The United States Navy

Navy Fact File

Extremely Low Frequency Transmitter Site Clam Lake, Wisconsin

Clam Lake, Wisconsin ELF transmitter site

The U.S. Navy operates two extremely low frequency radio transmitters to communicate with its deep diving submarines. The sites at Clam Lake, Wisconsin and Republic, Michigan are operated by the Naval Computer and Telecommunications Area Master Station – Atlantic. The Clam Lake site, located in the Chequamegon National Forest in Northern Wisconsin, is the site where testing began for ELF communications more than 30 years ago. The site has more than 28 miles of over-head signal transmission line that form part of the "electrical" antenna to radiate the ELF signal from the two-acre transmitting facility.

Mission

The Clam Lake ELF radio station broadcasts messages to the fleet as required by the Navy Submarine Broadcast Control Authority in Norfolk, Virginia or Pearl Harbor, Hawaii. For the U.S. submarine fleet to perform its mission, it must remain silent and be undetectable. The Navy's ELF communications system is the only operational communications system that can penetrate seawater to great depths and is virtually jam proof from both natural and man-made interference. It is a critical part of America's national security in that it allows the submarine fleet to remain at depth and speed and maintain its stealth while remaining in communication with the national command authority.

This requirement was confirmed in 1984 when Department of the Navy Secretary John Lehman testified "In my judgment, the ELF system is essential to the national defense. The survivability of the Trident and Poseidon submarines depends on their ability to remain undetected. They must also maintain continuous communication with the President and Secretary of Defense." With other systems, continuous communication is possible only when submarines deploy a receiving antenna while operating at or near the surface. This requirement imposes an enormous restriction upon the submarine's operating depth and its speed, as well as increasing its exposure to detection. The ELF system permits submarines to receive communications without reducing speed or operating at the surface. Thus, the ELF system represents a critical safeguard against a scientific breakthrough in submarine detection by another nation using aircraft or satellite systems that exploit non-acoustic phenomena such as kelvin wakes and internal waves near the surface.

How ELF Communications works

ELF communications systems make use of a principle in physics where the attenuation of radio signals (electromagnetic waves) from seawater increases with the frequency of the signal. This means that the lower the frequency a radio transmission, the deeper into the ocean a useable signal will travel. Radio waves in the Very Low Frequency (VLF) band at frequencies of about 20,000 Hertz (Hz) penetrate seawater to depths of only tens of feet. The Navy's ELF system operates at about 76 Hz, approximately two orders of magnitude lower than VLF. The result is that ELF waves penetrate seawater to depths of hundreds of feet, permitting communications with submarines while maintaining stealth.

View of a typical Clam Lake ELF antenna

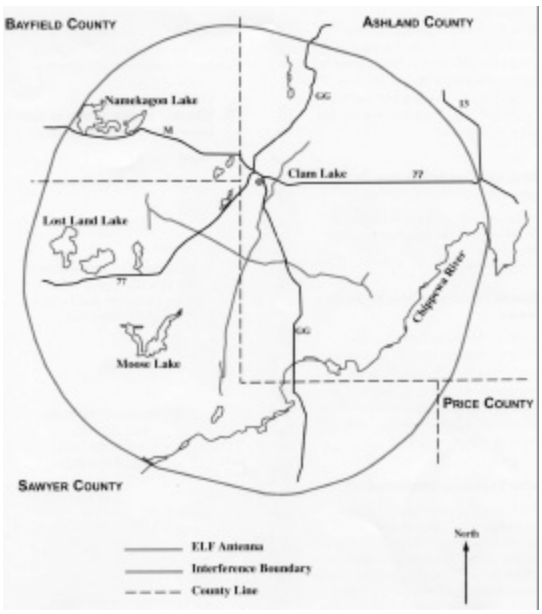
Current: June 28, 2001

Each ELF antenna works as an independent horizontal electric dipole. The two ELF transmitting sites synchronize their transmissions to provide greater coverage to most of the earth's oceans in which United States submarines operate. They are located geographically to take advantage of the bedrock layer (Precambrian metamorphic) and overlying rocks (Paleozoic) of the Superior Upland shield. This geological formation channels ELF currents deep into the ground and effectively increases the size of the antenna for more efficient signal transmission. The conductivity of the bedrock layer helps to improve the efficiency of the antenna system (that is, the lower the conductivity, the more improvement in effective transmitted power). The areas chosen for the ELF system have low conductivity rock (rock that does not conduct electricity well) that produce the best results for creating an ELF antenna. In these areas, electrical current flows deep into the ground (hundreds of meters) before returning to the opposite antenna terminal ground.

