A BROADBAND NETWORK COST MODEL:

A BASIS FOR PUBLIC FUNDING ESSENTIAL TO BRINGING NATIONWIDE INTEROPERABLE COMMUNICATIONS TO AMERICA'S FIRST RESPONDERS

OBI TECHNICAL PAPER NO. 2

FEDERAL COMMUNICATIONS COMMISSION | MAY 2010

EXECUTIVE SUMMARY

In March 2010, the FCC released its National Broadband Plan (NBP), which made significant recommendations for improving access to broadband communications across America and for enhancing the role of broadband in public safety and emergency response. In particular, the NBP proposed a comprehensive strategy for creating a nationwide interoperable public safety broadband wireless network ("public safety broadband network") for first responders and other public safety personnel. This strategy includes:

- ➤ Creating an administrative system that ensures access to sufficient capacity on a day-to-day and emergency basis;
- ➤ Ensuring there is a mechanism in place to promote interoperability and operability of the network; and
- ➤ Establishing a funding mechanism to ensure the network is deployed throughout the United States and has necessary coverage, resiliency and redundancy.

In this paper, the Omnibus Broadband Initiative (OBI) provides support for the NBP's public funding recommendations for the nationwide interoperable public safety broadband wireless network. This paper also explains how public safety agencies can leverage the deployment of 4G commercial wireless networks to greatly reduce the overall costs of constructing their nationwide broadband network.

INTRODUCTION

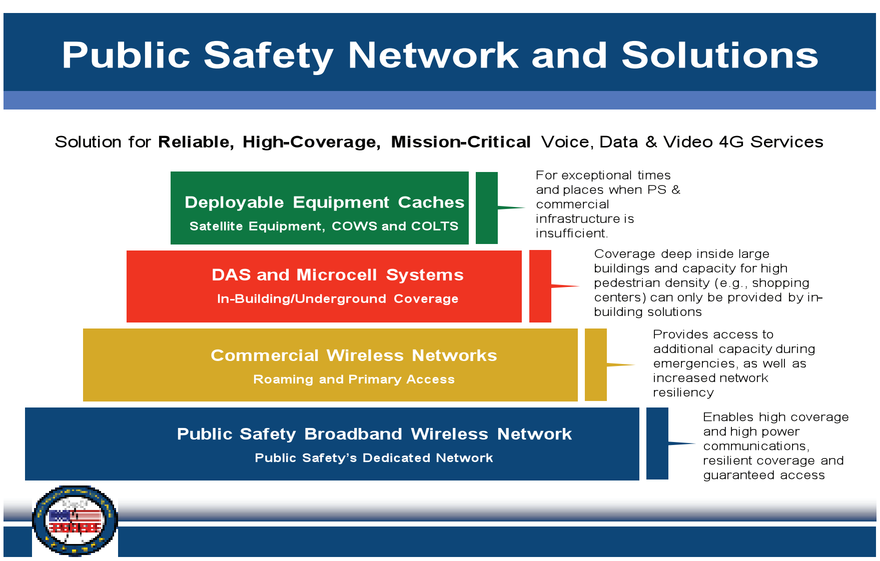
The NBP's vision is to create a communications system that allows public safety agencies to take full advantage of cutting-edge broadband technologies. It is therefore essential that public safety agencies have access to commercial technologies, ruggedized for public safety use. This leveraging of commercial technologies will enable public safety agencies to achieve greater communications capabilities, but at much lower costs.

The NBP's vision for the future of public safety broadband communications encompasses several elements:

As shown in Exhibit 1, a multi-pronged approach will provide public safety with greater dependability, capacity and cost savings. First, the hardened network will provide reliable service throughout a wide area. Second, since emergency responders will be able to roam on commercial networks, capacity and resiliency will improve (at a reasonable cost). Third, localized coverage will improve through the use of fixed microcells and distributed antenna systems (DAS)—like those that provide indoor coverage in skyscrapers. Fourth, equipment can be retrieved from caches and used during a disaster when infrastructure is destroyed, insufficient or unavailable, and fire trucks, police cars and ambulances can become mobile picocells.[1]

The NBP requests total public funding to support the construction and on-going costs of the public safety broadband network. The total present value of the capital expenses and ongoing costs for the network over the next 10 years is approximately $12-16 billion. State and local governments could contribute funds to cover some of these costs, and there may be additional cost-saving methods that reduce this estimate—such as sharing federal infrastructure, working with utilities or use of state and local tower sites.

Exhibit 1:
The Future of Public Safety Broadband Communications



The NBP proposes the creation of a public funding program of as much as $6.5 billion capital expenses (capex) in constructing the public safety broadband network. Public funding will be targeted at constructing a public safety overlay network that exploits existing commercial and public safety narrowband infrastructure, as well as: expanding rural coverage; strengthening existing infrastructure; and developing an inventory of deployable equipment. To ensure interoperability, the funding agency should condition all funding awards on compliance with Emergency Response Interoperability Center's (ERIC) requirements.

The public funding program is designed to achieve nationwide interoperability while preserving a great deal of local flexibility. Although ERIC will set common standards and practices for the nationwide network, public safety agencies at the regional or local level may issue Requests for Proposal (RFPs) and then voluntarily enter into contract with the commercial partners of their choice. This approach will empower each region or locality to satisfy its unique communications needs while promoting vigorous competition among commercial operators and systems integrators for public safety customers.

The NBP also suggests a public funding method, such as imposing a minimal public safety fee on all broadband users, to fund the network's ongoing costs, which include operating expenses (opex) and appropriate network improvement costs. The public funding agency should be charged with disbursing these funds, and any use of such funds must contribute to the operation or evolution of the network and comply with ERIC requirements.

The cost model the NBP used to calculate capital expenses and ongoing costs for the network and to inform its recommendation for the public funding program was validated through multiple approaches.[2] First, a detailed radio frequency (RF) model was constructed, and its RF assumptions were validated through a technical analysis that used data acquired from several major commercial service providers, their competitors and vendors. Costs were based on appropriate comparables, including tariff rates, actual proposals from service providers for similar network builds and operations, and information obtained directly from service providers, equipment vendors, and integrators. Detailed cost scenarios were also developed—and compared with cost scenarios provided by service providers and equipment vendors—to further validate costs.[3]

ASSUMPTIONS

The NBP's proposal for a public safety public funding program is designed pragmatically to ensure achievement of high-quality public safety broadband wireless service. The planned network focuses on data and video service initially. Over time, it will support wireless voice services used routinely by first responders, and eventually the specialized voice services provided to first responders via the land mobile radio (LMR) service today. The model assumes data and video services via IP transport in the early years, evolving to the target of interoperable mission-critical voice, data and video IP networks and applications in the long term, supported by necessary innovations for mission-critical service.

