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- [Science](#)
- [General](#)
- [Business](#)
- [Archives](#)

**NEWS INDEX**

- [This Year](#)
- [2004](#)
- [Archives](#)

**PUBLICATIONS**

- [Inside Illinois](#)
- [II Archives](#)
- [II Advertising](#)
- [About II](#)

[Postmarks](#)

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## Insects, viruses could hold key for better human teamwork in disasters

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CHAMPAIGN, Ill. — In a new and novel study, scientists are looking to nature – specifically, to ants, bees and viruses – for ways to improve human collaboration during disaster relief efforts.

At the center of the scientists' sights are a subgroup of their own species – specifically, civil engineers, who historically have had a limited role in such efforts, especially those involving critical physical infrastructures.

Supported by a five-year \$2.37 million grant from the National Science Foundation, and supplemented by the University of Illinois at Urbana-Champaign, the research team at Illinois is attempting to draw inspiration from the collaboration patterns that honeybees and ants use, and the spread patterns viruses typically take.

The ideas the researchers develop will “augment current collaboration among first responders, including civil engineers, to extreme events involving critical physical infrastructures,” said Feniosky Pena-Mora, the principal investigator of the study and a professor of [civil and environmental engineering](#) at Illinois.

“The manner in which extreme events are addressed will influence the future of our cities, as well as redefine the role of the civil engineer,” Pena-Mora said.

In the epidemiology area of their work, the researchers are looking at the spread of infectious diseases in human populations. In the entomology area, they are looking at honeybees' (*Apis mellifera*) collaborative decision-making process when selecting a new hive or foraging, and at



*Click photo to enlarge*

Photo by Kwame Ross

Nosh Contractor, left, and Feniosky Pena-Mora look to nature – specifically, to ants, bees and viruses – for ways to improve human collaboration during disaster relief efforts.

ants' (*Solenopsis invicta*) behavior when they are under threat.

The research team, which includes biological, computer and social scientists and civil engineers, will apply their natural-world findings to three major areas: collaboration among organizations involved in disaster-relief efforts; the use of information technology to support preparedness, response and recovery tasks; and the emerging role of civil engineers as key first responders to disasters.

The study, "Information Technology-based Collaboration Framework for Preparing Against, Responding to and Recovering from Disasters Involving Critical Physical Infrastructures," was funded as part of NSF's Information Technology Research Program for National Priorities

Co-principal investigators in the study, all from the U. of I., include Noshir Contractor, professor of [speech communication](#) and of [psychology](#); Indranil Gupta, professor of distributed systems in the department of [computer science](#); Andrea Hollingshead, professor of speech communication and of psychology; and Gene Robinson, professor of [entomology](#) and of [neuroscience](#). Stuart Foltz, also a co-principal investigator, is a civil engineer at the U.S. Army Corps of Engineers' Construction Engineering Research Laboratory in Champaign.

Other researchers include Liang Liu and Khaled El-Rayes from Illinois' department of civil and environmental engineering, Lucio Soibelman from Carnegie Mellon University and Brian Brauer from the [U. of I. Fire Service Institute](#).

At the core of the research team's effort is the belief that civil engineers should be key players in disaster relief operations involving critical physical infrastructures – a fourth group of "first-responders," along with firefighters, police and medical personnel.

According to Pena-Mora: "The civil engineer's role – particularly the engineers and contractors who were involved with the original design and construction of the critical physical infrastructure – needs to be extended beyond infrastructure life-cycle management and sustainability to also involve first response against disasters.

"These professionals are able to provide more accurate information to support the decision-making process during the preparedness, response and recovery phases of a disaster."

For example, soon after the Sept. 11 terrorist attacks, inaccurate site maps were distributed to the emergency response teams in Manhattan. A week later, the World Trade Center design firm provided updated maps with accurate subsurface locations.

Contractor said that one of the challenges being explored

in the new research is “how first responders have to rely on local information and often work in the absence of global information.”

“An emergency-response strategy based on complete global information being made available instantly to all responders is fundamentally flawed,” Contractor said. “Instead, we need to develop a strategy that leverages cutting-edge research in information technology to enable the rapid assembly and deployment of ad hoc, flexible networks of responders who act largely on the basis of local information. Such a strategy would be enormously helpful in helping us cope with disasters such as the recent tsunami in the Indian Ocean.”

One of the ways these researchers hope to advance understanding of the dynamics of communication and knowledge networks among first responders is by “‘learning’ basic principles on how bees and ants are able to effectively self-organize based on local information,” said Contractor, who directs the Science of Networks in Communities group at the [National Center for Supercomputing Applications](#) at Illinois.

According to Illinois’ Gupta, the ad hoc communication networks the researchers eventually develop to spread critical information among first responders also will “mimic the epidemiological spread of viruses and rumors.”

“Epidemiological algorithms can be used in large groups of participants to spread, collect and search for information,” Gupta said, adding that “the resulting software systems can scale to networks with hundreds or thousands of first responders, as well as withstand unresponsive participants and poor communication channels.

“This behavior is very similar to how rumors or fads spread in society and viruses spread in populations, both rather reliably and rapidly.”

Understanding insects’ collaborative behavior also will help in the development of more efficient and effective ways of coordinating knowledge.

“Although human social systems are far more complex than insect societies, where a reduced set of rules govern the behavior of each insect for a given situation and the group’s behavior emerges from such interactions, these models may be useful in understanding the basic principles and best practices to be considered when developing strategies that will coordinate knowledge sharing in chaotic social settings where a small set of rules applied to local information drives decision-making,” Hollingshead said.

Put another way, while individual honeybees process only “partial and local information,” they are able, through interactions with each other, to produce “a coherent response to a change in their environment,” said Robinson, an expert on honeybees.

To date, no specific application has been found in

computer science or engineering domains using bee behavior as a source of analogy.

However, the researchers envision a smooth transition of concepts from the collaborative honeybee behavior to solve complex tasks, like foraging, into the disaster relief context, because of the modeling similarities of both settings.

Although many research initiatives have used ants as a source of knowledge in telecommunications and transportation, no specific application has yet been found that applies models of ant behavior under threatening situations for any given application in engineering. However, the way ants “detect and propagate alarms and the interactions produced in ant colonies can be used to model complex systems and cascading effects,” Robinson said.

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