VLF/LF Submarine Communications
by Mujahadin

In the formative days of my RF intelligence gathering youth, I was frustrated at the real lack of solid information (at least to myself) with concerns to VLF/LF submarine communications in the 80's and into the early 90's. This lack of information continued up until several months ago, when I stumbled upon a great wealth of material in *gasp* hard copy. As this material crossed my hands I was immediately able to plug huge gaps in my own personal knowledge as well as add new understanding to techniques of this mostly unknown to me method of operation. The subject matter I will attempt to present will be taken from dozens of documents, with various clarifications given where I believe they I are needed. These will be done with no additional notice and free of charge.... Be assured that in no way will the integrity of the material be compromised. An assumption is also made of the readers basic understanding of RF principles and some of the nomenclature involved. For the first time in an easily consumable form, much of this material is virgin in nature. Be gentle. If dry technical stuff bores you, then skip down to the end.

The basis for this group of documents I found all started with a formal communiqué from the Commander of Space and Naval Warfare Systems Command directed to a particular research establishment. This is from 1985. Old news you say? Perhaps.. but the stuff contained herein fills in many blanks for me. I hope it does for you as well. By the way, 7 years later in 1992, interoperability tests were finally officially performed between US and UK stations.

In the communiqué, the Commander expressed a desire to assure a fundamental compatibility between NATO STANAG-5030 standards and the US Navy's own VLF/LF Broadcast System, for present and future considerations, in transmitting and receiving multichannel VLF/LF broadcasts. Don't forget that at this time, there were several expansionist activities being undertaken by the superpowers. The US and UK were developing technology at a quick rate, and interoperability in this arena was necessary to facilitate joint efforts... after all...we are dealing with NATO.

The VLF/LF broadcast system must provide reliable and accurate message delivery at maximum available data rates and over great ranges from shore based transmitting facilities to submerged Fleet Ballistic Missile (FBM) submarines. The VLF/LF System is the primary means of communication to deployed FBM submarine forces and is, therefore, critical to the exercise of strategic command and control.

Although some common equipment had been installed in the transmitting facilities of the VLF/LF System, each station within the system was of unique design. This situation resulted from many factors . The difference between these stations created logistic support and training problems which were to be reduced by minimizing the differences. Coverage of the FBM submarine operating areas was provided by stations in three operational areas: Atlantic, Mediterranean, and Pacific areas. Broadcast overlap and redundancy was required to insure continuity of broadcast during out-of-service periods (casualty or maintenance) of individual stations.

All VLF stations posses VERDIN transmit capability. VERDIN is a digital communications system permitting expansion of the submarine broadcast from single-channel operation to two or four channel MSK operation with a concomitant increase in capacity and flexibility of operation. VERDIN provides both high and low data rates of operation. VERDIN was originally designed for manual (torn tape) message input to each of the four communication channels; however, increased traffic and the development of new communications systems has necessitated the automation of the input function. The VLF/LF System was the primary link of the FBM command and control network. It was assigned a primary role in the National Command Authority (NCA) World Wide Military Command and Control System (WWMCCS) special communication link direct to the operating forces, and was assigned a support role in the JCS Minimum Essential Emergency Communications Network (MEECN). Provision was made for automatic preemption of the submarine broadcasts for transmission of Emergency Action Messages (EAM) [note... short wave buffs may be familiar with the SKY KING broadcasts which were essentially EAMs]. At the time, VLF/LF broadcasts provided the only available means of communication which permitted a submarine to remain submerged and covert.

In 1988, SPAWAR had asked NAVOCEANSYSCEN to develop the NISBS. NISBS is a store and forward message processing system comprised of primarily of two ruggedized personal computers called Red and

Black Formatters. As the names suggest, the Red Formatter provides message processing and formatting functions on clear text or "red" data while the Black Formatter processes only cipher text, or "black" data. This system architecture mirrored the architecture selected by NATO which is described in STANAG 5030. In the NATO Fixed Submarine Broadcast System (FSBS) the transmit stations (BRS) are "black", that is, encrypted data relayed to them usually over leased phone lines. Message data is typically encrypted at the same place where the messages are generated, called the Broadcast Keying Station (BKS). Thus, the BRS uses a Black Formatter and the BKS uses a Red Formatter.