An incentive-based partnership model is assumed for the estimates, (except under Section E), under which public safety network operators will partner with commercial operators or systems integrators to construct and operate the network using the 10 megahertz of 700 MHz public safety broadband spectrum. Under this model, the vast majority of sites will be built by a commercial partner, either a wireless operator, equipment vendor or a system integrator. The model assumes a 700 MHz Long-Term Evolution (LTE) network. Costs include installing and operating the dedicated 700 MHz Radio Access Network (RAN) and sharing back-haul and IP core transport systems, including ancillary and support systems and services. The IP network architecture enables public safety agencies to have their own dedicated servers for applications and services requiring high levels of security and privacy. The projected costs are not discounted for competitive bidding dynamics, such as strategic value to RFP respondents.[4]

The model assumes that the 10 megahertz of 700 MHz public safety broadband spectrum will be "lit" using LTE technology by exploiting commercial infrastructure, which would result in significant cost and operating efficiencies. LTE commercial rollout is planned with availability to 95% of the United States population by 2015.[5] The public safety capability will be added to this network with targeted site upgrades. The network will be built to support standard commercial devices that operate at low power levels of 23 dBm (decibels of the measured power to 1 milliwatt). In-building penetration loss assumptions are assumed for the non-rural population areas. Public safety will then be able to achieve better coverage and performance than commercial systems by using higher-gain devices with specialized antennas. For highly rural areas, the cost model assumes deployment of a network to support vehicular coverage with externally mounted antennas (EMA) to achieve 99% population coverage.[6] Cell sites in highly rural areas are accounted for as a blend of sites built on existing structures and new sites. Hardening for all sites is also accounted for in the model,[7] and the model further assumes that deployable caches of equipment will be available for emergency use.[8]

Ongoing costs were also calculated on the basis of an incentive-based partnership model. This model assumes that backhaul, core network, managed IP services and ancillary services will be paid through an operating expense charged through a managed service fee. This managed service fee is based on the existing air card managed service fee structure—with the radio access network (RAN) share of the service eliminated, since public safety partners will be using their own spectrum for their primary service.[9]

There are several factors that result in lower capacity requirements for the core network. These include roaming on commercial wireless networks, priority wireless service on commercial broadband 700 MHz networks, deployables (*e.g.*, next generation cells on wheels (COWS) and cells on light trucks (COLTS)) and in-building supplementation, which provide resiliency for capacity surges, increased coverage and increased redundancy.

CAPITAL EXPENSES (CAPEX)

As much as $6.5 billion in capital funding will be required over a 10-year period to provide advanced public safety broadband network capabilities to agencies that collectively serve 99% of all Americans.

The 10-year estimate of $6.5 billion in capex was developed based on the following assumptions (see Exhibit 2):

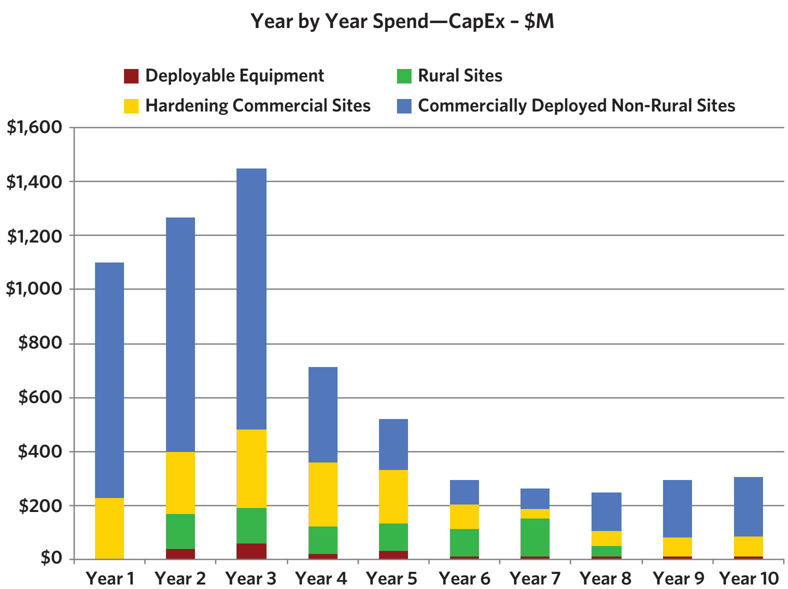
- $4.0 billion to equip 41,600 commercial towers with dedicated public safety broadband spectrum RAN capabilities;
- $1.5 billion to harden the commercial towers (improving reliability, particularly when commercial power is lost);
- $0.8 billion to equip 3,200 rural towers with public safety broadband spectrum RAN capabilities by upgrading towers (75%) and installing and equipping new towers (25%) and hardening those towers; and
- $0.2 billion to provide for a fleet of public safety deployables (a mix of next generation COWS, COLTS, etc.), vehicular area network systems and non-recurring engineering costs for handset development.[10]

Based on this model, a reasonable year-by-year projection of capital expenses is depicted in Exhibit 3.[11]

Exhibit 2: Capex Chart

Item	Cost	Notes
41,600 Commercially Deployed Non-rural Sites	$4.0 B	Excludes hardening costs Ethernet over fiber backhaul connectivity to commercial carrier's backhaul Assumes PS RAN (lit) added to 100% of sites (conservative)
Hardening of Existing Commercial Sites	$1.5 B	Assumes 100% of sites need hardening (conservative)
3,200 Rural Sites (includes hardening)	$0.8 B	Assumes EMA, blend of 25% new and 75% upgraded sites
Deployable Equipment and Development	$0.2 B	COLTS, COWS, vehicular area Distributed systems , NRE for handset development, etc.
TOTAL CAPEX	**$6.5 B**	

Exhibit 3: Annual Capex Projection



ONGOING COSTS

As previously noted, public funding, such as broadband user fees, will fund the ongoing costs of the network and the network evolution.[12] Following a ramp-up coinciding with the network's expansion, the cost of funding operating costs will reach approximately $1.3 billion per year by the 10th year of construction. The $1.3 billion figure was arrived at on the basis of the following assumptions (see Exhibit 4):

- ➤ $0.9 billion for IP Managed Services and Transport including backhaul and core from commercial operators exclusive of opex for the public safety RAN;
- ➤ $0.2 billion for Managed Services for the dedicated public safety RAN;
- ➤ $0.2 billion for additional ongoing costs for rural areas (microwave backhaul, additional site lease cost, etc.); and
- ➤ $0.025 billion for operations support for deployable equipment.

In addition, the Plan suggests that this fund be reviewed on a regular basis. Part of this review should also consider whether additional funding is required for network upgrades.

