The High Frequency Active Auroral Research Program

HAARP

Background

The High Frequency Active Auroral Research Program has as its goal, the study of the ionosphere to advance our understanding of its basic physical properties and behavior and to learn how to develop new communication, navigation and surveillance systems that are better able to deal with its variabilities. The program operates a new and modern facility, known as the HAARP Research Station near Gakona, AK and sponsors a broad research program in the areas of plasma physics and radio science using that facility.

Work on the HAARP Research Station was begun in 1993 following a one year environmental impact analysis. The first functional facility was completed in December 1994 with three passive, diagnostic instruments and an evaluation prototype HF transmitter consisting of 18 antenna elements and a net radiated power of 360 kW.

In March 1999, the HAARP Research Station had been developed to an intermediate level capable of high quality ionospheric research with the addition of several additonal instruments to the diagnostic suite and an improved HF transmitter utilizing 48 antenna elements and with a net radiated power capability of 960 kW. Between 1999 and 2006, 20 major research campaigns and numerous shorter studies were conducted at the facility. The results of this research have yielded new discoveries and have identified new areas to be studied. The results of research sponsored by HAARP have been reported in peer-reviewed scientific journals including The Journal of Geophysical Research, Geophysical Research Letters, Radio Science, the Institute of Electrical and Electronic Engineers, and Nature.

Beginning in 2003, the program began the final stage of development at the HAARP Research Station. In addition, between 2003 and 2006, new instruments were added to the facility including a new UHF Ionospheric Radar and a telescopic dome for optical observations. The HF transmitter now consists of 180 antenna elements having a net radiated power capability of 3,600 kW, thus completing its development as originally planned. Although the HF transmitter is complete, the program continues to improve and develop the suite of scientific instruments at the facility to enhance its scientific product.

The following sections discuss individual aspects of the facility in greater detail. Some photos of the current facility are available in our Photo Index section.

The High Frequency Transmitter and Antenna Array

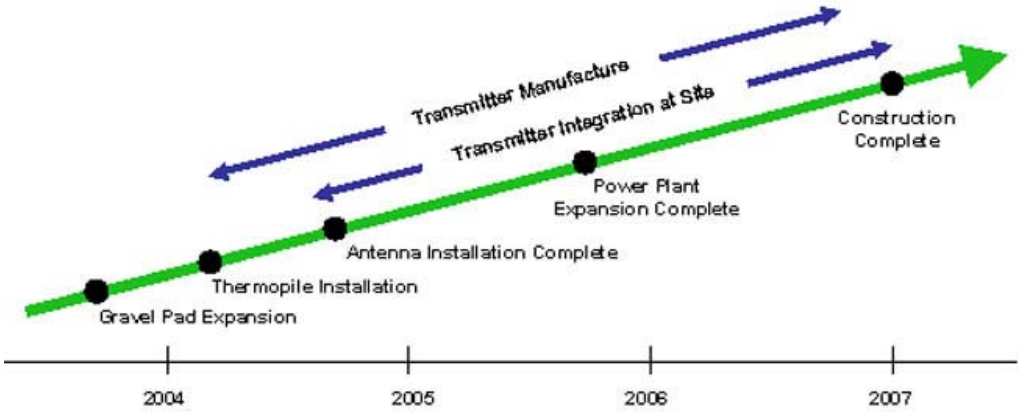
Work began on completing the HF Transmitter system, also called the Ionospheric Research Instrument (IRI), during fall 2003. Previously, research at the facility utilized a 48 element antenna array situated on a 5 acre gravel pad, originally constructed in 1993. During the fall and winter of 2003-2004, this pad was expanded to a total area of 35 acres to support the 15 X 12 antenna elements comprising the completed IRI antenna system. Specialized antenna tower supports called thermopiles were installed during the winter of 2003-2004 at precisely surveyed locations within the new pad. These thermopiles have integral passive cooling systems to stabilize the marginal permafrost subsoil below the gravel surface. During the summer of 2004, the 132 additional antenna towers and dipole elements were installed on the thermopiles. Concurrently, the original elevated ground screen was removed and a new ground screen installed below the entire 180 antenna element array.

Early in 2004, work began to manufacture the 132 new transmitters required for the completed high power HF system. Twenty-two new transmitter shelters were manufactured and positioned throughout the antenna array to house the transmitters as they were completed and delivered to the site. Work also began to upgrade the distribution systems for prime power, and for the low level signal and control systems.