NATO FSBS Overview

The NATO Submarine Broadcast System consists of 4 VLF/LF transmitters located at Anthorn, UK; Tavolara, Italy; and Rhauderfehn, Germany. These are the NATO Broadcast Radiating sites. There are also other transmitters that may be available for NATO operations. These nationally owned systems are located in Ste. Assize, France; Rugby and Criggion, UK; and Annapolis, Maryland. The transmitters are capable of operating in all the NATO Standard Agreement (STANAG) 5030 modes. Mode N1 is a single channel, Continuous Wave, Frequency Shift Key, On-Off Keying mode using Morse Coded transmission. Mode N2 is a single channel, 50 baud FSK mode. Mode N3 is a two channel 100 baud Time Division Multiplexed MSK transmission, with each channel operating at 50 baud. Mode N4 is a four channel, 200 baud TDM MSK transmission with each channel operating at 50 baud. The four NATO transmitters will transmit using this four channel Mode N4. Mode N5 is also a four channel 200 baud TDM MSK transmission. For US transmitters three channels belong to the US as nationally controlled and formatted and may or may not comply with STANAG 5030 formats depending on the operational configuration. Mode N6 is a two channel 100 baud TDM MSK transmission similar to Mode N3, but one channel is nationally controlled and formatted.

NATO MODE	Channels 1 2 3 4	Channel Data Rate (bps)	Modulation	COMSEC Device
N1	x	variable	CWOOK	Off-line
N2	x	50	FSK	Vallor/Jason
N3	x	50	MSK	Vallor
	x	50	MSK	Vallor/Jason
N4	x	50	MSK	Vallor
	x x x	3x50	MSK	Vallor/Jason
N5E	x	50	MSK	Vallor
	x x x	3x50	MSK	National
N5N	x	50	MSK	Vallor
	x x x	3x50	MSK	National
N6	x	50	MSK	Vallor
	x	50	MSK	National

Here's a key part for you conspiracy buffs and black helicopter watchers. Read between the lines here... this again added at no extra cost.

-----conspiracy-alert
The US Navy is incorporating STANAG 5030 interoperability into its Fixed Submarine Broadcast System through a program called the NATO Interoperable Submarine Broadcast System (NISBS). NISBS provides the US with a NATO interoperable message preparation, management, formatting, and transmission capability. NISBS can relay US General Service (GENSER), Special Intelligence (SI), bilateral and multilateral (NATO) broadcast formatted in accordance with STANAG 5030. NISBS will provide the Commander, Submarine Forces, US Atlantic Fleet (COMSUBLANT), NATO-wide VLF/LF communications interoperability for effective command of US and NATO submarine forces.
-----end of conspiracy-alert

NISBS provides a gateway to the US VLF/LF transmitters for submarine broadcasts originated by COMSUBACLANT and Commander Submarine Group Ten (COMSUBGRU 10). The NISBS Message Formatter provides the capability for COMSUBLANT to use NATO VLF/LF transmitter assets, such as those at Anthorn and Novik. It also provides the NATO Commander, Submarine Forces, Eastern Atlantic (COMSUBEASTLANT), headquartered in Northwood England, with the ability to relay broadcasts from designated US transmitters.

The overall NATO VLF Submarine Broadcast System Coordinator (SDSC) is COMSUBEASTLANT. He coordinates the allocation of VLF assets and channels for NATO VLF operations with the Broadcast Coordinating Authorities (BCOA) in each area. The SBSC also integrates national assets made available to NATO into the NATO Submarine VLF Broadcast System. The Commander, Naval Forces South (COMNAVSOUTH) acts as alternate (ALT) SBSC. Each BCOA is responsible for the management of the NATO FSBS and ensures the interoperability of all components of the NATO FSBS by specifying the mode of operation and the cryptographic equipment used for each broadcast.

Within each Submarine Operational Authority (SUBOPAUTH) area, a Broadcast Control Authority (BCA) is required to manage the broadcast loading. The BCA controls the content of the submarine broadcast and is responsible for vetting the broadcast and generating the broadcast schedule. The designated location of the BCA is the Broadcast Control Site (BCS). All NATO primary BCAs are interconnected. That is, COMSUBEASTLANT, the BCA for Anthorn, is connected directly to Commander, Allied Naval Forces Baltic Approaches (COMNAVBALTAP), who is the BCA for the transmitter at Rhauderfehn, Commander, Allied Naval Forces Northern Norway (COMNAVNON), the BCA for Novik, and the Commander, Submarines Forces Mediterranean (COMSUBMED), the BCA for Tavolara.

