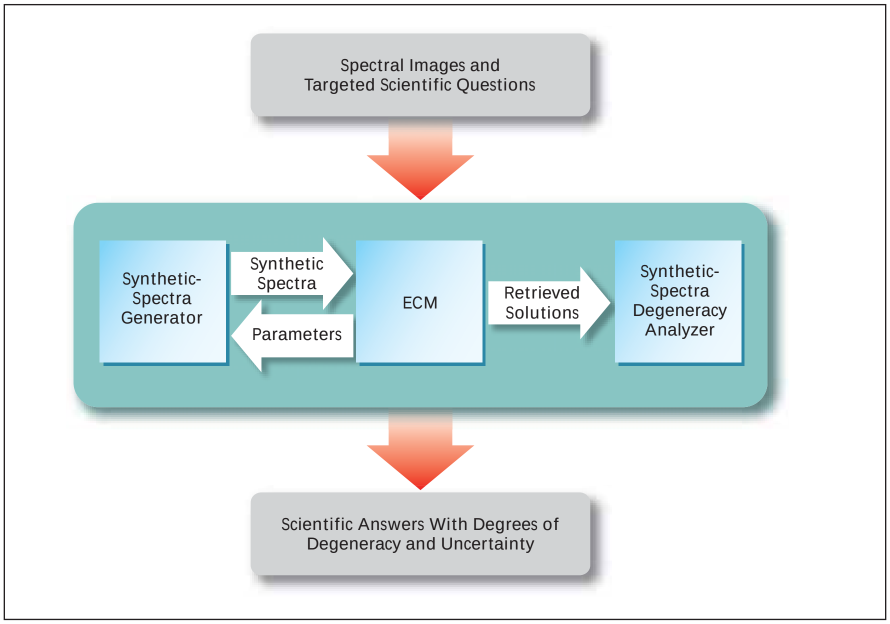

This **Conceptual Framework for Spectral Retrieval**, and the software that implements it, comprises three modules that interact in an iterative process.

space, using criteria that make searching computationally far more economical than in complete-enumeration ("brute force"), Monte Carlo, or random searches. (As used here, "unbiased" characterizes a search that does not depend on initial *ad hoc* guesses by experts.) Other advantages include the following:

- Optimal solutions are found;
- Better interpretations of planetary spectral and angular data are possible, and initial tests have shown these interpretations to be consistent with ground truth; and
- The methodology is not limited to specific problems, and can be extended to solve problems of greater complexity.

This work was done by Richard Terrile, Wolfgang Fink, Terrance Huntsberger, Seungwon Lee, Edwin Tisdale, Paul Von Allmen, and Giovanna Tinetti 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-42564, volume and number of this NASA Tech Briefs *issue, and the page number.*

Monitoring Disasters by Use of Instrumented Robotic Aircraft

Real-time synoptic data would help in coordinating and planning responses.

Ames Research Center, Moffett Field, California

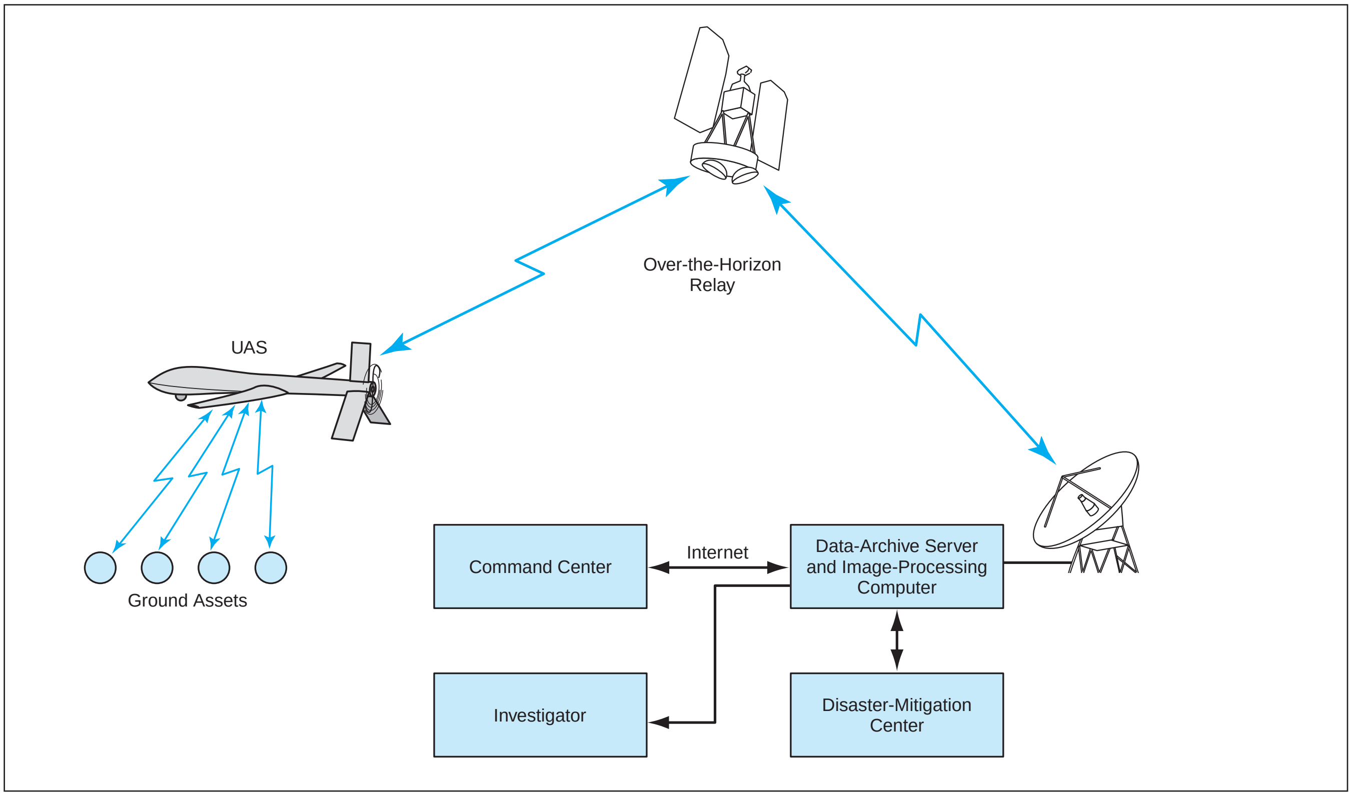
Efforts are under way to develop data-acquisition, data-processing, and data-communication systems for monitoring disasters over large geographic areas by use of uninhabited aerial systems (UAS) — robotic aircraft that are typically piloted by remote control. As integral parts of advanced, comprehensive disaster-management programs, these systems would provide (1) real-time data that would be used to coordinate responses to current disasters and (2) recorded data that would be used to model disasters for the purpose of mitigating the effects of future disasters and planning responses to them.