The eight-watt ELF signal radiates from the dual-site system and travels around the world through the atmospheric layer between the earth's surface and a zone of charged air particles known as the ionosphere. As these electromagnetic waves pass over the oceans surface, some of their energy passes into the ocean. This energy, or signal, reaches submarines almost worldwide at depths of hundreds of feet and traveling at operational speeds. All Navy submarines are equipped with ELF receivers that can decode ELF transmissions. ELF broadcast signals provide a one-way message system to submarines that is slow, but reliable. The submarines can receive ELF messages but they cannot transmit ELF signals because of the large power requirements, the large transmitter size, and the large antenna required to transmit ELF. Submarines can communicate on or near the ocean's surface with higher data rate systems such as satellite communications systems.

Location

The Northern Wisconsin area was selected as a location for the Navy's ELF facility because of its geology. The low conductivity bedrock is important because the ELF wave uses the bedrock to help complete the signal path for the antennas. The Navy selected the Clam Lake site because of these geological conditions and the opportunity to conduct the early research work on federal land and minimize or eliminate the need to disturb landowners, homeowners, and communities. The ELF antenna's layout in the Chequamegon National Forest uses techniques such as "screening" (using trees, changes in geography, and changes in antenna direction) to improve the visual appearance of the system in the forest. The creation of the antenna right-of-way also played an important role in the in the State of Wisconsin's successful re-introduction of elk into Northern Wisconsin. The antenna right-of-way is about 75 feet wide, allowing elk and deer to move freely and quickly through the Chequamegon National Forest in the area near the 28 miles of antenna lines. Additionally, the Navy's maintenance cycle of clearing brush in the right-of-way continually renews young plants that are important to elk, deer and other wildlife. The rights-of-way for the antenna and the grounding array are open to the public.



Location of Clam Lake transmitter site and the fence mitigation program

History

During the late 1950s, researchers and scientists theorized that extremely low frequency radio waves could deeply penetrate the oceans and would permit communications with deep-diving nuclear powered submarines. This theory suggested the potential for a unique capability not available with other radio frequencies, and the U.S. Navy began testing in the extremely low frequency radio spectrum. The Navy needed to determine the feasibility of building such a communications system for sending messages to submerged submarines such as the Polaris missile boats. If ELF transmissions worked as hoped, Navy submarines would not have to rise to or near the surface to receive messages from the national command authority. This would allow the submarines to remain hidden at depth, be more difficult to detect, and improve operational safety while maintaining a link to the national command authority.

Navy research into ELF transmissions involved investigating several different concepts. Project Sanguine envisioned a hardened, dispersed, surface deployed extremely low frequency radio communications system. SHELF – or Super Hard ELF – was a proposal for a deep underground ELF communications system. SEAFARER – or Surface ELF Antenna For Addressing Remotely Employed Receivers – was another proposal for an unhardened surface-deployed ELF antenna system using buried antennas. Finally, the ELF system we know today — a two-transmitter site

communications system with the transmitter facilities and antenna system above ground — was evaluated and ultimately chosen for implementation.

Initially, the extremely low frequency transmitter and antenna system was envisioned to be very large and capable of transmitting control orders to the submarine fleet. The initial concept was for the system to be able to function after a direct attack. The conceptual design of the original Project Sanguine system included more than 100 buried transmitter bunkers and a buried antenna array covering more than 3,000 square miles. The initial Project Sanguine theoretical and experimental work was done between 1958 and 1963 at the David Sarnoff Laboratory of RCA in Princeton, N.J. A field test site – known as Test Site Alpha – was built with facilities in North Carolina and Virginia in 1962 and was used to demonstrate the concept by sending signals to a deeply submerged submarine 2,500 miles away the following year. In 1968, the Navy constructed a test facility in the Chequamegon National Forest. Both above-ground and buried antenna system tests, as well as initial scientific studies of potential biological and ecological effects of ELF transmissions were conducted at the Wisconsin Test Facility. The Navy coordinated extensively with the U.S. Forest service to avoid significant biological and ecological impacts and developed measures to repopulate disturbed easement areas with recommended plant species. Additionally, since the Navy ELF communications system had the potential to induce voltages on long conductors such as local power lines, telephone lines and fences, research into procedures to reduce the impacts of ELF transmissions on utilities and other long, metallic objects was successfully conducted (called the Interference Mitigation Program).

All of the Navy tests on these systems operated in the 40 to 50 Hz and 70 to 80 Hz bands — the same as the submarines receiver system. During the mid-to-late 1970s, the Wisconsin Test Facility was used to send messages during a number of tests conducted on submarines in both Atlantic and Pacific Oceans and under the Arctic ice cap to assess the utility of the system. The Environmental Impact Statement was prepared and supplemented as required by changes in the system's concept. After analyzing the results of the research and the various systems that might be employed, the current ELF communications system was selected because it was the smallest and most cost effective system meeting the Navy's mission requirements.

In the mid-1980s, the Wisconsin Test Facility was upgraded and re-designated as the Wisconsin Transmitter Facility, and construction of a second transmitter facility 148 miles away in Republic, Michigan was proposed. In 1985, the Clam Lake site attained an initial operating capability. In the Fall of 1989, when the Michigan site became fully operational, the Wisconsin site was renamed the Naval Radio Transmitter Facility Clam Lake. The entire ELF communications system became fully operational October 1, 1989 when the two transmitter sites began synchronized transmitting of an ELF broadcast to the submarine fleet 24-hours a day, 7-days a week.