Work began during 2004 to increase the on-site prime power generation capability to the capacity required by the completed IRI. Four additional diesel-generators were taken out of storage, refurbished

and installed in the power plant at the facility. The engines and their associated components including the mufflers and stacks were modified to meet exhaust emission and acoustic noise requirements. Following completion of this work in 2006, the HAARP Research Station now has an installed power generation capability of approximately 12.5 MW.

After acceptance testing at the factory, individual 20 kW transmitters were delivered to the site in groups of 6 beginning early in 2005. Each transmitter was then installed in a shelter, tested again and prepared for integration with the other system elements. Integrating the transmitters with the antennas, and with the low level signal, control and power distribution systems began during 2006 and ended with the delivery of the final transmitters early in 2007. The prime contractor for completing the IRI was BAE Systems, Advanced Technologies with major subcontractors Continental Electronics Corporation (for the transmitters) and Antenna Products Corp. (for the antenna system). The following figure shows the timeline over which the HAARP HF Transmitter was completed.



Although the construction of the IRI is complete, work is still required to validate the system for technical performance and for compliance with signal purity and safety requirements required by regulatory agencies. This evaluation began during March 2007.

HAARP Scientific and Monitoring Instruments

The HAARP observatory has a diverse suite of scientific instruments which operate continuously, providing important data to characterize the physical processes in the ionosphere produced during operation of the facility's high power HF transmitter. They are also used during research periods to help determine the optimum operating conditions for the HF transmitter.

When the HF transmitter is not in operation, the instruments provide real-time data on geophysical parameters that describe and characterize the background ionosphere and magnetosphere under typical conditions ranging from quiet to disturbed (in response to a solar flare, for example). Current data from many of these instruments are available on our web site.

Significant additions have recently been made to the instrument suite at the HAARP Research Station. The UHF Ionospheric Radar, acquired in conjunction with the University of Alaska, Fairbanks (UAF), is a phased array consisting of 512 antenna elements and operating at a frequency of 446 MHz. This diagnostic radar is particularly useful for the study of ionospheric physical processes during operation of the high power HF transmitter. The instrument installed at HAARP is a small portion of a much larger design developed for the National Science Foundation (NSF) by SRI International. (You can read more about the NSF Advanced Modular Incoherent Scatter Radar or AMISR). At its current level of development, the HAARP UHF radar can readily detect plasma and ion lines and many of their properties during operation of the high power HF transmitter.

Another important new diagnostic instrument, an 8 X 8 antenna element imaging riometer, has recently gone into operation at the HAARP Research Station. This instrument monitors the weak galactic background noise at a frequency of 37 MHz using a receiving antenna pattern that permits mapping the ionospheric absorption in 64 overhead patches. This instrument, which was also acquired in conjunction with UAF, is similar to a larger imaging riometer currently in operation at the Poker Flat Research Range near Fairbanks.

A new optical shelter has recently been installed at one of the remote instrument pads at the facility.

The new shelter includes a 14 ft. telescope dome with shutter and is rotatable through 360 degrees of azimuth. In addition, a new computer controlled telescope has been added to the existing suite of optical imagers and photometers used during imaging research. Taking advantage of its narrow field of view and sensitive CCD imager, the telescope allows the study and characterization of fine structure in the faint airglow produced under certain conditions of HF transmitter operation.

The following listing shows the scientific instruments currently in operation, either at the HAARP Research Station or off-site:

- Modular UHF Ionospheric Radar (446 MHz, 512 elements)
- All sky riometer
- Imaging riometer 8 X 8 Array
- Fluxgate Magnetometer
- Induction Magnetometer
- Ionosonde
- Optical Shelters and 14 ft Dome
    - All-sky imagers
    - Computer Controlled Telescopic imager
- Tomography Chain (150/400 MHz satellite receivers)
  Cordova -> Kaktovik
- VHF Radar (139 MHz)
- Ionospheric Scintillation Receivers
    - SATSIN (Chistochina/Nebesna)
    - GPS-NOVATEL
    - Total Electron Content
- Radio Background Receivers
    - Multiple Off-site Broadband ELF/VLF Receivers
    - SEE Receiver string
    - HF - UHF Spectrum Monitor
- HF 2-30 MHz High Angle Receiving Antenna

Pioneering Ionospheric Radio Science Research for the Twenty-First Century

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