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From TV to Public Safety
THE NEED FOR FUNDAMENTAL REFORM IN PUBLIC SAFETY SPECTRUM AND COMMUNICATIONS POLICY

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Abstract

The events surrounding Hurricane Katrina and the 9/11 attacks demonstrated that the communications systems used by first responders in the United States are not adequate to meet the challenges of a post-9/11 world. The U.S. system is based on assumptions that local agencies should have maximal flexibility at the expense of standardization and regional coordination, that commercial carriers and municipal systems have little role to play, that public safety should not share spectrum or network infrastructure, and that narrowband voice applications should dominate. Many programs have been proposed to incrementally improve public safety communications systems, but without any fundamental changes to these policies, such incremental changes are likely to have limited impact.

However, a tremendous opportunity is coming thanks to the transition to digital television; 24 MHz of spectrum has been identified for reallocation from TV to public safety in 2009, roughly doubling the public safety spectrum below 2 GHz. Unless policymakers act, this new spectrum will be managed under these same old policies.

This paper explains why it is time for fundamental reform. Policy reforms should include some combination of: shifting some responsibility and authority for decisions about public safety communications infrastructure from many independent local government agencies to the federal government; further expanding the role of commercial service providers, municipal Wi-Fi networks, and other systems that serve the public; allowing public safety to share spectrum, and possibly multi-purpose network infrastructure as well, with other users; and further expanding capabilities beyond traditional voice communications. Since the TV band spectrum reallocated to public safety has few legacy systems that must be accommodated or moved, it is an excellent place to launch a new policy.

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1 Introduction

At 9:59AM on September 11, 2001, the first of many evacuation orders was transmitted to police and firefighters in the World Trade Center's North Tower. Police inside the building heard the order, and most left safely. However, firefighters could not receive the order on their communications equipment. People watching television at home knew that the unimaginable had already occurred—that the South Tower had collapsed—but many firefighters inside the North Tower would never learn of this. When the North Tower fell 29 minutes after that first evacuation order, 121 firefighters were still inside. None survived.[1]

While the number of lives lost on 9/11 was especially great, there is nothing unusual about loss of life due to failures in the communications systems used by first responders, where first responders include firefighters, police, paramedics, and the National Guard. These communications failures occur all across the country, after large disasters such as hurricanes and earthquakes, and in emergencies too small to make the news, such as police car chases and burning houses. When public safety communications systems do not work, it can endanger the lives of first responders and the citizens they protect. Especially in a post-9/11 world, we cannot afford to be unprepared for disasters, either natural or man-made. As observed by the House Select Bipartisan Committee to Investigate Hurricane Katrina, "without functioning communications systems, first responders and government officials cannot establish meaningful command and control, nor can they develop situational awareness necessary to know how and where to direct their response and recovery."[2]

After watching public safety communications systems fail on 9/11 and after Hurricane Katrina, with tragic results, the American public and its leaders have begun looking more seriously at these systems. As a result, policymakers have considered a variety of remedies. Most have been small incremental adjustments to long-standing policy. Incremental change is sometimes useful, but clearly its impact is limited. The one possible exception is the transfer of 24 MHz of premium spectrum to public safety in 2009, as part of the transition from analog to digital television. This could have a tremendous positive impact on public safety communications systems, if it is accompanied by other policy changes. Otherwise, the problems that have plagued public safety's current spectrum allocations are likely to occur again in the new allocation. Unfortunately, as matters stand, policymakers seem likely to preserve the antiquated status quo, thereby forfeiting an opportunity to make communications failures less common, to use spectrum more efficiently, and to reduce the costs borne by taxpayers.

The purpose of this paper is to demonstrate the need for more fundamental reform, to present a range of possibilities that policymakers should consider, and to indicate how spectrum from the digital TV transition could be used to advance these possibilities.

Section 2 describes the policies that have produced today's public safety communications systems, and why it is time for fundamental change to those policies. Section 3 presents alternative directions for the future. Section 4 describes the current debate over how TV spectrum will be used for public safety, which largely assumes small incremental changes to traditional policies. In contrast, Section 5 discusses how the reallocation of TV spectrum could be used to advance fundamental change. The paper is summarized in Section 6.

2 Questioning Today's Orthodoxy for Public Safety Communications

Section 2.1 presents basic assumptions that have long dominated how public safety communications are provided. Section 2.2 explains why it is time to question such assumptions. Criteria for judging a good system are presented in Section 2.3, and Sections 2.4 through 2.7 describe how today's basic assumptions can be harmful based on these criteria.

2.1 Today's Basic Assumptions

Today's public safety communications infrastructure is built on a number of traditional assumptions.

- It is assumed that primary responsibility for and authority over public safety communications lies with local governments. In most states, final decisions about infrastructure are made by individual municipal public safety agencies such as fire departments or police departments, beyond the control of even the central units of local government, such as the Chief Technology Officer for a city or county. Federal agencies provide some assistance in the form of grants or technical advice, but the majority of the funding also comes from local governments.

- It is assumed that public safety agencies must operate their own communications systems, and cannot make significant use of commercial companies or municipal networks that provide wireless services (although commercial companies usually provide wireline services without controversy).

- It is assumed that public safety communications must take place in spectrum that is dedicated entirely to public safety, using equipment that is dedicated entirely to public safety. Thus, public safety cannot share spectrum allocations or network infrastructure with either commercial subscribers or other government users.

- It is assumed that narrowband real-time voice communications is the principal application for public safety. Other forms of communications are secondary in importance, or they are not available at all. Moreover, in most cases, voice communications are provided separately from other services. (Thus, in the spectrum to be reallocated from TV, proposals to provide voice communications as one of many services over a broadband network have received less serious attention.)

2.2 A Time for Change

The above assumptions have prevailed in the U.S. for many decades, so why question them now? Because the world has changed.

First, 9/11 marks a fundamental change in requirements. It is now far more important that we be prepared to respond to large-scale disasters that require a cooperative response from many public safety agencies. A failure rate for interagency communications that was acceptable before 9/11 may not be acceptable today, even if that means giving up some local autonomy.

Second, the technology has changed dramatically. The results of this progress are obvious in commercial and military wireless systems, but are not so apparent in public safety systems. In many cases, current policy and its emphasis on flexibility is an impediment to adopting new technology. For example, effective use of wireless technology can require coordinated planning over a wide frequency band, a large geographic region, or both. Moreover, useful maps or photos may be stored in a jurisdiction far from the emergency, and such information cannot be shared dynamically unless public safety agencies in both jurisdictions have independently decided to invest in a shared infrastructure to connect them.

