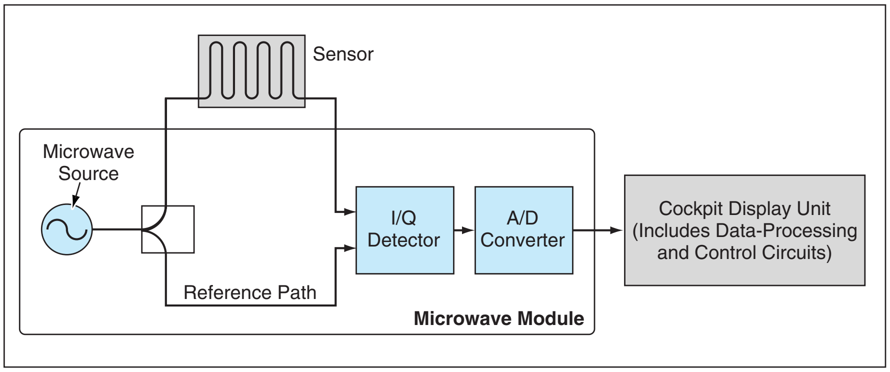


Figure 1. The **Sensor Is a Section of CPW or SL Transmission Line** flush with an aircraft surface. The magnitude and phase of the microwave signal arriving at the I/Q detector is affected by the amount of ice and/or water coating the sensory section of the transmission line.

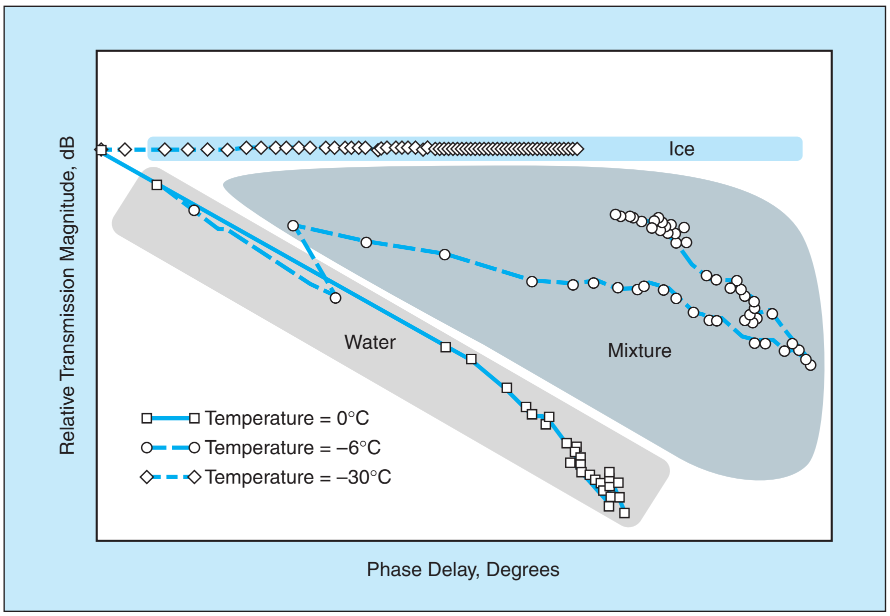


Figure 2. This **Normalized Response in the Magnitude/Phase Plane** was obtained in tests of a slot-line sensor at three temperatures. Three distinct regions of the magnitude-vs.-phase plane make it possible to distinguish among coats of ice, water, and mixtures thereof. In the important case of pure ice, the amplitude shift is negligible and the thickness of ice is indicated by the amount of phase shift.

tinuous-wave microwave signal source, the output of which is split onto a sensor path and a reference path. The sensor path consists of a microwave transmission line that includes a sensory portion of either the ground-plane coplanar-waveguide (CPW) type or the slot-line (SL) type. Whichever type is used, the sensory portion of the transmission line is mounted flush with the aircraft surface at the desired ice-detection location. With the exception of the sensory portion of the transmission line, the aforementioned circuitry is enclosed within an electrically conductive box. The sensor- and reference-path outputs are processed through an in-phase/quadrature (I/Q) detector, then through an analog-to-digital (A/D) converter. The output of the A/D converter is sent to data-processing and control circuitry in a cockpit display unit.

The data-processing subsystem computes the magnitude and phase of the sensor signal relative to those of the reference signal, and uses the sensor signal obtained when the sensor is bare to normalize the response of the system when water and/or ice are present. The normalized magnitude and phase response of the system serves as an indication of the thickness of ice and or water (see Figure 2).

This work was done by Philip J. Joseph, Dennis P. Glynn III, and John C. Joseph of Dedicated Electronics, Inc., for **Glenn Research Center.**

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17135.

