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Comments on:

FCC White Paper

The Public Safety Nationwide Interoperable Broadband Network: A New Model for Capacity, Performance and Cost

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Executive Summary

In June 2010, the FCC published its second white paper supporting its recommendations in the National Broadband Plan (NBP) submitted to Congress in March of this year. The first white paper detailed the FCC's ideas related to the cost of building and operating a nationwide public safety Broadband network. I reviewed that document and prepared my own white paper challenging many of the FCC's assumptions and questioning its findings.

This second white paper details the FCC's analysis of the capacity of the 10 MHz of spectrum already assigned to the public safety community and claim that 10 MHz of broadband spectrum (5 MHz by 5 MHz) will be sufficient for most public safety broadband requirements well into the future. The following is my response to the FCC's second report.

In the introduction to the Capacity Paper, one of the authors recaps points made in more detail in the body of the paper:

> *"The Federal Communications Commission ("FCC") has performed a technical analysis of the capacity and performance of the public safety broadband network assuming that the National Broadband Plan recommendations concerning this network are implemented. This analysis includes examining different emergency situations based on actual experiences and as submitted in the record of the National Broadband Plan. This analysis shows:*
>
> 1. *The 10 megahertz of dedicated spectrum allocated to public safety in the 700 MHz band for broadband communications provides more than the required capacity for day-to-day communications and for each of the serious emergency scenarios set forth below.*
> 2. *For the worst emergencies for which public safety must prepare, even access to another 10 megahertz of spectrum would be insufficient. Accordingly, priority access and roaming on the 700 MHz commercial networks is critical to providing adequate capacity in these extreme situations. Moreover, priority roaming is a cost-effective way to improve the resilience of public safety communications, along with its capacity, in a way that a single network cannot provide.*
> 3. *The capacity and efficiency of a public safety broadband network will far exceed the expectations of someone who has only experienced narrowband land mobile radio (LMR). This is because of the system architecture, density of cell sites, density of cell sectors per site, network and spectrum management, and the use of new and emerging technologies.*
> 4. *Public safety can make more capacity available when and where it is needed by using all of its spectrum resources appropriately and effectively, no matter how much spectrum is available (e.g., use the 700 MHz band for mobile devices and other frequency bands for fixed devices)."*

In reviewing the assumptions the FCC used in reaching these conclusions, I take issue with the following:

1. The FCC is trying to equate voice with data traffic information. Voice communications requires far less spectrum per conversation than broadband data services require. Further, the types of data have a huge impact on the amount of bandwidth available and the capacity of the network within a given cell sector.

2. The FCC claims that video data rates of 256 Kbps will provide sufficient video resolution for most public safety video applications. I and many others disagree with this assumption for many of the video feeds that will be employed by public safety.
3. The FCC claims that land mobile radio systems (LMR) are underutilized most of the time. This is not a correct assumption. LMR systems, as used by public safety, do have periods of light usage, but there are many times every week when these systems are supporting voice traffic that is beyond the capacity of both the existing LMR systems and the capabilities of the dispatch centers to keep up with the demand.
4. The FCC believes that roaming onto commercial networks will occur on a sporadic basis. My research shows that having only 10 MHz of spectrum available will result in having to roam on commercial networks in at least the top 100 metropolitan areas on a daily basis, and for long periods of time for each occurrence.
5. The FCC assumes that the public safety community will have access to 60 MHz of broadband spectrum (its own and that operated by commercial networks). This assumption is not based on any current rules that mandate commercial priority roaming or type of priority roaming and assumes that the winner of the D Block at auction will make its spectrum available for use by the public safety entities, yet its current recommended rules for the D Block auction do not require such cooperation between the public and private sector.
6. The FCC based its usage models only on major scenarios spread out over large geographic areas of a city or jurisdiction. There are no assumptions that look at capacity requirements for smaller incidents that occur on a daily basis and are fairly local in nature and, therefore, will have broadband coverage from only one or perhaps two cell sectors.
7. The FCC believes that local ordinances need to be changed to require the installation of inbuilding network cells (femto, pico, or distributed antenna systems). Yet the FCC has no authority to require that local communities actually do update their existing ordinances, nor does it take into account the cost of providing this inbuilding coverage, nor how it is to be integrated into the network.
8. The FCC's discussion of how much spectrum is already available to the public safety community is flawed in a number of ways. It counts the broadband spectrum at 4.9 GHz that provides only local-area coverage and does not penetrate buildings, it includes the 220 MHz band that is presently used in only one area of the United States because of a conflict on the Canadian border, and it does not take into account that existing channelized spectrum cannot be aggregated into spectrum that could be used for broadband because the channels already allocated to public safety are interleaved with channels assigned for other land mobile radio services.
9. The FCC claims that the public safety community's only rationale for requesting that the D Block be reallocated to public safety is so it can build fewer cell sites and therefore a less expensive network. This assumption is wrong, since public safety is planning to make use of the same number of cell sites recommended by the FCC (44,000 nationwide). The additional spectrum being requested is to provide additional capacity for the network.
10. The FCC used the New York City report on bandwidth requirements to support its own position. However, instead of using all of the assumptions provided in that report, it chose to discount the requirements listed for video services and use its own assumptions as to the number of video feeds that would be required and the bandwidth consumption of each connection.
11. The FCC assumes for the purpose of this paper and in its general findings, that a guard band is not needed between the D Block and the public safety spectrum. However, on May 18, 2010, the FCC requested comments from interested parties to provide input on whether or not a

guard band will be needed, even though the assumptions in its white paper are based on a guard band NOT being necessary.

12. The 700 MHz commercial spectrum that was already auctioned and on which networks are in the process of being built did not carry any requirements for priority access for the public safety community. It is unclear to me whether the FCC has the authority to now require these network operators to provide some type of priority roaming with the public safety community.

It is clear that those involved in preparing the FCC white paper on capacity tried to make the results fit the recommendations they already included in their National Broadband Report to Congress. In reality, this capacity study should have been prepared and released prior to their recommendations to Congress. The FCC focused only on major events or incidents and did not run scenarios based on day-to-day operational requirements. These daily incidents will occur in small geographic areas, sometimes within only a one or two block area of a city or within one-quarter or one-half mile of a jurisdiction. In many cases, these areas will only have broadband coverage from one or two cell sectors. Since this is the norm for public safety responses, this should have been the criterion for evaluation of the amount of spectrum required.

The FCC statement that capacity is based on a number of cell sectors per site, times the amount of spectrum available within each sector, divided by the frequency reuse factor, is true and correct. However, its assumption that public safety would build out fewer sites if it had more spectrum available is not correct. In the case of public safety and its planned network, doubling the amount of spectrum it has available will double or more the amount of bandwidth available within each cell sector. Therefore, the assumption that total capacity is based on other factors as well is not correct. The proper calculations should look at a single cell sector, map the bandwidth available within that cell sector, and then calculate the amount of data traffic (data and video) that will be required both inbound and outbound for typical incidents including a building fire, bank robbery, hostage situation, gang fight, and other incidents that occur on a daily basis but in random locations within jurisdictions.

Further, their discussion of cell sectors and capacity assumes that incidents will occur in areas already heavily covered by commercial network operators. This too is a flawed assumption. If we look at New York City as an example, the commercial operators have learned from experience that in the Theatre District, when the shows let out, the demand for voice and data services will peak. The network operators design and build their systems based on this type of demand, primarily in identifiable locations. The reality of the situation is that criminal events, fires, and other emergencies are not predictable by location, and in many instances the demand for public safety services will occur in areas of the jurisdiction that are lightly served by commercial operators, but bandwidth must be available for public safety.

It is my opinion that the authors of the paper were charged with reinforcing the position previously taken by the FCC that the D Block should be auctioned to a commercial operator. Instead, they should have been charged with taking an uncommitted view of the needs of the public safety community and developing a paper based on an understanding of the differences between commercial and public safety networks and requirements. It appears that this FCC white paper was developed for the purpose of further justifying a position it already recommended to Congress in the National Broadband Report. There are many discrepancies in the FCC white paper and a number of assumptions that, while they may be valid for commercial networks, are not valid for a mission-critical public safety broadband network.

