CROWN CASTLE

08/02/2018

NYC RFP

Prepared for: New York City

Submitted by: Crown Castle Solutions LLC

The pathway to possible.

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Introduction / Introductory Statement

Crown Castle Solutions LLC ("CCS" or "Applicant") submits this proposal for a mobile telecommunications franchise (the "Proposal") in response to the City's request for proposals dated June 12, 2018 (the "RFP"). CCS seeks a franchise for the installation and use of mobile telecommunications antennas and related facilities on New York City ("City")-owned street light poles, traffic light poles, privately owned utility poles and certain street furniture in the City including the fiber serving the mobile pole top network.

As a neutral host provider, CCS is uniquely positioned to help the City meets its short and long term broadband goals. In addition to utilizing City-approved equipment specifications provided in the RFP, CCS has included additional equipment installation and configuration options and a corresponding Counter Offer to the City, which seeks to:

- Promote the City's vision and objectives with respect to increasing the health, safety and welfare of its residents and visitors;
- Provide the City's residents and visitors with 5G enabled wireless broadband access and other broadband access of the City's choice (i.e. Wi-Fi);
- Increase the availability and by extension the value of the City's assets;
- Enable Smart City and internet of Things ("IoT") technologies that will place the City at the forefront of innovative Cities worldwide; and
- Position the City at the forefront of mobile broadband deployment while enabling a fast and flexible method of deployment that is mutually beneficial to the City and CCS.

By way of background, Crown Castle Solutions Corp. was formed as a wholly owned indirect subsidiary of Crown Castle International Corp on December 17, 2001. On December 29, 2014, Crown Castle Solutions Corp converted to a limited liability company and changed its name to Crown Castle Solutions LLC.

1. Technical Proposal

REQUIREMENT

Proposed Equipment. *Equipment and facilities which would be located on Street Operations Poles, including at least a schematic design for, and photograph of, the equipment intended to be installed including known power requirements.*

RESPONSE

In accordance with the requirements set forth by the RFP, CCS proposes to utilize the equipment specifications outlined in Exhibit A, titled, "Approved Equipment Design Drawings" (the "Approved Equipment"). While recognizing the Approved Equipment as the current standard approved by the City and its agencies, CCS has provided four additional options that will immediately enable faster wireless broadband deployment in unserved and underserved areas of the City while enabling critical communications infrastructure that is important to the health, safety and welfare of City residents and the progress and technical evolution of the City. The four options are not mutually exclusive and can be deployed in various combinations to suit the needs of the franchisee and City.

Figure 1

Proposal: Approved Equipment Design

This Approved Equipment has been deployed since the onset of the Mobile Pole Top Franchise in 2004. Architectural drawings and photos of existing deployments are attached in Exhibit A. Figure 1 reflects existing installations on three pole types in the City – M2 (top left), FS (top right and bottom left) and Bishops Crook (bottom right).

While the Approved Equipment met a need when it was originally approved in 2004, it is no longer sufficient to meet the growing needs and demands of all mobile users or to enable 5G deployment in the City. The current Approved Equipment will lead to an increased number of locations in the City and undermine the City's stated preference for neutral host applications.

CCS is a neutral host provider of broadband infrastructure. We view our role as providing the infrastructure to facilitate an open and robust competitive retail service market. Operating as a neutral host, CCS can facilitate a high-level of service based on competition and accelerate the entrant of new service providers.

An overview of the equipment specific proposals can be found below in the equipment table in Figure 2. An Equipment Exhibit Matrix, which lists the shroud and antenna sizes, is located in the Appendix. Accordingly, CCS proposes the following options:

Proposal + Exhibit	Equipment Cabinet/Shroud	Antenna(s)	Pole Type	Tennant Capacity	Areas of Deployment	Exhibit (Refer to RFP)	Technology
Proposal (Exhibit A) : Existing Approved Equipment Specification	DoITT Cabinet: 9"D x 35"H x 15.5"W 2.8 cubic ft	26"H x 2"D 48"H x 2"D 60"H x 2"D 72"H x 2"D	Metal Street Light Wood Utility Pole	1 to 2	Zones A, B, C	Exhibit A	4G
Wooden Utility Poles (Exhibit B-1) : (Equipment Approved by ConEd)	Utility Approved Larger Cabinet, DoITT Style: 12"D x 42"H x 23.9"W 7 cubic ft	24"H x 14.6"D 48"H x 8"D 26"H x 8"D	Wood Utility Poles	3 to 4	Zones B, C	Exhibit B-1	4G, Enhanced 4G, 5G, Milimeter Wave
DOT Control Box Type 8 (Exhibit C) : (DOT Cabinet Deployed Throughout the City)	DOT Control Box Type 8: 15"D x 43"H x 21"W 7.8 cubic ft	75"H x 2"D- Antenna Option #1	Metal Street Light	3 to 4	Zones A, B, C	Exhibit C	4G, Enhanced 4G, 5G, Milimeter Wave
DOT Control Box Type 12 (Exhibit C) : (DOT Cabinet Deployed Throughout the City)	DOT Control Box Type 12: 15"D x 49"H x 21"W 8.9 cubic ft	75"H x 2"D - Antenna Option #1 60"h x 4"D - Antenna Option #2 24"H x 14.5"D - Antenna Option #3	Metal Street Light	3 to 4	Zones A, B, C	Exhibit C	4G, Enhanced 4G, 5G, Milimeter Wave
Optimal 5G/IoT Deployment Configuration for Zones A, B & C (Exhibit D)	See Exhibit D (Small Cell Volume Needs)	See Exhibit D (Small Cell Volume Needs)	Metal Street Light Wood Utility Pole	3 to 4	Zones A, B, C	Exhibit D	4G, Enhanced 4G, 5G, Milimeter Wave

Figure 2

Option #1: Wooden Utility Pole Utility Approved Specifications

CCS shares the City's commitment to making New York the most connected city in the world, so that opportunities are available to all of its residents. We believe we can align our respective goals to achieve this vision. We are especially proud of the fact that 74% of our or our parent company's current nodes and 58% of our proposed nodes in the City are located outside the borough of Manhattan, proving just how committed CCS is to serving traditionally underserved communities.

A recent Pew report about home broadband usage underscores the urgency of this issue. The survey found that while non-broadband users increasingly agreed that they were at a major disadvantage compared to broadband users in accessing crucial information, such as job opportunities or government services, "price sensitivity...is a larger concern for non-adopters who are more likely to recognize the importance of high-speed connection." The report further states, "Reliance on smartphones for online access is especially common among younger adults, non-whites and lower-income Americans."[1]

The de Blasio Administration has laudably made bridging the City's digital divide one of its key priorities and CCS is eager to play a role in expanding digital access to underserved communities. With households rapidly going to wireless-only and mobile broadband data usage skyrocketing, a robust mobile infrastructure system throughout the five boroughs will advance the City's goal of bringing every New Yorker reliable, high-speed broadband service by 2025. More flexibility with regard to current restriction on equipment size limitations and form factors will help make this possible.

[1] Pew Research Center: Internet/Broadband Fact Sheet (February 5, 2018): http://www.pewinternet.org/fact-sheet/internet-broadband/

This is why we believe that an immediate impact can be made through the deployment of the utility approved equipment configurations on wooden utility poles in the outer boroughs.

CCS proposes to deploy the utility approved equipment specifications on wooden utility poles in Zone's B and C. This configuration has been approved by and consistently deployed in numerous municipalities outside of the City such as the Town/Village of Harrison, Town/Village of Mamaroneck, City of White Plains and the Town of Greenburgh, just to name a few. Con Edison is the operating utility who has approved of this proposed specification. A similar equipment configuration has also been approved by the utility Orange and Rockland, PSE&G and Verizon (landline) and deployed in many municipalities in Rockland County and throughout Long Island and New Jersey.