US and NATO submarines located in the middle and north Atlantic and Arctic Ocean areas are serviced by transmitters located at the Naval Radio Transmitter Facility (NRFT) in Annapolis and NRTF, Driver, Virginia. Submarine broadcast messages are injected into the network by the Submarine Satellite Information Exchange Subsystem (SSIXS) II Terminal located at the Broadcast Control Authority (BCA), Headquarters in Norfolk, Virginia. The alternate BCA is the COMSUBGRU 10 at Kings Bay Georgia. It is intended that COMSUBGRU 10 will be the primary BCA for multilateral and US/UK bilateral broadcasts. In addition, a requirement exists to install a SSIXS II Terminal at Commander, Submarine Forces for the Pacific (COMSUBPAC) to support multilateral broadcasts.

PHASE 1 of the testing was during May-August 1989, and additional testing was completed in 1991. The stated purpose of this testing was to determine compatibility between the various STANAG 5030 receivers that were in use at this time by different nations. Lab testing utilized the NCCOSC VLF/LF test bed.

PHASE 2 was scheduled to be carried out in the second quarter of 93. This phase was directed specifically towards US NISBS. The test was to use a prototype of a 'Black Formatter' (more on this later), which would inject a STANAG 5030 signal into the external channel of something called a 'Verdin Control Unit' (more later). Several of the previously mentioned 'N modes' were used here. Eventually the Nuclear Attack Submarine (SSN) which receives these messages will send the output to a patched-in KWR-46 for decryption and from there to the AN/UGC-136CX for alphabet conversion and printout. A SSIXS NATO terminal will inject a NATO broadcast from the Alternate BCA at Kings Bay to the BKS at NRTF Annapolis via dedicated high speed 2400 BPS lines. The intersite link will use KG-84C cryptographic devices. COMSUBLANT (shore monitor) was to perform monitoring with the Enhanced Verdin System and UGC-136CX (a teletype unit).

Schematic of NSBTS Architecture.

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                         BCA: COMSUBLANT or COMSUBGRU 10
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      US
      SSIXS ----> KG84C --\
                       \
                            \
      US/UK               \
      SSIXS ----> KG84C ----->MUX AND MODEM -------/
                      /         /
                           /          /
      UK                /          /
      SSIXS ----> KG84C --/             /
                              /
                             /
                             /
   Intersite Link (2400 baud)           /
 ------<----------------------------<----
 |
 |                                       VERDIN
 |      /------>KG48C-> US RED                External Channel---
 |     /           FORMATTER                               |
 |     /           AN/UYK-83  ---->KWT46 ---> ANAPOLIS          |
 |    /                          BLACK FORMATTER --
 ->DEMUX AND MODEM-->KG48C-> US/UK RED                    AN/UYK-83
          \              FORMATTER  ---->KWT46 ---> DRIVER
           \                             BLACK FORMATTER---
           \                             /    AN/UYK-83|
            \------>KG48C--> NATO RED            /           |
                                 FORMATTER ---->KWT46--->/   DRIVER LF   |
                                                     FSK MODULATOR
                         ============
                              BKS: ANAPOLIS
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If the terms above are not familiar then reread previous passages of this text. It took me forever to make that for you so I hope it's clear!

PHASE 3 involved US/UK testing. It was to require a shore-based receiver preferred stationed at Holy Loch or Thurso, being the ease of which engineers could test RF stuff because of the location of nearby equipment at Thurso.

Now a look inside a typical VLF transmitting station.

Not only does a VLF station require extensive equipment, but several means of preparedness in various methods, as exemplified in the following information.

