via someone else's rooftop transceiver, or portable wireless device, in a multi-hop fashion.

Microcells within a community are aggregated into cells by use of a local-area-network (LAN) backbone of higher speed wireless and/or wired connections. Every time a microcell connects to the wireless backbone, microcells or individual users in surrounding blocks can also connect to the network. Repeating this process, a network serving a wider area would be built. At various locations, the wireless traffic would be placed on the Internet backbone.

The proposed architecture is envisioned as extending Moore's law to Internet bandwidth and thereby offering an economic benefit. Moore's law (which is not really a law but an informal prediction that closely approximates what has been observed in industry) states that the numbers of transistors per unit area in microprocessors double about every 18 months. The consequences of Moore's law include both increasing capacity of the affected equipment and lower per-unit costs. The extension of Moore's law to Internet bandwidth has been estimated to offer the potential to reduce the cost of 1 Mb/s of Internet bandwidth to only $1 per month after ten years.

This work was done by Payman Arabshahi, Andrew Gray, Clayton Okino, and Tsun-Yee Yan of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-30452, volume and number of this NASA Tech Briefs *issue, and the page number.*

Improved Thermoplastic/Iron-Particle Transformer Cores

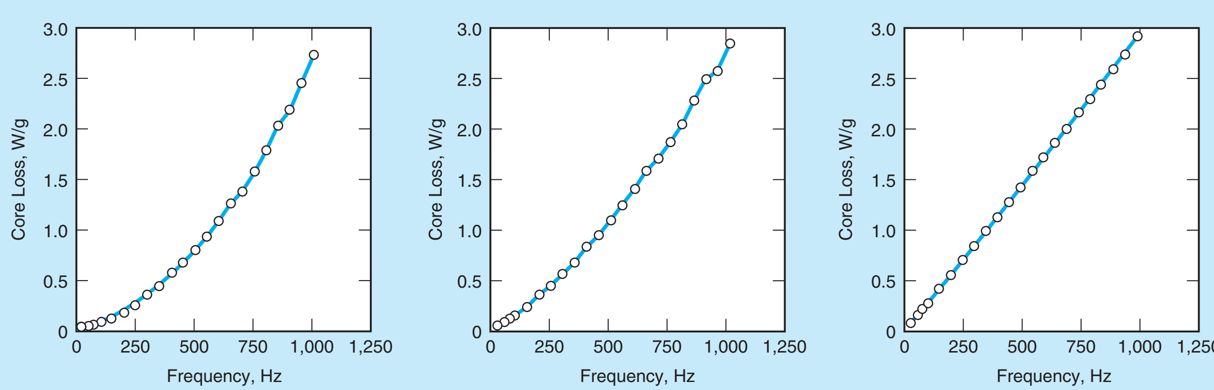
Proper choice of particle-size distribution results in minimal eddy-current loss.

Langley Research Center, Hampton, Virginia

A method of fabricating improved transformer cores from composites of thermoplastic matrices and iron-particles has been invented. Relative to commercially available laminated-iron-alloy transformer cores, the cores fabricated by this method weigh less and are less expensive. Relative to prior polymer-matrix/iron-particle composite-material transformer cores, the cores fabricated by this method can be made mechanically stronger and more magnetically permeable. In addition, whereas some prior cores have exhibited significant eddy-current losses, the cores fabricated by this method exhibit very small eddy-current losses. The cores made by this method can be expected to be attractive for use in diverse applications, including high-signal-to-noise transformers, stepping motors, and high-frequency ignition coils.

The present method is a product of an experimental study of the relationships among fabrication conditions, final densities of iron particles, and mechanical and electromagnetic properties of fabricated cores. Among the fabrication conditions investigated were molding pressures (83, 104, and 131 MPa), and molding temperatures (250, 300, and 350 °C). Each block of core material was made by uniaxial-compression molding, at the applicable pressure/temperature combination, of a mixture of 2 weight percent of LaRC™ (or equivalent high-temperature soluble thermoplastic adhesive) with 98 weight percent of approximately spherical iron particles having diameters in the micron range. Each molded block was cut into square-cross-section rods that were used as core specimens in mechanical and electromagnetic tests. Some of the core specimens were annealed at 900 °C and cooled slowly before testing. For comparison, a low-carbon-steel core was also tested.

The results of the tests showed that density, hardness, and rupture strength generally increased with molding pres-



Loss per Unit Mass of Low-Carbon Steel Core, Showing Strong Nonlinearity Due to Eddy-Current Loss

Loss per Unit Mass of Core Made From Particles of 30 to 80 Mesh, Showing Slight Nonlinearity Due to Weak Eddy-Current Loss

Loss per Unit Mass of Core Made From Particles of 100 Mesh, Showing Near-Linearity Due to Smallness of Eddy-Current Loss

The **Total Losses as Functions of Frequency** were measured in three cores at a magnetic induction of 5 kilogauss (0.5 Tesla). In general, the total frequency-dependent loss in a given core is the sum of a linear hysteresis contribution and a quadratic eddy-current contribution. Hence, the near-linearity of the curve in the 100-mesh case is evidence of low eddy-current loss.

sure and temperature, though the correlation was rather weak. The weakness of the correlation was attributed to the pores in the specimens. The maximum relative permeabilities of cores made without annealing ranged from 30 to 110, while those of cores made with annealing ranged from 900 to 1,400. However, the greater permeabilities of the annealed specimens were not associated with noticeably greater densities.

