Where We Have Been
For many years, both land mobile radio (LMR) manufacturers and public safety users seemed to accept that the communications solutions that worked for public safety services (law enforcement, fire, emergency medical services (EMS), public service) would largely work for the others. In the early days of radio communications for public safety, from the 1930s to the 1960s, this model certainly worked fairly well. Users were happy to get a mobile radio that talked to a dispatcher, and later a portable radio that allowed even more mobility for law enforcement officers, emergency medical personnel, and fire officers.

But expectations began to change in the 1970s and 1980s for two reasons. Firstly the public safety missions were becoming more complex. In law enforcement, many other functions besides patrol wanted the ability to communicate instantly. Detectives, traffic, and other functions sought to use radio communications. Also patrol officers began to want to use portable radios inside buildings. In the fire service, portable radios began to move from being just a command tool for fire officers, to a tool for interior fire suppression, search and rescue, and ventilation teams. In the 1970s, paramedicine began to take off in several key cities, but physicians were uncomfortable with paramedics interpreting electrocardiograms (ECGs), and administering cardiac-related drugs, because such tasks had previously been the domain of doctors only.

Secondly, at the same time that missions were becoming more complex, technology was advancing and allowing additional features beyond just push-to-talk (PTT) to better serve those evolving missions. For example, analog signaling was added to many conventional systems allowing unit identification (ID) numbers to be sent. Emergency alarm signals, selective calling, and simple status and message transmissions could be sent saving air time, and improving officer safety.

Receiver voting systems were developed to allow systems to cover wide geographical areas. In cities such systems were used to improve in-building coverage. Transmitter steering systems were also built to improve the talkout coverage. Finally simulcast systems combined with receiver voting began to develop to allow really very wide area or regional systems, with users able to communicate across very large geographies.

Trunking allowed a group of radio channels to be shared among many user talk/work groups, based on the statistics of radio traffic usage. Channels were used more efficiently, and many more talk/work groups could be created for each public safety mission. APCO Project 16 defined the functions used in trunking, but unfortunately not the signaling ‘handshake,’ so interchangeability of radios among different manufacturer’s systems was not possible.

Specialized equipment began to appear for paramedics. Telemetry was added to portable radios to allow three-lead ECGs to be transmitted from the cardiac patient in the field to the emergency room physician, as popularized by the TV show “Emergency.” The technology was pushed even further as physicians concerned with the ultimate liability of actions by paramedics remaining with them, insisted on the ability to interrupt a paramedic in mid-sentence, by requiring in many areas that physician to paramedic radio communications be full duplex. In the U.S., the Federal Communications Commission (FCC) set aside a special group of UHF paired “MED” channels for use in ECG telemetry systems. Remember at the time cellular telephones were still in the experimental stage, and mobile telephone service was restricted to the privileged few in major cities, so creating telemetry and full duplex for these unique needs of EMS was both radical and costly. Yet systems were built across the country, and paramedic advanced life support (ALS) service became the standard of field care that most citizens came to expect.

Law enforcement officers were increasing their use of data. In law enforcement, every intervention must be recorded, because today’s domestic disturbance could end up being tomorrow’s assault or homicide. So in the 1970s, law enforcement officers began to use custom-built mobile data terminals in their patrol cars. These terminals were slow in speed because of the signaling available at the time, but provided a full QWERTY keyboard and screen designed to work in the patrol car environment that could be dark at night and full of glare during the day. These terminals allowed an officer to interrogate a local, state, or federal database of stolen vehicles, warrants, etc., so the officer would know what he was doing.

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In 1989, APCO Project 25 (P25) began to formulate a standard that would take advantage of digital modulation and signaling, to provide both conventional and trunked radio systems. By specifying both the functionality and the signaling handshake (air interface), interchangeability of subscriber (user) radios with infrastructure (base stations, voting equipment, trunking switches, and dispatch consoles) could finally be realized.

The common themes here are that in general, each public safety mission used similar radio systems, with the thought being that a wide-area system that worked for law enforcement would also work for the fire and EMS services, and public service workers could also use such systems. However, some individuality of solutions was also appearing, in ECG telemetry for paramedics, and mobile data computers for law enforcement.

Where We Are Today
Today the missions of public safety have evolved even further, with corresponding demands on the communications systems that support those missions.

