An Ionosonde for the 21st Century

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The ionosonde is as fundamental to monitoring and understanding the upper atmosphere as are the seismograph to the solid earth, the magnetometer to geomagnetism, the barograph to meteorology, the wave and tide recorder to oceanography, and sonar to marine-acoustic applications. Ionosondes have fulfilled their role from the time of primitive analog instruments nearly 80 years ago, until present-day digital systems. On average, about 200 ionosondes have been deployed globally under the administration of many government and academic institutions.

Modern ionosondes can and should face the challenges posed within the Space-Weather framework, and they must serve expanding research opportunities in geophysics, plasma and radio physics. No longer merely "devices for making ionograms", they enjoy the remarkable sensitivity of MF/HF radio to complex plasma structure, in turn exploiting the sensitivity of ionization to nearly every internal and external geophysical influence. Diagnostics in three spatial dimensions, with single-site resolution extending from tens of meters to hundreds of kilometers, with millisecond resolution and unlimited (and adaptive) temporal continuity, can now be demonstrated. Dynamic descriptions of irregular plasma structure are usefully statistical at less than about the Fresnel scale (a few km), and become usefully deterministic toward larger scales.

Fortunately, modern digital technology enables a cost-effective approach to the design of a modern ionosonde, while assuring rapid data processing, dissemination and archival tasks. A new system now in the engineering stage of development will be modular, with at least four parallel, identical, digital receivers, giving at least 20-bit I/Q echo processing with dynamic range exceeding 80 dB. Digital (programmable) definition of output waveform and receiver performance assure echo phase coherence and low RFI generation. An open-source operating system will permit continuing evolution of measurement capabilities for monitoring and research applications.

Extensive data analysis capabilities are demonstrated at present using the NOAA Dynasondes at EISCAT (Tromsø Norway) and the USU Bear Lake Observatory, and are available in real time on the Web (e.g., *http://dynamite.eiscat.uit.no/jww*).