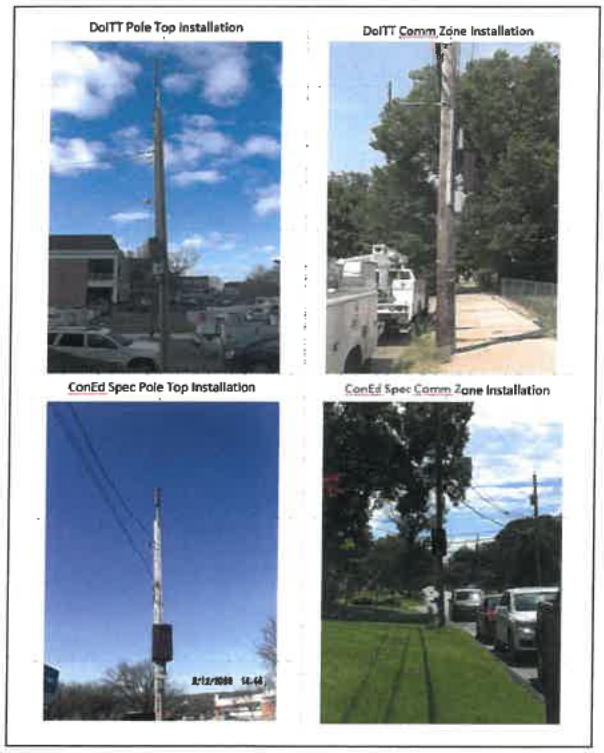


Figure 3

The City would recognize immediate benefits of this configuration given the presence of over 1700 current utility poles locations in the outer boroughs of Bronx, Brooklyn, Queens and Staten Island.

Architectural drawings and photos of the utility approved equipment are contained in Exhibit B-1. A comparison of the City Approved Equipment compared to that of the Utility Approved Equipment can also be found in Exhibit B-1 and in the photos in Figure 3.

For comparison purposes, photos of other installations on City utility poles by other entities and/or similarly certificated providers can be found in Figure 4. The specification proposed by CCS is much smaller in volume and less visually obtrusive than other current and ongoing attachments by others, which the City permits.

CCS further proposes to utilize the strands between wooden utility poles owned by the utilities to strand mount antennas and radios by over lashing equipment on said strands. Other utilities are utilizing this deployment method in the City.

An example of strand mounting is located in Exhibit B-2.

Figure 4

Option #2: Existing City Approved Equipment – DOT Control Box Specifications

Given the City's existing departmental and regulatory approvals of the DOT Control Boxes as well as the City and general public's familiarity with their deployment throughout all five boroughs, CCS proposes to replace two existing Approved Equipment configurations with one Approved Equipment configuration in areas where minimizing or elimination is demonstrated. This option would maximize the neutral host model and enable the deployment of 5G technologies in the City more quickly. This model would also minimize the number of deployments required, freeing space on City-owned assets for valuable Smart City technology, such as DOT's current deployment of the connected vehicle program.[2]

An architectural drawing and photo simulations of this option is contained in Exhibit C. Examples of the proposed DOT Control Box scenario can be found in the below photos. The DOT Control Boxes would be mounted low, similar to how they are mounted today. They can also be mounted higher up on the pole. Examples of this scenario can be found in Exhibit C.

Option #3: Use of Link NYC and Alternate Street Furniture

CCS seeks to utilize the Link NYC infrastructure under the terms outlined in the City's RFP and has entered discussions to secure an agreement that will maximize existing infrastructure in the City's public way.

[2] Press Release: NYC DOT Advances to Phases Two and Three of Federal Connected Vehicle Pilot Program (September 28, 2016). Link: http://www.nyc.gov/html/dot/html/pr2016/pr16-094.shtml

Furthermore, CCS seeks to utilize the street furniture options called out in the RFP in addition to other solutions in the City's public way including but not limited to planters, waste receptacles/ trashcans, newspaper dispensers and stands, phone booth banks and bollards.

CCS also seeks to utilize all light poles and street furniture in City parks, some of which have not been permitted by DOITT under the current franchises. CCS seeks to modify such poles and street furniture so that equipment can be embedded within or under the poles or street furniture and result in the most aesthetically pleasing design for the Parks Department.

A select sample of street furniture options are reflected in Figure 5.

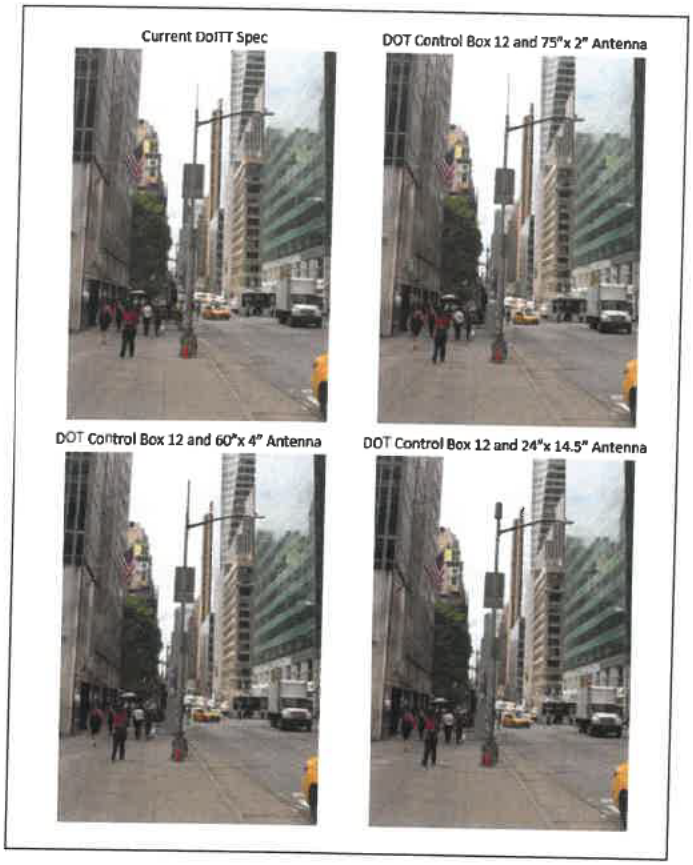


Figure 5

Option #4: Optimal Configuration

The next generation of mobile networks is already upon us and the technologies of 5G and beyond must contain the following characteristics to work effectively:

1. Higher System Capacity
2. High Data Rates
3. Lower Latency
4. Mass Connectivity
5. Energy Efficiency and,
6. More Agile

The City has the ability to influence the speed, quality and technological evolution of infrastructure designed to enhance and accommodate broadband services throughout the City. The success of 5G, CBRS, Smart City and Connected Vehicles are all-dependent upon the coexistence of current and emerging small cell technology, which must utilize existing and new infrastructure in the City's public right-of-way.

Figure 6

The City's approval of the Optimal Configurations outlined by CCS is crucial to ensure that the City's constituents have immediate access to advancements in technology, including enhanced 4G and new frequency bands and corresponding equipment developments designed to accommodate the lower, millimeter wave (28-39 GHz) frequencies that support 5G. The current City-approved equipment dimensions under the existing franchise are simply too restrictive to take advantage of technology and allow necessary enhancement and evolution of broadband services as contemplated by the City's administration. The City's openness and flexibility with regard to approval of Optimal Configurations will reduce the risk that the City will be left without the necessary infrastructure to support the emerging technologies reflected in Figure 7 below.

Historically, the wireless industry has been focused on the deployment of a single frequency band. Given consumer and business demand, this has radically changed. Carriers are rapidly investing in their networks to accelerate growth that cannot be achieved under the existing City Approved Equipment configuration. The City, together with neutral host providers, is urged to leverage all available and necessary frequencies and associated frequency bands to deploy not just the technologies of the present but of the future. This necessitates the need for more equipment boxes at the current Approved configuration or larger equipment with the associated requirement of multiple ports per band, which is an impossibility with the City approved whip antenna approved for deployment today.

We believe that if the City sticks to its current form factors ("Approved Equipment Configuration"), they are essentially giving up any dream of 5G or even enhanced 4G. More shroud space and having canister antennas to take advantage of and maximize sub 6 GHz frequencies works as an interim or short term solution, but does not address the new Millimeter Wave ("MM Wave") form factor which requires the equipment form factor shown in Exhibit D titled "Small Cell Volume Discussion".

CCS recognizes that this optimal solution is a phased approach and one that may enable larger equipment to be deployed before smaller equipment may replace the larger configurations. CCS is uniquely positioned to work with the City as a partner to optimize the near-and-long-term technological needs and advancements as the most experienced neutral host company with fiber capacity, which can also suit the needs of the City.

