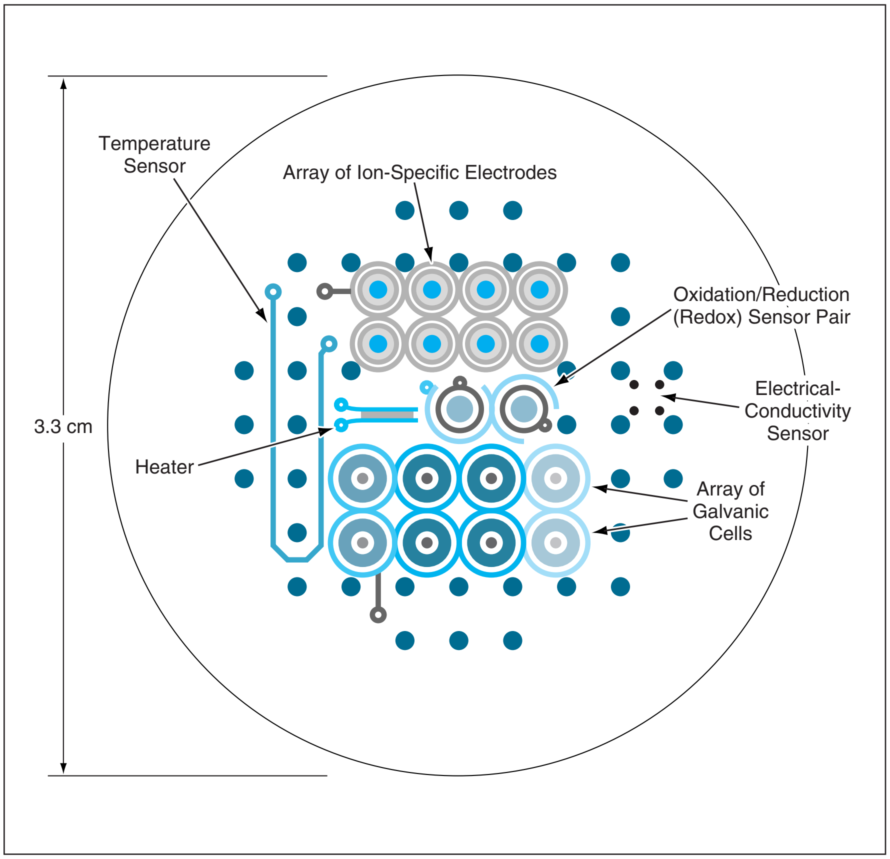
Electronic Tongue for Quantitation of Contaminants in Water

The main advantage is ruggedness.

NASA's Jet Propulsion Laboratory, Pasadena, California

An assembly of sensors, denoted an electronic tongue, is undergoing development as a prototype of compact devices for use in measuring concentrations of contaminants in water. Thus far, the electronic tongue has been tested on ions of Cu, Zn, Pb, and Fe and shown to respond to concentrations as low as about 10 parts per million. This electronic tongue is expected to be capable of measuring concentrations of other metal ions and organic compounds. Potential uses for electronic tongues include monitoring the chemical quality of water in a variety of natural, industrial, and laboratory settings; detecting micro-organisms indirectly by measuring microbially influenced corrosion; and characterizing compounds of interest to the pharmaceutical and food industries.



A **Heater and Sensors of Five Different Types** are all mounted together on a compact ceramic substrate.

This version of the electronic tongue includes a heater, a temperature sensor, an array of ion-specific electrodes, an oxidation/reduction sensor pair, an electrical-conductivity sensor, and an array of galvanic cells, all on one compact ceramic substrate (see figure). Special-purpose electronic excitation and readout circuitry for the sensors has also been constructed.

The main advantage of the electronic tongue, relative to electrodes of this type used traditionally to assess water quality, is extreme ruggedness.

The types of measurements that can be performed by use of the sensors on the electronic tongue are quite varied. The best combination of types of measurements for a given application depends on the specific contaminants that one seeks to detect. Experimental studies to identify such combinations were in progress at the time of reporting the information for this article.