The bottom line for me is that the FCC delivered a report that attempts to once again justify its position that 10 MHz of spectrum is sufficient for use by public safety on a daily basis and that during the occasional times when this is not enough, public safety will be able to make use of commercial network operators' spectrum on some as yet undefined type of priority access. Further, the studies referenced in this report look at broadband capacity from a macro level rather than from a cell sector level. The result is a paper that does not address the real-world broadband requirements of the public safety community on a daily basis, though it does meet the FCC's goal of justifying its recommendations already presented to Congress.

Andrew M. Seybold
Note: My full response to the FCC's capacity white paper is below in PDF format.

Comments on the FCC White Paper on Capacity

Section I: Introduction

In this section of the paper, the FCC reiterates its belief that "*creation of incentive-based partnerships with commercial entities*" will provide many advantages for the public safety community. However, the National Broadband Report does not include any information concerning this type of sharing nor does it require the winners of the D Block auction to work with the public safety community. The FCC seems to believe that the winners of the D Block will be willing to work with the public safety community on a joint build-out. If, as the FCC is presently proposing, the D Block is auctioned in 10 licenses, and the licenses are won by various commercial operators or green field operators, the burden placed on the public safety community to obtain agreements with the D Block winners could materially delay the construction of the public safety side of the network.

Further, as detailed below, 10 MHz (5 MHz X 5 MHz) of spectrum does not provide sufficient capacity for daily public safety needs, let alone enough capacity for commercial operators (the D Block). Thus it is unlikely that the winners of the D Block spectrum will be willing to voluntarily encumber a portion of their commercial spectrum. It is our belief that if public safety is restricted to its own 10 MHz of spectrum, it will have to roam onto the D Block or other commercial spectrum on a daily basis in many of the top 100 metro areas (see below). The FCC is basing some of its recommendations on the fact that the LTE technology supports priority access and roaming. However, the method of priority access (next in line for service or ruthless pre-emption) has not been discussed nor has the number of priority access levels been clarified. The FCC appears to be conducting research and reaching its own conclusions AFTER its broadband report was forwarded to Congress. Many of these issues should have been investigated prior to submission of the report. Now each of the FCC white papers, the previous one on network costs and this one on capacity, are viewed by many as reports designed to reinforce the FCC's recommendations after the fact. It is easy to deliver white papers that "prove" a specific, predetermined view.

It is also unclear to this author whether the FCC will be able to convince the existing 700 MHz spectrum winners that even though they won the spectrum at auction, they must now agree to priority roaming for public safety services. If this roaming will occur on a daily basis, as we believe it will, the value of their spectrum will be impacted as will the level of service they will be able to provide to their customers. If, in a given city, one network operator decides to cooperate with public safety while another operator decides not to, the operator that will not have to share its network with public safety will have a marketing advantage. It will be able to use 100% of its spectrum all of the time while the cooperating network operator will not be able to guarantee full access to all of its spectrum during emergency incidents, when, it has been proven time and again, the demand for both public safety and consumer and business usage in a given area all peak to load requirements that cannot be handled by any network operator. If network operators have to share some of their spectrum during these events, both the public safety community and the network operators' customers will suffer loss of service. And if public safety does not have ruthless pre-emption, it will end up, even with priority, competing with the networks' customers for service.

Another of the FCC's assumptions in this paper has to do with its vision "*that coverage and capacity of the public safety broadband network will be supplemented through in-building systems and through provision of deployable cell sites and vehicular relays.*" It does not say where and how many of these deployable cell sites (cells on wheels or COWs) will be stationed, who will own them, who will pay for them, and how they will be deployed. If they are staged in only a few areas of the nation, the transport time to an emergency scene could be hours if not days and they would not be available at the start of the incident when capacity will be critical. During a major storm or disaster, these COWs will be a welcome addition to capacity for long-term operations, but many incidents are kept from becoming major incidents by decisive action on the part of first responders in the first few minutes or hours. This is the critical period of time when those in charge of the incident need all of the information about the incident available to them, and when they need to disseminate video and other data to those who are in the field as well as back to the dispatch or command center.

The use of vehicular relays or vehicular repeaters has become standard practice within the first responder community for voice services. It is not clear from the LTE specifications if and when this type of device will be supported. However, the 3GPP standards body has addressed the issue of vehicular relays. Unless there is a demand for these devices, the cost of their deployment will be high, and it is not clear exactly how an LTE broadband network will be able to integrate these types of devices. Unlike traditional voice systems employed by the first responders today, LTE networks control the power levels of the devices in the field, decreasing the transmit power if a device is close to the cell center, and increasing it if the device is out toward the edge of the cell. This method of power control is vital to minimizing interference to and from the various sites as well as to and from field devices. Adding vehicular relays that would be capable of higher power or that will use external antennas could easily unbalance the power management important to the LTE network. Further, it remains unclear whether the devices carried by those in the field will have to include additional radios in order to use these relays. In short, the vehicular relay method of supplementing the coverage and capacity of the public safety systems is proven, but there are a large number of logistical problems associated with this approach on LTE networks.

Section II: Why the Plan Meets Public Safety Capacity Requirements: Baseline Capacity

This portion of the paper starts out with the contention that the public safety community already has 60 MHz of spectrum available for broadband use, and that overall, the allocation of spectrum per user for public safety is now 25 times that of commercial providers. There are a number of statements here to which we take exception. The first concerns the 50 MHz of broadband spectrum at 4.9 GHz that the FCC includes in its figure of 60 MHz available for broadband. While licensed for public safety use, this spectrum is adjacent to the 5.8 GHz Wi-Fi unlicensed band and the characteristics of this band make it unsuitable for any type of wide-area broadband coverage. This is a band that can be used for local-area but NOT wide-area communications, therefore it should not be included in the FCC's broadband-available number. This takes the FCC's 60 MHz available for broadband down to 10 MHz of spectrum presently licensed to public safety in the 700 MHz band.

If we deduct this 50 MHz of local-area spectrum, we end up with public safety allocations of 47.1 MHz including the 24 MHz at 700 MHz. Prior to the release of the 700 MHz spectrum, public safety had operated its systems in a total of 23.1 MHz of spectrum in the 30, 150, 450, and 800 MHz bands, with some use of 470 MHz shared with TV stations in major metropolitan areas, and a small slice of 220 MHz spectrum authorized for use in upstate New York because there is a conflict with Canadian spectrum usage on some of the public safety bands. Of the 23.1 MHz of spectrum that has been allocated to public safety over the last 60 years, all of it is channelized AND the channels are intermingled with other land mobile radio systems. Even if there was enough spectrum in any one of the bands, it could not be aggregated for broadband usage.

That this spectrum has been allocated over a 60-year period, that none of it is contiguous, and that it is spread over six to eight different portions of the spectrum is what led to the lack of interoperability for public safety in the first place. Elsewhere in its paper, the FCC contends that this 23 MHz of spectrum is lightly used most of the time. What it doesn't point out is that many times during every week of the year, there is substantial demand for this spectrum, which results in delayed dispatches and response times. States that have been aggressive in building statewide, interoperable voice networks on the spectrum available to them have found that they do not have the capacity to handle the demand for voice radio traffic. For example, Indiana's statewide wireless public safety communications network is now facing overcrowding issues due to a lack of spectrum,[1] and this is for a statewide system that supports 52,000 registered users.

We also find fault with the number of first responders the FCC claims would need access to the network. Its number cited in a footnote on page 4 of its report states in part, "*public safety: According to the Bureau of Labor Statistics, U.S. Department of Labor, there are 1.1 million police, fire and EMS professionals. This number excludes some first responders, such as volunteer firefighters. For this analysis, we assume 2 million public safety users.*" It does not include volunteer firefighters nor does it count other organizations that will need access to this interoperable spectrum such as federal agencies, and agencies and organizations that take on the status of "first responder" during some types of incidents. For example, an automobile that has hit a telephone pole and has a high-power electric line on top of it requires first responder response from the electric company to disable the power line prior to any rescue attempt by fire and EMS personnel. We believe that the true number of users should be in the 4 to 5 million range.