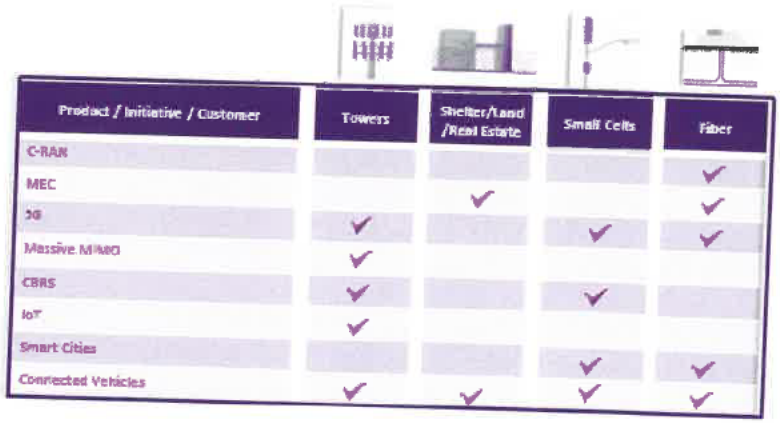


Figure 7

In short, CCS seeks a long-term partnership with the City, which advances the City's position and competitive marketplace with regard to the deployment of next generation technologies. In addition to or in combination with Options 1, 2 and 3 above, this involves but is not limited to the following:

1. Replacing any City pole with a Smart Pole design (approved by the City) that can accommodate a minimum of 4-wireless carriers and City infrastructure at no cost to the City. Poles would be reserve engineered to accommodate all users of said pole.

2. Place street furniture encompassing equipment cabinet/shroud contents near any existing pole not replaced with a Smart Pole design and/or allow the equipment cabinet/shroud configuration depicted in Exhibit C and/or D including proposed antennas, which can support a minimum of four providers in a single pole attachment plus the City's technologies.

REQUIREMENT

Services Provided. *The services to be provided by such equipment and facilities, including the extent to which such equipment and facilities will be capable of serving multiple telecommunications providers.*

RESPONSE

CCS's infrastructure is used by wireless carriers to provide telecommunications services. In many cases, CCS owns the fiber that transports the carrier's voice and data traffic from the antennas to a central location and out to the public switched telephone network or the Internet. Optimal equipment space and configurations will enable more technologies to be deployed and critical technologies that will benefit the health, safety and welfare of City residents and visitors such as:

1. Safety Platforms
2. Education Platform
3. Smart City Technologies
4. Health Applications
5. Wirelessly enabled IoT technologies
6. And more...

REQUIREMENT

Method(s) of Installation. The proposer's method(s) of installation of such facilities and equipment (including, materials required by clause (i) a description of the mounting procedures and techniques to be used to attach the facilities and equipment to the poles and a description of any connecting facilities proposed to be used as described

RESPONSE

The following scope of work reflects a typical method of installation of the proposed facilities. This scope is not intended to apply to non-standard or unique situations that may arise during construction and are considered to be outside of the typical scope.

- Install shroud/enclosure at proposed height on pole.
  - For Wood Poles
    - The shroud, meter and cut off breakers are unitized onto a common backplane referred to as a skid.
    - The skid is bolted through the pole.
  - For Metal Street Lights
    - Metal banding straps are used and run through the shroud bracket around the pole and locked in place with buckles.
    - The bracket is bolted to the back of the shrouds.
- Run coaxial and ground wire up pole to designed to the Antenna's enter
  - For wood poles:
    - Cable is run inside a protective conduit or shield on the outside of the pole.
  - For metal street lights, a 2" hole is drilled into the pole to run cable inside and up to the antenna.
- Install Antenna at proposed height on pole.

- For Wood Poles
  - Antennas can be mounted at the top using a pole top mount, which is banded around the pole and bolted through the pole.
  - Antennas can be mounted on the face of the pole (Comm-zone) using a standoff mount, which is also banded and through bolted on the pole.
- For metal street lights
  - A pole top mounting bracket is placed at the top of the pole and is fastened using set bolts. These bolts are tightened equally around the top of the pole.
  - The antenna is then bolted to the top of the mounting bracket.

- Terminate cable ends
  - Coaxial and ground cables are terminated to dress nicely to antenna at the top and radio within the shroud.
- Installation of radios within the shroud
  - Radios are mounted to customized brackets within the shroud.
- Power Installation
  - Overhead Power
    - Power cable run along messenger strands from one utility pole to the next, terminating at the proposed node location. Power cables are run from the node within the conduit up to a weatherhead where the utility makes the connection to their power system.
  - Underground Power
    - Power cable run in conduit as per electrical codes, to proposed node location.
  - Power Requirements
    - Power requirements for overhead and underground are typically [redacted] from the facility point.
      - *For Metal Street Lights:* [redacted]
      - *For Wood Utility Poles:* [redacted]
- Fiber Installation
  - Overhead Fiber
    - Fiber run along messenger strands from one utility pole to the next, terminating at the proposed node location.
  - Underground Fiber
    - Fiber run underground using common trenching in conduit or micro trenching, terminating at the proposed node location.

REQUIREMENT

Maintenance & Repair. List the proposer's plans for maintenance and repair, and/or removal of such facilities and equipment, including, in particular, the proposers plan to ensure that all construction will be performed and completed in full compliance with the City's standards and specifications.

RESPONSE

CCS and its contractors and vendors, shall comply with all local, state and federal laws and standards that apply to the proposed use in the public right of way. This includes but is not limited to, the 2016 DoITT Handbook, Standard Highway Specifications Volumes I and II issued by the City of New York Department of Transportation (November 1, 2010) or any current versions of the above documents.

In order to maintain the high standard that is expected from our teams, CCS will ensure that:

- Our work will be performed in a first class, competent manner in conformity with the customary standards applicable to such work in the public rights of way.
- All companies and persons performing work on behalf of CCS are technically, financially, and legally ready, willing and able to perform the work and are familiar with and knowledgeable of applicable governmental requirements, industry standards and the operation of wireless telecommunications facilities to the extent necessary to carry out their duties in a professional, complete and competent manner.
- A thorough vetting process is completed to ensure that personnel and contractors have the requisite personnel, competence, skill, physical resources, and any required professional qualifications to perform the work and that it has and shall maintain the capability, experience, training, registrations, licenses, permits and governmental approvals required to perform the work.

CCS further assures that all construction will be performed and completed in full compliance with applicable local, state and federal standards. This includes the FCC's radio frequency energy exposure limits, standards, and signage requirements.

Examples of documents that demonstrate that the radio frequency energy exposure from existing and proposed facilities will not exceed the maximum permitted levels established by the FCC can be found in Exhibit E.

Operations Approach

CCS, through its parent Crown Castle International Corp ("Crown Castle"), provides operations support for all of our small cells/networks through real-time network monitoring and maintenance at no cost to the customer. Three primary operations roles support the small cell network:

- **Network Monitoring**—CCS, through its parent Crown Castle , operates a full-scale carrier grade Network Operations Center ("NOC") 7/24/365 days that monitors the small cell network status. This center has all the necessary backup and recovery procedures, along with a highly qualified in-house staff.

The NOC staff also provides first and second level troubleshooting which includes verification of commercial power availability, checking and resolving issues with network monitoring circuits and resetting of hub and node small cell equipment if necessary.

- **Network Operations**—The small cell Operations Manager supports third level troubleshooting, creation of uptime reports, tracking of RMA (Return Material Authorization) status, developing, and updating NOC troubleshooting procedures. The small cell Operations Manager is also responsible for keeping the City and wireless carrier contact information current and performing any required software upgrades of the small cell equipment.
- **Network Maintenance**—Field Technicians respond to network outages and perform periodic maintenance on the small equipment. They test and replace coaxial cable and fiber optic cable, inspect, troubleshoot and replace small cell hardware, and test and repair electrical systems, including battery backup units.

Details of the Crown Castle NOC Monitoring Services and the response times to address emergencies and services failures are outlined below.

CCS understands the critical need to respond to and resolve emergencies and service failures. Our resources will be available to respond to outages on a 24x7x365 basis in order to resolve issues as soon as possible. Response times are shown in the second chart on the next page.

Given, the reliance on wireless as either the primary or only means of communication by the majority of City residents and visitors, CCS respectfully requests that the City take the official position with Con Edison that any pole with critical communications infrastructure attached, including but not limited to, small cells, NYPD, FDNY, autonomous vehicle equipment, shall receive priority power restoration for the benefit of all New Yorkers. Con Edison has expressed their willingness to do this should the City make the request.