EMI considerations, frequency approvals, as well as airfield clearance. Microwave and landline cables for intra-station connectivity. Several 250KVA uninterrupted DC power supplies serving Commo Center and Satcom Facilities. One system online while the other in standby mode. Each capable of supplying power for 15 minutes. Where no commercial power is available, like in the Holt Station in Australia, several (up to 6) 3MW generators are made available to provide all AC power necessary for the Commo Center Facility operation. Normally 2 online, 2 on standby. The generators also supply power to Transmitter Site, VLF Site and to base facilities. Commo Center equipped with 4 Air Handlers for air conditioning at 58 tons each... 2 online 2 in standby. The Satcom Facility will have its own system... totaling 48 tons of 9 units, which cools Digital Communication Subsystem (multiplex/demultiplex equipment) which is a part of the Defense Satellite Communication Subsystem.

Communication Security Equipment (CSE) Room houses all the security equipment and Red (classified) and Black (unclassified) patch and test facility. Message Center houses RIXT Terminal. Sends/receives ship/shore messages and monitors certain broadcast channels. Microwave Room housed multiplex/demultiplex equipment and the radio which provides connectivity to the Receiver Site. Terminal Control Facility functions as the interface between the transmission elements and provides the technical direction coordination technical supervision of transmission media and equipment quality control service restoral and status reporting for effective communication to the users It consists of patching facilities, test equipment, teletype orderwire and voice frequency carrier terminals to multiplex teletype circuits to/from the HFT (high freq transmit), HFR (high freq receive), and VLF sites.

Control Room houses transmitter control console which consolidates the controls and instruments necessary to operate the transmitter.

Helix House: the matching network which is the tunable coil in series with the antenna, the transmitter termination, and the antenna termination are all located in the Helix House.

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2 stations were setup for the purpose of initially testing this interoperability. H.E. Holt in Australia, and Waihawa, Hawaii.

During the testing phases of this operation, temporary equipment at the Holt and Waihawa facilities included:

2 AN/UYK-83 computers (primary/spare)
20 Mhz 80386
40 meg removable drive
10 megs memory
2 serial IO boards
Microsoft DOS 4.01
Procomm
Editor
ADA for DOS (compiler and debugger)

Compact Time Integrity Modem (CTIM) Mobile Unit Rack
These modems accept 50,100, and 200 baud and relay data to the transmit site by:
packetizing data into 8 bits
appending time packet
runs in conjunction with VERDIN unit by advancing
the ppm by 1 second to provide time compensation buffer

2 transmit CTIM
2 receive CTIM
3 MD 5062 Modems
Cesium clock with 50 baud divider circuit or equiv

Simon 5 data analyzer
cables
tools

However at Holt, there were some additional requirements.
off the air monitor device
MD-856 modulator or modulator/simulator
patch panels
teletype units 50 bps 7.0 unit Baudot
RAN TSEC/KWT 46 channel

An AN/UYK-83 will be installed at the Hawaii site with software which will be able to send synchronous 200 bps test data to the transmit CTIM. Data will be clear text for testing that will not route the data to the AN/WRR-7. Pretty interesting method mentioned herein....in order for thorough testing with this technique, a particular VERDIN Control Unit Simulator was necessary to generate pseudorandom data on channels 1 2 and 3. The data simulation must include simulating the PG-7 card functions of the VERDIN Control Unit. This card forces clear stop bits on channel 3 of the broadcast.

This particular testing phase did not require on-air transmissions...this is where the simulators came in handy. Also, there were 8 tests to be conducted using various hardware configurations procedures and time durations with emphasis on Data Collection and analysis.

example: Test 8
Live Secure Verdin Broadcast without RAN channel

Configuration: VERDIN AN/WRR-7 in mode 23E. VERDIN CEP tape
of test. Black Formatter will not find channel
4 and will pass data through to Receive CTIM.
Duration: 6-12 hours

Data Collection: CEP Data printed out on TTY. Condition of CTIM
status lights.

There was also a time schedule of these tests right down to the minute.
Keep in mind that at this point, the US had to be out of the Holt facility
by Oct 1 92.