Location of ELF transmitter sites

In conjunction with the development and construction of the ELF system, the Navy sponsored a variety of environmental and ecological studies. In the 1970's the Navy sponsored a wide range studies, most being laboratory studies, that were conducted by independent researchers and Navy laboratories. This research culminated in a 1977 review by the National Research Council (NRC) of the biologic effects of electric and magnetic fields associated with the proposed Seafarer system. The NRC concluded, "… *the likelihood of serious adverse biologic effects of Seafarer is very small*." In conjunction with the upgrade of the ELF system in the mid-1980's, the Navy initiated two additional efforts; a literature review and an unprecedented ecological monitoring program. The American Institute of Biological Sciences (AIBS) was requested to provide an evaluation and analysis of the extant professional literature published since January 1977 about biological and human health effects of extremely low frequency non-ionizing electromagnetic radiation germane to the Navy's ELF system. In 1985, the AIBS concluded in its report, "*It is unlikely that exposure of living systems to ELF electric and magnetic fields in the range of those associated with the Navy's ELF Communications System can lead to adverse effects on plants and animals*." The unprecedented twelve year ecological monitoring program, which began in 1982, included in situ studies near the transmitter facilities in both Wisconsin and Michigan. At the conclusion of the field studies, the Navy requested the National Research Council to review the findings of the twelve year program. In 1997, the NRC committee published its findings which agreed with

the general findings of the Navy that, "…*the researchers' observations provide no evidence of statistically significant, wide-spread, adverse effects of EMFs associated with the ELF antennas*." The Department of the Navy, through a contract administered by the Naval Undersea Warfare Center, employs Information Ventures Incorporated to actively monitor and evaluate ELF EMF literature relevant to the operation of the ELF Communications System.

Operation and Management

The ELF transmitter site at Clam Lake is managed by a Detachment of the Naval Computer and Telecommunications Area Master Station Atlantic in Norfolk, Virginia (known as NCTAMS LANT). This organization operates all U.S. Navy shore-based communications sites east of the Mississippi River and several outside the continental United States. NCTAMS LANT works with the Space and Naval Warfare Systems Command to ensure the ELF transmitter systems are kept current and maintained to be operational at all times. The Naval Undersea Warfare Center in Newport, Rhode Island is SPAWAR's technical direction agent and ensures that the system operates properly and that the receivers onboard the submarines will receive, recognize, and decode the broadcast messages.

The Navy estimates the local economic impact of the Clam Lake facility to be approximately $6,000,000 annually. The Clam Lake facility, is staffed by two NCTAMS LANT civil service employees and about 30 contractor employees. The facility spends about $2,000,000 per year in employee payroll and local supplies and services (FY2000). The site staff operates the transmitter facility, conducts maintenance on the equipment and antenna system, and maintains the antenna right of way. The facility purchases services and supplies such as electricity, trash removal, fuel for vehicles and generators, office supplies and materials locally. The Navy spends about $400,000 annually on electricity purchased from the local Wisconsin power utility. When the local Wisconsin utilities experience near peak electrical demand, the Naval transmitter facility can bring as many as three Cummins diesel 1,000 kilowatt three phase power generators online to supply up to three million watts of power for the site – making the power normally used by the site available to local electric power companies to meet their peak load requirements.

Clam Lake power generation plant

The Department of the Navy, through a contract administered by the Naval Undersea Warfare Center, employs IIT Research Institute to mitigate the potential that ELF has to create interference for local utilities and coupling on fences. Through IITRI, which contracts with local power and telephone companies, the Navy has an ELF mitigation program for fences, telephone, cable television and electrical distribution systems to reduce or eliminate ELF interference. This program ensures that Wisconsin electric power customers have electrical power that is free from spurious electrical transients. Questions regarding the fence mitigation program at Clam Lake should be directed to IIT Research Institute, PO BOX 56, Clam Lake, WI 54517 or call 715-794-2463. An e-mail may also be sent to elf@spawar.navy.mil

Future System Improvements

The Navy conducts extensive inspections of the ELF system and antenna grounding (or earth return) system to ensure their safe operation. An Antenna Well Grounds System was introduced in the mid-1980s, as part of a transmitter facility upgrade at the end of several of the ELF antenna lines, with a resulting improvement in safety. Well Grounding Arrays require less maintenance, reduce ground surface electrical potentials and minimize potential impacts to local habitat.

Clam Lake antenna earth return well head

Based on the success of this previous ground terminal upgrade work, the Navy anticipates replacing the other existing grounds for the antenna at the Clam Lake site in the next several years. In conjunction with these upgrades, the Navy will work with the U.S. Forest Service – the manager of the Chequamegon National Forest – to ensure the required ecological, environmental, cultural and historic requirements are met.