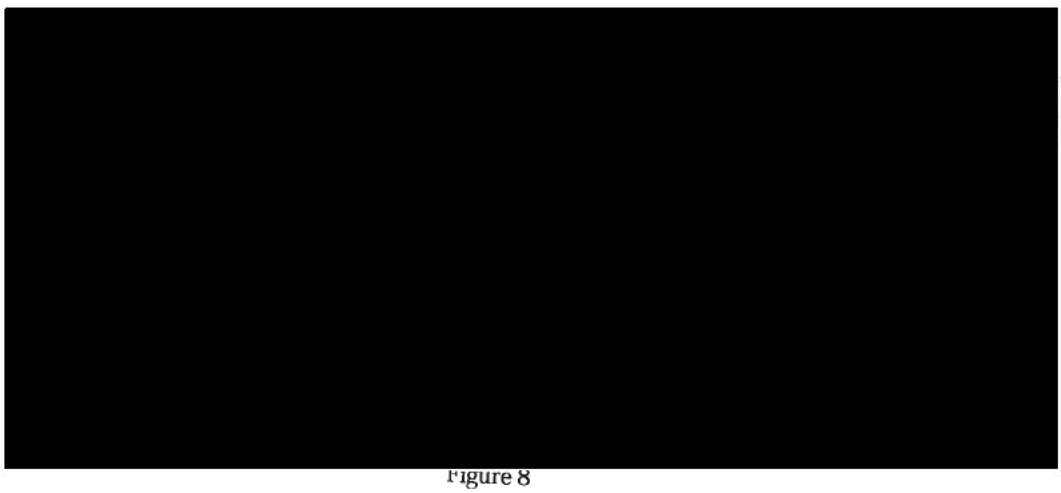


Figure 8

Figure 9

*After verification of alarm and generation of trouble ticket by NOC

**Note that minor non-service impacting notifications are only dispatched during business hours.

In the escalation table below, NOC staff and supervisors perform first and second level troubleshooting and operations engineers conduct third level troubleshooting.

Figure 10

REQUIREMENT

Maintaining City Property. Proposers plans for maintaining City property in good conditions during the term of the franchise.

RESPONSE

CCS will ensure all work is completed in accordance with DoITT, DOT and City design and building standards including but not limited to the DOT Highway Standards. CCS will work with DoITT, DOT and any other City agencies required to ensure that the pole, its foundation, any additional attachments on the pole are protected and not disrupted during any installation and/or removal by CCS. Should there ever be a problem that is the result of any work performed on behalf of CCS, CCS shall correct/repair such problem to the satisfaction of the DOT upon inspection and post-inspection.

In addition, CCS performs a thorough multi-point annual inspection and will dispatch a qualified technician to any location where there is an alarm for a visual inspection and/or required maintenance or repair. The multi-point annual inspection checklist is included in Exhibit F.

On at least an annual basis, CCS will perform the following scheduled maintenance:

Inspect equipment status lights, air filters, AC & DC power cables, fiber connector, RF cables, splitter, antenna, and perform battery inspection and maintenance, ensure all mounting brackets are secure and inspect for external hazards to the site, such as loose structures near antennas, leaning pole, bare cables, etc. Any issues or problems are to be escalated to the appropriate parties, internal or external to CCS and managed through to resolution;

REQUIREMENT

Deployment Timeframe. The time period during which the proposer anticipates installing the franchise facilities and, to the extent the proposer's system generally is not yet operational in the City, an anticipated time line for such system to become operational in the City.

RESPONSE

For new reservations, the desired timeframe to NTP granted is 90-120 days.

REQUIREMENT

Materials. *The material contemplated in subsection (a)(2) of Section 5 above;*

RESPONSE

The materials utilized for deployment consist of but are not limited to the following:

- Fiber
  - Singlemode Fiber
  - Typical (6) strands per node
- Shroud
  - Metal Shrouds
  - Plastic Shrouds
  - Fiberglass Shrouds
- Antennas
  - Square panel antennas
  - Omni directional whip antennas
    - Smaller Typical 2" -3" diameter. 4 feet in height
  - Omni directional canister antennas
    - Large Typical 24" diameter. 4 feet in height
    - Installed on MSL's, wood utility poles and custom poles
- Coax Cables
  - ¼" diameter cable can be used on metal street-lights to save space within pole at a shorter distance to antenna.
  - Typical ½" cable is run as a hardline to the antennas
- Power Cable/Line

- DC power Cable to power radios
- Hub Equipment
  - Switches
  - Routers
  - Fiber patch panels
  - Coax jumpers between Hub cabinets
  - Fiber jumpers between switches

REQUIREMENT

Agreement of Termination of Existing Franchise Statement. Existing Franchisees who obtain a franchise under the terms of this RFP must agree to the termination of their existing franchise(s). A statement acknowledging such agreement must be included in this proposal.

RESPONSE

CCS acknowledges and agrees that the granting of a new franchise under this RFP shall terminate the existing franchise that CCS holds, even if the term of the original franchise has not yet expired. Nothing in this submission shall be construed as a waiver of any of the rights, privileges and remedies conferred upon CCS under current or future local, state or federal law or any controlling authority.

2. Legal and Managerial Proposal

REQUIREMENT

Indicate the extent the proposer has secured any necessary authorizations, approvals, licenses and/or permits required to undertake the activities proposed and an acknowledgement that the proposer will not undertake such activities unless and until such authorizations, approvals, licenses and/or permits are obtained (for any system and/or equipment that requires FCC licensing, the proposer must confirm in its proposal that such system and/or equipment is, or will be prior to installation, fully licensed by the FCC

RESPONSE

As a current franchise holder, CCS is familiar with all Federal, State and City requirements necessary to deploy the contemplated equipment in the City Right of Way. As it has historically done, CCS will obtain all necessary approvals prior to deployment.

CCS provides telecommunications services. Specifically, it carriers voice and data traffic handed off to it by its customers, who are usually, but not exclusively, wireless service providers. It carries such traffic through Crown Castle's fiber optic lines from antennas located on utility poles in the ROW to a central location, commonly referred to as a "hub", and from there, either back to another remote location or out to the public switched telephone network or Internet. CCS shall confirm that its wireless service provider customers maintain all necessary licenses—FCC or otherwise—required by State or Federal law.

REQUIREMENT

Describes the managerial experience and capabilities of the proposer;

RESPONSE

Who is Crown Castle Solutions?

Crown Castle together with its subsidiaries is a customer-focused, neutral host organization that builds and maintains shared broadband infrastructure to support all broadband delivery technologies. Our comprehensive portfolio of towers, small cells, site access, and fiber provides fixed and wireless access to essential data, technology, and services, for people and communities. Our extensive network infrastructure and deep experience in operating as a neutral host opens the door to countless opportunities and possibilities to expand broadband services.

Crown Castle owns and operates approximately 40,000 cell towers and 60,000 route miles of fiber supporting small cells and fiber solutions across every major US market. This nationwide portfolio of communications infrastructure connects cities and communities to essential data, technology and wireless service – bringing information, ideas and innovations to the people and businesses that need them. We have over 15 years of experience building small cell solutions networks in over 500 municipalities around the country and currently have more than 60,000 small cell nodes on air or under contract.

Company Background:

Crown Castle has been in the business of owning and operating network assets for over 20 years. We recently strengthened that commitment with the acquisition of eight regional fiber providers, including Sunesys, Fibernet Direct, Wilcon and Lightower.

In addition to a larger footprint and expanded solutions, our combined team now brings years of valuable experience and expertise to our fiber customers.

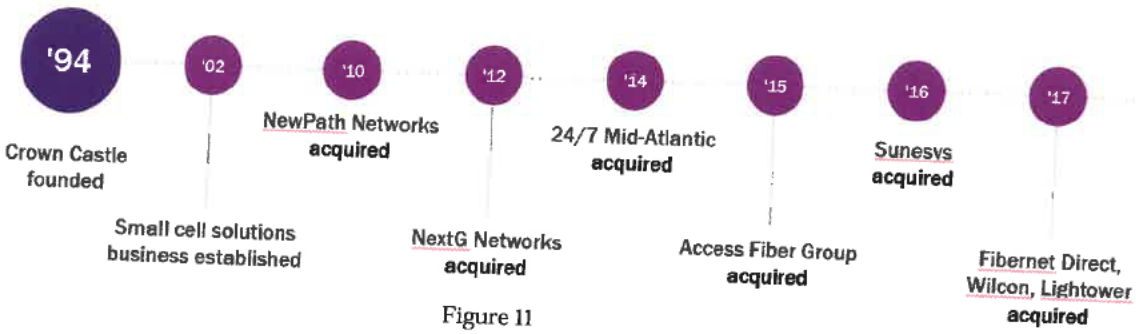


Figure 11

The demand for DAS is growing rapidly, and CCS has the expertise, strength and long-term commitment to support its continued growth. Crown Castle is a customer-focused organization with an in-market presence supported by more than 100 regional offices across the U.S. Each regional office is led by a district manager who has complete

responsibility for their assets. The district manager is supported by a district team, which includes project managers, construction managers, project coordinators, property specialists, tower structural analysts and account executives. Their roles are to properly manage the assets, and support and/or manage customer installations ensuring projects are completed on time and within budget. In addition, they ensure that our sites continue to offer industry leading co-location opportunities. This in-market presence has allowed our teams to develop long-standing relationships with local jurisdictions and customers. In addition, these relationships and our in-market knowledge have led to reduce the installation time of wireless carriers on our towers and DAS networks.