Third, costs have changed. In particular, the rapid growth of commercial wireless services has led to mass production, and low costs. Thus, equipment used by public safety could be much cheaper than was once possible, if it is similar enough to equipment used in commercial markets. On the other hand, demand for spectrum has increased making it more valuable. Thus, the many public safety systems designed to reduce equipment costs by consuming more spectrum are far less appropriate today, particularly considering the opportunity costs of spectrum inefficiency to the larger economy.

Finally, some people have expressed frustration over the progress achieved, despite all of the money allocated to incremental improvements. As stated by the House Select Bipartisan Committee to Investigate Hurricane Katrina, "*Despite hundreds of millions in federal funding* for technology and communications,

the absence of true communication interoperability within and between affected jurisdictions severely hindered rescue and response efforts at all levels of government (emphasis added)" after Hurricane Katrina.[3] After all, Secretary of Homeland Security Michael Chertoff said in May 2006 that his Department alone had "allocated over $2.1 billion to states for interoperable communications" since 2003.[4] *Perhaps the problem is not a lack of resources for incremental change, but a lack of vision to promote more effective change.*

Not only is this a time to question old assumptions. There is also an extraordinary opportunity coming to adopt a new approach in the band reallocated from TV spectrum, which has few legacy communications systems that must be altered or replaced, and few entrenched bureaucratic procedures.

2.3 Properties of a Good System

By considering a new approach to public safety communications, we could try to make progress in the following critical areas.

- *Interoperability:* Interoperability is the ability of individuals from different organizations to communicate and share information. It has often been cited as a major problem for public safety in the U.S. For example, when first responders from multiple public safety agencies arrived at Columbine High School after the shooting in 1999, interoperability problems were so great that they had to rely on runners to carry written messages from one agency's command center to another.[5]

- *Spectral efficiency:* It is technically possible to support today's first responders using far less spectrum.[6] When spectrum is used inefficiently, there is a greater risk that public safety will experience a shortage. With a shortage, systems would become highly congested during large emergencies, forcing first responders to either wait for long periods before communicating or to interrupt each other. Many public safety agencies have expressed concern that a shortage of public safety spectrum is coming,[7] even assuming they do get 24 MHz of television spectrum. If we respond to the shortage by simply allocating even more spectrum to public safety, and using that spectrum inefficiently, then less spectrum is available for other purposes.

- *Dependability and Fault Tolerance:* Critical pieces of the system should rarely fail. Of course, some failures are inevitable when a hurricane the size of Katrina hits, but this need not bring an entire system down. In a fault tolerant design, other parts of the system will continue to operate, and compensate for failures to the extent possible.

- *Advanced capabilities:* Today, public safety systems primarily provide voice. There are many other services that could be useful, including broadband data transfers, real-time video, and geolocation which would allow dispatchers to track the precise location of first responders during an emergency.

- *Security:* Systems should be designed so hostile parties cannot easily attack the communications system or eavesdrop on first responders—even for interagency communications. Protecting interagency communications from eavesdroppers is a greater problem, because protection must run end-to-end, and the two agencies at each end of the conversation often have dissimilar technologies today.

- *Cost:* Obviously, the cost to build and operate public safety communications systems should be as low as possible.

Recent incremental efforts at reform have tended to address one problem at a time. For example, spectrum has been reallocated to address the problem of spectrum scarcity, with limited attention to interoperability. There are grant programs specifically intended to improve interoperability, without consideration for spectrum efficiency, dependability, or the capabilities made possible by new technology. However, there

are multiple problems that put lives at risk, and they are interrelated. Interoperability may be improved by deploying a piece of equipment for "translations" that will cause the entire system to fail if this one component fails, which makes the system less dependable. Interoperability can also be improved by boosting coverage areas and thereby consuming far more spectrum for the same communications.[8] Similarly, relieving scarcity by allocating more spectrum to public safety with little thought to standards could make interoperability failures even more common. The best way to improve systems is to address all objectives together rather than piecemeal.[9]

In the coming sections, we will review the four basic assumptions described in Section 2.1, and the impact of these assumptions on the criteria listed above.

2.4 Let Each Local Agency Decide: Flexibility Above All

As discussed in Section 2.1, U.S. policy places responsibility for first responder communications systems primarily with local governments. From the perspective of the federal government, this is a policy of *flexibility*. The Federal Communications Commission (FCC) gives public safety agencies the flexibility to decide how they will use their spectrum, while the Department of Homeland Security (DHS) and the Department of Justice offer grants that give local agencies flexibility on how to spend the money. The advantages of local control are that local decision-makers are able to match local resources (e.g., tax dollars) to the most pressing local needs. This is an important advantage, but it comes at a cost.

There is an inherent tradeoff between flexibility and interoperability. For example, a long distance phone call typically passes through multiple telephone networks. There are no interoperability problems between Verizon customers and Qwest customers, even though multiple distinct systems are involved, because these companies have largely abandoned flexibility in favor of standardization and a consistent national (and global) architecture. On the other hand, U.S. policy gives each public safety agency the flexibility to choose technology quite unlike that of its neighbors. Thus, interoperability failures do not occur because public safety agencies have somehow failed to follow the American vision of flexibility. These failures occur because agencies are following that vision.

Flexibility also greatly reduces spectral efficiency.[10] When engineers design a wireless communication system to cover a large area, they can maximize capacity and minimize spectrum use by carefully determining where each transmitter is located, which technology it uses, what area it covers, and which block of spectrum it uses. These techniques can conceivably increase spectral efficiency by orders of magnitude. However, it is not possible to adopt this approach if each municipality makes decisions independently. Decisions to minimize spectrum use and to ensure seamless coverage must be made across large regions with many municipalities.

For example, according to a report published in 1996, public safety needs 95.3 MHz of additional spectrum by 2010.[11] Although it is a decade old, this is still the most widely cited estimate of spectrum needs for public safety. However, they based their analysis on many assumptions, including a continuation of policies that promote the independence of each local agency. Had they instead assumed the kind of frequency reuse that can easily be achieved with modern technology when a single system is designed to cover a large region, and kept all other assumptions the same, they would have estimated that public safety already had more than enough spectrum in 1996 to meet its needs in 2010. This does not imply that public safety needs no new spectrum, but it does imply that the shortage may have more to do with ineffective public policy than with technical necessity.

