Random Antenna Arrays Boost Emergency Communications

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(PhysOrg.com) -- First responders could boost their radio communications quickly at a disaster site by setting out just four extra transmitters in a random arrangement to significantly increase the signal power at the receiver, according to theoretical analyses, simulations and proof-of-concept experiments performed at the National Institute of Standards and Technology.

The NIST work, described in a forthcoming paper,* may provide a practical solution to a common problem in emergency communications. The vast amount of metal and steel-reinforced concrete in buildings and rubble often interferes with or blocks radio signals. This was one factor in the many emergency communications difficulties during the response to the attacks on the World Trade Center on Sept. 11, 2001.

Antenna arrays have been studied and used for years, but the latest NIST work provides several new twists. Unlike the typical case in which antenna arrays boost signals to or from a distant target, a first responder's radio would be relatively close to the portable transmitters, ideally within the perimeter of the array. More importantly, since disaster sites rarely allow for niceties of design, NIST studied the benefits of a fast and imprecise technique—randomly placed antennas combined with coarse signal matching. The signals produced by the radio and portable transmitters need to operate at the same frequency and roughly in phase, such that the radio waves are fairly well synchronized and thus build on each other. Phase-matching was performed manually in the experiments but might eventually be possible remotely.

The NIST experiments covered a range of communications scenarios, using up to eight transmitters at different locations as well as objects such as concrete blocks that scatter radio waves. Across all experimental scenarios, researchers observed at least a 7 decibel median power gain—roughly a five-fold increase in the median received power—when splitting the power among four in-phase transmitting antennas, compared to using just a single transmitter. More important, researchers observed a 2.5 to 4-fold increase in the median signal at the radio receiver when using four in-phase transmitters instead of four randomly phased transmitters. More than four extra transmitters offered diminishing returns. (Unlike conventional repeaters, which re-send signals to maintain transmission strength across long-distance networks, the antennas in the NIST scenarios transmit the same signal at the same time to multiply its strength.)

Project leader Chris Holloway envisions portable transmitter devices shaped like hockey pucks, incorporating a small antenna and phase-shifting electronics, which could be thrown on the ground or stuck on a wall with the antenna always upright. “The idea is that someone, or even a robot, would have a bag of these things and would drop them off as they go through a building,” Holloway says. Other authors include a guest researcher from Sandia National Laboratories and a collaborator from the University of Colorado at Boulder. The work was funded in part by the Office of Community-oriented Policing Services of the U.S. Department of Justice.

*More information: W.F. Young, E.F. Kuester and C.L. Holloway. Measurements of randomly placed wireless transmitters used as an array for receivers located within the array volume with application to emergency responders. IEEE Transactions on Antennas and Propagation, (forthcoming.)

Provided by NIST