WE HEAR YOU

As federally funded researchers continue to test digital radio technologies, manufacturers bring to market new and improved models, based in large part on user input, that perform better on the fireground — but there's work still to do

Not everyone is a fan of digital radios. In fact, many argue that such radios are inadequate for emergency communications because they fail to deliver clear voice transmissions in certain environments. This is especially true on the fireground, where roaring pumpers, chain saws and street noise often overwhelm voice communications between incident commanders and firefighters.

To study the issue further, the U.S. Commerce Department's Public Safety Communications Research (PSCR) arm is conducting a second round of digital radio performance tests to determine whether improvements have been made regarding fireground communications. The tests are being held as part of a joint effort between the National Institute of Standards and Technology and the Institute of Telecommunications Services, and will evaluate the noise pollution that interrupts communications on the fireground, said D.J. Atkinson, a lead electronics engineer at PSCR.

A couple of years ago, the International Association of Fire Chiefs' Digital Project Working Group performed initial investigations into digital radio use on the fireground and offered best practices to manufacturers, Atkinson said. The current tests, being held in a controlled environment at PSCR laboratories in Boulder, Colo., will quantify what improvements have been made and target where work still is needed to further enhance audio quality for public-safety communications, he said.
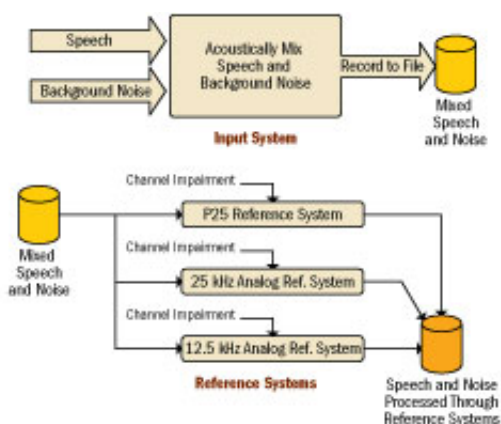
The tests compare digital and analog communications technology in laboratory simulations of public-safety communications environments (see graphic). Atkinson said that speech and noise from such environments will be tested in a manufacturer-independent manner using reference communication systems.

"This is accomplished through the examination of the
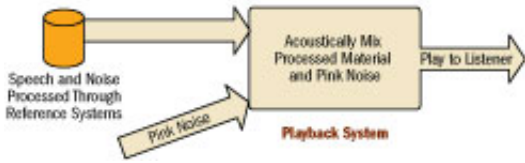
system performance in a subjective listening test, in which the relative performance among the systems is measured in a quantitative and repeatable way," he said.

Communication degradation also is being tested, specifically the effect of fireground background noise. Researchers will include law-enforcement and EMS background noise, as well. For example, Atkinson's team recorded noise at a local nightclub then scientifically determined the level of noise that would be encountered if police or EMS responded to an incident at a bar, and how such background noise would affect their communications.

For the first time, intelligibility —how understandable the speech is coming across the radio — and radio channel degradation will be tested, Atkinson said.

"We are adding both background noise and channel impairments — bit error rate, things like that — to see how those problems may compound to see if that has any additional detrimental effect or intelligibility issues," he said.

Atkinson expects to find measurable improvements in comparison to the first test. But he admits that digital radios "still have a little way to go before [they] are the best that they can be."

Fundamental design

Manufacturers are working with end-users to develop digital radios that solve voice clarity issues with a form factor tailored to users working in hazardous environments. For example, Motorola developed its multiband portable firefighter radio with end-users in mind, by studying human stress reactions, participating in live-fire training and listening to fire personnel's feedback on prototypes. The result was an ergonomic radio with a two-microphone design and acoustic- and noise-cancelling software that filters out fireground noises.

At Motorola, a hazard radio's development starts with internal experts and outside academics who research how people process information under stress, a condition known as high-velocity human factors, said Mark Palmer, a psychologist and director of the company's human factors and research division.

"Staff scientists research how people operate under high levels of stress and what it

means for the design of products, with a focus on firefighters and police," he said.

Field tests are next. For the company's firefighter radio, engineers worked with the Sunrise (Fla.) Fire and Rescue Department. As part of the partnership, a dozen Motorola engineers were outfitted with bunker gear and spent a day participating in live-fire training exercises, said Div. Chief Tom O'Connell.

"Engineers began to learn the shortcomings of communications under [fireground] environments," he said.

Palmer said that scientists learned the difficulty of communicating while also trying to put out a fire. In addition, they found that the heavy equipment used by firefighters – including bunker gear, heavy gloves and self-contained breathing apparatus (SCBA) — causes a situational disability that can hinder communications during an incident.

"You start to appreciate the problems firefighters go through … simple things like changing a channel so they can talk to each other," Palmer said. "This does not make us experts on being a firefighter, but it does show us the barriers and problems."

O'Connell said that company engineers then presented rough designs to firefighter user groups and asked about ergonomic needs, such as the size and height of knobs, with consideration given to gloved hands. They also documented the frequency range of background noises encountered on the fireground, such as a rotary saw cutting through metal or diesel engines revving.

Documenting what firefighters experience and listening to their feedback is part of participatory design, or co-creation, said Bruce Claxton, Motorola's senior director of innovation and design. Claxton said that such knowledge was used in the design phase to develop a physical prototype that could perform in extreme environments. In this phase, the company realized the unique nature of firefighting and the need to custom-fit a radio to that work environment — for instance, that the radio is accessible while wearing bunker gear. It further drove the desire to develop a tailored form factor that offered unique ergonomics specific to the fire service, he said.

"Ergonomics was a key driver for good design," Claxton said. "It was a fundamental principle."

Claxton said that because knobs and buttons needed to be more easily located and

operated with gloved hands, company designers tested out exaggerated controls and radio form factors.