But even using the FCC's number, what it fails to take into account is that most incidents are local in nature and that there will be a concentration of vehicles and personnel in small geographic areas for long periods of time, all needing access to video and data services. As more units and personnel respond to an incident, there will be an increased need to receive information regarding the incident and their assignments. Today, this information is disseminated primarily using the voice channels assigned to a jurisdiction. However, when the broadband network is in place, much of this information will be shared in a digital format including video transmitted from units already on the scene. This concentration of personnel will also lead to the arrival of the press and a number of citizens who are curious about the incident or whose home or business is part of or adjacent to the incident. This, in turn, will lead to increased network usage both for the public safety network and the commercial networks. If, as we believe, public safety will have more demand for digital services than it has spectrum (based on the 10 MHz currently allocated), there will be a need for public safety to roam onto these already congested commercial networks and, even with priority access, there will be delays and loss of information that could end up causing the additional loss of life and/or property.

We believe that the FCC should not have looked at the network capacity issues from a nationwide or major incident basis where there is access to the network through many different cells sites and cell sectors, but rather within the confines of typical daily incidents that take place in much smaller areas of several city blocks or within one-quarter or one-half a mile in which the number of vehicles and personnel will be concentrated and where broadband coverage will be limited to one or possibly two cell sectors. The FCC's report tries to equate voice and data traffic, and the total number of users for a given incident. However, in practice, much of the voice traffic during these typical incidents is taken off the network voice systems and moved onto channels where units can talk to each other without having

[1] Crisis-comm network nearing capacity http://tribstar.com/local/x1703931790/Crisis-comm-network-nearing-capacity

to use the main network. The incident commander will stay in contact on the main network channel, but teams in the field will be assigned simplex or tactical channels.[2] Therefore, the voice traffic will be spread over many different channels enabling teams to communicate among themselves without interfering with other teams at the same incident. The team commanders will be in direct contact with both their own team and the incident commander.

In the case of the public safety broadband network, all of these teams will have to rely on the total bandwidth provided within a single cell sector or two. According to the FCC's own calculations, the total available bandwidth for a cell sector using 10 MHz of spectrum will be 7.5 Mbps down to devices and 3.25 Mbps for the uplink (from the device to the network).[3] However, this bandwidth is not available in the entire cell sector; the amount of bandwidth will diminish toward the cell edges. The FCC's report states that cell edge data capacity will be an acceptable 256 Kbps and points to the National Public Safety Telecommunications Council (NPTSC) report which states "that a system that supports 256 kb/s per video device throughout the coverage area, including edge of cell, is sufficient for public safety in urban areas (and lower data rates are acceptable in suburban and rural areas)" in support of its position. This report was generated in 2007 and was based on technology that was then available in the market. Since this report was published, there have been many studies that conclude that video data rates of 256 Kbps do not provide the level of resolution that will be needed for various kinds of incidents.

For example, in the case of a hostage situation where a sniper is in place and watching the hostage taker and hostages inside a building through a window, video at 256 Kbps will not provide the level of detail needed by the swat team commander and the incident commander, and several other video feeds will probably be needed simultaneously. A number of commercial companies have demonstrated video over LTE at various levels of resolution and have found that 1.2 Mbps video is required in many cases for both the type of resolution and depth of field necessary to be able to properly assess an incident. Even deferring to the Department of Homeland Security's SAFECOM program, we find that 512 Kbps video may be needed. If we run the FCC's own calculations against the benchmark of 512 Kbps video, we come up short on a cell sector basis. However, using the same numbers but with 20 MHz of spectrum, we can achieve the required 512 Kbps of video service availability for a given cell sector.

Also in this section, the FCC tries to make a case concerning the cost of mobile devices if the D Block is not auctioned to a commercial network operator or green field company. Its contention is that the device costs will be higher because there will not be enough demand to reach quantities necessary to provide devices at reasonable pricing levels. On the surface this may appear to be true, but the fact is that many public safety devices will necessarily differ from commercial devices in a variety of ways. They must be hardened products with bright screens that can be viewed in bright sunlight, they must have greater battery capacity, and they must be built for single-handed use (public safety personnel cannot be required to make use of devices that require the use of both of their hands while involved in an incident). By their very nature, they will cost more to build than typical commercial devices. Enabling these devices to work on the lower portion of the 700 MHz band (on AT&T and Verizon's spectrum) will

[2] Channelized Communications http://andrewseybold.com/1456-channellized-communications

[3] Appendix of FCC white paper on Capacity: "In this Appendix, we analyze public safety use of broadband wireless communications employing a network built in accordance with the FCC Cost Model in 10 megahertz of spectrum in four scenarios depicting various types of emergencies. For each scenario, we calculate the expected value of utilization[3] of the network.[3] We assume for purposes of this analysis an LTE network whose capacity averaged over each sector[3] is 7.5 Mb/s (downlink) and 3.25 Mb/s (uplink). These figures represent average throughput and are in-line with current industry benchmarks"

drive the costs even higher. The D Block devices will cost more, but they will cost more than commercial LTE devices as well.

One thing the FCC did not consider in its argument for cost savings is that if the D Block is auctioned and all of the commercial devices built for the D Block licensee are capable of operating on the public safety spectrum, the odds of hackers making their way onto the public safety spectrum and disrupting mission-critical communications are increased dramatically. However, if the devices are built to support the lower bands on the commercial networks and a combined D Block and public safety band for public safety, the commercial devices deployed on the upper and lower 700 MHz commercial spectrum will not be capable of operating in the public safety spectrum, thus reducing the chance of intentional hacking by those interested in proving they are smart enough, or the criminal element who want to disrupt public safety's ability to communicate during an incident or a terror attack.

In Section II, A. Network Capacity Drivers, the FCC attempts to explain that merely increasing the amount of spectrum available does not necessarily mean an increase in capacity. However, here, as elsewhere in its white paper, the FCC seems to be saying that it does not believe public safety will build out its broadband networks to commercial standards and that public safety is only asking for more spectrum in order to be able to construct networks that have fewer cell sites. Therefore, the additional spectrum is needed for added capacity.

This is the formula used by the FCC:

$$\text{Total capacity} = \frac{(\text{\# of sites}) * (\text{\# of sectors per site}) * (\text{Capacity/MHz}) * (\text{\# of MHz of spectrum})}{\text{Frequency Reuse Factor}}$$

The problem with this formula is that it is based on the total number of sites in a system. As discussed above, we need to be looking at the total amount of available bandwidth on a sector-by-sector basis and not based on a total number of cell sites. If we change the formula to reflect the capacity of a single cell sector, we are left with only two numbers:

1) A cell sector with 10 MHz of spectrum available (5 X 5 MHz) has an average throughput capacity of 7.5 Mbps
2) A cell sector with 20 MHz of spectrum available (10 X 10 MHz) has an average throughput capacity of 15+ Mbps

When planning a public safety broadband system, or for that matter a commercial LTE network, these are the only numbers that have any relevance on a day-to-day basis. During a major disaster that covers a large geographic area, there will be more total system capacity. However, toward the epicenter of the incident, we are back to having to contend with the amount of bandwidth available in each cell sector.

According to the FCC, commercial networks are built out using a high density of cell sites, and this is a true statement. However, the FCC does not mention that when commercial operators calculate cell sector capacity, they build in "headroom," or more precisely, they do not plan on a cell sector being full during normal operation. This type of design allows other customers to come into a cell and not be denied service. Thus in reality, the total bandwidth available for load planning purposes is less than the maximum available bandwidth in each cell sector. The calculations are made by determining projected cell sector loading during times known as "busy hours," or the times when demand for service is highest.

Unlike voice networks where there are specific demand peaks before and after work hours, for example, peak data demand occurs more often during each day.