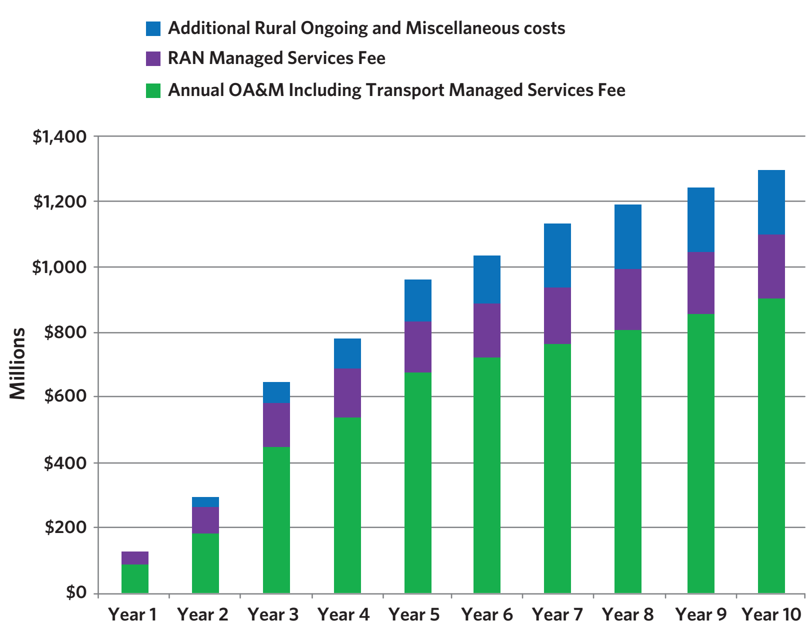
COST OF SEPARATE PUBLIC SAFETY NETWORK

In this section, we compare costs incurred with an incentive-based partnership as described in Section B and costs incurred when an entirely separate dedicated system (stand-alone network) is built for public safety. While the cost estimates for the incentive-based partnership are based on extensive analysis, the costs of the stand-alone network described here are less detailed, in part because of the potential range of ongoing costs. The comparative analysis results in a $6.3 billion capital cost for the network under the incentive-based partnership approach as compared to a $15.7 billion capital cost for a stand-alone public safety network. The cost comparison for these two approaches for both capital and operating costs is even more extreme.

Exhibit 4: Ongoing Network Costs Chart

Item	Cost	Notes
Annual OA&M Including Transport Managed Services Fee	$0.9 B	For 3 million Public Safety Subscribers at $25 per month
Annual RAN Managed Services Fee	$0.2 B	44,800 Sites at $1500 per year for site equipment, OA&M, and $2400 for additional lease cost (this achieves a 99% population coverage)
Additional costs in rural areas (microwave backhaul, additional site lease costs, deployable OpEx)	$0.2 B	Microwave antenna, power and maintenance lease; miscellaneous ongoing costs
TOTAL ONGOING COSTS	**$1.3 B**	

Exhibit 5: Ongoing Costs - Ramp Up (EXAMPLE)



The technical requirements and capabilities under both approaches are identical and consistent with the assumptions of this paper. Thus, the total number of cell sites remains 44,800.[13] In an incentive-based partnership, we must consider the marginal cost of adding a new radio access network for public safety to an existing tower or site, which already has backhaul to a functioning core network. While it may be necessary to harden the tower or site, many functions can be leveraged. In contrast, for a stand-alone network, we must estimate the full cost for public safety capabilities rather than just incremental costs. The differences emerge in the cost per cell site in both capex and opex; the costs in zoning and site acquisition, because of the need for many more new cell sites beyond the base required for public safety LMR networks; the costs of backhaul from the cell sites; and the costs for a core network.

In this analysis, we considered the complexity and scope of constructing a nationwide stand-alone public safety network, in which 80% of the 44,800 sites would be new builds. To avoid comprehensive due diligence requirements and to reduce development costs and time to market, wireless carriers and public safety agencies generally prefer to locate on existing structures rather than build new towers. However, public safety sites must be suitable from a zoning perspective. In many jurisdictions, especially in suburban and rural areas, towers are allowed only on commercially or industrially zoned parcels. Some areas allow towers at agriculturally zoned locations, but most do not allow towers on residentially zoned land, forest land or restricted areas. In addition, sites must not have conditions—such as rocky soil conditions, wetlands, impenetrable trees, possible hazardous waste on properties, high voltage power lines and significant distance to the cell tower site from the main road where utilities are located—that would make constructing a tower extremely expensive. Landowners must also be willing to lease sites at acceptable rates.

Therefore, we assumed that, in urban areas, there are many different antenna sites, such as roof top locations, that public safety agencies can leverage. In suburban and rural America, however, new site acquisition, zoning and construction will in general be substantively higher.

Our analysis indicates that a stand-alone public safety network would be substantially more expensive than a network constructed under the incentive-based partnership approach. Conservatively, the stand-alone network would require at least 2.5 times more capex, excluding deployable equipment, and proportionally even more in ongoing costs.[14] The total present value of the capital expenses and ongoing costs for the stand-alone network over the next 10 years is approximately $34.4 billion, taking into consideration that capex is $15.7 billion and ongoing costs are 1.5 times the total capex amount.[15] This analysis is consistent with both the Verizon study for the Southern Governors Association, which posited $19 billion for initial capex and total costs of $61 billion over 10 years for capex and ongoing operations,[16] and publicly available information about the costs of New York City NYCWiN broadband network.[17] These results are not surprising given that the incentive-based partnership approach leverages the commercial assets of cellular firms that have large economies of scale by serving 40-100 million customers. By contrast a separate public safety network would not be able to leverage the same assets nor have the same economies of scale, since it would effectively serve only a few million first responders while providing similar nationwide coverage. Further, a separate public safety network does not have similar economies of scope, such as sharing an IP core network with other uses.

This lack of scope is compounded if the public safety entity is operating on an LTE network that utilizes spectrum in a band class assigned exclusively for the public safety community. This would be the case if the D block was reallocated to public safety. In that situation, there would be no commercial service provider in LTE Band Class 14 in the 700 MHz band. While technically such a system could be deployed and supported, the costs of the network equipment, most notably the devices, would increase substantially. Without the ability to leverage the economies of scale of a commercial deployment in a band class, there is significantly less market incentive to develop network equipment and devices capable of operating in that band. Therefore, public safety would have to pay significant premiums for equipment and devices under such a scenario.

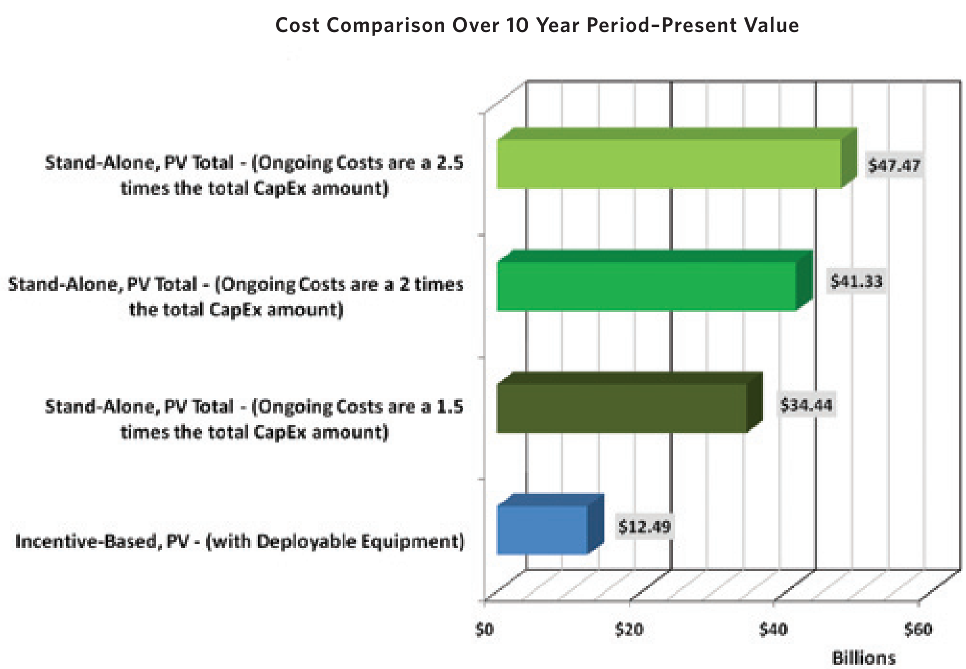
Exhibit 6 compares the costs of these two approaches. Overall, the partnership reduces capex and opex by at least 60%.