The areas provide complete staff support including: service delivery, finance, property, regulatory, licensing, legal, engineering and field operations personnel. This staff provides additional support to our districts in the daily operation of our tower assets and support of our customer application process. Area offices are supported by the organization's headquarters in Pittsburgh and Houston.

Figure 12

Network Operations Center Services

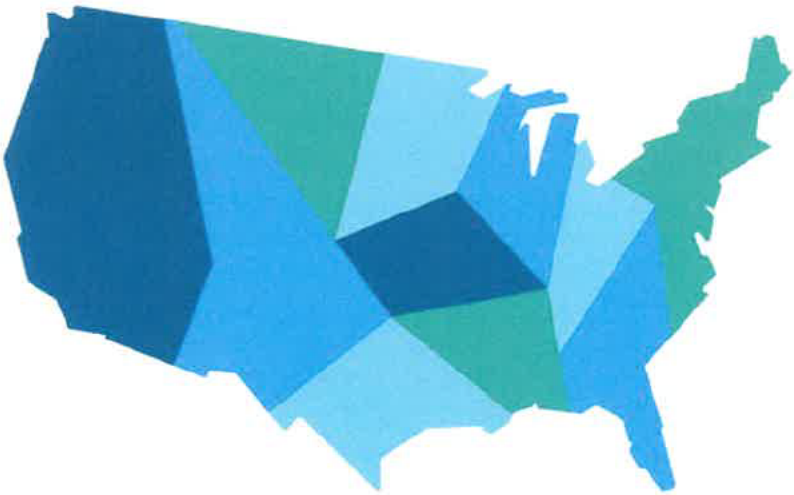
We maintain and manage an extensive database of approved contractors throughout the country that provide services such as site acquisition, construction, construction management, engineering, and drive testing. We are serious about our customer relations, and monitor our customers' sentiment by sending out an in-depth customer survey on a quarterly basis.

Our infrastructure connects people to essential data, technology and wireless service—and transforms everything around us.

- **People:** We connect people to the devices, apps, and data they rely on to communicate, stay informed, and live their lives to the fullest.
- **Communities:** We provide connections that improve safety and efficiency and make communities better places to live. We give police officers, firefighters, and EMTs secure access to the information they need to react quickly to emergencies. We help deploy exciting new technologies that build smarter communities and create new opportunities for cities and technology companies alike.
- **Businesses and organizations:** We make sure businesses and other large organizations have secure access to the essential data and applications they need to embrace new technologies and stay ahead. Our fast, secure fiber networks support new learning technologies in schools and promote groundbreaking research

in higher education. We give stadiums, convention centers, amusement parks, and other venues the wireless coverage and capacity to accommodate large crowds.

Crown Castle, through various subsidiaries, provides wireless carriers with the infrastructure they need to keep people connected and businesses running. With its portfolio of towers and small cell nodes supported by fiber, Crown Castle is the nation's largest provider of shared wireless infrastructure with a significant presence in the top 100 US markets with a total enterprise value of over $62 billion dollars. Crown Castle's diverse network infrastructure portfolio, coupled with more than 49 offices strategically located across the U.S. and with more than 5,000 employees, provides Crown Castle intimate local knowledge of each of its assets



40,000+
towers

approximately
60,000
small cells on air or under contract

approximately
60,000
route miles of fiber

Figure 13

Strength and Stability

Crown Castle is an S&P 500 company listed on the NYSE, and has established itself as a REIT (real estate investment trust).

Key Financial Information about Crown Castle:

- A "Fortune 1000" company
- Traded on the New York Stock Exchange (Ticker Symbol: CCI)
- Total revenue of more than $3.5 billion
- Total enterprise value of more than $44 billion

Crown Castle is publicly traded and subject to Sections 13 and 15(d) of the Securities Exchange Act of 1934. Annual reports on Form 10-K can be found under the investors section at www.crowncastle.com. The 2017 Annual Report is included in Exhibit F.

Crown Castle has over 20 Professional and NCAA Division 1 Sports Venues on-air, under construction or under contract. Our DAS networks have supported such diverse events such as the NFL's Big Game in 2008, Fiesta Bowls, BCS Championship games, Mardi Gras Celebrations, and the 2012 NBA All-star game. In addition, CCS has a network on-air at the University of Phoenix Stadium in Glendale, AZ, site of the 2015 NFL's Big Game.

By designing, developing, and operating cost-effective fiber-fed DAS networks, CCS helps clients improve signal strength and network capacity and coverage. Specializing in indoor and outdoor DAS solutions for the private and public sector, we offer industry-leading expertise across a variety of markets including:

- Colleges and universities;
- Venues, including stadiums, arenas and theme parks;
- Hotels, resorts, casinos;
- Densely populated urban areas;
- Public Right-of-Ways

REQUIREMENT

Describes whether the facilities proposer proposes to install on City poles will be serving one or multiple telecommunications service providers.

RESPONSE

Our networks employ a neutral host model, which means that multiple carriers can share the same infrastructure. A neutral host network establishes a single economical platform and integrates all providers who seek to conduct consumer-based business and provide wireless broadband or fiber services to the served locations. Once a neutral host network point is established, it becomes available to share with all providers who wish to deliver consumer based broadband services.

As the largest and most established neutral host provider nationwide, Crown Castle has the experience and resources to provide broadband platforms to all market entrants servicing the residents, businesses, and government institutions of New York. As a current neutral host partner in New York, Crown Castle and its affiliates have built and maintained infrastructure that directly and indirectly supports consumers of broadband technology across all five boroughs. Crown Castle's City presence is substantial, local and involved.

The existing Approved Equipment (Exhibit A) may have met network demand when the original franchise was granted in 2007. Over a decade later, a new landscape has been shaped with the increase in wireless use not only

for voice but also for data and the technologies that rely on data – including Smart City technologies, IoT, consumer, business and municipal demand.

Mobile use accounts for over 70% of internet use worldwide. That number will continue to grow according to Zenith Media (see article and figure to the right)[3]. CCS's commitment to building and maintaining infrastructure to support this future mobile demand can be leveraged in New York.

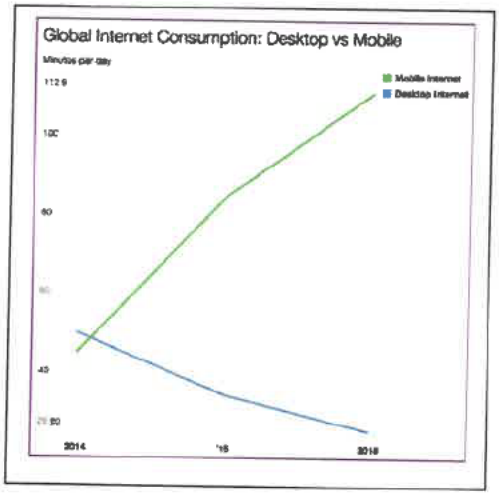


Figure 14

Crown Castle Solutions Organizational Chart and Points of Contact:

The below organizational chart reflects the names and titles of the executive and senior leadership and local points of contact responsible for operating the proposer's system.