Flexibility has the same impact on infrastructure cost. By designing fixed infrastructure across a large area, one can greatly reduce the amount of equipment needed, which is why regions with greater political *fragmentation*—i.e., more government units per square mile—end up deploying far more equipment. Indeed, the number of communications towers constructed today in a county depends more on the number of municipal governments in that county than on the county's population, size, or terrain.[12] Flexibility can also increase expenses for mobile handsets. For example, in many cities, fire trucks must carry many kinds of radios, in the hope that at least one will work at every fire.

A regional or national plan would also make it much easier to design a system that is fault tolerant—i.e., one that can continue to operate even after a significant percentage of its transmitters fail. This is possible through planned redundancy, and by designing the system to reconfigure to make optimal use of whatever devices are still operational. This kind of coordinated redundancy is unlikely to emerge when each local agency is responsible only for itself, but could occur when systems are designed over large areas.

Finally, if all public safety agencies adopted the same technology, then when first responders from different agencies communicate, they would all still have access to the same security features such as encryption and authentication. Thus, these security features would work as well for interagency communications as they do for intra-agency communications.

2.5 Commercial Service Providers Need Not Apply

For the most part, first responders are served by public safety agencies, and not commercial wireless service providers. This policy is generally justified by the fact that the requirements of first responders are more demanding than those of the general public, so commercial wireless service providers are unable to provide adequate services. More specifically, public safety needs coverage anywhere an emergency might occur, and not just those regions with a high density of paying customers. Public safety needs systems that are highly dependable, which means they need more backup transmitters, more backup power supplies, and more rugged handsets. Public safety also needs greater protection against criminals or terrorists who would deliberately take down the system. In many cases, commercial carriers do not provide these capabilities to the extent public safety might wish—at least not today.

Unfortunately, public safety systems do not always meet these same standards. Public safety systems also have holes in coverage. Components also fail in these systems, where there are no backups. Consequently, commercial systems are sometimes used when public safety systems are inadequate. For example, after Hurricane Ivan hit Western Pennsylvania in 2004, flooding destroyed equipment at the Carnegie Fire Department and the wireless system failed. To ensure that they could run search and rescue missions, first responders scrambled to fill the void by signing up for service with Nextel and Verizon Wireless, whose systems were fully operational around the City of Carnegie.[13] Unofficially, many police and firefighters routinely carry cellular phones as backup when the official system proves inadequate. They do this at their own expense. Thus, public safety does use commercial services from time to time, but often without careful and systematic thought about how to do it well. It is clear that the chances of communicating during an emergency would be improved if first responders could use any system that is still operating after an emergency, regardless of whether this is a public safety system, a commercial system, a municipal Wi-Fi network, or anything else.

Note that while public safety has demanding needs for mission-critical real-time applications, much of public safety communications is not mission-critical, so failure is tolerable, or first responders can simply try again later. For example, police officers can benefit from filing reports from a laptop in their car, but a temporary outage of this service is not life-threatening. Thus, commercial services or municipal Wi-Fi systems may be adequate as a secondary provider of communications services. Moreover, where public safety infrastructure offers only voice services, first responders can expand their capabilities through use of other systems. For example, this is why the Pittsburgh police use data services from a commercial cellular carrier to supplement their own voice-only communications system.

In addition to adding capabilities and improving dependability, use of other systems can sometimes reduce costs. The fact that public safety has its own systems, and its own technologies, ensures that public safety systems will be expensive, and innovation will be slow. The commercial market is much larger, which brings mass production and rigorous competition. This drives prices down, and gives all parties incentive for continuous improvement.

But can a commercial wireless system be the primary provider of communications to public safety? Today, probably not.[14] We should not be surprised if a commercial wireless carrier does not offer a service that meets public safety's high standards for mission-critical communications. Smart shopkeepers do not stock

products intended to appeal to people who have vowed never to enter their store. The real question is whether commercial carriers could serve public safety if policies changed. It is technically possible to prioritize public safety traffic to guarantee capacity in an emergency. It is also technically possible to improve back-up power supplies, coverage areas, and other attributes to meet the needs of public safety. Whether or not profit-seeking commercial carriers can do this for public safety without increasing the cost to serve commercial users is unclear, but policymakers should at least give commercial carriers the opportunity to try.

2.6 Public Safety Does Not Share

First responders generally communicate over infrastructure that is dedicated to public safety, and over spectrum dedicated to public safety. This ensures that other kinds of traffic will not interfere. It is also probably necessary today because when each public safety agency makes its own decisions, there is no single voice with sufficient authority to represent public safety agencies throughout a region when discussing the possibility of sharing either infrastructure or spectrum with some other entity.

Communications systems for public safety must have sufficient capacity for those unusual periods when there are major emergencies involving many first responders. However, much of the time, public safety systems carry little traffic, and even less that is mission-critical.[15] Thus, the capacity is unused much of the time. If there were sharing, someone could use these idle resources, thereby increasing spectral efficiency and possibly decreasing costs.

There are two ways to share. One is to share infrastructure—i.e., with infrastructure that serves public safety and other users. As discussed in Section 2.5, public safety must have priority, but much of the time their demands will be low.

It is also possible to share spectrum without sharing infrastructure.[16] Consider the case where there is one system for public safety, and another for commercial cellular. Each system has its own spectrum, but there is a band in which either of them is capable of operating. Most of the time, the band is dedicated exclusively to the commercial carrier, but whenever there is a major emergency, the band is dedicated exclusively to public safety on a priority-in-use basis. For both systems, this is almost as good as having dedicated spectrum all the time. (More complex and dynamic forms of spectrum sharing are also possible,[17] and some deserve serious investigation to determine whether spectrum efficiency can be further increased while still meeting appropriate safety standards.) The principal disadvantage of this sharing arrangement is that during major emergencies, the commercial cellular system must rely on spectrum bands to which it has exclusive access, which will decrease cellular call completion rates during these emergencies.

2.7 Emphasis on Voice Communications

As mobile devices in military and commercial wireless systems have added new capabilities, such as the ability to transfer images, video, and data files, and location technology that allows devices to be tracked, these capabilities have been slow to arrive in public safety systems. The Safecom Program in the DHS has identified many applications of these capabilities that might prove useful to first responders.[18] Some of these applications are not mission-critical, and can therefore be done over multi-purpose public networks operating in unlicensed bands, or through commercial services using privately-licensed spectrum, but some are mission-critical at data rates that require broadband allocation of spectrum. For example, real-time high-quality video could allow doctors in a hospital to observe patients at a remote disaster, and provide immediate advice to paramedics at the scene.