This work was done by Marlin Buehler and Gregory Kuhlman of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

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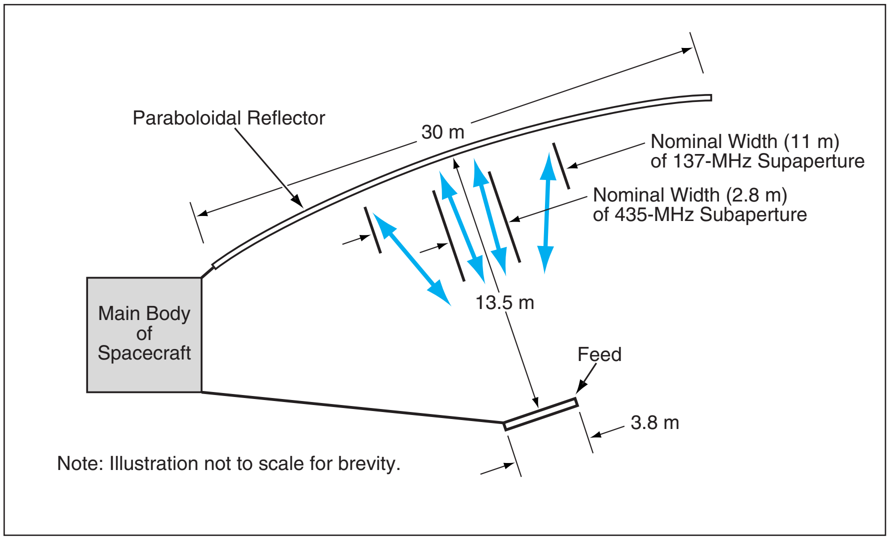
Radar for Measuring Soil Moisture Under Vegetation

Polarimetric data would be acquired at two frequencies.

NASA's Jet Propulsion Laboratory, Pasadena, California

A two-frequency, polarimetric, spaceborne synthetic-aperture radar (SAR) system has been proposed for measuring the moisture content of soil as a function of depth, even in the presence of overlying vegetation. These measurements are needed because data on soil moisture under vegetation canopies are not available now and are necessary for completing mathematical models of global energy and water balance with major implications for global variations in weather and climate.

The two proposed frequencies (137 and 435 MHz) are low relative to frequencies ordinarily used in radar systems. One reason for choosing these frequencies is that they are low enough to enable penetration of vegetation and of soil to the required depths. Another reason for choosing these frequencies, in conjunction with polarimetry, is that prior research has shown



A **Lightweight Paraboloidal Mesh Reflector** would be subilluminated by a feed that would generate fan-shaped beams at 137 and 435 MHz.

that measurement data from at least two frequencies and multiple polarizations are needed to make it possible to separate the vegetation-canopy and soil contributions to the radar returns so as to be able to estimate the soil moisture content.

One of the principal challenges in designing the proposed system is posed by the need for a large antenna to form the required polarimetric measurement swath at the two chosen frequencies. A current state-of-the-art design would entail an antenna-and-feed mass of about 3 tons (≈2.7 tonnes), which would be impractically heavy. In contrast, the antenna and its feed in the proposed system would weigh only about one-tenth as much. In addition, the antenna could be stowed compactly during launch into orbit.

The proposed antenna (see figure) would include a lightweight paraboloidal mesh reflector about 30 m wide. A dual-polarization stack-patch array feed would generate beams having a highly controlled fan-like shape to subilluminate the reflector in synthesized approximately rectangular apertures: the feed would be designed and operated so that its radiation pattern would synthesize a 30-by-11-m aperture at 137 MHz and a 30-by-2.8-m aperture at 435 MHz. The feed would have dimensions of about 3.8 by 1.2 by 0.1 m.

Another principal challenge in designing the proposed system is to refine and verify the algorithms used to retrieve soil moisture contents at depths ranging from centimeters to meters under substantial vegetation. Such retrievals involve inversion of mathematical models that (1) characterize vegetation and its interaction with soil and (2) represent soil as a multilayered medium containing random boundaries and varying permittivity. The details of such retrievals are complex and require detailed sensitivity analyses and demonstrations with real measurement data. Planned development efforts include experiments using a simple tower-based radar system to obtain data to estimate soil moisture contents and compare the estimates with actual values obtained by use of soil-moisture probes. It will also be necessary to optimize the design to minimize the adverse effects of propagation of radar signals through the ionosphere and to develop post-processing algorithms to correct for what remains of these effects after optimization of design.

This work was done by Mahta Moghaddam, Delwyn Moller, Ernesto Rodriguez, and Yahya-Rahmat-Samii of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
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