Exhibit 7 provides a cost comparison over a 10-year period for capital and on-going expenses. It shows that the total present value of the capital expenses and ongoing costs for the stand-alone network over the next 10 years would be approximately $41.3 billion or $47.5 billion—with capex at $15.7 billion and ongoing costs at either two or 2.5 times the total capex amount.[18]

Exhibit 6:
Incentive-Based Partnership vs. Stand-Alone Public Safety Network Capital Expenses

Comparison Cost of 44,800 Sites		
	Incentive-Based Partnership	**Stand-Alone Public Safety Network**
Urban Upgraded Site	$95,000	$163,752
Urban New Site	N/A	$223,752
SubUrban Upgraded Site	$95,000	$213,752
SubUrban New Site	N/A	$288,752
Rural Upgraded Site	$216,000	$247,232
SubUrban New Site	$363,000	$394,632
Total CapEx for Sites including Hardening	$6.3 B	$12.6 B
Backhaul - Installation to Core Fiber Ring, Non-Rural Sites	$0	$2.1 B
IP Core Equipment, Network Operations Centers	$0	$1 B
TOTAL CAPEX	**$6.3 B**	**$15.7 B**

Exhibit 7:
Present Value Cost Comparison



APPENDIX A: DEPLOYABLE EQUIPMENT

The public funding program includes funding for two distinct use cases of public safety deployables:

1. Rapidly deployable full cellular systems that can be deployed for public safety use when either:

   a) A natural disaster or other emergency has occurred in a remote area where there is no public safety 700 MHz cellular system (*e.g.*, a train crash with chemical spills in a remote area or a forest fire in a wilderness area); or
   b) The working public safety cellular system for a cell site or larger area has been destroyed or is temporarily inadequate. The systems deployed in such circumstances are sometimes referred to as Cells on Wheels (COWs) and Cells on Light Trucks (COLTs). LTE enables a new generation of this equipment that will be much lighter than current equipment.[19]

2. Vehicles equipped with technology that enables the first responder occupants of the vehicle to use the vehicle communications systems as a relay connecting their handheld to a remote base station. When the officer leaves the vehicle to go into a building or to the physical site of accident (*e.g.*, to investigate a car rolled over an embankment or to pursue a suspect on foot), the handheld device communicates back to the vehicle, which in turn relays the communications back to the closest cellular tower—which may be reachable only from a high-gain vehicle. In effect, the vehicle becomes a vehicular area network (VAN).

The deployable caches included in the public funding will serve all major metropolitan areas and will include sufficient fleets for each state to ensure adequate deployment to reach any emergency within a small number of hours.

This part of the public funding program also includes money for Non-Recurring Engineering costs for the specialized chipset and software development to enable the development of public safety LTE devices in the market that take advantage of commercial capabilities and also ensure the development of any specialized needs for public safety devices. For example, public safety devices must operate in Band Class 14 and be able to roam into other LTE 700 MHz band classes.

APPENDIX B: NETWORK COST MODEL ASSUMPTIONS

- Network Build Model:
  - A pragmatic approach that achieves high quality wireless broadband service using spectrum dedicated for public safety—the 5+5 MHz public safety broadband spectrum—to provide public safety with a dedicated Radio Access Network (RAN).
  - Assumes that public safety agencies on an area-by-area basis will collectively issue a Request for Proposal (RFP) for that area for the building out of the public safety broadband network.

- Potential partners: The respondents to the RFP may include any of the following:
  - A commercial wireless operator with an existing network, particularly a Long Term Evolution (LTE) network in the geographic area with 700 MHz spectrum (other than the D Block) that adds equipment to "light-up" the public safety broadband spectrum;
  - A commercial wireless operator who is a D Block auction winner and is simultaneously building out the LTE Band 14 profile that includes both D Block and public safety spectrum; or
  - A systems integrator who is participating by itself or building out as part of an Land Mobile Radio (LMR) or other build for public safety that builds a broadband wireless network only for the public safety broadband spectrum.
  - The lowest-cost build would be the synchronous build with the D Block, while the highest cost build would be a stand-alone build by a systems integrator.

- Funding is based on an asynchronous build where existing operators' infrastructure would be expanded to include the "lighting" of the public safety 700 MHz broadband spectrum to give public safety a dedicated RAN.
  - Assumes LTE commercial rollout availability to 95% of the population will be achieved by market forces by 2015.
  - For the 95% that are likely to be served by LTE-based operator plans, this would be an asynchronous expansion by an operator who has built out an LTE network.
  - For highly rural America, where there is not market commitment for an LTE network, build out was modeled to use 2G infrastructure plus new towers where necessary.

- Subscriber device model:
  - Commercial power levels (23 dBm) for handheld devices, except in highly-rural areas. Public safety agencies can choose to equip their officers with slightly larger handheld devices with small external antennas and larger batteries, thus gaining 2 to 3 decibels (dBs) of additional power. These devices will provide public safety officers with superior coverage and high speed near cell edges.
  - In highly rural areas the subscriber device supported by the network is a vehicular device using an externally mounted antenna (EMA). Commercial handheld devices will also work in these areas for much of the area within a cell site, but at reduced speeds as one gets closer to the cell edge.
  - The model contains no device funding for handheld or the vehicular device with the EMA, as that was assumed to be the responsibility of each individual agency.
  - The subscriber devices should be substantially lower in costs than they are today for public safety because of the ability to leverage the commercial device ecosystems. In the operating system, the baseband chipset and the RF chipset are the components of the device that require high volumes to drive costs down. These components will also be used in commercial deployments and thus will be in high volume.

- Network services:
  - Data and video services via IP Transport in early years offering a more reliable, high performance, and more cost-effective version of the commercial wireless aircard services that some public safety officers purchase today.
  - Commercial voice via VoIP over LTE in the medium term as that becomes available on LTE networks.
  - Interoperable, mission-critical voice, data and video IP networks and applications as the long-term target.

- Link budget assumptions:
  - In-building penetration loss assumptions are the same as commercial LTE except for highly-rural, which is modeled for vehicular EMA coverage. As noted above, public safety officers can achieve performance superior to commercial performance with handhelds with small external antennas.
  - LTE Commercial Speeds with 95% area coverage (256 Kbps uplink typically) can be achieved on top of an LTE commercial service cell site infrastructure with minimal site supplementation.
  - Vehicular coverage for highly rural areas to achieve 99% population coverage.

