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 geo-rectified 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.

Complexity for Survival of Living Systems

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

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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-Su-pervised 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

equations that describe the evolutions of probability densities that represent the uncertainties. The coupling is effected by fictitious information-based forces that are gradients of the information potential, which, in turn, is a function of the probability densities. The probability densities are associated with mental images — both self-image and nonself images (images of external objects that can include other agents). The evolution of the probability densities represents mental dynamics. Then the interaction between the physical and metal aspects of behavior is implemented by feedback from mental to motor dynamics, as represented by the aforementioned fictitious forces.

The interaction of a system with its self and nonself images affords unlimited capacity for increase of complexity. There is a biological basis for this model of mental dynamics in the discovery of mirror neurons that learn by imitation. The levels of complexity attained by use of this model match those observed in living systems. To establish a mechanism for increasing the complexity of dynamics of an active system, the model enables exploitation of a chain of reflections exemplified by questions of the form, "What do you think that I think that you think...?" Mathematically, each level of reflection is represented in the form of an attractor performing the corresponding level of abstraction with more details removed from higher levels. The model can be used to describe the behaviors, not only of biological systems, but also of ecological, social, and economics ones. a