We do not yet know what the design criteria will be for LTE, but we can look at a DSL build-out to understand the relationships of the numbers. With DSL, the network is designed with a standard ratio of 20:1, which means 3 Mbps of data access is available for twenty subscribers. But for the twenty customers, the network is built for an average of 1 Mbps, which assumes that not all 20 subscribers will be using the network at once. This ratio is different for wireless and may in fact be based on 30, 40 or even 50:1. This is important to know because an incident within a given cell sector will break that model due to the high number of users requesting service at one time. If we use these figures and revisit the numbers the FCC provides in the white paper appendix, we find that the system capacity is vastly different from the capacity numbers shown by the FCC. If we push the capacity per cell sector up to 75% utilization, we end up with a total sector capacity of 5.63 Mbps for a 10 MHz system and 11.25 Mbps for a 20 MHz system. These numbers could be lower and have a huge impact on the total bandwidth available during an incident. Adding another 10 MHz of spectrum will provide public safety with more capacity on a sector-by-sector basis. Again, running the calculations in the FCC's white paper appendix using these numbers produces a very different view of the available cell sector capacity.

Typical commercial networks are built out over time and more cell sites continue to be added where there is increased demand for service for a number of years after the initial construction. Demand for commercial capacity can also be planned for. For example, all of the network operators in New York City have more cell sites located near Times Square than in a comparable area in other parts of the city. This is because of the high volume of customers around Times Square and because they know that before and after Broadway shows or other events, network capacity must be increased in these areas to handle the potential demand for services. Even with all of this planning, it is possible to run out of available spectrum. Recently, AT&T announced it would be deploying Wi-Fi access in the Times Square area to help off-load some of the demand for broadband data services over its network.[4]

When designing a public safety broadband network, it is possible to review crime patterns and plan for areas where more capacity will probably be needed, but you cannot plan for incidents that may occur in areas that are not normally affected by high crime rates. For example, in October of 2006, a private plane crashed into a 50-story apartment building on the Upper East Side of Manhattan[5] where crime rates are not normally high, and in 2009 a US Airways plane landed in the Hudson River[6] where one would not normally think a lot of capacity would be needed.

In both of these incidents, all of the commercial networks were quickly jammed beyond capacity as on-lookers, survivors, and the media descended on the areas. The public safety voice channels were also overloaded, and in both instances there needed to be coordination between multiple agencies including several federal agencies. While airplane crashes are, thankfully, few and far between, these are only two examples of incidents that can and do take place in portions of metro areas where you would not build out as many cell sites as you would in Times Square. In both of these cases, public safety would have eaten through its bandwidth capabilities quickly, but having the additional 10 MHz of spectrum from the D Block would have made a huge difference in the total on-scene capabilities of the various agencies that responded.

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[4] http://www.computerworld.com/s/article/9177327/AT_T_adds_Wi_Fi_hot_zone_to_relieve_Times_Square_congestion_

[5] http://www.independent.co.uk/news/world/americas/plane-crashes-into-new-york-apartment-block-419676.html

[6] http://www.cnn.com/2009/US/01/15/new.york.plane.crash/

Designing and building broadband networks is not something where a network is built once and never expanded. However, commercial network operators have a distinct advantage because they pre-plan their network architecture to concentrate more capacity in known areas of congestion. If there is a pre-planned event such as a World Series, Super Bowl, or some other large event, cells on wheels can be pre-installed. In the case of public safety systems, the incident types and locations are not as predictable, so it is imperative that each cell sector be deployed with the maximum possible capacity.

Further on in this section of the white paper, the FCC states:

"Another way to increase capacity is to provide supplemental infrastructure to expand available capacity. There are unique strategies for increasing capacity within buildings, where a substantial amount of cellular network traffic originates. Additional infrastructure, such as distributed antenna systems (DAS) and pico cells, can be installed inside buildings to improve coverage and offload traffic from external cell towers. These approaches decrease strains on the available cell site infrastructure. The NBP recommends that building codes be changed or enacted to enable greater use of these technologies and that FCC rules be developed that enable and facilitate their use. Further, additional outreach by the federal, state and local governments to building and facility owners can assist in ensuring that this technology is widely pervasive as 4G networks are deployed.

Capacity can be further expanded by utilizing deployable communications systems, such as next generation cell sites on wheels (a.k.a. "COWs" or "COLTs"[7]) and vehicular relays, as is frequently done with today's wireless technologies during disasters and major incidents or events. The NBP recommends deployment of these technologies for public safety broadband use, through a program that would help fund caches of equipment throughout the country that can be rapidly deployed to the site of any major disaster."

I do not believe that the FCC or the federal government has the authority to require changes to local ordinances that would require homeowners, apartment building owners, and office building owners to install distributed antenna systems and picocells (or femtocells). Further, there is a problem with the FCC's logic in this recommendation. Picocells or femtocells would, in fact, increase the broadband capacity inside a given building, but the data would have to be carried over the building's Internet connection back to the main public safety network center where it would have to be integrated with the main broadband network. If the building picocell or femtocell is using DSL or cable bandwidth (or even a T1 line) for backhaul, the effective capacity increase is limited to the capacity of the backhaul. For example, Starbucks offers free Wi-Fi services that it advertises as 802.11G or up to 56 Mbps. However, since it uses a T1 line for backhaul, the maximum bandwidth available within any Starbucks is the capacity of the T1 line (1.54 Mbps). Moreover, the Internet is NOT a mission-critical network.

The public safety community has been hampered by a lack of inbuilding coverage on its land mobile radio channel systems and for years has been struggling with the issue of inbuilding systems. The public safety community has no authority to require inbuilding coverage and building owners strongly lobby against these costly requirements. The FCC believes that these devices will contribute to the overall capacity of the networks, but did not calculate the cost of their deployment or the ongoing costs of the backhaul required to add them to the network. Therefore it is unrealistic on the part of the FCC to include these devices in its calculations of capacity availability for public safety broadband.

[7] "COW" and "COLT" are common industry terms for Cell On Wheels and Cell On Light Truck.

The most glaring of issues here is that distributed antenna systems (DAS) do not increase capacity, they merely make it available inside buildings that are not covered by external cell sites. The reason distributed antenna systems do not increase capacity is that they require a donor cell. They communicate with an external cell sector, making use of that cell sector's capacity and amplifying the signals inside a building. The use of distributed antenna systems will increase data coverage but will do nothing to increase the amount of data capacity available at an incident.

The idea of using deployable communications systems was discussed earlier in this paper, and their applicability would depend on where they are stored, who maintains them, and how long it takes to transport them to an incident. Further, these deployables will require backhaul to the main network, and with LTE networks, they must be interfaced with the network so they can become part of the system. All of this is time consuming and assumes that backhaul data transport is available for this purpose at every scene where deployables might be important in helping with capacity constraints.

Next up is the FCC's recommendation that the public safety community should rely on other transmission technologies such as wireline and fixed wireless technologies for video, which will "*enable public safety to preserve its 700 MHz capacity for mobile broadband communications.*" This recommendation is based on a belief that all video needed at an incident can be delivered by using fixed cameras that are already in place, and that public safety has access to these video feeds. They may have access in some cases, but it is not only the dispatcher who needs to view the camera feed in question, the field incident commander and others at the incident need to view the video as well. The feed from the wired camera will need to be sent over the 700 MHz broadband network if it is to be of value to those at the scene. We also know that many of the video cameras will need to be deployed by personnel at the incident. The only way to transmit this data to others in the field plus the command center will be via the 700 MHz broadband network.

Some of these video feeds will require higher resolution than others. In the case of the sniper on the roof watching a hostage situation unfold through a window, a higher resolution color video stream will be needed. When monitoring congestion on a freeway, a black and white camera with less resolution will suffice. The only way public safety can make use of aerial cameras today is by working with the news media when available. If this video is available, it is high resolution and would need to be rebroadcast over the broadband network to deliver it to those at the incident. It should be noted that the use of cameras in helicopters and airplanes is prohibited by the FCC in both the 700 MHz band and the local-area 4.9 GHz band presently assigned to public safety.