For some applications, the availability of interoperable broadband wireless is not sufficient. For example, if the doctors described above are a thousand miles from the disaster at the Centers for Disease Control, then public safety agencies on both sides of the conversation must also be connected to a backbone network, probably wireline, that can provide adequate capacity and quality of service. Today, this is not always possible.

3 Alternative Visions

The weaknesses discussed in Section 2 can only be addressed with a broadband network that was designed as national infrastructure, and not as a loose concatenation of thousands of local systems. There are a number of ways to achieve this. In this section, we discuss some alternative visions of what public safety infrastructure and policy might look like, and some advantages and challenges associated with each vision. As discussed in Section 2.5, it is possible that public safety might make use of multiple wireless communications systems. Thus, we begin with various options for a *primary* system, which would at minimum support mission-critical voice communications, and possibly more. We then present some alternatives for *secondary* systems, should any be used.

In all of these models, note that there need not be any connection between how the communications infrastructure is designed and run and how that infrastructure is used. Local public safety agencies are free to design their organizations, their emergency response procedures, and their cooperative relationships with other agencies in whatever manner maximizes effectiveness. (Such issues are beyond the scope of this paper.) A police chief can develop a strategy to fight crime in his jurisdiction without caring who keeps the police radios working, just as he does not care who supplies the department with electricity.

3.1 Primary Systems Run by Government Agencies

Today, primary public safety communications systems are designed and run by government agencies. As described in Section 2.4, they are run by many thousands of independent local agencies, and this leads to interoperability failures, inefficient use of spectrum, lower dependability, and higher costs. One obvious response is to continue to rely on government agencies, but to move away from flexibility and towards standardization and a consistent nationwide architecture defined by one or more federal agencies.[19]

Even with a national architecture defined at the federal level, the federal government may or may not actually operate the infrastructure.[20] Certainly, one option is for a federal agency such as DHS to deploy and operate a nationwide system. The federal government would pay directly for the infrastructure (although not necessarily the mobile devices used by first responders that connect to this infrastructure.) Another option is for local or regional entities to continue operating the systems, but systems must be designed to be a piece of the national system, and consistent with the national architecture, as opposed to an autonomous system that was clumsily glued to its neighbors. This arrangement is not new. For example, the Internet consists of many thousands of independent networks under separate administrative control, all of which operate and cooperate using protocols and architectures approved by the Internet Engineering Task Force.[21] Similarly, there are many telephone companies around the world using consistent standardized technology.

There is already one government program to develop a nationwide wireless network explicitly for law enforcement and homeland security. This network will be developed by federal contractors under the direction of the Departments of Homeland Security, Justice, and Treasury.[22] This Integrated Wireless Network (IWN) will support 80,000 federal agents and officers. Ironically, the IWN program was intended as a "cost avoidance measure" because its creators understood that a single network shared by these departments would be much cheaper than separate networks for each agency, and would be consistent with the National Telecommunications and Information Administration's drive towards spectral efficiency.[23] However, the IWN program did not take the obvious next step towards cost-savings and spectral efficiency by supporting state and local first responders. Thus, tens of thousands of public safety agencies would continue to run their own networks. Even though the IWN will be available to only a few percent of first responders—i.e. those from federal agencies—the network must still cover the entire country. The program is expected to cost between $3 and $30 billion.[24]

One challenge with developing a nationwide system for all first responders is migrating from current systems without a disruption. This challenge becomes vastly simpler with the spectrum made available by the digital TV transition. We now have the opportunity to construct a nationwide system using some or all of that new spectrum, and allow local agencies to gradually migrate from the current systems to the new

one over a period of years.[25] As they abandon their outdated technology and old spectrum allocations, some of these bands could become available for other uses.

There is also a significant bureaucratic challenge, as federal and local agencies adjust their roles and their budgets.

3.2 Primary Systems Run By Commercial Wireless Carriers

An obvious way to serve first responders using commercial carriers is simply to seek service from today's cellular companies. This has advantages. Multiple networks are already operating in much (but not all) of the country, and competition between these carriers drives costs down and quality up. However, as discussed in Section 2.5, today's systems would rarely meet public safety standards as the primary provider of mission-critical communications. Perhaps this would change if carriers were encouraged to bid for public safety business, but this remains to be seen.

An alternative is to seek bids for a new nationwide system that would be specifically designed to serve public safety, and run by a commercial provider. Many European nations have adopted this approach, using the TErrestrial TRunked RAdio (TETRA) standard[26] defined by the European Telecommunications Standardization Institute (ETSI) in 1995. For example, the British Government has signed a contract with British Telecom, which will build a TETRA-based wireless system and operate that system for 19 years in return for 2.5 billion pounds.[27] The system is intended for public safety, although it covers not just first responders, but also other public service agencies and even community health centers. Thus, the U.K. gains the efficiency and dependability of a national system, with no possibility of interoperability problems, all provided through the existing expertise of British Telecom.

Although details are still forthcoming, it appears that Verizon is making a similar proposal,[28] wherein it would operate in 12 MHz of spectrum in the 700 MHz band that is currently intended for public safety after the digital television transition. Based on press reports to date, it appears that Verizon would serve public safety users only, in return for a fee. No spectrum or infrastructure would be shared with users who are outside of public safety.

As discussed in Section 2.6, public safety systems must be designed for peak demand, but public safety demand is usually far below peak. Thus, further efficiencies could be gained if a network serves both first responders and commercial users, where the former have priority. Cyren Call,[29] a start-up run by Nextel founder Morgan O'Brien, has requested a no-bid grant of 30 MHz in the 700 MHz band to establish just such a network in the U.S. This 30 MHz would come from spectrum that Congress currently expects to be auctioned, probably for around $5 to $10 billion.[30] In a sense, this reallocation of spectrum represents an upfront investment by the federal government. (In the Cyren Call proposal, public safety would still get its 24 MHz of additional spectrum in the 700 MHz band.) The network itself would be built and operated by a number of commercial carriers operating in different regions, while Cyren Call plays the role of network manager by setting service requirements, negotiating deals with equipment and service providers, overseeing compliance with requirements, and managing the flow of payments.