- Grant funding:
  - Public funding for paying for the RFPs is based on a commercial winning bidder installing and operating a dedicated public safety broadband 700 MHz RAN that shares backhaul, IP Core transport systems, including ancillary and support systems and services. Public safety agencies may choose to operate dedicated servers for specific applications and services that contain sensitive information.
  - Funding is based on the full costs of dedicated RAN build. There is no discount of the prices included for competitive bidding dynamics, such as strategic value to RFP respondents, although such discounts are likely.

- Operating expense assumptions:
  - Backhaul, core network and managed IP services and ancillary services provided via wireless operator or systems integrator and paid through opex charged for a managed services fee.
  - Managed service fee based on 2010 aircard managed service fee structure with RAN share of service eliminated.
  - Annual opex fee incurred for management and maintenance of public safety broadband 700 MHz RAN.

- Capital expense assumptions:
  - Cell sites in rural America are treated as a blended build of new sites on existing structures and new sites.
  - $95,000 blended average per site capex for adding public safety broadband to commercial LTE cell site.
  - $35,000 hardening per site for commercial LTE sites.
  - $216,000 average per site capex for adding public safety broadband to existing sites in most rural areas, including $75,000 per site for hardening.
  - $363,000 average per site capex for public safety broadband new sites in the most rural areas, including $75,000 per site for hardening.
  - Priority wireless service on commercial networks, deployables and in-building supplementation provides for capacity surges, more extensive coverage and more resiliency, thus lowering site requirements on the core network.
- The model will be refined based on real-life experience in future public funding years.

APPENDIX C: UNDERLYING EQUIPMENT AND COST FOR CAPITAL EXPENSE ASSUMPTIONS

EQUIPMENT AND COSTS FOR BLENDED AVERAGE PER SITE CAPEX FOR ADDING PUBLIC SAFETY BROADBAND TO COMMERCIAL LTE CELL SITES.

Non-Rural Site Configuration A and B, for Asynchronous Build
Two different types of configurations (A and B) are used for the underlying equipment for adding public safety broadband to commercial LTE cell sites. In addition, structure heights, or distances from the eNodeB to Antennas for the site locations, were evaluated for cost at 75 feet and 150 feet. The main differences between configuration A and B are that configuration A uses rigid coax and configuration B uses fiber and remote radio heads (RRH). Configuration A uses rigid coax from the eNodeB at the base of the structure/tower up to the top of the tower or structure/tower where the antennas are located. Configuration B uses fiber from the eNodeB at the base of the structure/tower up to the top of the tower or structure/tower where the antennas and RRH are located.

EQUIPMENT AND COSTS PER SITE CAPEX FOR ADDING PUBLIC SAFETY BROADBAND TO EXISTING SITES IN HIGHLY RURAL AREAS, INCLUDING HARDENING.

Rural Site Configuration A and B, for Asynchronous Build
Two different types of configurations are used for the underlying equipment for adding public safety broadband to highly rural areas. In addition, structure heights, or distances from the eNodeB to Antennas for the site locations, were evaluated at 225 feet. Microwave equipment and hardening are also included in the underlying cost analysis.

EQUIPMENT AND COSTS PER SITE CAPEX FOR PUBLIC SAFETY BROADBAND NEW SITES IN HIGHLY RURAL AREAS, INCLUDING HARDENING.

Two different types of configurations (A and B) are used for the underlying equipment for new sites in highly rural areas. In addition, structure heights, or distances from the eNodeB to antennas for the site locations, were evaluated at 225 feet. Microwave equipment and hardening was also included in the underlying cost analysis. New sites in highly rural areas also included Site Acquisition and Construction of up to a 225 foot structure/tower.

HARDENING

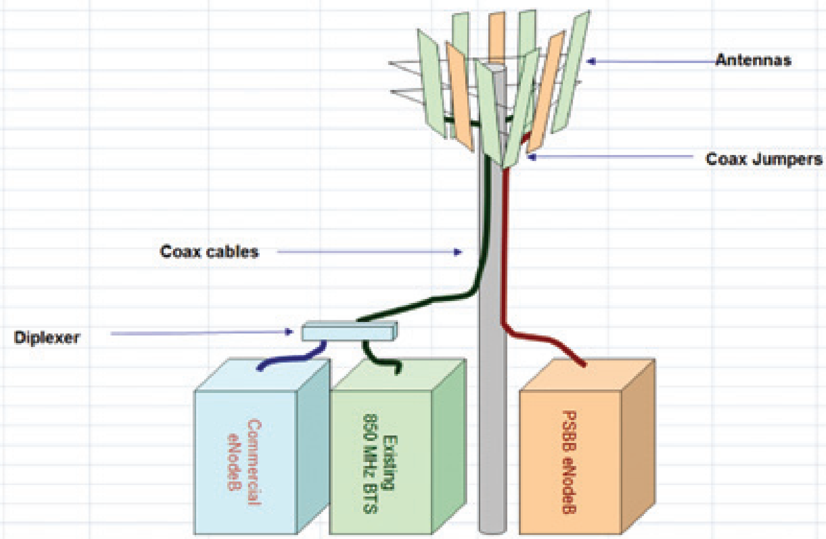
Hardening includes additional batteries and battery cabinet, structural analysis and improving the cell-site structure and antenna survivability designed for a wind loading, according to the Electronics Industry Association Structural Standards for Steel Antenna Tower and Antenna Supporting Structures (EIA/TIA-222). For rural sites, hardening also includes adding generators and associated equipment.[20]

MICROWAVE

Microwave equipment includes all equipment, path survey and installation for the microwave system. In addition, FCC applications, coordination and zoning are included in the cost structure.

Non-Rural Site Configuration A, for Asynchronous Build

Non-Rural Site configuration for Asynchronous Build where existing operators infrastructure would be expanded to include the "lighting" of the public safety 700 MHz broadband spectrum to give public safety a dedicated RAN.



