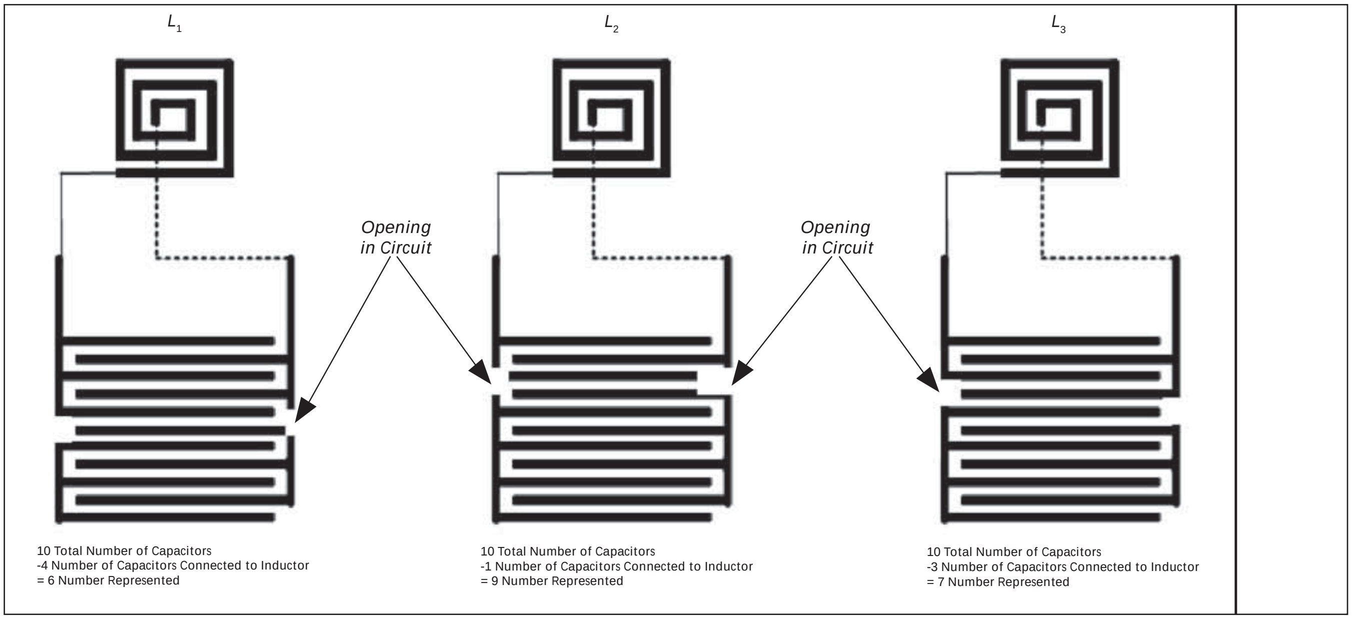


Three Resonant Circuits contain interdigitated-electrode capacitors that can be trimmed to encode digits between 0 to 9. In this case, they have been trimmed to encode the number 697.

digit to be represented by that circuit. N electrode pairs represent the digit 0 with the corresponding resonance frequency having the lowest assigned value. To encode a given nonzero digit (m), one punches a hole or makes a cut in the electrode pattern so as to disconnect m of the electrode pairs (or, sets of electrode pairs) from the inductor, reducing the capacitance and thereby increasing the resonance frequency to a value assigned to represent the digit m. The resulting frequency, ω_m, becomes (the capacitance for each electrode pair or set of electrode pairs is C)

$$\omega_m = \frac{1}{2\pi\sqrt{(N-m)L_iC}}$$

In the example shown at the left side of the figure, to encode the digit 6, one disconnects the electrodes of the lowermost 6 of 10 electrode pairs. If there is a need to encode more than one digit (e.g., three digits as in the figure), then one can fabricate the corresponding number of resonant circuits having the same capacitor arrangement but having inductance values (L_1, L_2, L_3) that differ sufficiently so that their resonance-frequency ranges do not overlap.