Today's broadband network helicopters transmit video that is of the quality needed by fire and other personnel during these times but 256 Mbps data is not adequate to handle these requirements. Public safety realizes that it will need to manage its bandwidth, but this type of bandwidth management will be much easier on its own network with its own controls. Using a combination of dedicated and commercial shared spectrum at an incident will require expertise and will be a time-consuming process. It would be far better if public safety had to share spectrum only in rare instances rather than on a daily basis, which will be the case with an allocation of only 10 MHz of bandwidth.

Last in this section is the FCC's discussion about how much bandwidth is enough bandwidth. Once again, it missed the point. In the FCC's estimation, there will be times when 10, 20, or even 30 MHz of spectrum will not be enough to meet the demand of the public safety community. This is a true and correct statement. In cases where it does not have sufficient bandwidth available, public safety will be forced to roam onto commercial networks. The question here is if this will occur daily, monthly, or occasionally. The FCC maintains that this need for roaming onto commercial networks will be on an occasional basis, but that assessment is based on bandwidth utilization that considers the total amount of bandwidth available within a system. In fact, the need for more spectrum will arise much more often than our analysis of cell sector capacity shows (see above). The FCC also states that "*Guaranteeing access to these networks will enable the public safety community to have access to substantially more capacity than a dedicated network can provide without vastly more dedicated spectrum than is under consideration. Roaming with priority access will also provide increased reliability and resiliency, especially if any roaming partner utilizes different cell tower sites for all or some of its network."* Yet neither the priority rules nor the type of pre-emption have been discussed with the commercial network operators. The FCC seems comfortable that priority access as defined in the LTE specification will be sufficient. However, this view is based on systems that have not yet been implemented, and using pre-emption that could force public safety to wait in line for access to the bandwidth in a given cell sector, pushing commercial customers to lower speeds but not kicking them off of the network in real time. This means that only a portion of the commercial network operators' spectrum will be available (to be determined by the network operator). Commercial operators will not want to have to explain to their higher paying customers why they could not access their broadband services.

The greatest point of disagreement between the FCC's report and our findings is that the FCC is considering total system bandwidth and we are more concerned about sector bandwidth. At my recent meeting with the FCC's Public Safety and Homeland Security Bureau's technology experts, there were two statements that really brought home to me their lack of understanding when it comes to the needs of the public safety community. The first FCC assumption was that the public safety community wants to model its broadband network after its existing voice networks with fewer high sites and therefore needs the additional spectrum. The other was that during an incident, if a command vehicle was not ideally located it might have to be relocated so it would be covered by a different cell sector with more capacity available. I can just imagine the instructions to the incident commander: "Move the command vehicle one-half mile further from the incident so we can get our video feed." Somehow I don't think this is going to happen. It is the same thing as telling a police officer involved in a shoot-out that he will have to move 20 feet to be able to call for help—and 20 feet from his position behind his car would put him directly in the line of fire. Good luck!

The FCC's final point in this section really tells the whole story about its white paper on capacity. It states, "*As long as sound network management is adhered to, including the provision of adequate funding to construct sufficient cell sites in the network area, the deployment of cutting-edge technology in each cell site, and the use of supplemental tools to increase capacity, network capacity for public safety communications will be significant in 10 megahertz of dedicated capacity."* Any time a statement starts out with "as long as" and then adds conditions on top of conditions, you can be assured that it won't end up being reality. And please note that the FCC used the word *significant* and not "sufficient" in this statement. Not only is the FCC hedging its bets and providing a report after the National Broadband Report was issued, it is carefully making sure that the wording is such that when it is proven wrong, it will be able to hide behind statements such as this one. But by then the damage will have been done.

Section II: B. Public Safety Communications Today

This section starts off with the following statement:

"Unless we are able to get past the mindset that network capacity is synonymous with spectrum, it would be natural to expect that the capacity from this 10 megahertz Block at 700 MHz will be comparable to what public safety has experienced in the past. This is not the case. The public safety LMR networks in use today consume a large amount of spectrum per user. This occurs in part because of legacy network design and technical considerations: public safety networks utilize radio systems with a relatively small number of high site towers and very sensitive radios. This technology and design greatly increases the amount of spectrum needed per user when compared to cellular architectures, which are used for today's commercial communications networks. Further, unlike cellular commercial systems, public safety communications have generally been locally operated, which necessarily results in spectrally inefficient overlapping, independent networks. The NBP recommends that the public safety broadband network utilize a cellular architecture with LTE technology and be deployed in a coherent manner throughout larger non-overlapping geographies. This should result in dramatic increases in spectrum and cost efficiencies, while handling heavier traffic demands than currently exist."

This entire statement, once again, shows the lack of understanding of the real world of public safety communications. Even the proposed public safety broadband network will be comprised of a number of local, metro, regional, and statewide systems. The FCC founded ERIC to assist in making sure that all of these networks are built to the same standards and will interface with each other. It is difficult to understand why the FCC believes that communications networks for public safety, which serve local jurisdictions first, and then coordinate with adjacent jurisdictions, regions, states, and then on a national level, should not be locally operated. There is a significant difference between the types of jurisdictional controls that are needed by local law enforcement, fire, and EMS and the construction of a network or combination of networks.

It is important to decouple the concept of a nationwide broadband interoperable network with the daily needs of local communities. The concept to which the FCC appears to be subscribing seems to suggest that there should be a single 911 answering point located in DC and that all dispatches be made from that center to the entire nation on an area-by-area basis. This, of course, is not a practical solution. What is really needed is to provide for local management of the communications resources of the broadband network with the ability to expand that interface of the local network to regional, state, and even nationwide interoperability on a when-needed basis. Local jurisdictions know more about their own requirements than someone sitting 200 or 2,000 miles away from the agency.

It is also clear from the following statement in this section that the FCC considers broadband systems fully capable of meeting all of the public safety community's voice requirements:

"For example, a recent study of public safety communications in the greater Los Angeles area showed that a shift from today's LMR technology to even a pre-LTE cellular technology could increase capacity per megahertz by a factor of 16. In other words, the study demonstrated that 10 megahertz of capacity on a cellular network would be the equivalent of 160 megahertz on an LMR-type network."

It is interesting that this cited example just happens to come from a paper written by one of the authors of the FCC white paper on capacity.[8] Further, it really underscores the fact that those within the Public Safety Bureau of the FCC, and the commissioners, do not understand the different types of voice

[8] J.M. Peha, "How America's Fragmented Approach to Public Safety Wastes Money and Spectrum," *Telecommunications Policy,* Vol. 31, No. 10-11, 2007, p. 605-618.

communications that are a requirement of the public safety community and not simply a "nice to have" set of capabilities.[9]

There is no doubt that for data services, broadband is more spectrally efficient than channelized communications. However, the FCC failed to point out that many broadband systems do NOT offer voice services. In the CDMA world, Verizon and Sprint, among others, have dedicated data channels for broadband and voice is still run on their 2G networks. Further, in the GSM world, most of the voice traffic is still run over 2G networks and not over the 3G networks, which are primarily reserved for data services. VoIP is, today, less spectrally efficient than 2G commercial voice services or channelized land mobile radio systems.

A blanket statement that more voice calls can fit into less spectrum over broadband is not correct today and will not be correct for the foreseeable future. Further, in order to reach the data speeds required for broadband services, you need far more spectrum than for voice calls. Add to this the fact that today's broadband services and those being planned for tomorrow cannot provide communications when the devices are not within cell coverage, whereas land mobile radio systems do have that capability, and it very quickly becomes clear that the issues indentified in the paper and cited in the FCC report are mixing apples and oranges in order to prove a point that is not based on the realities faced by either the public safety or the commercial wireless community.