Public safety agencies would pay for services on this network much as consumers pay for cellular services today. As discussed in Section 2.5, dual-use infrastructure can work well if meeting public safety's stricter requirements for coverage, dependability, and security does not make the system too costly for commercial users. For example, a system serving only public safety would naturally be designed to maximize coverage, but a company deriving much of its revenues from commercial users will focus on population centers. Cyren Call proposes to bring terrestrial wireless coverage to 99.3 percent of the U.S. population, but only 63.5 percent of the nation's area (75 percent of the area within the contiguous U.S.). This may have value for urban areas, but clearly other solutions must be found for rural areas. (Cyren Call proposes satellite communications for these areas.)

The biggest challenge when many public safety agencies are served by a single commercial company is ensuring that this company has incentive in perpetuity for providing outstanding services at reasonable

prices. If the only choices for public safety are to pay whatever this company asks or to discontinue wireless communications for first responders, then public safety is in trouble. A traditional solution is to impose cost and quality regulation, as is done with utilities. It is not clear whether such regulation would deter commercial companies like Cyren Call and Verizon from entering this market. There are also other ways to mitigate this risk, such as the following.

- Individual public safety agency agencies have little power to negotiate with a nationwide company. Thus, this task can be given to a single national entity such as a federal agency or national consortium that represents all public safety agencies in negotiations.

- Contracts must clearly define performance standards across many criteria, including but not limited to dependability, security, coverage, and quality of service, so companies will not be rewarded for cutting corners.

- Contracts could run for long periods, so renewals can be negotiated well in advance. The 19-year contract in the U.K. is an example.[31] If a contract is not renewed, this leaves more time to create an alternative.

- Public safety might not be required to pay for its last few years of service. If the contract is renewed, then payments continue without interruption. If not, the company must provide several years of services without payment, which increases the company's incentive to renew, and public safety can use the money they would have paid to prepare for whatever is next.

Still, the commercial company is in a stronger bargaining position than public safety, which is dangerous. This is especially true when the company serves both commercial and public safety users, as in the Cyren Call proposal, so the latter users can be lost with limited reduction in revenues. More extreme measures would make the company as dependent on public safety as public safety is dependent on the company. For example, it might be established when spectrum is allocated that if the company fails to negotiate a deal acceptable to public safety, then the spectrum license is immediately revoked, even if 99 percent of the network's users are not associated with public safety. License renewal could also depend on input from DHS and other responsible public safety agencies. To go even further, the contract with public safety might require the company to surrender its infrastructure to the next contract-winner if the negotiation fails. Similar measures have been proposed in the past for a highly subsidized telecommunications provider "of last resort" in rural areas. Under this arrangement, there is no risk that vital public safety infrastructure will become unavailable, because it can always be reassigned. The challenge here is giving the company adequate incentive to invest in infrastructure it could lose someday. Again, this requires long-term contracts and early negotiations.

In return for provisions such as the above that protect public safety from monopoly service providers, government might offer provisions that protect commercial carriers from other risks. For example, the government might guarantee that payments from public safety will not fall below a given level, even during the transition period when many public safety agencies are not yet making use of the new network.

Commercial companies also go bankrupt—especially new companies with innovative business plans. Contracts must also address this possibility, so critical infrastructure will not be lost to public safety, and there will be no disruptions in service. This problem is not new. Companies that operate other forms of critical infrastructure do go bankrupt from time to time, so there are models to follow.

3.3 Secondary Systems

A variety of options are possible as secondary systems, assuming that the mission-critical voice communications are provided through a primary system. These possibilities are not mutually exclusive, so several could be adopted.

Cellular carriers: As discussed in Sections 2.5 and 3.2, cellular carriers can compete to offer services to public safety, and if this is viewed as a secondary system, the diversity of networks available to public safety can greatly increase dependability and coverage, even if individual commercial networks do not always meet public safety's requirements. It can also bring new services, such as 3G data communications, where these are not offered by the primary system.

A nationwide commercial carrier: As with the Cyren Call and Verizon proposals, a commercial company could provide services to public safety across the nation, but on a secondary basis, focusing on services such as broadband that are not widely available today to public safety. One such proposal comes from M2Z Networks,[32] which has offered to provide free services to first responders in return for just 20 MHz of spectrum near 2.1 GHz, which is less valuable than spectrum in the 700 MHz band. (M2Z Networks also pledges to provide broadband services to most of the U.S. population, and to pay five percent of its revenues to the U.S. Treasury.) Their network would cover 95 percent of the U.S. population, so presumably the percentage of area covered would be considerably less than the 63.5 percent proposed by Cyren Call.[33] Since the services are free, there is obviously no danger of M2Z Networks overcharging. However, it is still necessary to worry about whether public safety's service requirements will be met adequately and in perpetuity, as discussed in Section 3.2.

Municipal infrastructure operating in unlicensed spectrum: More and more cities are creating or facilitating the creation of municipal multi-purpose broadband wireless networks using Wi-Fi technology. Municipal systems that blanket a city with wireless broadband coverage, or just serve strategically placed hotspots, are proving they can play a useful role for public safety. In some regions, this is already occurring (see sidebar below).[34] These Wi-Fi-based municipal systems are relatively low-cost, they provide high data rates, and they can serve many needs including but not limited to public safety. While this technology's ability to completely cover a large region is currently not adequate for some mission-critical applications, it is fine for fixed applications like transferring data from a fixed surveillance camera to a remote command center, or for applications in which lives do not depend on ubiquitous and instantaneous access—such as transferring arrest reports from a police car back to the station, for example. Many (but not all) of the broadband applications identified to date for public safety[35] could be accommodated in this way using currently available technology.

Ad hoc networks: Ad hoc networks are ideally suited for applications in which all devices are mobile or are transported to an emergency as needed. These systems have little or no fixed infrastructure, and must automatically self-configure to form a functional network. For example, such networks might be set up quickly among portable devices placed in a burning building, or between police cars that are traveling at 90 miles per hour.[36] This is also an effective solution for cases in which much of the communications is local—e.g., to allow public safety devices operating within an urban subway system to communicate with each other at high data rates. These networks could operate effectively in unlicensed bands, or in the 4940-4990 MHz band allocated to public safety. The former would be far less expensive, because it would be possible to use off-the-shelf mass-produced components. Consequently, this is probably the appropriate choice with the many applications for which current commercial technology is adequate. The latter has the advantage of being largely free from congestion, because it is available only to public safety. Thus, there may be cases in which this is preferable.