Law Enforcement: Law enforcement has evolved to beyond just patrol, traffic, and detective functions. Law enforcement officers are expected to participate in community policing to integrate better with the citizens they serve. Intelligence-led policing requires that field officers be given more information on the situations that they are about to encounter. Specialized teams combating organized crime, drugs, youth gangs, and terrorists have been formed in many areas. Hostage negotiation teams, special weapons and tactics (SWAT) teams, K9 units, search-and-rescue teams, and bomb-disposal teams, all play an important role in modern law enforcement. Weapons of Mass Destruction (WMD) are now something law enforcement trains for after the events of Oklahoma City, London and Madrid and Tokyo subway events. As the criminal justice system has had to accommodate larger jail and prison populations, these corrections facilities have more inmates, and therefore more guards required. Once the person leaves incarceration, parole officers have to check on their status. Many of these functions did not even exist 50 years ago; now chief officers and sheriffs have to provide these functions to protect the population.

In terms of communications, law enforcement is requiring access to more and more local, state, and national databases on criminals, stolen vehicles, warrants and wanted persons, lost or missing persons, etc. Access to these databases requires data speeds in excess of what can be accomplished on narrowband LMR radio channels, so the majority of law enforcement agencies today are using current cellular telephone systems at third-generation (3G) data speeds of between 200 Kbps and 28 Mbps, depending on the carrier and what transport scheme is being used. Of course, such systems provide no priority to public safety users, and the history of such systems overloading on traffic or going down during storms and blackouts and other events is well documented. Video recordings inside the vehicle, and now on the officer, are allowing officers to document arrest procedures, struggles during the arrest, and refute claims of excessive force or brutality. Such videos also become powerful training tools. But because the data speeds needed are not generally available in mobile radio systems for real-time video, such video is primarily stored on hard drives. Surveillance video is now common in many cities, allowing dispatchers and supervisors to advice incoming law enforcement units as to what is happening in the street. Such video also assists in catching criminals in the act and providing court evidence later to increase conviction rates. The security afforded by using nationally standardized Advanced Encryption Standard (AES) encryption allows organized crime, anti-drug, anti-terrorist, and hostage negotiation teams to work without fearing their communications are being monitored.

Fire Service: The fire service has become an “All Hazards” service. Technical rescue, hazardous materials intervention, mass casualty incidents (MCI), and water rescue, are all part of the training and services that the fire department is expected to provide to its citizens, in addition to the traditional services of fire suppression and fire inspection. In most departments an emphasis on fire safety education both in the schools and with the adult population has helped decrease the number of fire deaths over the years.
The fire service’s early experience with digital P25 systems created some concern in fire circles. The International Association of Fire Chiefs (IAFC) formed several committees to look at best practices, and testing of digital radios in high-noise environments has gone through two stages of testing. As the vocoder software that changes the analog voice to digital signals improve, and as vendors introduce noise-cancellation capabilities in their portable radios (and one vendor offers it in a mobile radio as well), the fire service is taking another look at digital systems. Several flavors of non-P25 digital systems have also emerged, but considerations of interoperability, both at the on-scene radio-to-radio level, as well as at the system level, must be considered. Some vendors include P25 conventional and analog modes of operation in the user radios to ensure radio-to-radio direct mode interoperability is achieved.

Other communications needs for the fire service of today include location, both of vehicles and personnel, and both outside (such as in wildland fire fighting or search and rescue operations), or in buildings. While Global Positioning Satellite (GPS) systems can provide outdoor location, providing indoor location is a much more complex problem.

The fire service in many areas has building preplan information stored on servers or hardened laptop computers carried on vehicles. Some departments are using WiFi or 3G cellular carrier connections to access databases of chemical information, hybrid automobile extrication instructions, etc.

EMS: For a period of time, physicians became comfortable enough with paramedics handling cardiac cases, that the use of the early UHF ECG telemetry systems was dropped. But now both medicine and technology have evolved to the point that paramedics can monitor parameters that were not possible before, improving diagnosis in the field. CO2 levels can be monitored with capnography, and together with oxygen saturation monitoring, provide a good indication of how well the patient’s respiratory system is functioning. Emergency medical technicians (EMTs) in most states now routinely take blood glucose readings to determine if diabetic suspected patients have low blood sugar. Paramedics are being asked to move from the traditional three-lead ECG to 12-lead ECGs which previously were only done in a hospital or clinical setting. A 12-lead ECG allows the paramedic to confirm in the field “ST elevated myocardial infarction,” which can be treated via angioplasty (a balloon inserted into a blocked artery) at an appropriate hospital facility. What is important is that this angioplasty be performed within a short time of the onset of the heart attack; patient recovery is greatly facilitated. Finally, portable ultrasound devices are beginning to be used by paramedics in the field to find pooled blood from internal bleeding in trauma cases, so that a surgical team can be readied for immediate intervention upon patient arrival at the hospital.

