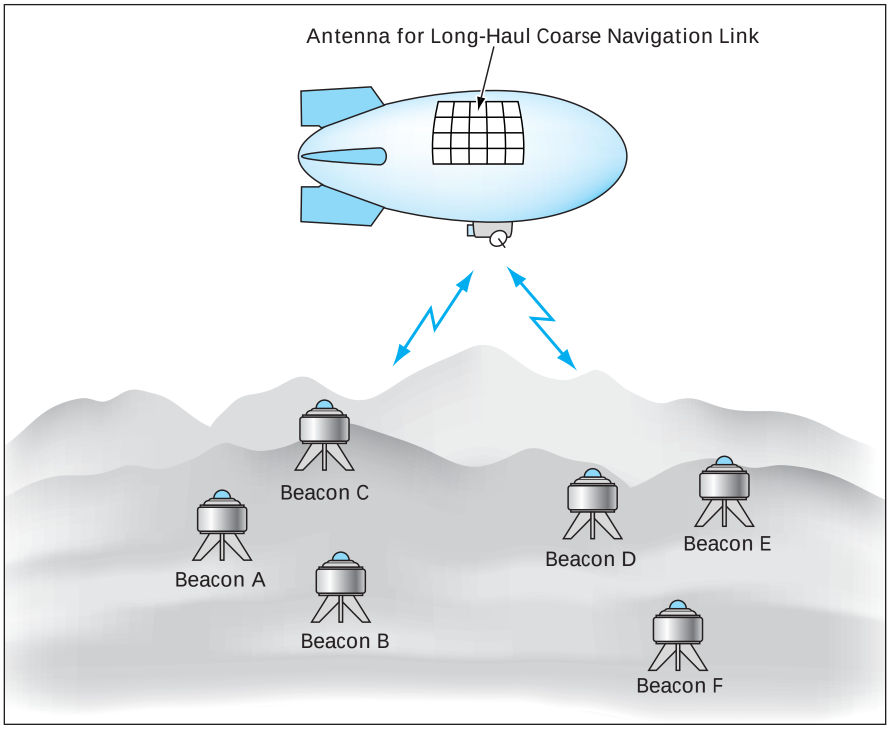


A **Robotic Exploratory Aircraft** (e.g., a miniature blimp) would transmit a radarlike signal to interrogate passive radio beacons on the ground. The navigation system of the aircraft would store the known locations of the beacons and would utilize the signals returning from the beacons to determine its precise position relative to the network of beacons. The navigation system would also synthesize a navigation map from a combination of the stored beacon location data and from prior and present coarse and fine position estimates.

fication (RFID) tags. The robot would transmit radarlike signals that would be modified and reflected by the passive beacons. The distance to each beacon would be determined from the round-trip propagation time and/or round-trip phase shift of the signal returning from that beacon. Signals returned from different beacons could be distinguished by means of their RFID characteristics. Alternatively or in addition, the antenna of each beacon could be designed to radiate in a unique pattern that could be identified by the navigation system. Also, alternatively or in addition, sets of identical beacons could be deployed in unique configurations such that the navigation system could identify their unique combinations of radio-frequency reflections as an alternative to leveraging the uniqueness of the RFID tags.

The degree of dimensional accuracy would depend not only on the locations of the beacons but also on the number of beacon signals received, the number of samples of each signal, the motion of the robot, and the time intervals between samples. At one extreme, a single sample of the return signal from a single beacon could be used to determine the distance from that beacon and hence to determine that the robot is located somewhere on a sphere, the radius of which equals that distance and the center of which lies at the beacon. In a less extreme example, the three-dimensional position of the robot could be determined with fair precision from a single sample of the signal from each of three beacons. In intermediate cases, position estimates could be refined and/or position ambiguities could be resolved by use of supplementary readings of an altimeter and other instruments aboard the robot.