"Today in our labs, we have bunker gear hanging on hooks and gloves and gear sitting in our design studio desks so designers can use the equipment while designing," he said. "It's not unusual to see someone in our office evaluating a prototype with full turnout gear on."

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As federally funded researchers continue to test digital radio technologies, manufacturers bring to market new and improved models, based in large part on user input, that perform better on the fireground — but there's work still to do

While ergonomics is tested in one lab, an acoustical lab was used to test the company's noise-canceling software and two-microphone noise-suppression design. Engineers simulated sound levels found on the fireground to develop filtering software that increased the voice volume by nearly 50% compared with previous versions, Claxton said. The new AMBE+2 1.6 digital vocoder helped improve voice intelligibility and loudness, he said.

"You can be in fireground environments, with roaring noise, and it is going to come out the receiver clear," he said.

Prototypes were built in-house and then the company delivered 24 radios, shoulder microphones and mobile chargers for the Sunrise fire department to test for two months, O'Connell said. A large emergency button was placed below the antenna so that users in blinding environments could find it with one finger, and a rubberized shell was developed for easier grip by water-soaked, gloved hands, he said.

After the radios were tested, Motorola made major adjustments to the radio based on user feedback, particularly regarding voice intelligibility, O'Connell said. He added that the tests also showed that sound volume had increased by 50% and that clarity also had improved, based on a side-by-side comparison with older radios.

"It greatly enhanced our communications in adverse environments," O'Connell said.

Motorola isn't the only company tapping into user experiences to improve upon its existing digital radio suite. Harris Corp. also builds new versions of its digital radio based on scientific studies and user feedback, said Kim Purdie, of the company's product manager for terminal products.

"It's extremely important that we get feedback from users," Purdie said.

For example, the company's Rochester, N.Y.- based team plugged into the Monroe County Public Safety Interoperability Committee, which consists of representatives from local, state and federal agencies, including police and fire professionals.

Purdie said that Harris's product team used a combination of focus groups and informal meetings to solicit user input. As the product evolved, the team would re-visit the users for feedback on changes to the design concept.

"The team leveraged multiband radios developed by the military side of the Harris business to determine what features users [in public-safety] did and did not want in a radio," she said.

On the national level, they teamed with the National Institute for Fire Control and the Department of Agriculture's U.S. Forest Service, Purdie said. As part of field testing, Harris radios were used by frontline forest firefighters in California and Florida.

"This direct interaction allowed the product team to assess user needs and develop technical solutions that the users might not have been able to envision," she said.

Purdie said that firefighters seek a product that can operate in extreme environments, is intrinsically safe and meets immersion ratings. Most important, it must offer voice clarity and adequate voice volume for safe fire operations.

"It is at a state with noise-cancelling technology, where digital voice is feasible for the fireground," Purdie said.

Field tested

The Maple Bluff (Wis.) Fire Department recently put manufacturer's analog and digital radios systems through voice-quality tests to determine which was most intelligible on the fireground and found that the addition of next-generation, digital vocoders did the best job of filtering out interfering noise that can affect voice clarity and voice volume,

Fire Chief Joshua Ripp said.

Ripp said that the combination department needed to upgrade its radio system because the county is expecting to replace its current VHF conventional system with a VHF Project 25 trunked system. It also plans to upgrade its VHF paging system as well.

"Narrowbanding goes into effect in 2013," Ripp said. "So we are looking at different radios and technologies out there and trying to figure out what a good radio for us would be."

Four full-time staffers, eight interns and 12 volunteers worked to accurately test each analog and digital radio's audio quality. Ripp said that they did their best to be consistent in their test methods; for instance, radios were placed the same distance from the pumper during testing. The transmission was received by a scanner and dumped into video recording equipment.

Ripp emphasized that although the tests have been completed, the department has yet to purchase any radios and has not endorsed any products. He said that they found, after comparing different models of radios manufactured by EF Johnson Technologies, that the key factor in improving digital voice was the use of next-generation vocoders.

Earlier this year, EFJ unveiled its new firefighter portable radio that had been upgraded with the AMBE+2 v 1.6 vocoder, which filters out background noise that usually overcomes the transmission of voice signals, even in the presence of a personal alert safety system (PASS), according to the company.

According to Ripp, the vocoder-enabled radios were able to process out the noise and send intelligible voice to the other end.

"When you compare the older vocoder to the … AMBE +2 vocoder, there is a marked [difference] between them in terms of handling the high-noise environment," he said.

However, PASS alarms and other loud sounds still caused an issue to some extent, regardless of whether the radio was analog or digital. As a result, Ripp believes that the new vocoder technology isn't ready yet for hazard-zone communications — although it may work perfectly fine for car-accident responses, he said — and that manufacturers need to improve on their noise-cancellation software. Nevertheless, he's impressed with the progress that's been made to date.

"I think we are at a point now where the manufacturers are stepping up to the plate and doing what needs to be done versus telling everyone they are using the radios wrong," Ripp said. "Before when the radios didn't perform as expected, it was always blamed on the people using them. Now the radios are getting designed to handle the specific voice issues that are popping up."

That's good news for fire departments, Ripp added. The FCC's mandated that all systems operating at 512 MHz or below move to 12.5 kHz-wide channels (or equivalent) from the current 25 kHz-wide channels by Jan. 1, 2013. Conventional thinking is that the FCC won't stop there, and eventually will require 6.25 kHz-wide channels in the name of spectrum efficiency. When that happens, departments will be forced to make the digital migration, Ripp said.

"It is one of those issues that I think we need to work on, because the next narrowbanding is going to go to 6.25 MHz voice transmission, and there's no way you can do it with analog," he said. "If we get forced down that road, it has to be digital."

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