In January of 1992, from COMNAVCOMTELCOM in Washington DC, there was an administrative telex sent out concerning the implementation of Defense Integrated Secure Network Subnetworks with Blacker Front End Processors. A reference was mentioned in that telex which stipulated that the DDN Classified Subnetworks (DSNET 1, 2, and 3) were to be integrated into the DISNET multilevel secure network using the Blacker System, and that various military departments and defense agencies utilizing DSNET1 are required to have these Blacker Front Ends (BFES) by August 31 1992 and that failure to meet the date would result in termination of services. Unfortunately I do not have this reference or the others which outline hosts and terminals that were officially registered on the classified subnetworks of the DDN, as known to DISA. *shucks* The Blacker device "will be a user installed piece of cryptographic equipment, with technical assistance available from SPAWAR and NESSEC". For existing subscribers, the following criteria were to be met prior to this Blacker implementation:

TCP/IP abilities
BFE hardware RS-449/MIlL-STD-188-114, not RS-232
BFE software to be X.25 standard modified to Blacker X.25, available from
Viz., Frontier, Wollengong, Loral, Cisco, and ATT.
Submission of a Host and Blacker Ignition Key (BIC)

Test results on the whole were not provided to me. The rest of the documentation included a rather interesting treatment of cryptanalysis at the bit level as concerns the equipment and previous mentioned 'Formats' and Modes.

Some questions I have and may attempt to answer myself if Ticom will allow me more space in the next release (and perhaps a more in depth look at the encryption methods of this technology and even some explanation of the signal structure of a typical message stream in a bit by bit format, and inclusion of BASIC code which will analyze the combining of spread spectrum MSK receivers into a least degraded reception model):

Did the UK NATO VLF receive capabilities perform error correction on restored Fibonaci bits? and if so, what algorithm was used? How did UK NATO VLF receivers utilize depth compensation and drift? How did UK NATO VLF receive systems recognize idle channels? specifically: any channel of any given Mode or even a single channel of a national broadcast.

addition:

Gentle breakdown of STANAG 5030 4 channel NATO format:
COMSUBCLANT
-acts as BCS for Channel 1
-maps data to 64-ary alphabet
-encrypts data
-receives other channels encrypted from other BCSs
-inverts channel 1 Fib bits
-retimes data
-inserts Wagner(13,12)EDAC (error detection and correction)
-sends processed channels to transmitter

That's it for now. This may bring back memories for you submariners or radio buffs, particularly the engineers out there. Its all unclassified stuff, but not widely known.

If someone doesn't post this info then it will simply die, and I personally don't want to see that. Perhaps in return, someone could submit a follow up with analysis of contemporary sub commo. I have so much information on this subject that it was hard to find a place to start, much less put it in a sequential order, and with that in mind please don't mistake that for not caring. Don't forget Cybertek #15 where I discussed in detail various weaknesses of the human body. Still kinda fun to read.

Greets to Ticom, Black_IC, DrHavoc, VLAD, Danny Gatton (rip), ARSCC(wdne), the unmentionable vampire, fc, Special Forces, then, now and forever.

mujahadin - the real Desert Storm.

Fas - Italy -

NATO Interoperable Submarine Broadcast System (NISBS) software upgrades have completed formal testing and are awaiting hardware upgrades to facilitate deployment. NISBS Software Release 3.1, deployed October 1994, implemented the standard configuration of software that supports NATO STANAG 5030 Modes N2, N3, N4, N5, and N6 with up to two modulator outputs. NISBS Software Release 3.2, deployed FY 95, added the synchronization of formatter clock to FTS and enhanced the remote circuit configuration to include the four-channel broadcast pass-through mode. NISBS Software Release 3.3, deployed at Niscemi, Italy, adds the capability to access the formatter remotely for status and error logs. These remote access logs accumulate information over a 30-day period.

Fas - Puerto rico -

The Fixed Very Low Frequency [FVLF] Site Upgrades program maintains and upgrades antennas and transmitters at the FVLF sites. the Transmitter Keep-Alive Program (TKAP)/Service Life Extension Program (SLEP) has been completed at Jim Creek, Lualualei, Cutler FVLF, and Aguada, PR. The SLEP improvements includes switchgear, circuit breakers, solid state Intermediate Power Amplifiers (IPAs) and pre-IPAs, assorted electrical components, and updated technical manuals. The AN/FRT-95(A) program will provide four 250 kW solid state LF transmitters. Sites planned to receive the new LF transmitters are: Aguada, PR; Keflavik, Iceland; Awase, Okinawa; and

Sigonella, Italy. The LF solid state transmitter upgrades improve area coverage in the Northern Atlantic and Northern Pacific regions. Testing of the first AN/FRT-95 (A) solid state LF transmitter was successfully completed at the Aguada, PR transmitter site. The AN/FRT-95(A) transmitter installation and antenna upgrades at Iceland were completed in FY95 while those at Awase, Okinawa were completed in early FY98.