Jay Brown
President & CEO

Robert Ackerman
SVP & COO

Cathy Pichet
East Area President

Lewis Kessler
East VP General Manager

Amir Abtahi
Implementation Director

Rory Whelan
Government Relations Director

Herb Drake
Operations Director

Betti Danti
Finance Director

Beryl Oremland
Human Relations Director

CCS or its subsidiaries has a local presence in the City with its Northeast Regional office in Whitestone, Queens employing over 250 employees in the City. In addition, CCS relies on over 1000+ vendor partners in New York State, which provides jobs to New York based companies many of which are City companies. The local team who handle the day-to-day operations are as follows:

Hanafi Bradai Radio Frequency Manager

Scott Debow
Operations Manager

Eli Elbaum
Government Relations Counsel

Morten Jespersen
District Manager

Esme Lombard
Government Relations Manager

[3] Zenith Media Article: "Mobile Expands its Global Share of Internet Use" (October 16, 2017). Link: https://www.warc.com/newsandopinion/news/mobile_expands_its_global_share_of_internet_use/39441

REQUIREMENT

Financial Capacity Proposal

RESPONSE

Key financial information about Crown Castle:

- Founded in 1994
- Member of the Standard and Poor's 500 Index
- A "Fortune 1000" company
- Total revenue of more than $3.5 billion (full year 2017 Outlook)
- Total enterprise value of more than $50 billion (As of 2/15/17)

A copy of the Investor Relations Presentation is attached in Exhibit F. The annual reports on Form 10K can be found on the investor's page at www.crowncastle.com.

4. Scope Proposal

REQUIREMENT

A statement as to which of the three zone options (A and/or B and/or C).

RESPONSE

Crown Castle Solutions LLC seeks a franchise that will include Zones A, B and C.

5. Compensation Proposal

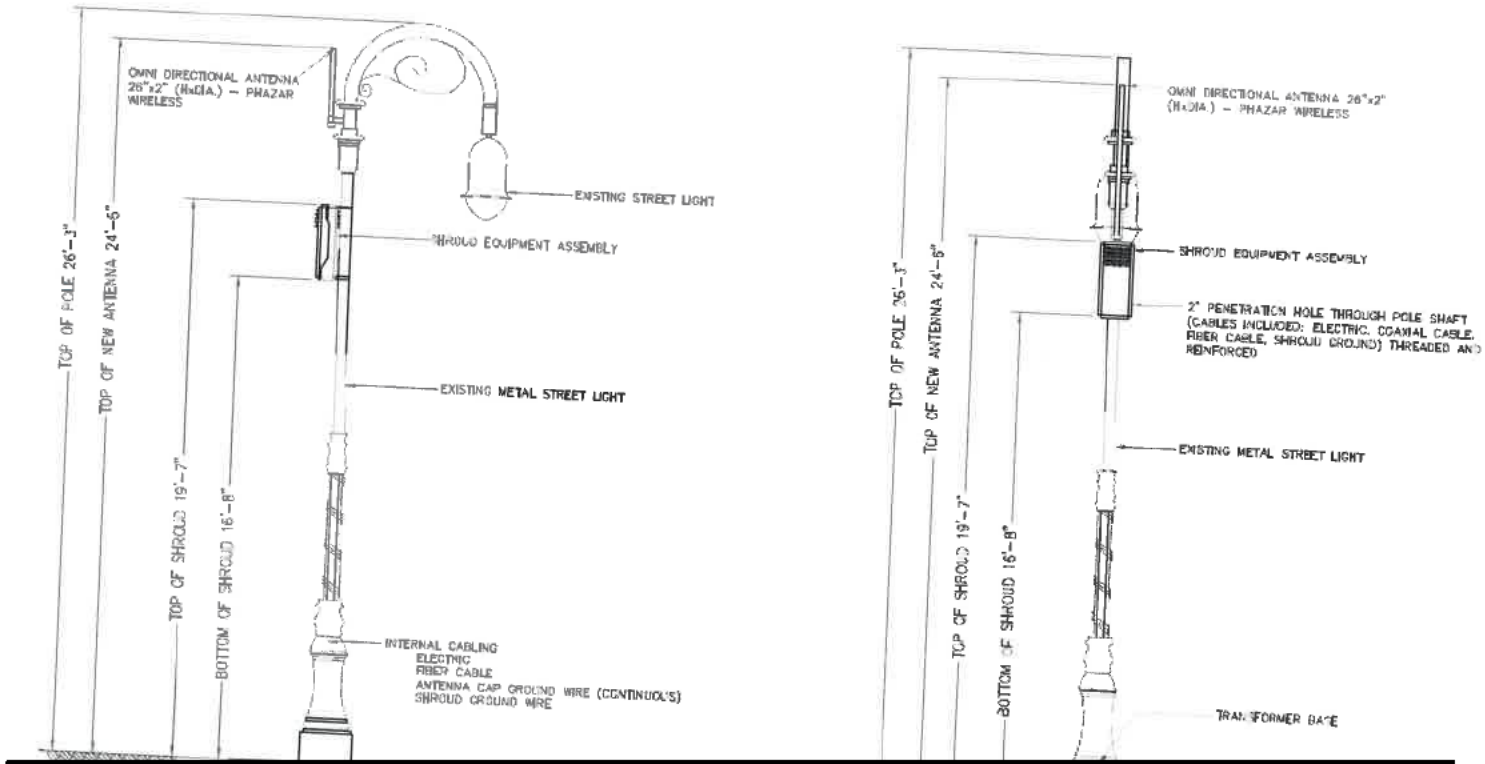
The contents of the Compensation Proposal are contained in the attached Confidential and Proprietary "Proprietary Information" attachment.

Exhibit A:
Proposal: Current DoITT Approved Configuration for Zones A,B & C

Exhibit A: Proposal - Current DoITT Approved Configuration for Zones A,B & C

Bishops Crook Style Pole – Sample Drawing

Pole Elevation

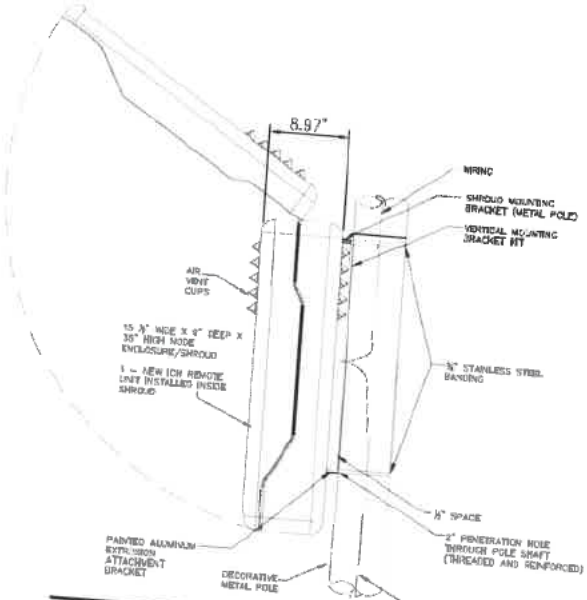


[redacted]

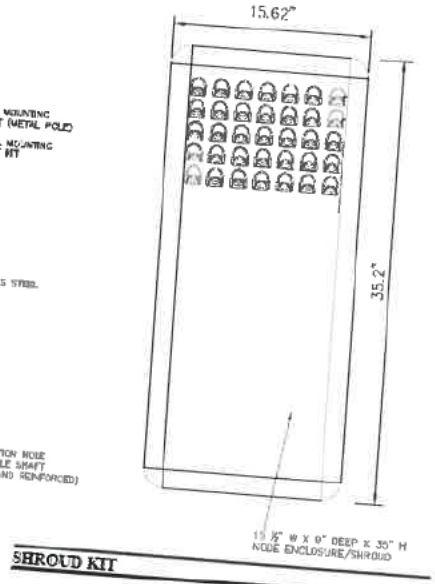
Exhibit A: Proposal - Current DoITT Approved Configuration for Zones A,B & C