This work was done by Clayton Okino, Andrew Gray, and Esther Jennings of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-40042

Superconducting Hot-Electron Submillimeter-Wave Detector

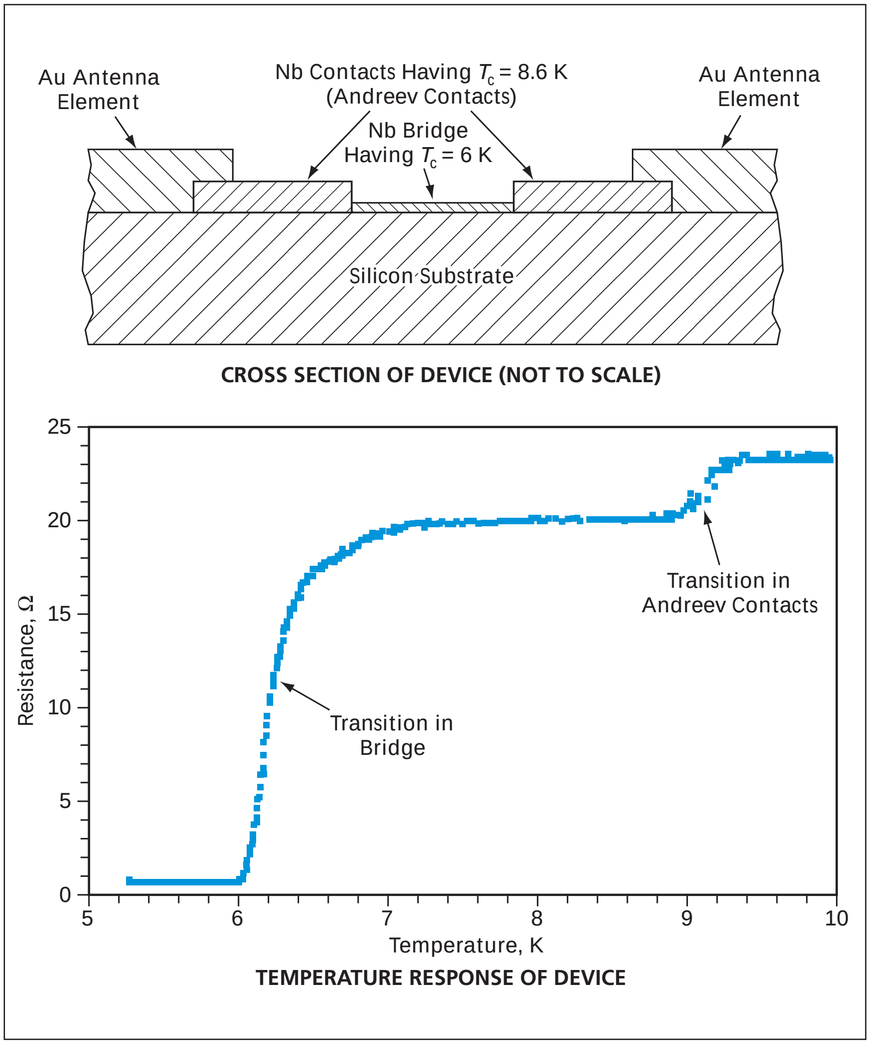
Sensitivity and speed are increased beyond those of related prior devices.

NASA's Jet Propulsion Laboratory, Pasadena, California

A superconducting hot-electron bolometer has been built and tested as a prototype of high-sensitivity, rapid-response detectors of submillimeter-wavelength radiation. There are diverse potential applications for such detectors, a few examples being submillimeter spectroscopy for scientific research; detection of leaking gases; detection of explosive, chemical, and biological weapons; and medical imaging.

This detector is a superconducting-transition-edge device. Like other such devices, it includes a superconducting bridge that has a low heat capacity and is maintained at a critical temperature (T_c) at the lower end of its superconducting-transition temperature range. Incident photons cause transient increases in electron temperature through the superconducting-transition range, thereby yielding measurable increases in electrical resistance. In this case, T_c = 6 K, which is approximately the upper limit of the operating-temperature range of silicon-based bolometers heretofore used routinely in many laboratories. However, whereas the response speed of a typical silicon-based laboratory bolometer is characterized by a frequency of the order of a kilohertz, the response speed of the present device is much higher — characterized by a frequency of the order of 100 MHz.