Another currently emerging trend is to use EMS personnel to provide health care in the homes of the elderly, sick, and disabled. However, care that can be provided is still limited to what the paramedic has been trained to do; if a physician could remotely “see” the patient and guide the paramedic on infrequent interventions, better care could be provided especially in rural areas.

EMS in some areas where 12-lead ECGs are required to be sent are using 3G cellular carrier services to transport the telemetry. In some areas without advanced life support service, EMTs are trained to set up and transmit the 12-lead ECG to the hospital where a physician will interpret the ECG and decide if the patient comes to an emergency room or a facility that can perform angioplasty. But for the most part, most EMS communications remain voice-centric, even with patient vital information. Software packages exist to record patient history and vitals to save time in transferring such information at the hospital, but the transfers are usually via an upload to a hospital server either manually or via a local WiFi wireless connection.

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The Future

In the future, new technologies will provide even more specialized communications services to public safety, and it will be possible to provide more customized solutions for each mission and service. Most experts predict that narrowband (25, 12.5, and 6.25 kHz channels) LMR systems will be around for many years to come. But after several years of industry-wide discussion, broadband long-term evolution (LTE) systems are on the horizon. Several pilot systems are being built out, with more to follow. LTE promises much faster data rates (upwards of 75 Mbps uplink and 300 Mbps on the downlink) to more than 200 users per cell site. With one block of 700 MHz broadband spectrum allocated, and another (the so-called D Block) under discussion, public safety users will surely have access to a large data pipe to do things never envisioned before. More importantly, the usage of that large LTE pipe will vary considerably among the public safety missions. User devices that operate on LTE systems, both on public carrier and the private nationwide public safety network, will become available, providing ‘smart phone-like’ features to public safety.

Law Enforcement:

Law enforcement will be able to send or receive real-time streaming video, enhancing officer safety and situational awareness. High-resolution mug shots, facial recognition software, and improved crime analysis software will assist intelligence-led policing efforts. State and large city fusion centers and real-time crime centers will receive more timely information and reports from the field officers, and will be able to disseminate information more easily back out to the field. Improved location information of field vehicles will allow faster response to calls for assistance, and enhance officer safety.

Fire Service:

Incident Commanders will be able to receive real-time video depicting the various sides of a burning building, saving time in doing regular “360 degree walks” and allowing more constant monitoring of fire spread, changing smoke conditions, etc. Access to high-resolution building plans, plumbing and electrical service schematics, water supply diagrams, and other information will be made faster and easier.

EMS:

Paramedics will be able to transmit 12-lead ECGs, together with the many other vital signs at the same time that today’s sophisticated defibrillators and patient monitor devices allow (blood pressure, pulse, blood oxygenation, CO₂ saturation, blood glucose levels, etc.). For the first time, this will enable emergency room personnel to have a continuous real-time picture of a patient’s condition, both in the field and as the patient is transported. Better decisions on what specialists, and what medical or surgical teams to activate, will be able to be made. Physicians will be able to see real-time video of trauma patient injuries, will be able to see field sonograms of the patient’s body, and will be able to interact with paramedics to guide procedures that are infrequently performed, such as a cricothyrotomy or complicated field childbirth. Telemedicine can become enhanced by paramedics or physician assistants in the field having a physician “looking over their shoulder” to help in diagnosis and treatment of injuries and disease.

As we have seen, as the missions and functions in the various public safety agencies have evolved, they have become more complex. At the same time, popular press and the entertainment media have raised citizens’ expectations for the level of service that will be delivered. New bandwidth-intensive software applications and solutions, transported on a nationwide public safety-grade broadband wireless network, will improve officer/firefighter/EMS personnel safety and efficiency, and improve service delivery and safety to the citizens.

Author Bio:

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