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A Public-Private Approach to Public Safety Communications:

The best way to make rapid and affordable progress in implementing the government's FirstNet plan is to start by taking advantage of the existing commercial infrastructure.

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After the tragic bombing at the Boston marathon, Boston's cellular networks instantly filled with calls. One company spokeswoman had to publicly plead with its customers "to use text or email to free up voice capacity for public safety officials at the scene." In other words, this nation allocates resources that are critical for emergency response through use of plaintive press releases. U.S. public safety agencies do have the alternative of using their own communications systems, although most of today's public safety systems are based on pre-Internet, pre-cellular technology that does not meet the needs or expectations of today's emergency responders.

As I argued in a 2006 article in *Issues*, part of the problem with traditional public safety communications systems is that many thousands of individual police and fire departments run their own systems, perhaps with a different technology than their neighbors, when what is really needed is a nationwide solution. There has since been movement in this direction, culminating in 2012 when the U.S. Congress funded the creation of a new nationwide network called *FirstNet*. However, FirstNet's success is still uncertain. A shift in priorities could put FirstNet on a better path. In particular, whereas much of current discussion of FirstNet revolves around building new infrastructure specifically for public safety—and new infrastructure should certainly be built—time and funding constraints should shift the immediate focus from building new infrastructure to leveraging existing infrastructure and commercial technology in new ways, including new forms of public-private partnerships.

By almost any measure, the thousands of public safety communications networks in the United States today are inadequate. The most discussed problem is lack of *interoperability*, which means that in many places emergency workers such as police and firefighters have incompatible communications systems that prevent them from interacting with one another. However, interoperability is just one of the problems. Current public safety infrastructure is unnecessarily expensive, because all these independent and overlapping networks require an order of magnitude more towers than would otherwise be needed. Indeed, if one wants to predict the amount of costly infrastructure that will be built in a region, the number of municipal governments in the region is a far better predictor than either the population or the area of the region. The unnecessarily large number of towers combined with pre-cellular technologies also make public safety an extremely inefficient user of spectrum, and preventing a shortage of available spectrum from hampering economic growth has become a high priority for the U.S. Government. Moreover, because so much equipment is designed specifically for the fairly small public safety market, mobile handsets for public safety typically cost an order of magnitude more than

handsets that are mass-produced for a consumer market. Finally, traditional public safety systems support only voice communications at a time when consumers carry phones that offer data capabilities and countless applications that would be very useful for emergency responders. In short, U.S. taxpayers expend billions of dollars more than necessary every year to perpetuate a system that fails to meet modern needs or exploit new technologies. The solution to all these problems is to build out a public safety network infrastructure that serves the thousands of municipal public safety organizations and is based on a single technical architecture that uses spectrum efficiently. At this time, such an architecture would be based on the fourth-generation cellular standard (LTE) and Internet standards (IP).

Such a system could save many lives. Imagine a city that has just been battered by a hurricane. Emergency responders from adjacent states rush to the city for search and rescue missions. Today they would come with incompatible communications equipment, so coordination would be a problem. Moreover, as we saw after Hurricane Katrina, even local responders may not be able to communicate if the hurricane destroys the towers they depend on, even if there are commercial systems still working. Those responders who are lucky enough to have access to a working system will have voice communications and nothing more. In contrast, with FirstNet, responders from all agencies will be able to communicate using whatever infrastructure has survived. In addition to voice communications, medics will send video of critical patients back to hospitals, police will distribute pictures of missing children over the airwaves, and firefighters will download the blueprints of damaged buildings to see how to enter safely.

The 2009 transition from analog to digital television created a once-in-a-generation opportunity to reinvent public safety communications by suddenly making bands of prime spectrum available nationwide. Under the right federal policy, it would be possible to adopt a single technical approach nationwide, and to choose an approach that uses the latest and most cost-effective cellular and Internet technologies to bring a wide range of broadband services to public safety. This new approach for public safety was endorsed by the government in the 2010 U.S. National Broadband Plan , and later by the White House. The idea became real in 2012 when Congress authorized funding and reserved 20 MHz of spectrum that was previously used for TV for the creation of *FirstNet*, a network for first responders. This raised expectations, which is both an opportunity and a danger. Now, the biggest threat to success for FirstNet may be the risk of not meeting these expectations quickly enough with the resources available. FirstNet's funding will fall somewhere between $2 billion and $7 billion, depending on how much money is raised in the future auction of spectrum that becomes available after some television broadcasters voluntarily choose to relinquish their spectrum. If the maximum of $7 billion is raised for FirstNet, it would be a great start, but still not enough money to build out infrastructure everywhere in the country. For example, the Federal Communications Commission estimated the cost of building an LTE network in the most populous areas that would provide indoor coverage to 95% of the population and outdoor coverage (or indoor coverage with the help of repeaters or externally mounted antennas) to 99% of the population. This plan, which could leave roughly 65% of the U.S. land area without coverage for a standa-alone handset inside buildings and 45% with no coverage at all, would cost between $12 billion and $16 billion over ten years, of which $7 billion would be capital cost. This