The statement by the FCC in this document that says*, "It would be a mistake to design a network based upon the public safety's past experience in using spectrum. Public safety agencies do not have significant incentives to use spectrum efficiently, because, unlike commercial entities, public safety agencies in America do not pay for spectrum"*[10] is confusing at best since the public safety community has already accepted the FCC's recommendation that the entire nationwide system should include 44,000 cell sites. It has never been contemplated by any public safety organization that public safety follow the land mobile radio model. It should be pointed out, once again, that the issue of capacity and capabilities should not be based on the number of cell sites across the nation, but needs to be calculated on a cell sector basis. None of the public safety entities that have been granted waivers by the FCC are planning to skimp on construction of their networks. A review of these proposed networks will show that they are being designed in accordance with standard commercial practices, and take into account the cellular nature of systems used for wireless broadband services. The assumption that the public safety community is attempting to build systems with fewer sites and therefore needs the additional 10 MHz of spectrum is a faulty assumption on the FCC's part.

The issue of how much spectrum is currently available to public safety is overstated by the FCC in some places in this report and stated correctly in others. In one part of the report, the FCC contends that public safety has access to 60 MHz of broadband-capable spectrum at present, but it is counting the 50 MHz of licensed spectrum in the 4.9 GHz range that is totally unsuited for wide-area data services. In yet another part of the report, it states that the public safety community currently has access to only 23 MHz of spectrum for all of its voice services. Not included is the additional information that this spectrum has been assigned over a 60-year period of time, and in many different frequency bands, which is the root cause of the interoperability issue public safety is facing today. Nor does the FCC acknowledge that this 23 MHz of spectrum is not contiguous, which means that today public safety's voice channels are intermingled with those of other land mobile radio users. It also means that even if

[9] http://andrewseybold.com/1456-channellized-communications
[10] Page 8 of the FCC white paper

the spectrum was contiguous, there is not enough of it available in any one band for it to be converted to broadband usage.

It appears that this FCC is determined to repeat the past by providing too little spectrum in one band while stating its willingness to "find" additional spectrum in a different frequency band if needed in the future. Our contention is that public safety has proven, with hard data, that 10 MHz of broadband spectrum (5 X 5) is not sufficient today and it certainly won't meet the needs of the public safety community in the future. If the D Block is not reallocated to public safety, more spectrum will be needed very soon. If that spectrum is located in another band, the public safety community will have to spend even more money adding that spectrum to its broadband network. There will be yet another round of new equipment and new cell site costs, and mobile and handheld devices used on the public safety broadband network will have to be discarded and replaced with new equipment at even higher costs. It makes little sense to build a network and then have to build an additional network that will only perpetuate the FCC administration's earlier mistakes.

Today there is an opportunity to provide additional bandwidth for public safety that is adjacent to its existing 10 MHz of broadband spectrum, the deployment of which would add little to the network and device costs. The D Block, which the FCC has recommended be auctioned to one or more commercial broadband operator, is adjacent to the existing public safety broadband spectrum and this spectrum is needed in order to ensure that public safety, for the first time, has sufficient contiguous spectrum to build a common, nationwide, interoperable broadband network.

Section III: How the Plan Meets Public Safety Capability Needs; Capability Back-Stop

In this section, the FCC continues to try to prove that there is enough capacity within the 10 MHz of previously allocated public safety broadband spectrum. Early in the section, it states that commercial providers will serve 2.7 times the number of users per megahertz than public safety. Here again, the FCC appears to be using numbers for public safety personnel that are too low. It does not acknowledge that during a major incident there are times when off-duty personnel are called back for the incident, nor does it discuss the fact that public safety incidents are usually within confined areas where the number of cell sectors available could be limited to one or two. It does not address the issue of blocked calls or lower data rates that are the result of overloading on the commercial networks that cannot be tolerated in the public safety environment. It should be noted that most of the commercial operators have discontinued their all-you-can-eat data plans in order to help manage their networks more efficiently because, especially in major metropolitan areas, they are experiencing cell sector capacity limitations.

In a footnote to this white paper,[11] the FCC describes how public safety networks are designed for worst-case usage and most of the time they are underutilized. We disagree with this assessment. In

11 For example, as was observed based on usage data from Denver's public safety communications systems, "[m]odern public safety wireless communications systems are generally designed for the worst-case scenario: a large-scale event which requires communication between large numbers of first responders, potentially from diverse agencies. . . . Most of the time, these systems operate at the low end of their designed-for capacity." Joshua Marsh, "Secondary Markets in Non-Federal Public Safety Spectrum," Telecommunications Policy Research Conference (2004). In addition, at its peak, the Minneapolis system handled over two times the number of calls during the I-35W bridge collapse that it would typically expect. During the busy-hour of September 17, 2008, the Harris County Regional Radio System handled almost twice as many PTTs than it would handle on a typical day. See Federal Communications Commission, Emergency Communications during the Minneapolis Bridge Disaster: A Technical Case Study of the Federal Communications Commission's Public Safety and Homeland Security Bureau's Communications Systems Analysis Division at 16-17 (2008) (Minneapolis Bridge Case Study), available at http://www.fcc.gov/pshs/docs/clearinghouse/references/minneapolis-bridge-report.pdf; see also Federal Communications

times of major incidents, the existing voice networks are called upon to operate beyond the capacity they were designed to handle and on Friday and Saturday nights as well as holidays, these networks are already overloaded and dispatch and response delays occur on a regular basis. Long ago, the FCC established guidelines for voice traffic loading on public safety networks.[12] In order to qualify for additional voice spectrum, if any is available, the criteria established by the FCC says that on a single conventional voice channel, the proper public safety loading should be 70 units, and when using trunked radio systems, that loading can be increased to 90 units. Most dispatch systems in the United States have exceeded these loading numbers because voice spectrum is in such short supply. Having broadband capabilities in addition to existing voice networks will reduce some of the overcrowding being experienced on the voice channels, but if there is not enough bandwidth available for day-to-day operations, public safety will experience the same type of overcrowding on its broadband network as it does on its voice networks.

It should be noted that the federal government agencies that are considered to be part of the public safety community include the Secret Service, FBI, and others, and that all of these have networks that are designed along the lines of today's public safety networks. It also should be pointed out that much of this spectrum is lightly used during normal operations but must be available at a moment's notice when needed. When looking at broadband services for all public safety agencies, especially a new broadband network that is intended to serve both day-to-day operations and interoperability requirements, the FCC does not take into account that many types of new applications and services will be developed to take advantage of this network. One example, which will keep police officers on the streets for more hours per shift, will be the ability to complete reports and file them from the field as opposed to the officer making notes with a pen and paper and then having to return to the office to transfer this information into a computer system. It is our contention that just as the iPhone and other smartphones have driven wireless broadband usage up by 5000% over the last two years,[13] the amount of data over public safety networks will also grow substantially as new applications are introduced and as broadband devices are extended from within the vehicles, as they are today, to being worn on the person.

Section III: B. Possible Future Capacity Expansions

The next section of the FCC white paper concerns LTE support of priority access and priority access on different levels. It also states "*Such prioritization schemes have been used successfully in military systems.*" What the FCC fails to disclose in this statement is that many of the military systems use pre-emptive priority—a system where those with high priority can have access to the network immediately and not have to wait for existing users to complete their traffic or to join a network and be assigned only a portion of the bandwidth. Until there are LTE services in commercial operation and agreements with commercial operators are in place, there is no guarantee that the type of priority access envisioned by the FCC will, in fact, be available. Further, as stated before, the FCC is of the belief that the need to employ commercial networks' spectrum on a priority basis will arise only "occasionally" while our findings show that based on cell sector capacity studies, the need to use commercial network spectrum will arise on a daily basis in most metropolitan areas. No matter how many cell sites are developed for

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Commission, Emergency Communications During Hurricane Ike: Harris County Regional Radio System: A Technical Case Study by the Federal Communications Commission's Public Safety and Homeland Security Bureau's Communications Systems Analysis Division at 12-13 (2009) (Hurricane Ike Case Study), available at http://www.fcc.gov/pshs/docs/clearinghouse/case-studies/Hurricane-Ike-Harris%20County-120109.pdf.

12 FCC Rules Part 90.269

13 http://blogs.broughturner.com/2010/02/overestimating-mobile-data-growth.html

the public safety system, or the overall capacity of a metro-wide network, the capacity per cell sector is the most important criteria for determining the amount of spectrum required.