The basic idea is to equip UAS with sensors (e.g., conventional video cameras and/or multispectral imaging instruments) and to fly them over disaster areas, where they could transmit data by radio to command centers. Transmission could occur along direct line-of-sight paths and/or along over-the-horizon paths by relay via spacecraft in orbit around the Earth. The initial focus is on demonstrating systems for monitoring wildfires; other disasters to which these developments are expected to be applicable include floods, hurricanes, tornadoes, earthquakes, volcanic eruptions, leaks of toxic chemicals, and military attacks.

The figure depicts a typical system for monitoring a wildfire. In this case, instruments aboard a UAS would generate calibrated thermal-infrared digital image data of terrain affected by a wildfire. The data would be sent by radio via satellite to a data-archive server and image-processing computers. In the image-processing computers, the data would be rapidly geo-rectified for processing by one or more of a large variety of geographic-information-system (GIS) and/or image-analysis software packages. After processing by this software, the data would be both stored in the archive and distributed through standard Internet connections to a disaster-mitigation center, an investigator, and/or command center at the scene of the fire.

Ground assets (in this case, firefighters and/or firefighting equipment) would also be monitored in real time by use of Global Positioning System (GPS) units and radio communication links between the assets and the UAS. In this scenario, the UAS would serve as a data-relay station in the sky, sending packets of information concerning the locations of assets to the image-processing computer, wherein this information would be incorporated into the geo-rectified images and maps. Hence, the images and maps would enable command-center personnel to monitor locations of assets in real time and in relation to locations affected by the disaster. Optionally, in case of a disaster that disrupted communications, the UAS could be used as an airborne communication relay station to partly restore communications to the affected area.

A prototype of a system of this type was demonstrated in a project denoted the First Response Experiment (Project FiRE). In this project, a controlled outdoor fire was observed by use of a thermal multispectral scanning imager on a



Monitoring by Instruments Aboard a UAS would provide information to coordinate actions of ground assets at the scene of a disaster. The UAS and one or more satellite(s) would also serve as communication relays.

UAS that delivered image data to a ground station via a satellite uplink/downlink telemetry system. At the ground station, the image data were georectified in nearly real time for distribution via the Internet to firefighting managers. Project FiRE was deemed a success in demonstrating several advances essential to the eventual success of the continuing development effort.

This work was done by Steven S. Wegener, Donald V. Sullivan, Steven E. Dunagan, and James A. Brass of Ames Research Center; Vincent G. Ambrosia of California State University — Monterey Bay; Sally W. Buechel of Terra-Mar Resource Information Services; Jay Stoneburner of General Atomics-Aeronautical Systems, Inc.; and Susan M. Schoenung of Longitude 122 West, Inc. For further information, access http://geo.arc.nasa.gov/sge/UAVFiRE/white paper.html or contact the Ames Technology Partnerships Division at (650) 604-2954. ARC-14999-1.

Complexity for Survival of Living Systems

Interactions between systems and their mental images enable unlimited increase of complexity.

NASA's Jet Propulsion Laboratory, Pasadena, California

A logical connection between the survivability of living systems and the complexity of their behavior (equivalently, mental complexity) has been established. This connection is an important intermediate result of continuing research on mathematical models that could constitute a unified representation of the evolution of both living and non-living systems. Earlier results of this research were reported in several prior *NASA Tech Briefs* articles, the two most relevant being "Characteristics of Dynamics of Intelligent Systems" (NPO-21037), *NASA Tech Briefs*, Vol. 26, No. 12 (December 2002), page 48; and "Self-Supervised Dynamical Systems" (NPO-30634) *NASA Tech Briefs*, Vol. 27, No. 3 (March 2003), page 72.

As used here, "living systems" is synonymous with "active systems" and "intelligent systems." The quoted terms can signify artificial agents (e.g., suitably programmed computers) or natural biological systems ranging from single-cell organisms at one extreme to the whole of human society at the other extreme. One of the requirements that must be satisfied in mathematical modeling of living systems is reconciliation of evolution of life with the second law of thermodynamics. In the approach followed in this research, this reconciliation is effected by means of a model, inspired partly by quantum mechanics, in which the quantum potential is replaced with an information potential. The model captures the most fundamental property of life — the ability to evolve from disorder to order without any external interference.

The model incorporates the equations of classical dynamics, including Newton's equations of motion and equations for random components caused by uncertainties in initial conditions and by Langevin forces. The equations of classical dynamics are coupled with corresponding Liouville or Fokker-Planck