Aguada transmits at a frequency of 28.500 kilohertz. Morse code is seldom, if ever, heard on the VLF band now, although it was once the only mode in use. The current mode at Aguada is reportedly Minimum Shift Keying [MSK] which makes maximum use of transmitter power and frequency spectrum by using a +/-50 Hz shift to send a 200 Baud data stream.

NATO Interoperable Submarine Broadcast System (NISBS) program accomplishments in CY 94 included successfully completed installation and testing at NCS HE Holt, Australia. The site is now operational, and the RAN channel of information is completely independent from U.S. channels. Successfully installed and tested NISBS at Naval Radiating Station Aguada, Puerto Rico. NRaD delivered NISBS Software Version 2.2 software, provided training, and participated in site validation testing and training. Messages were generated in CONUS, transmitted to Puerto Rico, and retransmitted VLF and OFF-THE-AIR monitored back in CONUS. The site is now operational. The site can retransmit three channels of U.S. information and one channel of NATO STANAG 5030 information simultaneously.

On May 7, 1999 Space & Naval Warfare Systems Center awarded Continental Electronics Corporation, Dallas, an Indefinite Delivery, Indefinite Quantity, Cost-Plus-Incentive-Fee type contract with an estimated amount of $5,626,886 to provide upgrades, modifications, engineering support, on-site technical services, material procurement and maintenance to extend the life of the Very Low Frequency Fixed Submarine Broadcast System sites at Cutler, Maine, Arlington (Jim Creek), Wash., Lualualei, Hawaii, Exmouth, Australia and Aguada, Puerto Rico. The scope of work includes manufacturing, assembly, integration, installation and testing. Place of performance will be the contractor's facility in Dallas, and the five Navy sites. Period of performance for the base period shall commence May 14, 1999 through September 30, 1999. This contract contains option line items, which, if exercised, will bring the total cumulative value of the contract to $34,529,696 (total dollar amount including options).

VLF Digitial Information Network/Enhanced System [VERDIN/EVS] is a legacy system that provides shore-to-submarine communications for subs operating at moderate depths and speeds. It is installed on submarines and TACAMO aircraft. On shore, it is located at all Fixed Very Low Frequency (FVLF) sites, off-the-air monitor systems and TACAMO communications centers. The VERDIN/EVS receiver will be replaced by SLVR.

Fas – verdin –

VLF Digital Information Network (VERDIN) is a VLF/LF communications system that provides secure command and control communications to the strategic and tactical submarine forces and airborne VLF relay aircraft (TACAMO). The VERDIN computer-assisted, multichannel, mulitmode, message handling system is an integral part of the fleet submarine communications network. It is designed to provide reliable, secure, long-range transmission and reception of submarine broadcast messages. VERDIN is being upgraded in accordance with STANAG 5030 to provide U.S./NATO interoperability for SSNs. The Enhanced VERDIN System (EVS) is a VERDIN product improvement developed to provide increased performance, reliability, and maintainability; a capability to process JCS directed 1600 baud mode MEECN interoperability; automatic mode recognition; message compression; automatic recovery/restart capabilities, giant step, high speed run up; and improved operator features for performance monitoring and fault location. The program replaced existing VERDIN processors, and modified the VERDIN equipment with a field change to permit 1600 baud MEECN interoperability on strategic submarines and TACAMO aircraft. The VERDIN/EVS receiver (R-1738) noise reduction circuit (NRC) field change has been incorporated into the EVS. This mod improves receiver performance in atmospheric noise. The non-linear adaptive processor (NONAP) has been provided to increase operational flexibility for submarines by pre-detecting differences between the desired VLF signal and noise interference; thereby enabling reception of messages during severe interference.