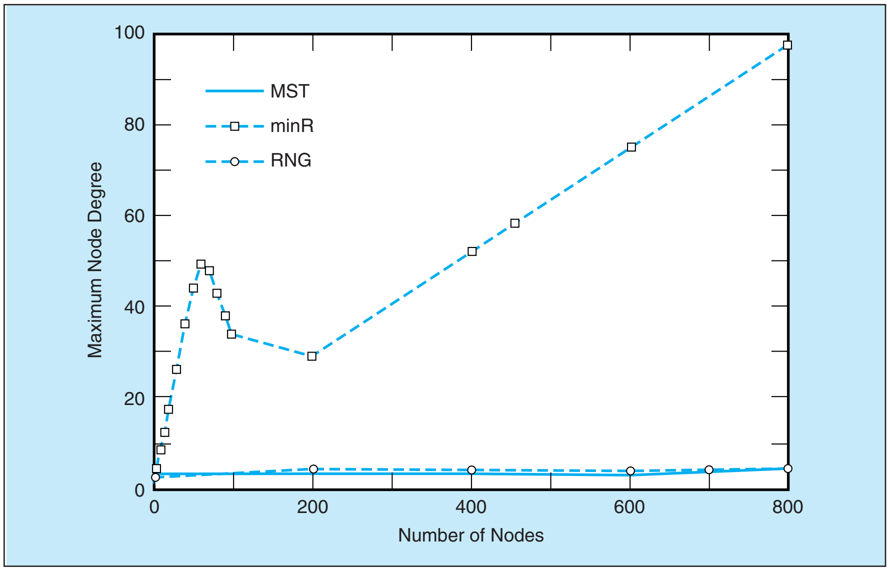
Routing Algorithm Exploits Spatial Relations

This algorithm is competitive with two prior algorithms.

NASA's Jet Propulsion Laboratory, Pasadena, California

A recently developed routing algorithm for broadcasting in an *ad hoc* wireless communication network takes account of, and exploits, the spatial relationships among the locations of nodes, in addition to transmission power levels and distances between the nodes. In contrast, most prior algorithms for discovering routes through *ad hoc* networks rely heavily on transmission power levels and utilize limited graph-topology techniques that do not involve consideration of the aforesaid spatial relationships. The present algorithm extracts the relevant spatial-relationship information by use of a construct denoted the relative-neighborhood graph (RNG).

The RNG algorithm is best described by reference to, and comparison with, two prior algorithms: one based on a construct denoted the minimum-radius (minR) graph, the other based on a construct denoted the minimum spanning tree (MST). The minR algorithm starts from the assumption that every node must use the same transmission radius, d. [As used here, "transmission radius" does not signify radius as the term is commonly understood; instead, it signifies an effective radius that depends on the ratio between the transmission power and the bit rate.] An iterative binary search is performed to find the smallest d that guarantees connectivity of the network. On each iteration, a graph with transmission radius d is computed. If the graph is found to be connected, then d is decreased for the next iteration. The algorithm stops at the finding of the value of d such that the graph is connected but at the next smaller



The **Maximum Node Degree** as a function of the number of nodes was computed for each of the three algorithms by averaging results from 1,000 computational simulations. (The degree of a given node is defined as the number of neighboring nodes that communicate directly with the given node. A higher node degree implies the need to schedule more time for communication via the given node.)

increment of d, the graph is partitioned into two or more sub-graphs. The number of operations needed to compute the minR graph is proportional to a number of the order of $n^2\log(s)$, where n is the number of nodes and s is the length of the side of a square of the same area as that containing the nodes.

The RNG of a set of nodes is the graph constructed according to the rule that any two of the nodes separated by distance l are connected by an edge only if there does not exist another node at a distance $<l$ from either first-mentioned node. The two nodes so connected are denoted relative neighbors. In the RNG, unlike in the minR graph, a different radius can be used for each pair of nodes. The RNG is a super-graph of the MST (which is described next) and a sub-graph of the graph of the Delaunay triangulation, which is a technique for connecting pairs of grid points with straight lines in such a way as to obtain an optimum tessellation of a grid area. The number of operations needed to compute the RNG is proportional to a number of the order of $n\log(n)$.

The MST is a sub-graph of the RNG. Therefore, one can use the RNG in the computation of the MST. An edge is included in the MST if it does not create a cycle in the graph. The construction of the MST involves disjoint sets. Nodes that are connected are placed in the same set. If a tested edge connects two nodes belonging to different sets, then the edge is added to MST and the two sets are united. If a tested edge connects two nodes belonging to the same set, then this edge creates a cycle and it is rejected. The number of operations needed to compute the MST is bounded by a number proportional to n, given that the RNG was pre-computed.

The comparison among the three algorithms is unavoidably complex because each offers both advantages and disadvantages with respect to the others. The figure presents an example of comparison with respect to the maximum node degree, which is only one of several different measures applied to results of computational simulations. The only general conclusion that one can draw from the comparisons by this and other measures is that the graph properties of the RNG are good, relative to those of the minR graph and the MST and that the RNG is suitable for efficient dissemination of information to all the nodes of a network.

This work was done by Clayton Okino and Esther Jennings of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

This algorithm is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30453.

Two-Finger EKG Method of Detecting Evasive Responses

John H. Glenn Research Center, Cleveland, Ohio

A system based on acquisition and processing of electrocardiographic (EKG) signals from two fingers has been proposed as a means of determining whether a person is answering questions evasively. The system — in effect, a "lie detector" of sorts, would be used to gauge prospective passengers' responses to questions at airport security checkpoints. The person to be interrogated would be required to put one finger from each hand onto two metal strips on a counter and would be instructed to relax and wait for the system to indicate that it is ready. Then a security person would ask the passenger a set of standard security questions. EKG signals acquired through contact with the fingers would be processed by an algorithm that would extract a single-value measure of the level of stress in the interrogated person. This measure would be used to determine whether the system should display a green or a red light to signify that the person is or is not, respectively, telling the truth. It has also been conjectured that the system may be useful for communicating with a person who is in a coma and, hence, unable to speak.

This work was done by Daniel Oldham of **Glenn Research Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland Ohio 44135. Refer to LEW-17441-1.