For this or any bolometer, a useful figure of merit that one seeks to minimize is (NEP)$\tau^{1/2}$, where NEP denotes the noise-equivalent power (NEP) and τ the response time. This figure of merit depends primarily on the heat capacity and, for a given heat capacity, is approximately invariant. As a consequence of this approximate invariance, in designing a device having a given heat capacity to be more sensitive (to have lower NEP), one must accept longer response time (slower response) or, conversely, in designing it to respond faster, one must accept lower sensitivity. Hence, further, in order to increase both the speed of response and the sensitivity, one must make the device very small in order to make its heat capacity very small; this is



A **Thin Nb Bridge** having T_c = 6 K lies between thicker Nb contacts having T_c = 8.6 K that, in turn, are connected to an antenna that couples submillimeter-wavelength radiation into the device.

the approach followed in developing the present device.

In the present device, the superconducting bridge having the T_c of 6 K is a thin film of niobium on a silicon substrate (see figure). This film is ≈1 µm wide, ≈1 µm long, and between 10 and 25 nm thick. A detector so small could lose some sensitivity if thermal energy were allowed to diffuse rapidly from the bridge into the contacts at the ends of the bridge. To minimize such diffusion, the contacts at the ends of the bridge are made from a 150-nm-thick niobium film that has a higher T_c(8.6 K). The interfaces between the bridge and the contacts constitute an energy barrier of sorts where Andreev reflection occurs. As a result, the sensitivity of the device depends primarily on thermal coupling between electrons and the crystal lattice in the Nb bridge. For this device, (NEP) = 2×10^{-14} W/Hz$^{1/2}$ and the response time is about 0.5 ns.

In order to obtain high quantum efficiency, a planar spiral gold antenna is connected to the niobium contacts. The antenna enables detection of radiation throughout the frequency range from about 100 GHz to several terahertz. In operation, radiation is incident from the underside of the silicon substrate, and an antireflection-coated silicon lens (not shown in the figure) glued to the underside of the substrate focuses the radiation on the bridge (this arrangement is appropriate because silicon is transparent at submillimeter wavelengths).

This work was done by Boris Karasik, William McGrath, and Henry Leduc of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).
NPO-43619

Large-Aperture Membrane Active Phased-Array Antennas

Large arrays are constructed as mosaics of smaller ones.

NASA's Jet Propulsion Laboratory, Pasadena, California

Large-aperture phased-array microwave antennas supported by membranes are being developed for use in spaceborne interferometric synthetic-aperture radar systems. There may also be terrestrial uses for such antennas supported on stationary membranes, large balloons, and blimps. These antennas are expected to have areal mass densities of about 2 kg/m^2, satisfying a need for lightweight alternatives to conventional rigid phased-array antennas, which have typical areal mass densities between 8 and 15 kg/m^2. The differences in areal mass densities translate to substantial differences in total mass in contemplated applications involving aperture areas as large as 400 m^2.

A membrane phased-array antenna includes patch antenna elements in a repeating pattern. All previously reported membrane antennas were passive antennas; this is the first active membrane antenna that includes transmitting/receiving (T/R) electronic circuits as integral parts. Other integral parts of the antenna include a network of radio-frequency (RF) feed lines (more specifically, a corporate feed network) and of bias and control lines, all in the form of flexible copper strip conductors on flexible polymeric membranes.

Each unit cell of a prototype antenna (see Figure 1) contains a patch antenna element and a compact T/R module that is compatible with flexible membrane circuitry. There are two membrane layers separated by a 12.7-mm air gap. Each membrane layer is made from a commercially available flexible circuit material that, as supplied, comprises a 127-µm-thick polyimide dielectric layer clad on both sides with 17.5-µm-thick copper layers. The copper layers are patterned into RF, bias, and control conductors. The T/R module is located on the back side of the ground plane