Bishops Crook Style Pole – Sample Drawing

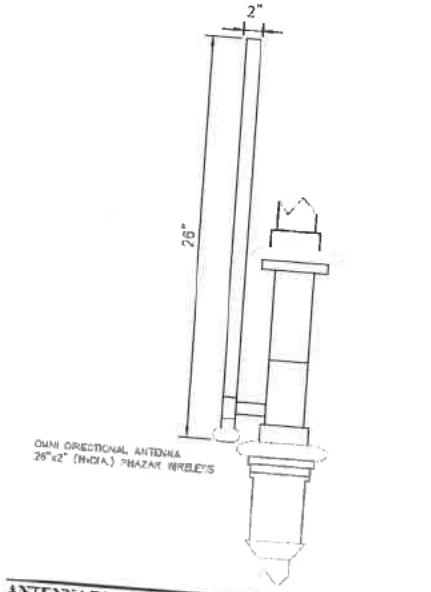
Mounting Detail



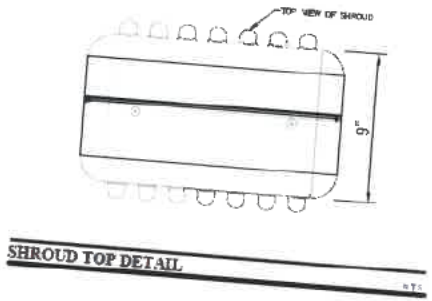
SHROUD DETAIL



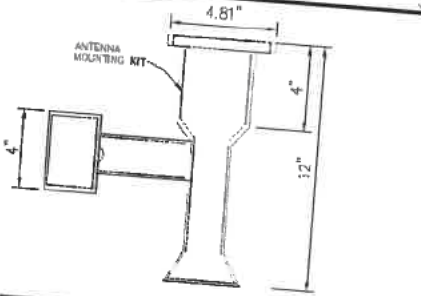
SHROUD KIT



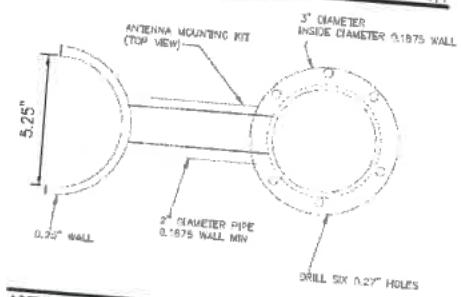
ANTENNA DETAIL



SHROUD TOP DETAIL



ANTENNA MOUNTING DETAIL

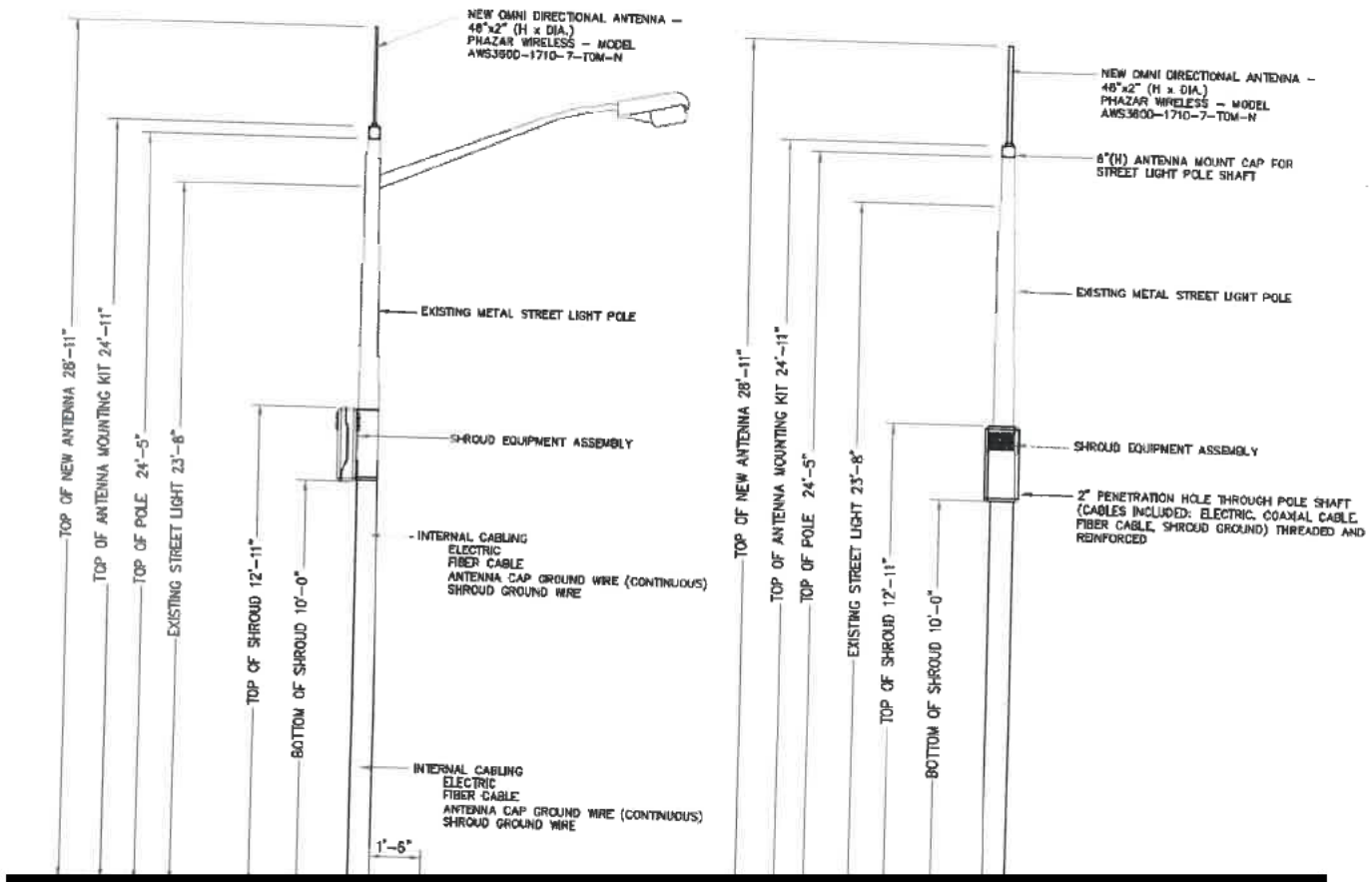


ANTENNA MOUNTING DETAIL (TOP VIEW)

Exhibit A: Proposal - Current DoITT Approved Configuration for Zones A,B & C

FS Style Pole – Sample Drawing

Pole Elevation

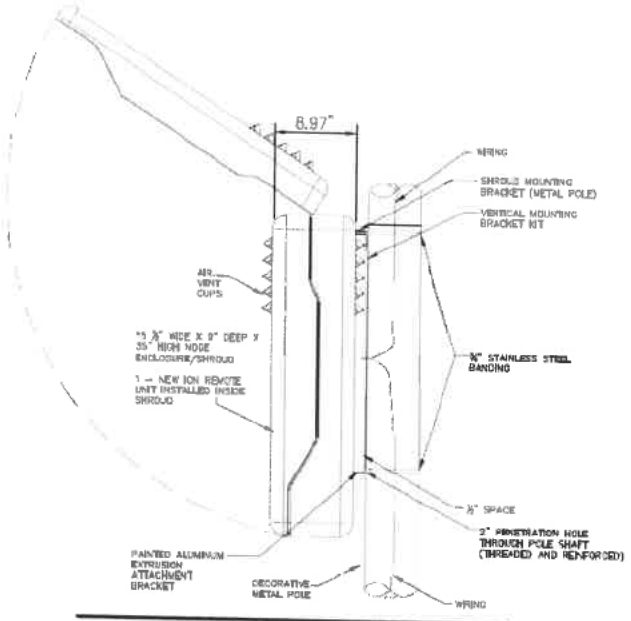


[redacted]

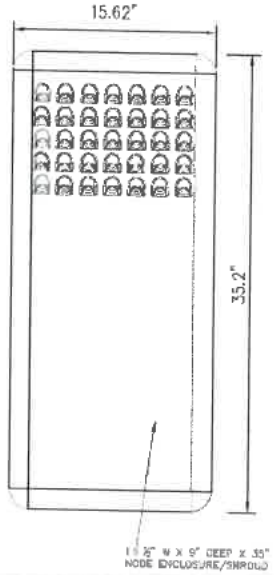
Exhibit A: Proposal - Current DoITT Approved Configuration for Zones A,B & C