Satellite networks: Satellite systems are outstanding resources, in that they cover vast regions, and they are immune from earthquakes, hurricanes, and most terrorist attacks. Thus, they may play an important role in sparsely populated areas where terrestrial coverage can be expensive, or in areas where terrestrial systems have been destroyed by a recent disaster.[37] However, they are generally not the first choice where good terrestrial options are available. The time it takes a signal to travel to a satellite and back is inherently problematic for some applications, including basic voice communications. Today's mobile satellite devices tend to be more expensive, larger, heavier, and more power-hungry than their terrestrial counterparts, which makes them less attractive for many first responders. (These are important issues for those proposed multi-purpose networks that would use satellites in rural areas where commercial services would not be profitable.)[38]

Public Safety Use of Municipal Wireless Networks Operating on Unlicensed Spectrum

by Naveen Lakshmipathy, New America Foundation

A growing number of public safety agencies across the country are utilizing municipal wireless infrastructure operating on unlicensed spectrum for public safety communications applications. By setting up secure private data networks for public safety communications, agencies can leverage multi-use broadband wireless infrastructure to cost-effectively place a wealth of efficiency-enhancing applications at the fingertips of public safety personnel. Rural towns and counties, from Pratt, Kansas and Morrow County, Oregon, to medium-sized and large cities like Corpus Christi, Texas and New Orleans, are finding great value in utilizing Wi-Fi-based municipal networks for public safety uses. Here are some examples:

New Orleans, LA

One high-profile example of the value—and reliability—of municipal unlicensed wireless broadband for public safety is the city of New Orleans. In 2004, prior to Hurricane Katrina, the city set up a wireless real-time video surveillance network to monitor strategic points around the city as part of the mayor's crime-fighting agenda. IP-based cameras, connected over a Wi-Fi mesh network and controlled remotely from police headquarters, were placed in high-crime areas. The cameras transmit live video that can be made available to any wireless device on the city's IP network. During the pilot phase of the project, conducted from January through August of 2004, the area covered by the surveillance network recorded 57 percent fewer murders and 30 percent fewer car thefts than in the same months the previous year.[39] Not only did the Wi-Fi mesh network enable an effective crime deterrence strategy, it also proved highly reliable when Hurricane Katrina hit the city. In the storm's aftermath, with telephone, cable and cellular systems out of service, the Wi-Fi network supporting the surveillance system was still relatively intact and the first to restore service. Soon, city officials decided to expand and open up the city's Wi-Fi network to relief crews, government workers and to the general public for free, in order to expedite cleaning, rebuilding and economic revitalization. The network initially covered 7-to-10 square miles in the central business district and the French Quarter, but will be expanded over the next three years to cover the entire city.[40]

Hermiston, OR

In a rural county without a single traffic light, the Morrow County Emergency Management Department built a 600-square-mile Wi-Fi-based network for the region surrounding the Umatilla Chemical Depot, an army chemical weapons facility. Though it also provides free broadband Internet access to the public, the network was built to enable planning of evacuations and other elements of emergency response in case of a major disaster, such as a nerve gas leak, at the chemical depot. Police officers are equipped with wireless laptops and are able to view live video and geographic information to help coordinate traffic and evacuations. In the event a nerve gas cloud passes over town, emergency responders will be able to find out the location and direction of the cloud. Emergency medical workers will be able to transmit patient data to hospitals from ambulances, and find out which hospitals have extra capacity, over the network. Though such an emergency has not yet occurred, the law enforcement community routinely uses the network for access to databases, and to file reports from the field.[41]

San Mateo, CA

San Mateo was the nation's first municipality to utilize a Wi-Fi mesh network for public safety applications. Using in-vehicle laptops, officers have wireless broadband access to LawNet, a countywide law enforcement intranet that provides access to the Amber Alert System, Sex Offender Database, and other data, including DMV records, high-resolution photos, etc. Officers can now file routine reports online and conduct in-field photo lineups, thereby minimizing the need to report back to the office for such tasks and keeping police officers in the field longer per shift. This acts as a "force multiplier"—enhancing efficiency and safety by making it possible to keep more officers in the field at any given time.[42]

4 The Current Debate over Public Safety in the 700 MHz Band

Thanks to the transition to digital television, 84 MHz of spectrum will become available in 2009, 24 MHz of which have tentatively been allocated for public safety. This roughly doubles the spectrum under 2 GHz that is allocated to public safety.[43] A nationwide block of this size, unencumbered with old equipment, is an extraordinary opportunity. Moreover, this spectrum is around 700 MHz, which means it has physical properties that are particularly useful when designing a communications system that must cover a large geographic region.

There is little evidence of this opportunity in the current debate over the 700 MHz band. Instead, there have been a series of proceedings about the bandplan which allow only minor incremental changes to the traditional policy assumptions discussed in Section 2.1.

A Spring 2006 FCC proceeding[44] focused on the possibility of using some of public safety's new 24 MHz allocation for broadband communications. Before these proceedings, the spectrum could be used only for narrowband voice communications and "wideband" (lower-speed) data communications. Broadband is needed to achieve high data rates, as might be needed for TV-quality video or the rapid exchange of mug shots. There has been little opposition to the idea of allowing broadband, at least in roughly half of the new public safety band, and this will probably allow the FCC to take a positive step away from the traditional emphasis on narrowband voice. However, merely allowing broadband is not the same as requiring all agencies to use a compatible broadband technology. Indeed, the introduction of broadband without standardization brings greater flexibility, but it also brings the potential for even greater interoperability problems than we have today.

A more controversial question is which portion of the 700 MHz band should be allocated to public safety voice communications, and which portion should be available for other public safety uses.[45] Many of the technical specifics of this disagreement are beyond the scope of this paper, but one rationale for disagreement is noteworthy here. There is strong support among public safety organizations to set aside one particular 12 MHz portion of this spectrum for narrowband voice, largely because public safety agencies have already purchased 600,000 devices to provide voice services, many of which operate in this band. There would be a cost to changing the frequency of this equipment.[46] In addition to this cost, public safety organizations also worry that reviewing old decisions is inherently problematic because the process is slow, and that changes may require discussions with Canada to prevent cross-border interference. Others, mostly from industry, have pointed out that by selecting a different 12 MHz band for voice, it would be possible to turn guard bands, which are of little practical use, into valuable spectrum for general use. This would be equivalent to giving public safety 2 MHz of additional spectrum, and by some proposals, efficiency gains in adjacent commercial bands would allow an additional 1 MHz to be shifted to public.[47] In addition, moving the voice allocation would create an even larger contiguous band for broadband, which has some additional advantages for public safety.