Configuration A

75 Foot site

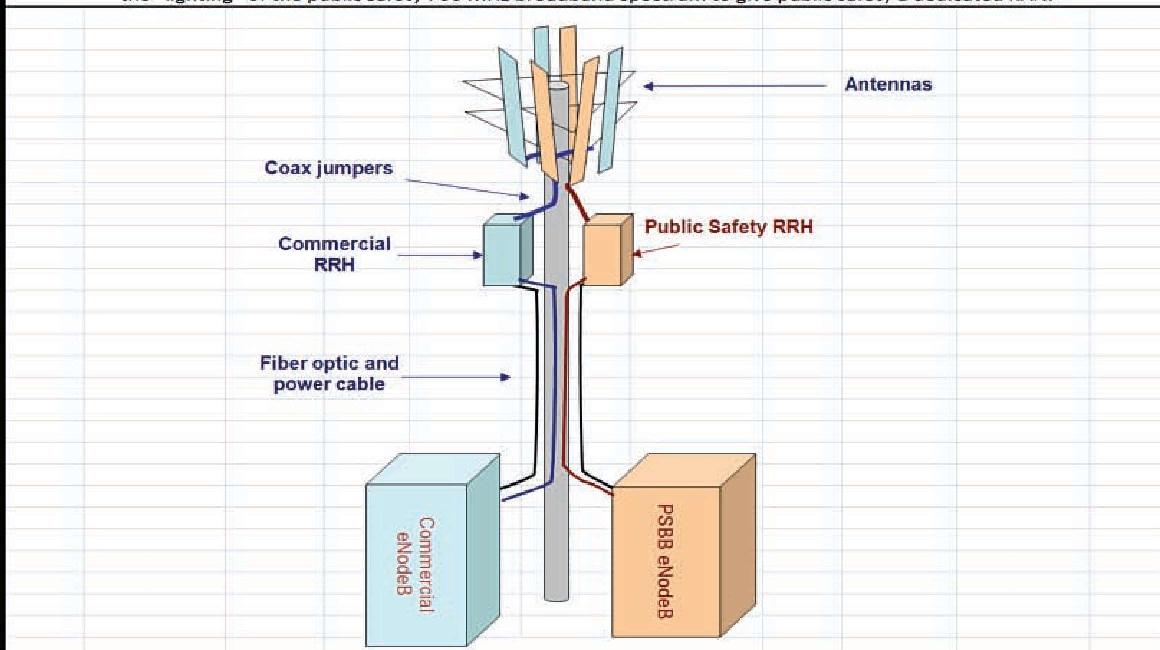
			Per Coax run	Per sector (2 Coax runs)
1/2" Low-Loss Foam Coax	$0.65	per foot	$58.50	$117.00
CONNECTOR 1/2" ONE PIECE RAPID FIT DM	$16.00	each	$32	$64.00
Coax Jumper, 6 foot, SCF12-50J	$54.00	each	$108	$216.00
MIMO Antenna and mounts	$2,250.00	each	$2,250	$2,250
1/2 inch GROUND KIT (CLAMP) FOR COAX	$12.00	Each coax run	$12	$24.00
Coax Clamps	$25.00	2 pkg/coax run	$50	$100.00
CUSHION HANGER ASSEMBLY 1/2 COAX (PACK OF 5)	$24.00	3 pkg/coax run	$72	$144.00
Tower Mounted Amplifier (TMA)	$1,550.00	each		
		Total above	$2,582.50	$2,915.00
			Configuration A	
		Tower Equipment	3 Sector Cost	$8,745.00
			eNodeB Termination Fiber Ethernet	$3,000
			eNodeB	$45,000
			Total Equipment	$56,745
			40% Eng.& Installation	**$22,698.00**
			Grand Total	$79,443.00

150 Foot site

			Per Coax run	Per sector (2 Coax runs)
7/8" Ultraflexible Foam Coax	$1.18	per foot	$194.70	$389.40
CONNECTOR 7/8" ONE PIECE RAPID FIT DM	$17.00	each	$34	$68.00
Coax Jumper, 6 foot, SCF12-50J	$58.00	each	$116	$232.00
MIMO Antenna and mounts	$2,250.00	each	$2,250	$2,250
7/8 inch GROUND KIT (CLAMP) FOR COAX	$12.75	Each coax run	$13	$25.50
Coax Clamps	$27.00	2 Each coax run	$54	$108.00
CUSHION HANGER ASSEMBLY 7/8 COAX (PACK OF 5)	$25.50	3 each coax run	$77	$153.00
Tower Mounted Amplifier (TMA)	$1,550.00	each	$1,550	$3,100.00
		Total above	$4,287.95	$6,325.90
			Configuration A	
		Tower Equipment	3 Sector Cost	$18,977.70
			eNodeB Termination Fiber Ethernet	$3,000
			eNodeB	$45,000
			Total Equipment	$66,978
			40% Eng.& Installation	**$26,791.08**
			Grand Total	$93,768.78

Non-Rural Site Configuration B, for Asynchronous Build

Non-Rural Site configuration for Asynchronous Build where existing operators infrastructure would be expanded to include the "lighting" of the public safety 700 MHz broadband spectrum to give public safety a dedicated RAN.

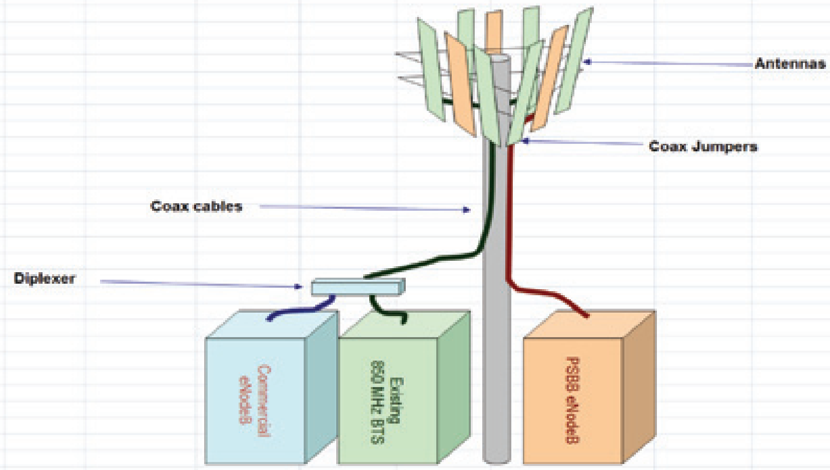


Configuration B

				75 Foot site: Per Fiber run	75 Foot site: Per sector (2 Fiber runs)	150 Foot site: Per Fiber run	150 Foot site: Per sector (2 Fiber runs)
Coax Jumper, 6 foot, SCF12-50J	$54.00	each		$108	$216.00	$116	$232.00
MIMO Antenna and mounts	$2,250.00	each		$2,250.00	$2,250	$2,250.00	$2,250
Remote Radio Head (RRH)	$4,875.00	each		$4,875	$4,875	$4,875	$4,875
Fiber Cable	$0.30	per foot		$27.00	$54	$49.50	$99
Power Cable	$0.05	per foot		$4.50	$9	$8.25	$17
Fiber Clamps	$11.00	2 pkg/run		$11.00	$22	$11.00	$22
Fiber connectors	$3.50	each		$7	$14	$7	$14
			Total above	$7,282.50	$7,440.00	$7,316.75	$7,508.50
				Configuration B		Configuration B	
			Tower Equipment	3 Sector Cost	$22,320.00	3 Sector Cost	$22,525.50
				eNodeB Termination Fiber Ethernet	$3,000	eNodeB Termination Fiber Ethernet	$3,000
				eNodeB	$45,000	eNodeB	$45,000
				Total Equipment	$70,320	Total Equipment	$70,526
				40% Eng.& Installation	$28,128.00	40% Eng.& Installation	$28,210.20
				Grand Total	$98,448.00	Grand Total	$98,735.70

Rural Site Configuration A, for Asynchronous Build

Rural Site configuration for Asynchronous Build where existing operators infrastructure would be expanded to include the "lighting" of the public safety 700 MHz broadband spectrum to give public safety a dedicated RAN.