The FCC's final point in this section is that "*LTE is in the early stage of technology deployment, and it will continue to progress,"* which is a true statement that should have been qualified with, "However, it will progress based on the stated needs of the commercial network operators that are concerned about issues that affect their own network performance." The FCC also states "*Commercial operators are constantly upgrading their network capabilities to take advantage of greater spectrum and operational efficiencies*." Yet in my discussions with the technologists within the Public Safety and Homeland Security Bureau, these people appear to believe that the public safety network will be built once and not enhanced, and that the number of cell sites will not be increased over time and as demand dictates. This is not a safe assumption, and since the FCC seems to believe that going forward, commercial broadband networks are the model for the public safety broadband network, then the same criteria should apply.

Section III: C. Efficient Use of Public Safety Spectrum

In this section of the white paper, the FCC focuses on the importance of spectrum management and contends that ERIC (the Emergency Response Interoperability Center) will be in a position to help public safety prioritize applications over this network. Again, it includes the roaming portion of its plan to demonstrate the role ERIC can play. However, public safety normally operates on a local basis and each community's needs, and their choice of applications and devices, will be different. The use of this network will be primarily on a local level, thus macro-management from ERIC will not be possible. ERIC's job, as I understand it, is much more confined to the task of making sure that all local, regional, and state networks can interconnect with each other and that devices used in one jurisdiction will work across the entire network when needed. Once again, the FCC seems to believe that federal oversight is all that will be needed to ensure sound network management.

Section III: D. The Role of Video and Future Bandwidth Intensive Applications

I have commented in depth on the differences between what the FCC believes is adequate for video data rates and what will be needed in the real world. Here again, the FCC's attitude is that no matter how much spectrum is available, it will never be enough for all of the video being contemplated for use by public safety. This is an accurate statement, but it does not address the issue of how much video can be employed using 10 MHz of spectrum in a given cell sector versus how much can be employed in the same size cell sector using 20 MHz of spectrum. The answer is more than double. And data rates will be higher in more portions of the cell sector with twice the amount of spectrum.

Public safety today operates in a mode where visual representation of an incident is provided by those on the scene through the use of voice communications. It is envisioned that this will change dramatically when broadband technologies become available. The use of video will add an entirely new dimension to public safety's ability to respond to incidents and to contain incidents that could escalate quickly. Yes, video will have to be managed, and the FCC believes that much of the video should be apart from the wireless broadband network, using wireline and other forms of transporting the video from a camera back to the dispatch center. But delivering video to the dispatch center is only half of the requirement. Once it is received at dispatch, it becomes much more valuable if it is transmitted to those in the field. Likewise, setting up cameras at an incident will provide all who are involved in the incident with the ability to see as well as hear what is happening. Both the dispatch center and incident command personnel will be able to make better, faster decisions about the best course of action. Giving public safety new tools to work with is important, but giving them new tools without the spectrum to use them is not an acceptable solution.

The FCC continues by saying that video resolutions that require 1.2 Mbps are not realistic and therefore should not be used, citing the cost of the network as a basis for this argument and pointing out that in order to support video of this resolution or higher, 2.85 times the number of cell sites would be needed. This statement does not include any data points and is simply presented as a statement of fact. The new FCC management has stressed from the first day of its term that the FCC would be a data driven organization, but in this part of the white paper as well as many others, statements are presented with no supporting data provided.

In reality, high-resolution video will sometimes be required. In the example used previously where a SWAT team sniper is on a rooftop watching a hostage situation unfold through a window, he has a high-resolution scope mounted on his rifle. If the sniper had a camera with high-resolution, it could provide a valuable video feed to the incident commander and others at the scene, and they could better plan their approach to the incident and perhaps save lives in the process. Video bandwidth has been and will continue to be an issue when it comes to how much is needed. However, there will be times when video will be required and if the incident commander deems it necessary for a specific incident, the capacity to provide it must be available.

Section 3: E. The Effect of Interference

This section deals with the issues of adjacent cell interference. The FCC claims that LTE will be more immune from adjacent cell interference than existing LMR systems, and that LTE can be better managed to mitigate next-cell interference issues. This is partially true. LTE handles adjacent cell frequency reuse in a number of ways. However, in a 10 MHz system, each cell will use exactly the same frequency, so minimizing interference through frequency reuse above 1-1 is not possible. This leaves LTE's inherent ability to provide soft frequency reuse. With this method of reuse, the system adjusts the power allocated to certain cell sectors to mitigate intra-cell interference. This is an efficient method of managing cell-to-cell interference, but it means that when there is interference, the amount of power (capacity) at the cell edge is diminished.[14]

During the discussion of the D Block and the public safety spectrum (which are adjacent), the FCC white paper, once again, contradicts itself. On the one hand, the paper claims that no guard band will be needed between the D Block and the public safety spectrum, while in another portion of the paper the FCC states that this is true as long at the two systems do not share the same tower sites.

As mentioned previously, in one of the footnotes to this section, the FCC compares and contrasts interference between LMR radio systems and LTE cell site systems. Since public safety is not planning to build its LTE network based on LMR standards, but rather on the cell standards that are being used in the commercial network world, this comparison is meaningless.[15] The FCC has built much if its case on

[14] http://www.mpirical.com/lms/file.php/1/LTE-Planning-Principles-Part-II.pdf

[15] One important reason that adjacent channel interference can more easily become harmful to LMR systems is that LMR systems are noise limited, meaning that radios must operate well even when they receive very weak signal levels. In contrast to LMR networks, commercial cellular networks are designed to operate despite significant interference. Accordingly, LMR-based networks are inherently more vulnerable to interference, including adjacent-channel interference, than commercial networks. The problem is compounded by differences in the number of cell sites deployed in a given region. The site density of commercial wireless networks is typically much higher than that of public safety LMR networks, as discussed infra. Thus, it is

its belief that the public safety community plans to force fit LTE broadband systems into its existing land mobile radio system designs even though the public safety community has continued to agree with the FCC that the entire system should be comprised of 44,000 cell sites. The FCC has been informed many times that this not correct, yet it continues to include this assumption in its documents to prop up its recommendations to Congress. Once again it must be made clear to the FCC that there is not and never has been such a plan.

Section III: Cost as a Driver for Network Capability

[Editor's Note: This section carries the same number as the previous section]

The main thrust of this section is explained in the first paragraph of the FCC white paper that states in part, "*If public safety uses commercial-scale components in its devices, they will benefit from commercial economies of scale. This is achieved in part by requiring the D Block licensee, and perhaps other 700 MHz licensees, to offer some devices that are also capable of operating in the public safety band. However, if there is no D Block commercial operator, then there will be no ecosystem of D Block commercial devices*." This statement indicates that the FCC does not believe vendors will step up to building chips and infrastructure for the public safety spectrum unless the D Block is auctioned to a commercial network operator, and that if the D Block is allocated to public safety, as it should be, then all of the devices will cost more and there will be little or no incentive for vendors to build these devices.

I have spent a lot of time over the past year addressing this issue, as have others. As of today, there are several chip-level vendors that have already undertaken the task of building chipsets for both the D Block and the public safety broadband network, and others are interested. The device may, in fact, be somewhat more expensive than commercial devices, but as I have stated elsewhere in this report, devices required for many within the public safety community will cost more due to their inherent design requirements: They must be resistant to water and shock, and ruggedized to withstand other typical usage conditions. My conversations with the chip-level vendors indicate that these devices can become available in a number of ways. First, several vendors have said they will build the chipsets and sell them at near commercial pricing if they receive non-recurring engineering funds in the $3-8 million range. This is a onetime expense that can be funded by monies set aside by Congress for these systems, if such funding is forthcoming.