This debate clearly demonstrates the limitations of today's decentralized methods of making decisions regarding public safety spectrum and infrastructure. For the sake of discussion, let us assume that bureaucratic delays associated with a policy change would not be too great, and that making better use of guard bands is not an option. Is it worth incurring the cost of moving up to 600,000 devices to another band to free 3 MHz? It has been estimated that auctioning 60 MHz of television spectrum should raise somewhere between $10 and $28 billion,[48] which implies that 3 MHz is worth roughly 1 billion dollars. This is $1700 per device that has been deployed. It would cost a tiny fraction of that sum to move these devices to another band. If there were a federal agency overseeing public safety infrastructure, it would gladly pay this cost to make 3 MHz available for use by public safety, but no one currently has the ability and mandate to play this role. On the other hand, for municipal public safety agencies struggling to provide vital services on dwindling city budgets, it would be a dereliction of duty to incur an unexpected equipment cost if they can possibly help it. After all, to them, spectrum is free, but equipment is precious.

A very recent proposal has the potential to relax traditional assumptions a bit further.[49] In this proposed bandplan, two 5.5 MHz blocks of spectrum would be adjacent, one for commercial license-holders, and one for public safety agencies. If the same broadband technology were deployed nationwide in both bands, then mobile devices that could operate in both bands would be much cheaper. This could allow first responders to make use of commercial spectrum in addition to public safety spectrum during major emergencies. Of course, this level of harmonization would be very hard to achieve with tens of thousands of public safety agencies making their own decisions independently, and it would be even harder with multiple commercial license-holders operating in this band in different parts of the country. The plan further proposes that a bidder for these commercial licenses should be given some form of preference if the bidder agrees to carry public safety traffic, and the preference would be even greater if the bidder agrees to build out its network beyond the areas of greatest commercial profit, and/or to enhance the network to meet public safety's stricter requirements.[50] The proposal has few details on the bidding preferences, and as discussed in Section 3.6, there are complex issues to address here. Nevertheless, it does advance the discussion about the role of commercial service providers. It remains to be seen how this recent proposal will influence the debate.

5 Next Steps Towards a More Effective Policy

In a December 2005 report to Congress,[51] the FCC correctly concluded that first responders would benefit from a nationwide broadband network. The digital TV transition affords us an historic opportunity to establish this network. However, without a policy change, this opportunity will be lost. In this section, we discuss how to move forward.

The initial focus should be on establishing a nationwide broadband network for data services, which are not widely available to public safety today. Each agency can migrate voice communications over to the new system when the agency is ready, yielding a gradual transition that never leaves first responders without service. After the migration is complete, outdated equipment operating in other bands can be discarded, and existing spectrum allocations can be released for other uses. Thus, providing public safety with spectrum and the ability to use it more efficiently today can free other spectrum in the future to be auctioned for licensed use or made available for unlicensed use. This might also make it possible to release public safety allocations in TV channels 14-to-20.

If this nationwide broadband system is to be run by a commercial company, a number of complex issues must be worked out with players like Cyren Call, Verizon, M2Z Networks, and others who may come forward. If the system is to be run by government entities, policymakers could begin the process today. This latter process is essentially the same regardless of whether the network will ultimately be run be one federal entity or a collection of local or regional entities. I recommend that policymakers pursue both paths in parallel.

The first step is to establish the technology and architecture for a nationwide broadband network that will meet the long-term needs of public safety. Both the FCC and DHS would presumably have roles to play in this process, with plenty of input from public safety organizations, equipment manufacturers, wireless service providers, and other stakeholders, as well as more objective researchers. The process itself should be patterned more on the development of an open technical standard than the typical rule-making of a regulatory body, or the opaque pronouncements that are possible for an executive-branch agency. Ultimately, architecture should be adopted based on open standards, for which no entity (other than the federal government) owns intellectual property. It would include a broadband backbone, which is likely to be based on the versatile Internet Protocol (IP), and standards for wireless communications. It would incorporate gateways to legacy public safety systems, as well as potential secondary systems such as commercial cellular carriers, municipal Wi-Fi systems, ad hoc networks, and satellite systems. Use of these secondary systems may allow the primary system to operate with less spectrum in the 700 MHz band.

Given the stakes of such a fundamental shift in public safety infrastructure, the process should consider a variety of current and emerging technical options and seriously investigate the long-term implications of each. Thus, funds should be provided to agencies like the Homeland Security Advanced Research Projects Agency (HSARPA) and the National Science Foundation specifically to engage forward-looking researchers outside of government in this process, much as the Defense Advanced Research Projects Agency (DARPA) has been used to consider major shifts in technology for military use.

It is also time to reevaluate the IWN program. There is no reason to invest billions of taxpayer dollars in a network that serves only federal first responders, when the vast majority of first responders work for state and local agencies. One possibility is to greatly expand this program such that the IWN supports all first responders, presumably in federal spectrum instead of the 700 MHz band. If this vast change in scope is not practical, then the IWN should be shelved, so that the funding intended for IWN can be spent on a more complete solution to the problems of communications for public safety and homeland security.

Assuming that new infrastructure is needed and it will be government-run, the next step is to design and build a nationwide network in the 700 MHz band based on the above architecture. The FCC must allocate spectrum from the 700 MHz band to public safety for this purpose. This need not increase the total amount of spectrum going to public safety, but it does mean that the FCC must abandon the policy of granting local public safety agencies maximal flexibility regarding use of spectrum at 700 MHz. This implies that none of the current bandplan proposals before the FCC can be adopted.

Federal funding will also be needed for construction of this nationwide public safety infrastructure, although much or all of the funding for the mobile devices held by first responders might come from local agencies. In the long run, the taxpayer dollars saved by an efficient system should be far greater than those spent, but not during the initial transition period. One possible source of funds is auction revenues from the TV spectrum that will be allocated for commercial use. Some have estimated the value of 60 MHz of this spectrum at between $20 and $28 billion, but the Congressional Budget Office scores it at $10 billion.[52] As I have previously proposed,[53] simply by ensuring that any auction revenues beyond the $10 billion projection ("score") by the Congressional Budget Office be earmarked for a nationwide public safety system operating in the 700 MHz band, it might be possible to raise well over $10 billion dollars without affecting current budget projections. However, this is just one of many options. Despite some of the rhetoric on this topic, there is no legitimate reason that Congress can only pay for critical public safety infrastructure from spectrum auction revenues. This is simply a useful accounting trick to make it appear that the infrastructure costs nothing. Surely in the age of terrorist threats on American soil, policymakers need no such excuses to spend money that will advance homeland security and public safety, especially when the short-term expenditures will lead to long-term savings.