Configuration A

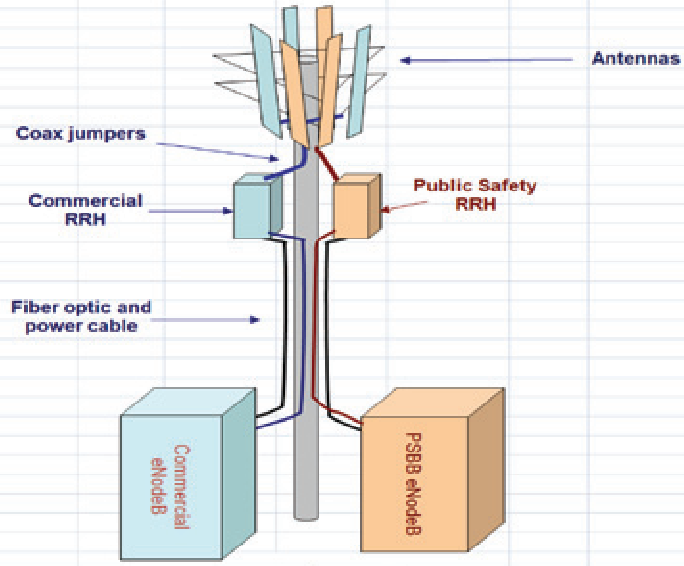
225 Foot site				
			Per Coax run	Per sector (2 Coax runs)
1-1/4" Premium Attenuation Coax	$2.95	per foot	$708.00	$1,416.00
CONNECTOR 1-1/4" ONE PIECE RAPID FIT DM	$17.00	each	$122	$243.00
Coax Jumper, 6 foot, SCF12-50J	$58.00	each	$116	$232.00
MIMO Antenna and mounts	$2,250.00	each	$2,250	$2,250
1-1/4" GROUND KIT (CLAMP) FOR COAX	$12.75	Each coax run	$19	$37.00
Coax Clamps	$27.00	2 Each coax run	$140	$280.00
CUSHION HANGER ASSEMBLY 1-1/4" COAX (PACK OF 5)	$25.50	3 each coax run	$201	$402.00
Tower Mounted Amplifier (TMA)	$1,550.00	each	$1,550	$3,100.00
		Total above	$5,105.00	$7,960.00
			Configuration A	
		Tower Equipment	3 Sector Cost	$23,880.00
			eNodeB Termination Fiber Ethernet	$3,000
			eNodeB	$45,000
			Total Equipment	$71,880
			40% Eng.& Installation	$28,752.00
			Grand Total	$100,632.00

Total Rural Upgrade Site	Cost
Hardening	$70,000
Microwave equipement	$45,000
3 sector Equipment and Installation	$100,632.00
Total:	$215,632

Total New-Build Rural Site	Cost
Hardening	$70,000
Microwave equipement	$45,000
Site Acquisition, Zoning	$57,400
Construction	$90,000
3 sector Equipment and Installation	$100,632.00
Total:	$363,032

Rural Site Configuration B, for Asynchronous Build

Rural Site configuration for Asynchronous Build where existing operators infrastructure would be expanded to include the "lighting" of the public safety 700 MHz broadband spectrum to give public safety a dedicated RAN.



Configuration B

225 Foot site

				Per Fiber run	Per sector (2 Fiber runs)
Coax Jumper, 6 foot, SCF12-50J	$54.00	each		$116	$232.00
MIMO Antenna and mounts	$2,250.00	each		$2,250.00	$2,250
Remote Radio Head (RRH)	$4,875.00	each		$4,875	$4,875
Fiber Cable	$0.30	per foot		$72.00	$144
Power Cable	$0.05	per foot		$12.00	$24
Fiber Clamps	$11.00	2 pkg/run		$11.00	$22
Fiber connectors	$3.50	each		$7	$14
			Total above	$7,343.00	$7,561.00
				Configuration B	
			Tower Equipment	3 Sector Cost	$22,683.00
				eNodeB Termination Fiber Ethernet	$3,000
				eNodeB	$45,000
				Total Equipment	$70,683
				40% Eng.& Installation	$28,273.20
				Grand Total	$98,956.20

Total Rural Upgrade Site	Cost
Hardening	$70,000
Microwave equipment	$45,000
Equipment and	$98,956.20
Total:	$213,956

Total New-Build Rural Site	Cost
Hardening	$70,000
Microwave equipment	$45,000
Site Acquisition, Zoning	$57,400
Construction	$90,000
3 sector Equipment and Installation	$98,956.20
Total:	$361,356

HARDENING COST		
Rural		
CAPEX	**Item**	**Cost**
	Additional Batteries and cabinet (8 to 12 hours minimum additional battery back-up)	$4,800
	20 KW Diesel Generator with 200 AMP Transfer Swich, CLIFFORD	$11,425
	Electrical wires to eNodeB and tower	$325
	1,000 gallon fuel tank	$1,750
	Fuel	$2,000
	Fuel Lines	$250
	Improve antenna survivability designed for a wind loading - 100 to 140 mph (The Electronics Industry Association Structural Standards for Steel Antenna Tower and Antenna Supporting Structures - EIA/TIA-222)	$5,500
	Improve Structural Standards for Steel Antenna Towers (The Electronics Industry Association Structural Standards for Steel Antenna Tower and Antenna Supporting Structures - EIA/TIA-222)	$25,750
	Structural Analysis per base station	$2,500
	Installation (40%)	$20,720
	Total:	**$75,020**
Non-Rural		
CAPEX	**Item**	**Cost**
	Additional Batteries and cabinet (8 hours minimum additional battery back-up)	$4,250
	Electrical wires to eNodeB and tower	$200
	Improve antenna survivability designed for a wind loading - 100 to 140 mph (The Electronics Industry Association Structural Standards for Steel Antenna Tower and Antenna Supporting Structures - EIA/TIA-222)	$3,500
	Improve loading and/or Structural Standards for structure or Towers (The Electronics Industry Association Structural Standards for Steel Antenna Tower and Antenna Supporting Structures - EIA/TIA-222)	$10,050
	Miscellaneous	$5,250
	Structural Analysis per base station	$2,500
	Installation (40%)	$9,300
	Total:	**$35,050**

	Optional Equipment not included	
	20 KW LP Generator with 200 AMP Transfer Swich, CLIFFORD	$7,900
	Portable, 8000 WATT GENERATOR, Transfer Switsh, GENERAC	$4,500

MICROWAVE SYSTEM (cost per 100 Mbps Ethernet terminal)	
Item	**Cost**
Microwave installation (6 and 11 GHz)	$14,500
1/2" Low-Loss Foam Coax ($0.65 per foot)	$156
CONNECTOR 1/2" ONE PIECE RAPID FIT DM	$32
6 foot, SCF12-50J	$108
Coax Clamps	$75
CUSHION HANGER ASSEMBLY 1/2 COAX (PACK OF 5)	$100
Microwave WG, Hydrator and Accessories (6 and 11 GHz)	$4,500
FCC Application and Coordination	$1,000
Microwave Antenna (6 or 11 GHz)	$2,500
Microwave Terminal HSB (6 and 11 GHz)	$17,300
Path Survey	$1,750
Zoning	$3,000
Total:	**$45,021**

REFERENCE

Tessco, http://www.tessco.com/ (last visited March, 6 2010).