estimate assumes costs would be decreased through a high level of cooperation with commercial carriers, which may or may not occur. Lack of cooperation could double or triple capital costs. Moreover, some responded to this analysis by saying that the network should support even greater data rates than the FCC had assumed, because public safety would benefit from higher-quality video. Increasing upstream edge-of-cell rates from 256 kb/s to 1.2 Mb/s was also found to increase capital cost almost threefold. Clearly, infrastructure cannot be built everywhere with this budget, even under best-case assumptions.

Some money may come from state and local sources, but the federal government will need to be the primary funder. Of course, Congress could appropriate more federal money. After all, this kind of infrastructure-building could save lives by strengthening public safety and homeland security, while creating jobs in the short term and saving taxpayer money in the long term. Such opportunities are rare. Nevertheless, additional funding from Congress seems unlikely given the current state of budget discussions. Thus, if FirstNet is to deliver useful services to the entire nation, rural as well as urban, it cannot rely only on building infrastructure to achieve this. Luckily, there are other options.

Meanwhile, if FirstNet cannot deliver valuable capabilities quickly, it may never get the chance. Congress gave states the ability to opt out of FirstNet entirely and to use that 20 MHz of spectrum in other ways. There are also a number of cities that have expressed a preference for running their own infrastructure. If many cities and states go their separate way, the result will recreate the public safety tower of Babel characterized by interoperability failures, costly custom-built equipment, and inefficient use of expensive infrastructure and valuable spectrum. At the same time, some of these states and cities are understandably anxious to move forward quickly on infrastructure that can save lives. FirstNet can keep them interested in being part of a nationwide system by making clear that concrete benefits are coming soon to every state that backs the FirstNet plan. FirstNet must move quickly, and this urgency should affect the approach to deployment.

Use what we have

The best way to provide useful services nationwide quickly and with limited funding is to leverage commercial infrastructure and technology as much as possible. However, there are strong forces pulling in different directions. Some public safety advocates envision a nationwide public safety infrastructure that is built specifically for public safety and does not make use of existing commercial systems, much as today's LMR (land mobile radio) public safety systems do not make use of commercial systems. This vision is based in part on the traditional view of public safety agencies that they should be in complete control of their resources, without the need to negotiate with commercial providers, and it is based in part on misconceptions about how far the budget can go. Under the 2012 law, this is simply not feasible, as it would take significant time to roll out all-new infrastructure nationwide and far more than $7 billion. Moreover, much of the money and time would be spent building infrastructure in densely populated areas that are already well served by multiple commercial providers. Even with infinite budget and time to deploy, this is not the ideal solution for public safety. When this stand-alone

network is not functioning, perhaps because a tornado hit a public safety tower, emergency responders would have no communications at all.

On the other side, there are those who envision emergency responders relying entirely on the products and services emerging from the commercial market. This might be profitable for the carriers, but it would also fail to meet public safety needs, as many public safety representatives have pointed out. It is obvious that there are parts of rural America that will not get LTE coverage any time soon, so emergency responders there cannot rely on the commercial market. Less obvious is the fact that even big cities include areas where signal reliability is inadequate for emergency response, and the cost of extending infrastructure to serve these areas better is not justified based on the number of paying subscribers who live there. Like coverage, infrastructure dependability is also a concern. Profit-seeking commercial carriers do not always have the incentive to provide sufficient power back-up or physical hardening to meet public safety standards. Similar issues exist in the handsets. Although public safety agencies can reduce costs by using components mass-produced for the consumer market wherever possible, emergency responders need features that may not emerge from a commercial market without a certain degree of coaxing. Of particular importance is the ability for user devices to communicate directly with each other, rather than requiring that all communications pass through a cellular tower. (Engineers in the Internet world refer to this as "ad hoc networking," and public safety users refer to it as "talk-around.")

