demonstration
126.KPP - Key Performance Parameters
127.LDR - Low Data Rate
128.LORA - Level of Repair Analysis
129.LOS - Line of Sight
130.LRU - Line Replaceable Unit
131.MAG - Marine Air Group
132.MARFOR - Marine Forces
133.MASINT - Measurement and Signature Architecture Intelligence
134.MATT - Multi-Mission Advanced Tactical Terminals
135.MAW - Marine Air Wing
136.Mbps - Megabits per second
137.MC - Manually Connected
138.MCC - Mobile Command Center
139.MCEB - Military Communications Electronic Board
140.MDU - Mission Data Update
141.MEF - Marine Expeditionary Force
142.MEU - Marine Expeditionary Unit
143.METOC - Meteorological and Oceanographic
144.MILSATCOM - Military Satellite Communications
145.MJPO - MILSATCOM Joint Program Office
146.MLDT - Mean Logistic Delay Time
147.MNS - Mission Need Statement
148.MOA - Memorandum of Agreement
149.MOP - Memorandum of Policy

150.MPT - Manpower, Personnel and Training
151.MRCs - Major Regional Conflicts
152.MRT - Manpackable Receive Terminal
153.MTBOMF - Mean Time Between Operational Mission Failure
154.MTN - M22 Tactical Network
155.MTT - Mobile Training Teams
156.MTTR - Mean Time To Repair
157.NAIC - National Air Intelligence Center
158.NATO - North Atlantic Treaty Organization
159.NAVFOR - Naval Forces
160.NAVSATCOMFAC - Naval Satellite Communications Facility
161.NBC - Nuclear Biological Chemical
162.NBCC - Nuclear, Biological, and Chemical Contamination
163.NCTAMS - Naval Computer and Telecommunications Area Master Station
164.NIMA - National Imagery and Mapping Agency
165.NIPRNET - Non-secure Internet Protocol Router Network
166.NITF - National Imagery Transmission Format
167.nm - nautical mile
168.NMC - Network Management Center
169.NMS - National Military Strategy
170.NRO - National Reconnaissance Office
171.NRTD - Near-Real-Time Dissemination
172.NSA - National Security Agency
173.O - Objective
174.O&M - Operational and Maintenance
175.ONI - Office of Naval Intelligence
176.OOB - Order of Battle
177.ORD - Operational Requirements Document
178.OTAR - Over the Air Re-keying
179.OTH-H - Over the Horizon Targeting
180.PBD - Program Budget Decision
181.PC - Personal Computer/Partially Connected
182.PIP - Primary Injection Point
183.PMIN - Producer Multi-level Interaction Net
184.RADINT - RADAR Intelligence
185.RBM - Receive Broadcast Management (Manager)
186.RBS - Readiness Based Sparing
187.RF - Radio Frequency
188.RFI - Request for Information
189.RO - Receive Only
190.RT - Receive Terminal
191.SASO - Stability and Support Operations
192.SATCOM - Satellite Communications
193.SATCOM - Satellite Communications
194.SBM - Satellite Broadcast Management (Manager)
195.SCI - Sensitive Compartmented Information
196.SHF - Super-High Frequency
197.SIGINT - Signal Intelligence
198.SIPRNET - Secure Internet Protocol Router Network
199.SMO - Support to Military Operations
200.SOA - System Operational Availability

201.SOF - Special Operations Forces
202.SOM - System Operational Manager
203.SPAWAR - Space and Naval Warfare Systems Command
204.SRT - Shipboard Receive Terminal
205.SRU - Smallest Replaceable Unit
206.SSRT - Sub-surface Receive Terminal
207.STAR - System Threat Assessment Report
208.T - Threshold
209.TACS - Theater Air Control System
210.TADIL-J - Tactical Digital Information Link J (NATO designation is Link 16)
211.TADIXS B - Tactical Data Information Exchange Subsystem B
212.TAFIM - Technical Architecture for Information Management
213.TBD - To be determined
214.TBR - To be reviewed
215.TCN - Terrestrial communications network
216.TCP - Transmission Control Protocol
217.TDDS - TRAP Data Dissemination System
218.TDL - Tactical Data Link
219.TDP - Tactical Data Processor
220.TED - Threat Environment Description
221.TEMP - Test and Evaluation Master Plan
222.TGRT - Transportable Ground Receive Terminal
223.TIARA - Tactical Intelligence and Related Activities
224.TIBS - Tactical Information Broadcast Service
225.TIE - Tactical Information Element
226.TIM - Theater Information Management (Manager)
227.TIP - Theater Injection Point
228.TOC - Tactical Operations Center
229.TOD - Time of Day
230.TOE-TOR - Time of Entry into IBS to Time of Receipt by user
231.TRANSEC - Transmission Security
232.TRAP - Tactical Related Applications
233.TRIXS - Tactical Reconnaissance Intelligence Exchange System
234.TS - Top Secret
235.TSBM - Transportable Satellite Broadcast Manager
236.TT&C - Telemetry, Tracking, and Commanding
237.UAV - Unmanned Aerial Vehicle
238.UFO - UHF Follow-On
239.UHF - Ultra-High Frequency
240.USACOM - United States Atlantic Command
241.USD - Under Secretary of Defense
242.USEUCOM - United States European Command
243.USSOCOM - United States Special Operations Command
244.USSOUTHCOM - United States Southern Command
245.USSPACECOM - United States Space Command
246.UTM - Universal Transverse Mercator
247.VHF - Very High Frequency
248.VSAT - Very Small Aperture Terminal
249.VTC - Video-Teleconferencing
250.WGS - World Geodetic System

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