This method offers the following advantages in addition to the ones mentioned above:

- A number can be read, irrespective of the orientation of a tag containing the resonant circuits that encode the number.
- Numbers can be read at distances greater than the maximum reading distances of optical bar-code readers.
- A tag can be embedded or enclosed in electrically nonconductive material.
- A tag is secure in the sense that once it is embedded or enclosed in a protective material, there is no way to alter the encoded number in normal use.
- The method cannot store or acquire information providing ease of mind to consumers when used in retail.

This work was done by Stanley E. Woodard of NASA Langley Research Center and Bryant D. Taylor of Swales Aerospace for Langley Research Center. Further information is contained in a TSP (see page 1).LAR-16483-1

Determining Locations by Use of Networks of Passive Beacons

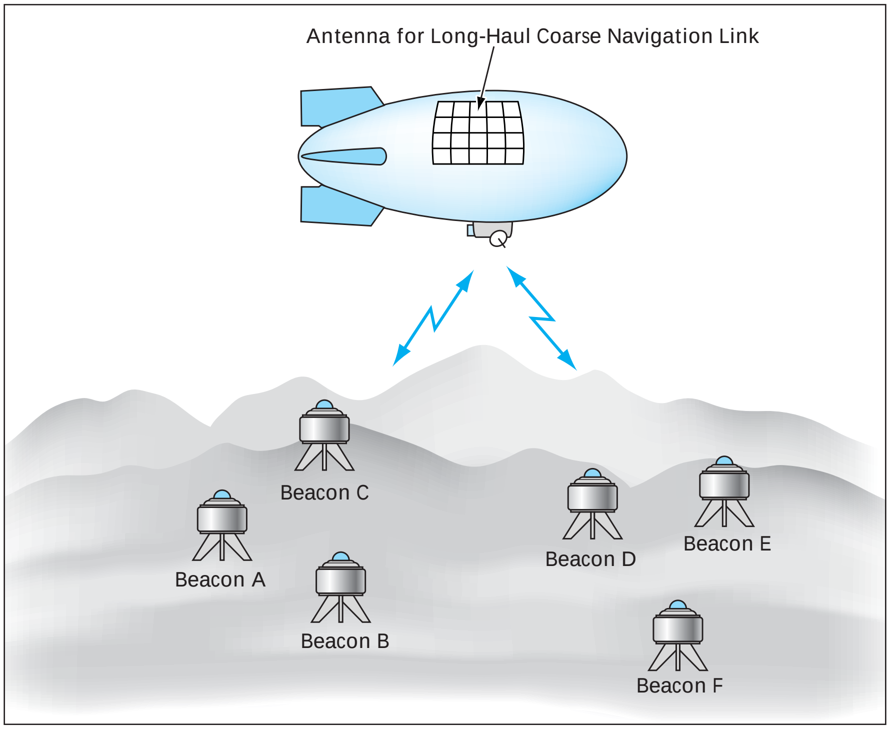
This method could be an alternative to GPS in some situations.

NASA's Jet Propulsion Laboratory, Pasadena, California

Networks of passive radio beacons spanning moderate-sized terrain areas have been proposed to aid navigation of small robotic aircraft that would be used to explore Saturn's moon Titan. Such networks could also be used on Earth to aid navigation of robotic aircraft, land vehicles, or vessels engaged in exploration or reconnaissance in situations or locations (e.g., underwater locations) in which Global Positioning System (GPS) signals are unreliable or unavailable.

Prior to use, it would be necessary to pre-position the beacons at known locations that would be determined by use of one or more precise independent global navigation system(s). Thereafter, while navigating over the area spanned by a given network of passive beacons, an exploratory robot would use the beacons to determine its position precisely relative to the known beacon positions (see figure). If it were necessary for the robot to explore multiple, separated terrain areas spanned by different networks of beacons, the robot could use a long-haul, relatively coarse global navigation system for the lower-precision position determination needed during transit between such areas.

The proposed method of precise determination of position of an exploratory robot relative to the positions of passive radio beacons is based partly on the principles of radar and partly on the principles of radio-frequency identi-



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