Considering these limitations, the best path is a hybrid strategy that leverages commercial infrastructure where possible, supplements it where necessary, and allows significant progress in a short time. A number of actions could be taken that would shift FirstNet's emphasis in its early years to taking advantage of existing commercial capabilities without compromising the overall approach of the FirstNet plan.

Priority Roaming Agreements. Although deploying infrastructure that operates in the mostly idle 20 MHz of spectrum that has been allocated to public safety is certainly worth doing, the best way to make high-quality LTE services available through much of the nation quickly and at little initial cost is by establishing *priority roaming* agreements with commercial carriers. With a priority roaming agreement, an emergency responder can tap into a commercial network and have priority access, thereby guaranteeing good quality of service even when the network is congested with traffic from non-emergency-responders. LTE offers a wide range of sophisticated features that support priority access, although negotiating the specific details with each carrier will require care. Indeed, in any region where this is possible, priority roaming agreements should be established with multiple carriers.

This has several enormous advantages. One is capacity. There are roughly three million U.S. police, fire and emergency medical services workers, but the commercial cellular infrastructure was designed to support over 320 million subscribers. Even in severe emergencies such as a terrorist dirty bomb attack in Manhattan, commercial networks can offer more capacity than prominent public safety groups have estimated they would need, and still have a lot of capacity left for civilian users. Moreover, being able to roam onto two networks increases capacity available to public safety by far more than the obvious

factor of two, because devices such as mobile video cameras that require high data rates can connect to the closest cell tower, regardless of provider. For a given amount of spectrum, the transmission rate achievable near the center of a cell is more than an order of magnitude greater than what is achievable near the edge of the cell. As long as cell towers of different carriers are not collocated, a device can often choose its carrier such that it operates near the center of a cell, and therefore requires far less spectrum. Another advantage is fault tolerance. If just one network, government or commercial, is working, emergency responders can communicate. Coverage is similarly improved, because a location is covered as long as a device there can connect to any one of the networks operating in its region.

Most important given the immediate constraints on FirstNet, priority roaming agreements can be established quickly. Although some public safety representatives have expressed concerns about roaming costs, the cost should be less than many people expect, assuming that the prices paid by public safety agencies are no worse than those paid by the general public. Roaming charges are probably proportional to public safety traffic, whereas infrastructure costs are fixed independent of utilization. One cost study showed that roaming is less expensive than building out new infrastructure in the long run if and only if the average utilization of the dedicated infrastructure built out for public safety is under 10% for the multiyear life of the equipment. By its nature, public safety traffic comes in bursts; utilization can be quite high during large emergencies but is very low most of the time. Utilization of a public safety network may exceed 10% in many areas, making build-out beneficial in the long run. However, utilization probably won't exceed 10% by much, meaning priority roaming is a reasonably cost-effective alternative. In the most severe localized emergencies, which might take place over a few square miles, typical roaming charges have been shown to be small compared to other costs, such as the overtime of emergency responders. The same cannot always be said for emergencies that affect very large areas, such as hurricanes, but there are other ways to protect the budgets of state and local agencies in these extreme cases.

Targeted infrastructure build-out. Since the FirstNet budget will not support nationwide deployment of infrastructure that operates in the public safety band, there will be a strong temptation to spend limited resources in a way that covers as many people as possible. In the short term, when funding is limited and the sense of urgency is great, this is precisely the wrong approach; it does not take full advantage of priority roaming. Initially, priority should be given to areas that meet one of two criteria. The first is : that coverage in this area is not sufficient using only priority roaming onto commercial carriers. This may mean bringing coverage to rural areas that have none, but it also means filling in gaps that are important for public safety in urban and suburban areas, such as Rock Creek Park in Washington, DC.

The other criterion for selecting an area for early build-out is if that area will not require government funding. In some parts of the country, commercial providers will be happy to subsidize the build-out as long as they can provide commercial services over any capacity not needed for emergency responders. This creates an opportunity for a public-private partnership. As discussed above, public safety utilization is likely to be low much of the time, and this idle capacity can be quite valuable, at least in big cities where demand is greatest. Indeed, commercial carriers may pay for the privilege of serving public safety in return for access to public safety spectrum. Unfortunately, judging from earlier studies, these

arrangements are probably only profitable for carriers in big cities. (There are those who hope to use this strategy to fund a truly nationwide build-out, and they are likely to be disappointed.)