The major practical result of the investigation was the discovery of an optimum distribution of iron-particle sizes: It was found that eddy-current losses in the molded cores were minimized by using 100 mesh (corresponding to particles with diameters ≤100 μm) iron particles. The effect of optimization of particle sizes on eddy-current losses is depicted in the figure.

This work was done by Russell A. Wincheski, Robert G. Bryant, and Min Namkung of **Langley Research Center.** *Further information is contained in a TSP (see page 1).*
LAR-15719

Cooperative Lander-Surface/Aerial Microflyer Missions for Mars Exploration

Bio-inspired principles of key functions are distilled, enabling missions to Mars using multiple microflyers in synergy with the existing surface assets to provide a robust telecommunication architecture for gathering scientific data.

NASA's Jet Propulsion Laboratory, Pasadena, California

Concepts are being investigated for exploratory missions to Mars based on "Bioinspired Engineering of Exploration Systems" (BEES), which is a guiding principle of this effort to develop biomorphic explorers. The novelty lies in the use of a robust telecom architecture for mission data return, utilizing multiple local relays (including the lander itself as a local relay and the explorers in the dual role of a local relay) to enable ranges ~10 to 1,000 km and downlink of color imagery. As illustrated in Figure 1, multiple microflyers that can be both surface or aerially launched are envisioned in shepherding, metamorphic, and imaging roles. These microflyers imbibe key bio-inspired principles in their flight control, navigation, and visual search operations. Honey-bee inspired algorithms utilizing visual cues to perform autonomous navigation operations such as terrain following will be utilized. The instrument suite will consist of a panoramic imager and polarization imager specifically optimized to detect ice and water. For microflyers, particularly at small sizes, bio-inspired solutions appear to offer better alternate solutions than conventional engineered approaches.

This investigation addresses a wide range of interrelated issues, including desired scientific data, sizes, rates, and communication ranges that can be accomplished in alternative mission scenarios. The mission illustrated in Figure 1 offers the most robust telecom architecture and the longest range for exploration with two landers being available as main local relays in addition to an ephemeral aerial probe local relay. The shepherding or metamorphic plane are in their dual role as local relays and image data collection/storage nodes. Appropriate placement of the landing site for the scout lander with respect to the main mission lander can allow coverage of extremely large ranges and enable exhaustive survey of the area of interest. In particular, this mission could help with the path planning and risk mitigation in the traverse of the long-distance surface explorer/rover. The basic requirements of design and operation of BEES to implement the scenarios are discussed. Terrestrial applications of such concepts include distributed aerial/surface measurements of meteorological events, i.e., storm watch, seismic monitoring, reconnaissance, biological chemical sensing, search and rescue, surveillance, autonomous security/protection agents, and/or delivery and lateral distribution of agents (sensors, surface/subsurface crawlers, clean-up agents). Figure 2 illustrates an Earth demonstration that is in development, and its implementation will illustrate the value of these biomorphic mission concepts.

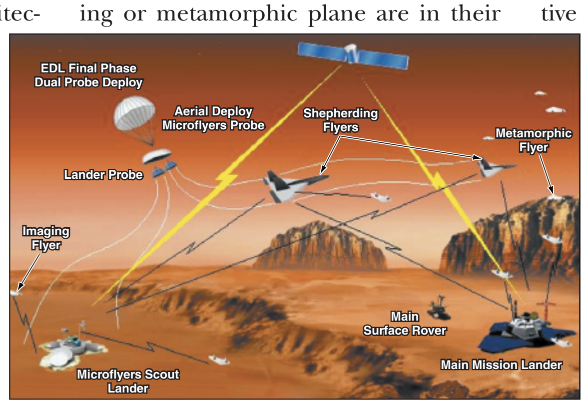


Figure 1: A **Biomorphic Mars Mission** is conceptualized here. (Note: EDL= Entry, Descent, and Landing.)

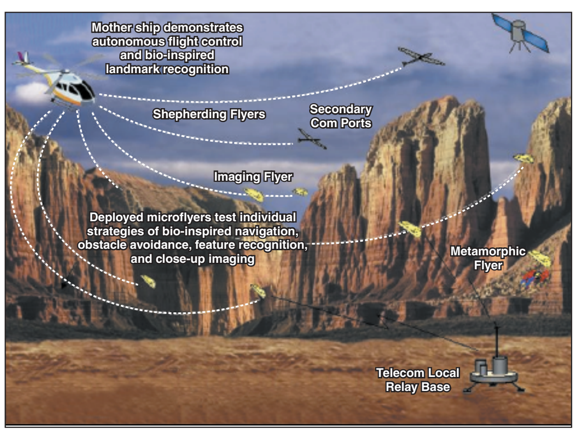


Figure 2: This is a **Conceptual Illustration of a Planned Demonstration**, "Bioinspired Engineering of Exploration Systems for MARS," to be performed at a MARS analog site on Earth. Here, microflyers work in synergy with the existing surface/aerial systems to enable new science endeavors. Multiple local comports provide a robust communication route for imagery downlink from the microflyers.

This work was done by Sarita Thakoor and Norman Lay of Caltech for **NASA's Jet Propulsion Laboratory** *and Butler Hine and Steven Zornetzer of Ames Research Center for the NASA Intelligent Systems Program. Further information is contained in a TSP (see page 1).*
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