Meridian Microwave, http://www.meridianmicrowave.com/#0%20-%206%20miles (last visited March, 6 2010).

Radio Frequency Systems, http://www.lwsonline.de/oxid/ (last visited March, 6 2010).

Huawei, http://www.huawei.com/site_products.do (last visited March, 6 2010).

Powerwave, http://www.powerwave.com/datasheets.asp (last visited March, 6 2010).

Clifford Power Systems, Inc., http://www.cliffordpower.com/ (last visited March, 6 2010).

Fred A. Nudd Corporation, http://www.nuddtowers.com/ (last visited March, 6 2010).

Telecommunications Industry Association, http://www.tiaonline.org/ (last visited March, 6 2010).

Commscope, “Wind Loading on Basic Antennas,” http://www.commscope.com/andrew/eng/support_document/tech_info/antennas/__icsFiles/afieldfile/2009/07/13/wind_loading_on_base_stationantennas_white_Paper.pdf

Valere Power Systems, http://www.eltekvalere.com/wip4/ (last visited March, 6 2010).

http://www.generac.com/Full_Product_Line/ , (last visited March, 6 2010).

APPENDIX D: CAPEX FOR PUBLIC SAFETY 700 MHZ BUILDS—STAND-ALONE

CAPEX FOR PUBLIC SAFETY 700 MHZ BUILDS - STAND-ALONE	Cost
Urban Cost per cell site for Upgrade	$163,752
Urban Cost per cell site for New Site	$223,752
SubUrban Cost per cell site for Upgrade	$213,752
SubUrban Cost per cell site for New Site	$288,752
Rural Cost per cell site for Upgrade	$247,232
Rural Cost per cell site for New Site	$394,632
% of Sites Upgraded (All Sites)	20%
% of Sites New Build (All Sites)	80%
Base Case Urban Areas, Upgraded Sites	$596,418,409
Base Case Urban Areas, New Sites	$3,259,801,634
Total - Urban	$3,856,220,043
Base Case SubUrban Areas, Upgraded Sites	$998,009,209
Base Case SubUrban Areas, New Sites	$5,392,736,834
Total - SubUrban	$6,390,746,043
Total - Non-Rural	$10,246,966,085
Upgraded Sites w/ EAM in Rural Areas	$155,113,357
New Sites w/ EAM in Rural Areas	$990,368,467
Hardening non-Rural Sites	$1,163,568,000
TOTAL RAN CAPEX FOR STAND-ALONE SCENARIOS	$12,556,015,909
Backhaul - Installation to Core Fiber Ring, Non-Rural Sites	**$2,078,672,676**
IP Core Equipment, Network Operations Centers	**$1,027,939,000**
Grand Total - STAND-ALONE Build for Public Safety	**$15,662,627,585**

ACKNOWLEDGEMENTS

The Omnibus Broadband Initiative acknowledges the efforts of Stagg Newman, Brian Hurley, Jon Peha, Pat Amodio, Ziad Sleem, Behzad Ghaffari, Jeffery Goldthorp, John Leibovitz, Tom Peters, Walter Johnston, Mike Iandolo, Jerome Stanshine, Yoon Chang, Kurian Jacob and Jennifer A. Manner in preparing this paper.

ENDNOTES

[1] For an extensive discussion of how the public safety broadband network will use deployable equipment, see Appendix A.

[2] A detailed discussion of the assumptions underlying the network cost model is provided in Appendix B.

[3] Because network designs and assumptions may change over time, it is imperative that the funding agency ensures that there is an annual review of the funding available for each program.

[4] Through partnering, RFP respondents will see an effective reduction in capex associated with their own network build out as well as an improvement in reliability through side hardening for public safety.

[5] *See* http://www22.verizon.com/Content/ExecutiveCenter/Richard_Lynch/mobile_world_congress/mobile_world_congress.htm (last visited Feb. 20, 2010); *see also* http://www.att.com/gen/press-room?cdvn=news&newsarticleid=30493&pid=4800 (last visited Feb. 20, 2010).

[6] The model excludes the costs of EMAs, which are components of subscriber devices used for vehicular coverage. EMAs are standard equipment used in public safety vehicles to improve coverage.

[7] We assumed $35,000 per site for hardening in non-rural areas, and $70,000 per site in highly rural areas.

[8] Portable user equipment or radios with ancillary support equipment stored and available for emergency use.

[9] We have not included any costs that might be incurred for roaming by the public safety operator on a commercial network. Public safety will be able to obtain roaming services at favorable commercial rates.

[10] This assumes a cost range from $100,000 to $400,000 for next generation deployable cell sites as well as a cost of up to $10,000 per vehicle for vehicular area network systems.

[11] Appendix C provides more detail on the cost model used to calculate overall capital expenses for the network. Actual costs for a particular region for a specific RFP will vary on a line-by-line basis.

[12] The proposed funding covers network operations. The funding is not intended to cover the operations of the services and applications running on top of that network nor various administrative functions associated with public safety network operations that agencies may incur. These costs which are part of day-to-day operations today which we have assumed will continue to be borne by the local agencies.

[13] Public safety regions could deploy networks with fewer cell sites, but such networks would provide worse performance, slower speeds, and less total capacity. For the case of the Stand-Alone build we used 20% existing public safety sites and 80% new sites, based on the number of LMR sites that typically serve a region compared with the number of cellular sites.

[14] Based on Sprint Nextel and Verizon Wireless annual reports for 2009, OpEx is approximately twice CapEx. Based on our analysis, the range of ongoing costs is 1.5 to 2.5 times the total CapEx amount, with two times the total CapEx amount as the norm. For some Stand-Alone networks, Ongoing Costs could be higher. For these reasons, we have estimated costs based on a range.

[15] Ongoing Costs equal to 1.5 times the total CapEx amount is the lower bound. Appendix D provides a more detailed cost breakdown of the CapEx for the $15.7 B

[16] *See* SGA Task Force: Achieving Interoperability for Public Safety Communications (2007); Response of Verizon Communications and Verizon Wireless (Mar. 16, 2007).

[17] *See* Henry Morgenstern, *NYCWiN Interoperable Communications: A Report on the New York City Wireless Network,* Counter Terrorist Magazine, Sept./Oct. 2008, available at http://www.thecounterterroristmag.com/pdf/Issue3.NYCWiN.Morgenstern.Lo.pdf (last accessed Mar. 26, 2010). *See also* Department of Information Technology and Telecommunications, Testimony before the City Council Committees on Fire and Criminal Justice Services, Public Safety, and Technology in Government Oversight – Implementation Status of the New York City Wireless Network (Feb. 25, 2008).

[18] See supra 14

[19] Letter from Brian Ponte, Vice President for Business Development, LEMKO Corporation, to Marlene H. Dortch, Secretary, FCC (Mar. 12, 2010).

[20] Many commercial sites today have battery back-up and structural hardening and back-up power systems for primary sites but not for secondary sites. The model assumed hardening and batteries for all sites with diesel generators as optional. In practice, the funds not needed for sites that are already hardened could be used for diesel generators at other sites. The localization of the RFP approach allows solutions to be tailored to the local needs and environment.