METROLOGY NEWS

The End of an Era: LORAN-C is Shut Down

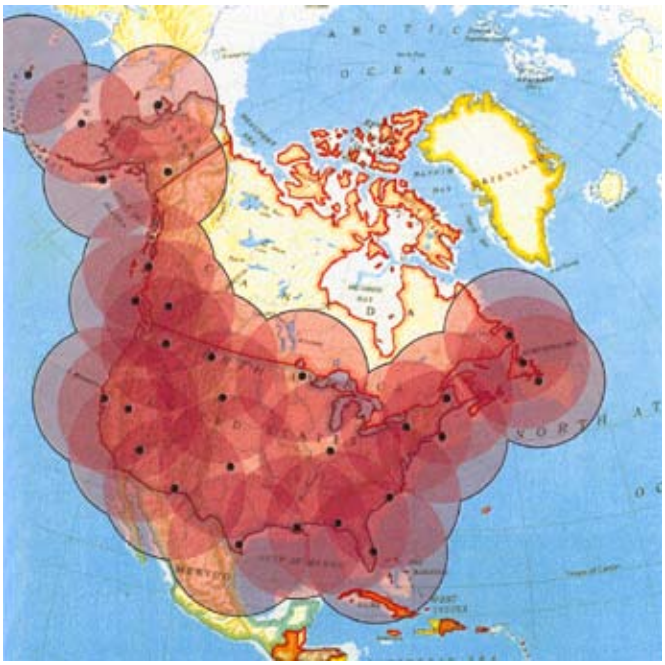
After many years of continuous operation, the LORAN-C system in the United States was shut down on February 8, 2010 at 20 hours, 0 minutes, Coordinated Universal Time. Operated by the United States Coast Guard (USCG), the LORAN system consisted of high powered (sometimes more than one megawatt) radio transmitters that broadcasted on a carrier frequency of 100 kHz. Its primary purpose was to serve as a navigation system for mariners and aviators. However, because all of its broadcasts were referenced to cesium oscillators located at the transmitter sites, LORAN was also known to many metrologists as a traceable reference source for frequency and time calibrations.

The termination of LORAN-C represents the end of an era. An acronym for Long Range Navigation, LORAN had a long and storied history. It was first established during World War II under a secret program that provided the Allies with a reliable and accurate means of navigating at sea. Later, small receivers suitable for aircraft were developed, and LORAN expanded to all aspects of the military. The first stations were built in the Atlantic by USCG construction detachments beginning in 1942. The system then expanded to the Pacific, and the LORAN system was used by the Army Air Force for invasions and bombing campaigns during the latter part of the war.

After WWII, the LORAN system was expanded to support both merchant and military use. Over a period of decades, new stations were built all over the northern hemisphere, located in remote areas as diverse as Scotland, Italy, the Philippines, Japan, South Vietnam, and Thailand. By 1974, the USCG was operating 45 stations. The stations located outside of the United States were turned over to their host governments by the end of 1994, but the USCG continued to operate 24 domestic stations. Nineteen of the U. S. stations were turned off on February 8, 2010. The remaining five stations are still on the air at this writing (April 2010) at the request of the Canadian and Russian governments, but are scheduled to be turned off no later than October 1, 2010.

The future of LORAN had been tenuous since the Global Positioning System (GPS) satellite navigation system was declared fully operational in 1993. The space based GPS system had many advantages over ground based LORAN. It provided better navigation accuracy, its signals were easier to receive, and it provides true worldwide coverage (LORAN never worked in the southern hemisphere). In addition, the many millions of dollars spent on GPS research and development led to very small and inexpensive receivers, which today are almost ubiquitous in cars, planes and boats.

For these and other reasons, LORAN found itself on the federal chopping block several times during the 1990s, and again during the Bush administration. However, each time supporters rallied to its defense and kept the system temporarily



The coverage area for timing signals of the North American LORAN-C stations prior to the decommissioning of the system. Most of these stations were turned off on February 8, 2010; the remainder will be turned off no later than October 1, 2010.

alive. LORAN supporters believed that it was not wise for the country to rely solely on GPS for navigation and timing, because a GPS failure could be costly to businesses, dangerous to travelers, and have serious consequences for the military. They argued that LORAN was the best available backup system because it provides very similar information to GPS but uses very different technology. For example, GPS provides a very weak spread-spectrum signal that is easy to interfere with or intentionally jam, making reception impossible in some cases. In contrast, the high power LORAN signal is nearly impossible to jam. GPS is powered by solar panels; LORAN is tied to ground power. The GPS satellites are in outer space, outside of U. S. boundaries, whereas the LORAN transmitters were operated in controlled space inside the U. S. boundaries. Another strong argument for the continued existence of LORAN was its low cost. Although estimates varied, nearly all agreed that the cost of operating LORAN for one year was less than $40 million USD, or about 1/5 the cost of launching a single GPS satellite.