Sharing infrastructure. In areas where commercial carriers already operate in their own spectrum, it is possible to deploy equipment that will "light" the public safety band as well by sharing many components, and this can greatly reduce costs. This may also involve some form of public-private partnership. When doing its cost estimates, the FCC looked at a variety of these cost-saving sharing arrangements. For example, under the sharing agreement, public safety may be able to make use of some or all of the following: existing cell towers, antennae, cabling, radio processing equipment, back-up power facilities, and the communications links between cell towers and the nearest communications hub. According to FCC estimates, capital costs would be 2.5 times greater without this form of sharing. Savings are even greater with a synchronous roll-out, i.e. if the radio area networks operating in the public safety band are deployed at the same time commercial systems are upgraded to LTE. Despite the tremendous cost savings, the approach has its detractors, because as long as funding is viewed as unlimited, it is easier for a government agency to build infrastructure if it does not have to cooperate with commercial companies

There is a risk when public safety begins to rely on infrastructure owned by commercial operators for its basic operation. Unlike priority roaming arrangements, public safety will generally rely on a single provider in any given location. Initially, carriers may compete with each other to obtain this business, but once one is chosen, FirstNet must avoid becoming locked into that operator, as this would allow the operator to demand unreasonably high rents when the contract is renewed. Risk of capture can be reduced by signing long-term contracts and soliciting bids for follow-on contracts several years before an existing contract expires. Moreover, carriers are much less likely to use their incumbent position to charge higher rents in those big cities where carriers derive significant benefits from access to public safety spectrum. Thus, it might be helpful when negotiating sharing arrangements to pair these cities with rural areas, and require carriers to share infrastructure throughout the combined areas.

Note that if this kind of infrastructure sharing with commercial carriers can be used to bring wireless services to emergency responders in a given area, then priority roaming can also be used to provide those same services. If the only goal were to serve these areas as soon as possible, priority roaming is probably the better choice, but infrastructure sharing is cost-effective where average utilization is high. Thus, both arrangements are desirable in the long run.

Multi-band mobile devices. Infrastructure is worthless without mobile devices to use it. Negotiating with device manufacturers and standards bodies to create devices that meet public safety needs should be a high priority for FirstNet. To obtain the benefits of priority roaming discussed above, devices must operate in the 20 MHz public safety band as well as bands operated by multiple commercial carriers. Some devices must be more rugged than is typical for the consumer market. Eventually, devices will be needed that support applications of importance to public safety, such as push-to-talk voice communications. This latter capability requires changes in the infrastructure as well as the handset and should be addressed in the standard-setting bodies.

FirstNet can gain the attention of manufacturers and standards bodies as long as it has the support of public safety agencies nationwide. If all of these agencies say they will purchase devices for local police and firefighters as long as those devices meet technical specifications set by FirstNet, then manufacturers will listen. The more states and cities opt out, the less effective this approach will be.

Mobile ad hoc networks. As proposed in the National Broadband Plan, fixed infrastructure should be supplemented with mobile devices that can form ad hoc networks, which means that the mobile devices in a region can communicate among themselves, even if there is no fixed infrastructure such as a working cell tower nearby. FirstNet can also make this happen. A good place to start would be to encourage agencies to equip police cars and fire trucks with such devices. This is a relatively inexpensive way to extend the reach of public safety infrastructure. In a location where the public safety network is reachable outdoors but not indoors, the mobile device on a fire truck may extend coverage into a burning building. Moreover, mobile devices that can form ad hoc networks are invaluable in areas where there is no functioning infrastructure, perhaps after a hurricane or earthquake. At least users in the disaster area could communicate with each other, even if they need some other means to communicate with people far away. FirstNet can make this happen in part by making sure that there is a common standard for public safety agencies nationwide and authentication services for those devices so that even devices from different agencies can work together, and can do so without serious risk of security breach. Because it serves the nation, FirstNet is also better positioned than any state or municipality to ensure that there are stores of mobile devices that can be moved to a major disaster wherever it occurs.

Conclusion

FirstNet is now positioned to provide emergency responders with high-speed mobile data services, at lower cost, higher spectral efficiency, and greater dependability than we have seen with previous public safety systems. To reach this potential, they must move quickly. The key to making rapid progress at low cost is leveraging commercial infrastructure and commercial technology. This begins by establishing priority roaming agreements with multiple commercial carriers and aggregating the demand of public safety agencies nationwide to convince device manufactures and standards bodies to meet public safety needs. Without rapid progress, there is a danger that states and municipalities will go their own separate ways, and this historic opportunity will be lost.

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