Very Low Frequency (VLF)

Very Low Frequency (VLF) communications transmitters use digital signals to communicate with submerged submarines on at frequencies of 3-30 kHz. The eighteen Trident submarines constitute about half the US strategic nuclear capability. The supporting infrastructure for these submarines includet connectivity links such as the Extremely Low Frequency (ELF), Very Low Frequency (VLF), and TACAMO Airborne VLF communications systems.
The Navy shore VLF/LF transmitter facilities transmit a 50 baud submarine command and control broadcast which is the backbone of the submarine broadcast system. The VLF/LF radio broadcast provides robustness (i.e., improved performance in atmospheric noise), availability, global coverage, and has seawater penetrating properties. The submarine VLF/LF broadcasts operates in a frequency range from 14 to 60 kHz and consists of five high powered, multi-channel MSK Fixed VLF (FVLF) sites and five multi-channel LF sites located worldwide. As part of the FY94 Base Realignment and Closure (BRAC), Navy Radio Transmitter Facility (NRTF) Annapolis closed in FY96 and NRTF Adak closed in FY97.

The submarine VLF/LF broadcasts are generated by the BCA or Alternate BCA from messages created locally by the C 2 processor, the SSIXS processor, or accepted for relay by the SUBOPAUTH. The BCAs and Alternate BCAs are connected to the transmitter sites by dedicated ISLs with the ability for JCS and USSTRATCOM to seize BCA, at any time, for EAM dissemination. At each of the transmitter sites, messages received over the ISLs are decrypted and input into the Integrated Submarine Automated Broadcast Processor System (ISABPS). Submarine VLF/LF broadcasts a continuous transmission sequence of prioritized messages which normally lasts two hours. It is generated by ISABPS and sent to the VERDIN transmit terminal. The VERDIN transmit terminal is used to multiplex, encrypt, encode, and modulate up to four 50 bps submarine broadcast channels into VLF/LF radio frequency signals which is amplified/radiated by the VLF/LF transmitter antenna. The Fixed Very Low Frequency Site Upgrades program maintains and upgrades antennas and transmitters at the FVLF sites. It consists of three individual programs: (1) The Solid State Power Amplifier-Receiver (SSPAR) program; (2) the Transmitter Keep-Alive Program (TKAP)/Service Life Extension Program (SLEP); and (3) Antenna Maintenance Program (AMP).

The SSPAR program could modernize the FVLF transmitter sites with solid state technology. This program could replace the current inefficient, unsupportable vacuum tube amplifiers and provide standardization for FVLF sites. The SSPAR program execution is being evaluated. SLEP is an interim program to extend the useful life of existing FVLF/LF equipment and systems until the delivery of SSPAR. The SLEP improvements includes switchgear, circuit breakers, solid state Intermediate Power Amplifiers (IPAs) and pre-IPAs, assorted electrical components, and updated technical manuals. SLEP has been completed at Jim Creek, Lualualei, Cutler FVLF, and Aguada, PR. H.E. Holt is scheduled to be accomplished in FY98. The AMP is administered by the Commander, Naval Computer and Telecommunications Command (NCTC) and provides for the ongoing maintenance and repair of FVLF/LF antennas and antenna components (e.g., insulators, top hats, guy wires, etc.).

As part of the overall DOD shore infrastructure reduction, NCTC and SPAWAR are examining modernization and cost savings alternatives within the submarine VLF/LF FSBS that could be accomplished which would maximize the return on initial investment. These study efforts, called the Smart Resource Management System (SRMS), are centered around consolidation of the shore VERDIN ISABPS equipment and more cost effective connectivity from the BCA/Alternate BCA to the BKSs and Broadcast Transmitting Stations (BTSs). Other initiatives being considered are Remote Transmitter Operation, Range Extension Mode, Power Management, Dynamic Channelization, and Split Array operation at the VLF sites.

SPAWAR is soliciting information from potential sources for the replacement, upgrade or modification of degraded, obsolete and maintenance intensive components, equipment and subsystems. The Very Low Frequency (VLF) transmitters are old vacuum tube technology with an average age of 37 years. The Very Low Frequency Ashore Lifetime Upkeep Effort (VALUE) is to extend the life of shore based submarine communications transmitter systems

Facilities

Call Letters	Location	Frequency	Power (kW)
NPM	NRTF Lualualei, Hawaii	21.4	480
NAA	NCTS Cutler, Maine	24.0	750/1000
NLK	NRS (T) Jim Creek, Washington	24.8	192
NAU	NRTF Aguada, Puerto Rico	40.75	100
	NCS H.E. Holt, Australia		