The most ringing endorsement for the continuance of LORAN was given in late 2006 by an Independent Assessment Team headed by Dr. Bradford Parkinson, a principal designer of the GPS system, who is often known as the “father of GPS.” Parkinson’s team unanimously recommended that an enhanced version of LORAN (called eLORAN), which had been under development for several years, be completed and “retained as the national backup system for GPS” for the next 20 years, stating that eLORAN had “critical safety of life, national and economic security, and quality of life applications.”

The station crew at the transmitter site at Las Cruces, New Mexico in 2008. Las Cruces was one of the 19 stations decommissioned on February 8, 2010.

In the end, however, none of these arguments were enough to save LORAN. Several inescapable facts remained: GPS worked better and LORAN equipment had been largely discontinued due to the popularity of GPS, thus very few LORAN users remained. The new eLORAN system would have certainly narrowed the gap between GPS and LORAN performance, but it faced a classic "chicken and egg" type of problem. Receiver manufacturers were understandably reluctant to build new equipment without any long-term commitment to eLORAN from the federal government. And without new receivers, it was nearly impossible to demonstrate the performance or utility of eLORAN.

Even more damaging to LORAN was the fact that the USCG, and its controlling agency, the Department of Homeland Security (DHS), appeared to be in favor of dismantling the system. In a submission to the Federal Register, the Coast Guard said LORAN was not established as, nor was it intended to be, a backup for GPS. DHS stated that continuing to study "if a single, domestic system is needed as a GPS backup," and commented that the continued operation of LORAN was "not necessary to advance this evaluation." Even President Obama weighed in, perhaps delivering the knockout punch, when he used LORAN as an example of government waste in a May 2009 speech. "This system once made a lot of sense, before there were satellites to help us navigate," Obama said. "Now there's GPS. And yet, year after year, this obsolete technology has continued to be funded even though it serves no government function and very few people are left who still actually use it."

It is certainly true that no technology lives forever and perhaps also true that LORAN had outlived its usefulness. At the end of the LORAN era, however, it's worth reflecting for a moment on the contributions that LORAN made to the metrology community:

- As early as 1963, the National Bureau of Standards (now National Institute of Standards and Technology - NIST), and the United States Naval Observatory (USNO) were able to remotely compare their time scales using common-view observations of LORAN-C signals.
- Before the advent of GPS timing receivers in the 1980s, timing comparisons between National Metrology Institutes (NMIs) were often made using LORAN, including most of the comparisons used to calculate Coordinated Universal Time (UTC).
- Several manufacturers built LORAN disciplined oscillators and timing receivers that were used as primary references for frequency and time in U. S. calibration laboratories. These manufacturers included Austron, Texas Instruments, Stanford Research Systems, Locus, and others. LORAN frequency and time products were sold by various manufacturers for more than 40 years and used in hundreds of laboratories.
- Telecommunication providers, including Sprint/Nextel, once operated thousands of LORAN receivers that provided the timing synchronization necessary to keep telephone networks operating in the absence of GPS.
- NIST once operated (from 1984-1993) a remote calibration service where more than 60 LORAN receivers were deployed at calibration laboratories. These receivers provided traceable frequency calibrations with an uncertainty of 5×10^{-13} after one day of averaging.

Finally, it is important to thank the USCG personnel, past and present, that operated the LORAN stations so reliably and accurately for so many years. They served their country for almost seven decades by providing service to the armed forces, by helping to keep the clocks on time, and by guiding mariners and aviators safely home.

— Special input from Michael A. Lombardi, NIST, lombardi@nist.gov

Dilip Shah: 2010 Woodington Award Winner

The 2010 Woodington Award recipient is Mr. Dilip Shah, who was presented the award during the 2010 Measurement Science Conference (MSC) in Pasadena, CA. Dilip received the award for his long career dedicated to improving the metrology community. He is President of E=mc3 Solutions, which provides training and consulting in *ISO9000/TS 16949*, *ISO17025*, measurements, and computer applications.

Dilip Shah receives the 2010 Woodington Award from Arman Hovakemian, MSC Chairman of the Board.