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ELF Communication: An Obituary

*The music in my heart I bore
 Long after it was heard no more.*

W. Wordsworth (1770-1850)

These plaintive lines from Wordsworth's poem, *The Solitary Reaper*, came floating into my mind as I read the headline "Navy Pulls Plug on Project ELF" [1]. On September 30, 2004, at the end of the previous government fiscal year, the US Navy essentially terminated its \$400 million Project ELF, when it silenced the twin ELF transmitters located in Michigan and Wisconsin.

The need for sending messages to deeply submerged ballistic-missile-carrying submarines was evident by the early 1960s, as the following quote from Capt. Beach [2] makes clear:

...If a Polaris submarine was to patrol on station with sixteen nuclear-tipped missiles on board, it was essential that positive, sure, national control be maintained over her operations. This was common sense, reinforced by a few other things such as Acts of Congress (including the original Atomic Energy Act), directives of the National Security Council, decisions of the Joint Chiefs of Staff, and flat-out orders from the Chief of Naval Operations...."

ELF (30-300 Hz) communication was found to be the solution to this problem, since ELF waves can propagate around the world within the spherical waveguide formed by the Earth and the ionosphere with minimal attenuation (around 1 dB per 1000 km [3]), and can penetrate sea water to useful depths with a relatively low attenuation (0.3 dB/m at 76 Hz [4]). It is worth recalling that the ELF communication channel is one-way, only: from the shore to the submerged submarine. (As Collin [3] has explained, a signal coming from the submarine suffers attenuation on its way to the shore, where it is easily overwhelmed by unattenuated atmospheric noise.) Even this low-bandwidth one-way ELF communication faced a tremendous technical hurdle in its implementation: when the wavelength is measured in thousands of kilometers, any practi-

cal transmitting antenna is electrically very small and, therefore, suffers from poor radiation efficiency.

To meet the challenge of transmitting a useful amount of ELF signal, the US Navy developed two huge transmitting stations in the Chequamegon National Forest, near Clam Lake, in northern Wisconsin, and in Upper Michigan's Escanaba State Forest [5]. Each horizontal transmitting antenna employed miles of wires, strung on hundreds of 40-foot poles. (This was a drastically scaled down version of the original 1960s' plan, which would have involved a radiation-hardened grid of buried cable, thousands of miles long, and hundreds of transmitters.) The receiving antenna on the submarine took the form of a long insulated cable, towed behind the submarine [4].

During their 15-year existence, the two transmitter locations have been frequently targeted by peace activists and environmentalists. For the record, the Navy spent about \$25 million on research and studies into public and environmental safety, and found no problems [5]. Under political pressure to "re-evaluate its priorities," the Navy recently decided that it would no longer operate the two transmitters, which cost about \$13 million a year. Even the associated infrastructure in Wisconsin and Michigan will be taken down over the next couple of years. The Navy will now have to make do with its VLF transmitters located around the world for communicating with its submerged submarines. For those engaged in the development and implementation of the ELF communication system, an era has suddenly come to an end.

References

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