Second, the chip vendors will build chips for this combination of bands and sell them to device vendors at a premium of between $10 and $20 each over commercial chip pricing. In the overall scheme of things, it is far better to have to pay a little extra for these devices than it would be to have to build a second generation of devices with broadband capabilities on multiple bands (the FCC has said if more spectrum is required it will "find it" in another portion of the spectrum). The public safety community does not accept that its special-purpose devices will be made available at the same prices that are paid for smartphones on commercial networks, especially smartphones that are subsidized by multi-year

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common for an LMR public safety radio to be far from an LMR cell site, receiving a weak signal that is close to the noise floor and close to a commercial cell site that is transmitting in adjacent spectrum. In this case, interference in the public safety spectrum allocation may be raised in the area directly around the commercial cell site, due to a) the presence of high levels of radiated power in out-of-band emissions; and/or b) intermodulation products that fall within the public safety channel; and/or c) in-band emissions that are too strong to be adequately filtered out by the public safety receiver. Thus, a commercial site using adjacent spectrum can create a coverage hole for LMR radios. This is called a "near-far" interference scenario. The larger the difference in site density between the commercial network and the adjacent public safety network, the greater the probability that this form of harmful interference will occur.

contracts. Our research shows that a wide variety of devices can and will be made available to the public safety sector for pricing in the $500 to $600 range.

The FCC states in this white paper that "*Although not required, NBP deployment costs were calculated using this approach, and the savings were considerable when compared to a stand-alone network dedicated to public safety and does not leverage commercial infrastructure,*" and in the paragraph above this is another statement "*If public safety uses commercial-scale components in its devices, they will benefit from commercial economies of scale. This is achieved in part by requiring the D Block licensee, and perhaps other 700 MHz licensees, to offer some devices that are also capable of operating in the public safety band.*" So on one hand, the FCC white paper is based on device and network pricing that coincides with that of a commercial operator on the D Block. On the other hand, it admits that currently there are no such requirements in the National Broadband Report. Within the same section, the FCC appears to be saying that it will require this type of device cost sharing even by network operators that have already paid for their spectrum and on a different portion of the 700 MHz spectrum.

This raises the issue of the cost differential between a commercial D Block operator and operators that have spectrum in the lower portion of the band. The cost of building a device that provides for operation in the A, B, and/or C Blocks as well as the public safety band will be lower (because of volume) than a device built for use in only the D Block and public safety band. It is hard to imagine that the FCC could mandate what would amount to a price advantage for one network operator over others competing for the same business.

This FCC white paper makes many references to incentive-based partnerships and the cost savings they will offer. However, nowhere in the National Broadband Plan nor this white paper does the FCC say it will require these partnerships, or what type of incentives would be included. The FCC has little if any incentives it can offer commercial network operators without the concurrence of or at the direction of Congress. As far as I am aware, the FCC has not had meetings with commercial network operators to discuss these incentive programs. If and when it does, the results will be very different if the public safety community will be roaming on the commercial networks on a daily basis as opposed to an "occasional" basis as the FCC contends will be the case. Once again, if you review the capacity capabilities of 10 MHz versus 20 MHz of spectrum given the same number of sites, and your calculations are based on cell sector capacity instead of systemwide capacity, the answer to this question will be very different.

Section IV: <u>Conclusion</u>

The Conclusion section of the white paper starts out with this paragraph: *"The NBP's recommendations for the deployment of a nationwide interoperable public safety broadband wireless network were developed over the course of almost a year of intense study, inquiry, analysis and meetings with and input from public safety leaders, communications engineers and industry experts. The result is a plan that will provide public safety with a nationwide, interoperable network that has the capacity for all day-to-day operations and with the innovation of public safety roaming and priority access across the 700 MHz cellular spectrum, surge capacity for emergencies, and even extraordinary contingencies."* And while I am sure this is true, I don't believe the FCC asked either the right questions or asked questions in such a way as to illicit answers that differed from its preconceived notions of what its recommendations should be. I find it difficult to understand how a bureau charged with overseeing Public Safety and Homeland Security communications has put itself at odds with the public safety community from the onset of this important project that should have been approached with a clean slate and open minds.

The FCC has placed too much faith in its own calculations of network capacity and has failed to review demand in terms of cell sector capacity, preferring instead to treat capacity as a networkwide issue. It is also relying on priority access and roaming over commercial networks when priority roaming over LTE is still only a part of the specification and has not been proven to work in the real world. The FCC's white paper is slanted toward its goal of protecting its recommendations to Congress in the National Broadband Report and misses the mark as a fair and complete assessment of the needs of the public safety community.

As stated, it is obvious to me that this white paper was written with the single goal of trying to shore up the FCC's position that the public safety community should be short-changed once again when it comes to the amount of spectrum it needs. In the appendix of this white paper, the FCC cites various large-scale emergency scenarios including one provided in the New York City White Paper on Capacity Usage. Interestingly enough, when discussing this scenario, the FCC discounts the resources those on the front line of these types of incidents call for in favor of its own interpretation of what will be needed. It also ignores the fact that building cell sites that are hardened and include back-up batteries and generators is a problem in a city where most of the cell sites in use are located on building rooftops where fire codes do not permit generators. Building a hardened network in major metro areas will require trade-offs in the number of cells that can be deployed and how many of these can be truly hardened and include back-up power and backhaul redundancy.

Finally, all of the FCC's calculators are based on multiple cell sectors covering a given area. This is not consistent with even the most robust of the existing commercial networks, thus the findings in the FCC white paper are suspect. For more than 60 years, the public safety community has been short-changed when it comes to spectrum allocations. Historically, the FCC has chosen not to commit the amount of spectrum needed by public safety. Now is the first opportunity for this wrong to be righted.

The FCC continues to equate the public safety land mobile radio systems to the new broadband system, but there are many differences between the two. First, over time, the land mobile radio spectrum that was added enabled the public safety community to separate its voice channels onto different parts of the spectrum. By doing so, it gave up the ability to interoperate but was able to use what meager spectrum resources it had been allocated for maximum benefit. For example, in the city and county in which I live, the fire departments for all of the cities and the county make use of the 150 MHz band, using radios capable of all of the channels in use throughout the county as well as channels that are used by Cal Fire and the Forestry Service. This provides a level of interoperability while accommodating as much voice capacity as possible. Meanwhile, the police and sheriff departments use channels in the 450 MHz band. They too have interoperability between the agencies, but in the event of a major incident, the fire and law enforcement agencies cannot effectively communicate with each other.

When implementing a common portion of the spectrum for broadband services, all of these agencies will be sharing the same spectrum and it will not be possible to isolate one from another. Network demand for broadband services will escalate and the result could be network blocking and dropped "calls," which simply cannot be tolerated during even daily incidents. It is imperative that this new network be designed and implemented so there is enough spectrum available for use during multiple daily incidents, and that this bandwidth be sufficient on a sector basis, not on an overall system basis.

The FCC white paper discussion about capacity is based on a view that public safety wants to build fewer cell sites, which is not a correct assumption since public safety has concurred with the FCC recommendation of 44,000 cell sites. It is also based on priority roaming on commercial networks that will only happen on an occasional basis and not on a daily basis as we believe. Then there is the premise that inbuilding network expansion will provide more capacity, which is not true when distributed antenna systems are used, and it is not within the purview of the FCC to mandate such expansion. Further, the cost of deployment was not included in the FCC's white paper on network costs. Finally, the FCC continues to believe that priority roaming over commercial networks will perform as advertised and will provide quick and easy access to commercial network spectrum—even though it has been proven that in times of emergency the demand loads on both the public safety and the commercial networks increase dramatically.

Our Recommendation

It is time for the FCC to revisit its recommendations for the allocation of the D Block that it presented to Congress. If the D Block is auctioned and the public safety community is short-changed once again, it will only be a few years before it will have to return to the FCC and Congress begging for additional spectrum. After more years of delay, perhaps the next FCC will find more spectrum for public safety, but it will be on yet another portion of the spectrum and cause needless increases in both network and device costs. The D Block is ideally suited to being combined with the public safety spectrum and the costs associated with building out 20 MHz of spectrum will be much less than building out two 10 MHz bands located in different portions of the spectrum.

Respectfully submitted,

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