In parallel with the path towards a government-run nationwide infrastructure, we must seriously consider the proposals of Cyren Call, M2Z Networks, Verizon, and perhaps others to come. A commercial public safety network may have the potential for greater benefits than a government-run system. This is especially true if the network also serves users outside public safety, so the system can be put to good use between emergencies, leading to much greater efficiencies in the use of expensive infrastructure and the use of scarce spectrum. However, a commercial system also carries greater challenges and risks. In particular, we can only rely on commercial companies if we can ensure that public safety's requirements will be met, including requirements for coverage, dependability, and security, and that requirements and fees can safely evolve over time as technology and needs change. Commercial companies will have strong incentive to cut costs and raise prices where they can, and public safety may be in a poor position to negotiate. Moreover, commercial companies who hope to derive their profits from paid subscribers will naturally try to avoid serving sparsely populated areas. This is why the current Cyren Call proposal would provide terrestrial service to only 63.5 percent of the U.S.,[54] and rival proposals may serve even less. As discussed in Section 3.2, the provisions that offer the greatest protection to public safety may also deter commercial companies from participating. It is not clear yet whether these issues can be resolved to the satisfaction of all. None of the proposals to date are sufficiently specific to address these issues. Since the risks and rewards of this approach are both great, more detailed consideration of these proposals is warranted.

Regardless of whether public safety's new nationwide network is operated by government or a commercial company, if it serves only public safety, then the spectrum allocated to this network will sit idle much of the time. In this case, the spectrum should be shared with another user who would have secondary access. Given that public safety would not need the spectrum often, secondary rights might be auctioned for almost as much as dedicated spectrum. Thus, for example, if public safety had exclusive access to 12 MHz, and primary access to 24 MHz that is shared with commercial systems, then this might be far better for both public safety and commercial users than giving public safety exclusive access to just 24 MHz. This could also generate greater auction revenues. Alternatively, the underutilized spectrum could be opened for limited sharing with unlicensed cognitive radios, with coexistence rules carefully defined to protect public safety from harmful interference.

Since commercial carriers could play a more important role for public safety, either as primary or secondary service providers, we should adopt policies that would increase their dependability. As I proposed have proposed previously,[55] policymakers should first provide market incentives for carriers to be more dependable. Carriers are rewarded for investing in better service only if customers are willing to pay more as a result. Today, customers cannot know which carrier provides the most dependable service, with or without a major disaster, so no one will pay more for a dependable service. If the FCC released annual report cards on each commercial carrier's dependability and security, then the carriers might have incentive to compete with rival carriers to be more dependable and secure. If we later come to view these carriers as critical infrastructure, policymakers should take the additional step of increasing their priority with respect to power restoration after a disaster.

6 Summary

American policies on communications systems for public safety have evolved over many decades, and there is reason to believe those policies have outlived their usefulness. In particular, the U.S. system is based on assumptions that local agencies should have maximal flexibility at the expense of standardization and regional planning, that commercial carriers have little role to play, that public safety should not share spectrum or infrastructure, and that narrowband voice applications should dominate. These policies have led to a system that fails too often, costs too much, consumes too much spectrum, and provides too few capabilities. Moreover, public safety requirements have changed after 9/11, and the technology has changed as well, so there are many reasons to consider a fundamental change in policy.

Some will argue that we cannot afford the cost of a change in policy. In fact, the current policies are so wasteful that a policy change could easily reduce the cost of public safety communications infrastructure, in addition to saving lives and saving spectrum.

The digital television transition will provide a new block of prime spectrum, where new forward-looking policies and more effective technologies can prevail. Some or all of this spectrum could be the home of a new nationwide system built on open standards and a consistent architecture. This system could be run by the federal government, or by a coordinated confederation of state and local government agencies, or by a commercial carrier. All of these options have significant advantages over the current approach. Assigning this responsibility to a commercial carrier offers the potential for greater efficiencies, but only if we find long-term solutions to some important challenges. A nationwide public safety system run by and for government has the advantage of being lower-risk.

There are steps we can and should be taking today towards this nationwide system. This includes either expanding IWN to meet the needs of state and local first responders or shifting IWN funding elsewhere, funding efforts inside and outside of government to develop an appropriate architecture for a nationwide public safety network based on open standards, raising funds to pay for the transition to a new nationwide system that is based on this architecture, and publicly evaluating proposals from commercial service providers to determine whether they can operate a network that would meet the long-term needs of public safety.

We must also change the way TV spectrum will be used for public safety. More specifically, for the 700 MHz band, we must abandon policies that allow each public safety agency to make technical choices that are incompatible with its neighbors. Thus, flexibility should be replaced by standardization and regional or national planning. Some of the newly allocated spectrum could also be shared between public safety and other users. This can be done in a manner that gives public safety ample capacity when emergencies hit, but makes valuable spectrum useful for other purposes the rest of the time. This approach may even raise additional funds through auctions, which could be used to build that new national public safety communications infrastructure.

This is also an appropriate time to consider how commercial carriers, broadband networks operating in unlicensed spectrum, and satellites can be used as secondary providers to public safety. A growing number of municipalities and counties already operate multi-use networks that include pervasive mobile data connectivity to police, fire, emergency response, utility, and other public safety-related services. While none of these secondary systems will operate in the 700 MHz band, their inclusion may affect the architecture of public safety's nationwide broadband network. Moreover, by making effective use of secondary systems, it might be possible to reduce the amount of dedicated spectrum allocated to public safety, and also improve dependability, reduce equipment costs, and introduce valuable new capabilities.

Some will complain that the steps discussed in this paper will take too long. It would certainly be better if there were a quick fix we could apply, but we have been spending time and money on quick fixes for years with little effect. More than five years have passed since 9/11, and still we wait for failed policies to suddenly become effective. It is time we at least start the process of meaningful reform to meet truly long-term needs for public safety and homeland security.

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