Ten years after 9/11, infrastructure interdependence still a challenge in US

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Al Wallace was watching the live television news coverage from Manhattan when his phone rang. Only a few hours after the unthinkable terrorist attacks on September 11, 2001, a program manager from the National Science Foundation called to ask for Wallace's help in assuring nothing like this could ever happen again.

Wallace, an expert in decision sciences and systems engineering, and a professor at Rensselaer Polytechnic Institute, readily accepted. Within two weeks, he and his team were at Ground Zero. The rubble was still smoldering. Wallace collected as much information as possible without disrupting relief efforts. His researchers scouted the area, took photos, copied maps, and spoke to whatever officials could spare a few minutes for an interview. A day or so later, Wallace and the group were told to leave.

Undeterred, the researchers turned to the Fourth Estate as a source of data. Every morning, they scoured *The New York Times* and *Wall Street Journal* for articles about infrastructure restoration and disruption. A systems engineer who studies the deep interconnectedness of seemingly independent events or entities, Wallace was looking for the story behind the newspaper stories. A few months later the research team returned to Ground Zero, fostering a partnership with emergency response officials as well as Rensselaer graduates who worked at major power utilities and telecommunications companies. After years of study, what emerged was a disconcerting picture of major infrastructure systems that were highly dependent upon one another. Even today, Wallace sees this deep

interdependency as a liability and threat to national security and the quality of life for its citizens.

“Our infrastructure is aging, and all of the different systems — such as power, water, communications, transportation, and hospitals — are managed independently. Our group looks at this situation from a 30,000-foot perspective,” said Wallace, the Yamada Corporation Professor at Rensselaer, and a member of the Department of Industrial and Systems Engineering. “We map out and try to better understand the interdependencies amongst these infrastructure systems. The more we know about how they depend on each other, the better we’ll be at planning for disaster situations when one or more are disrupted or unavailable.”

The classic example of interdependent infrastructure systems is a power plant that runs on coal, where the coal is shipped to the plant via trains that require power from the plant in order to operate. While this chicken-and-egg situation is less subtle than most of the interdependencies that emerged in New York in the wake of the World Trade Center attacks, the idea is the same: the absence of one critical piece of infrastructure will have far-reaching, unanticipated, and often disruptive effects on the entire system.

Since 2001, Wallace’s group has published several widely cited studies that map out the tangled dependencies in Manhattan and New York at the time of the terrorist attacks and during the long road to recovery. Along with the practical applications of this new knowledge, the research has interesting theoretical implications. The researchers employed complex mathematics and computer algorithms to construct working models of infrastructure interdependency. Their work led to additional interest and funding from the National Science Foundation, and these studies continue today.

Partnering with the U.S. Department of Homeland Security and the University of North Carolina, Wallace's group developed prototype software that enables emergency response officials to physically see the interdependencies among the area's civil infrastructure systems, including wastewater, phone lines, and power. One example that emerged is a hospital in North Carolina designated as the area's primary medical relief center in the case of a hurricane. A key factor is the hospital's backup generator, which ensures the facility has electricity even if the power grid goes dark. In their studies, Wallace's group discovered the hospital sources its water supply via a nearby pump station, which requires power to run and lacks a backup generator. So even if the hospital can remain open during a storm, its operations will be severely limited by a lack of running water.

The software created by Wallace's team will help emergency response officials identify these kinds of problems ahead of time, and plan accordingly. The software also enables officials to input data about a particular storm or hurricane, in order to forecast how much damage will be wrought by the extreme weather. So far, training exercises with the software are going well, including one with emergency responders in North Carolina prior to Hurricane Irene, Wallace said. Next, the researchers will look at ways to incorporate social infrastructure, such as hospitals and storm shelters, into the software.

Working on these different projects with Wallace were Rensselaer professors Joe Chow, John Mitchell, Tom Sharkey, and Wallace's former graduate student David Mendonca, who has since joined the Institute faculty. Wallace has a joint appointment in the Department of Civil and Environmental Engineering at Rensselaer, and is a member of the university's Center for Infrastructure, Transportation, and the Environment.

Additionally, he commended the engineers and managers at power utility

Con Edison and telecom company Verizon for their efforts in the immediate aftermath of the Sept. 11, 2001, attacks. Wallace said these companies exhibited tremendous innovation and improvisation in successfully restoring two interdependent infrastructures—power and communications — ;and meeting the president's challenge of getting New York City's financial infrastructure up and running.

Wallace said visiting Ground Zero and his work in the wake of the World Trade Center attacks was a "life-changing" event, and he hopes his research will open people's eyes to the urgent need for richer understanding and better management of the interdependent infrastructure systems that persist today.

"The enormity of the attacks was simply overwhelming. There's just no other way I can describe it," Wallace said. "I wanted to do whatever I could to contribute to the cause of making our nation safer. In my view, the best way to do this is improving our infrastructure. Not just to reduce our vulnerability to terrorist attacks, but to make it more resilient to wear and tear. To encourage better funding and oversight for infrastructure projects, and to take advantage of new materials and advanced sensing technology. There are some good solutions out there, but they require us to take a long-term view. We need to plan ahead, and not just be reactive."

Provided by Rensselaer Polytechnic Institute