FS Style Pole – Sample Drawing

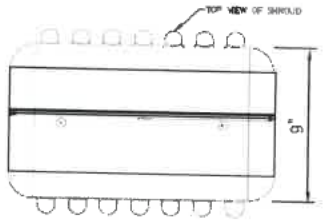
Mounting Detail



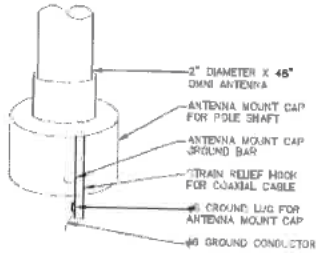
SHROUD DETAIL



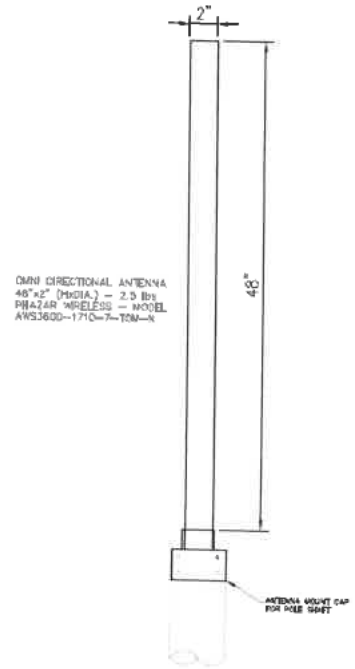
SHROUD KIT



SHROUD TOP DETAIL



ANTENNA MOUNTING DETAIL

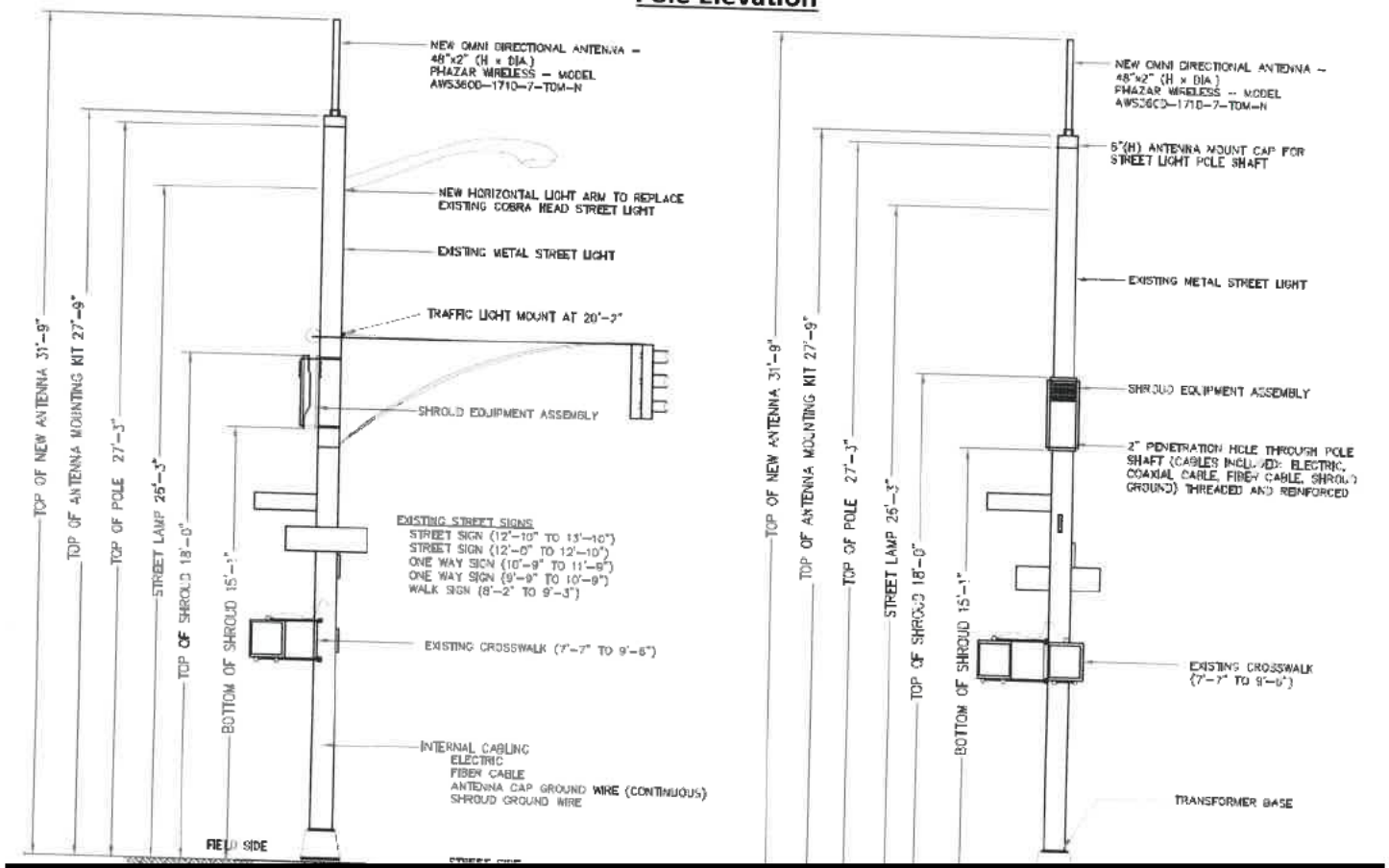


ANTENNA DETAIL

Exhibit A: Proposal - Current DoITT Approved Configuration for Zones A,B & C

M2 Style Pole – Sample Drawing

Pole Elevation

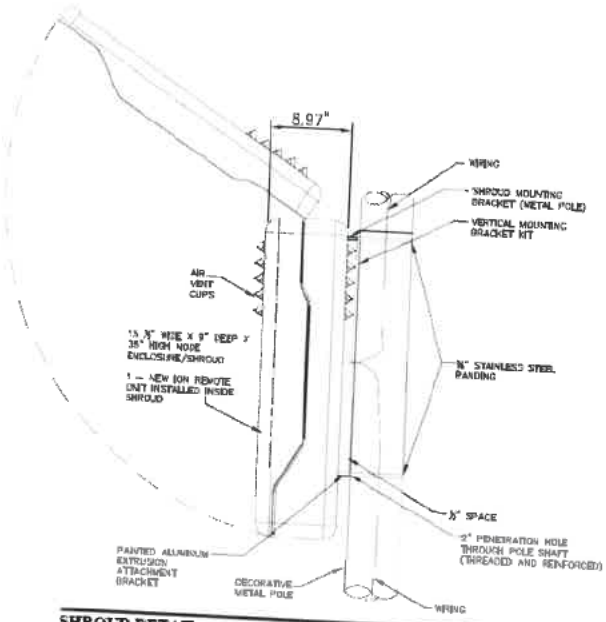


[redacted]

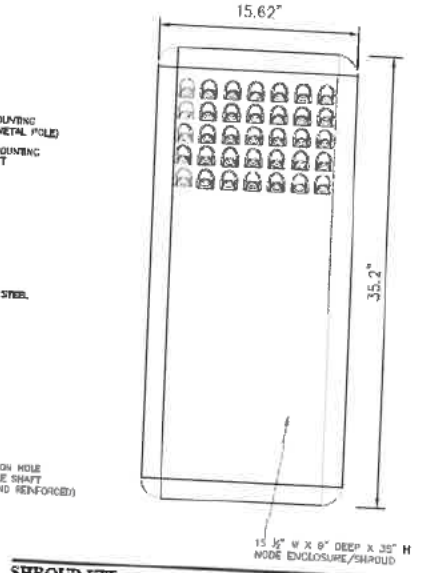
Exhibit A: Proposal - Current DoITT Approved Configuration for Zones A,B & C

M2 Style Pole – Sample Drawing

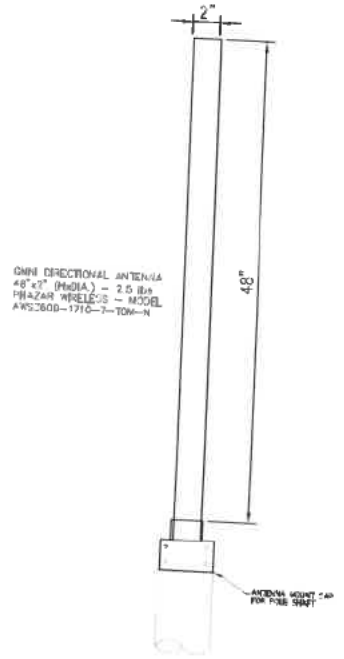
Mounting Detail



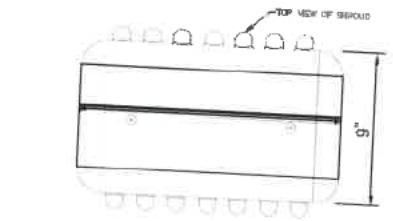
SHROUD DETAIL



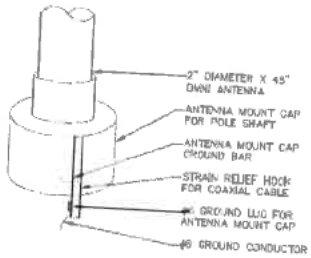
SHROUD KIT



ANTENNA DETAIL



SHROUD TOP DETAIL



ANTENNA MOUNTING DETAIL

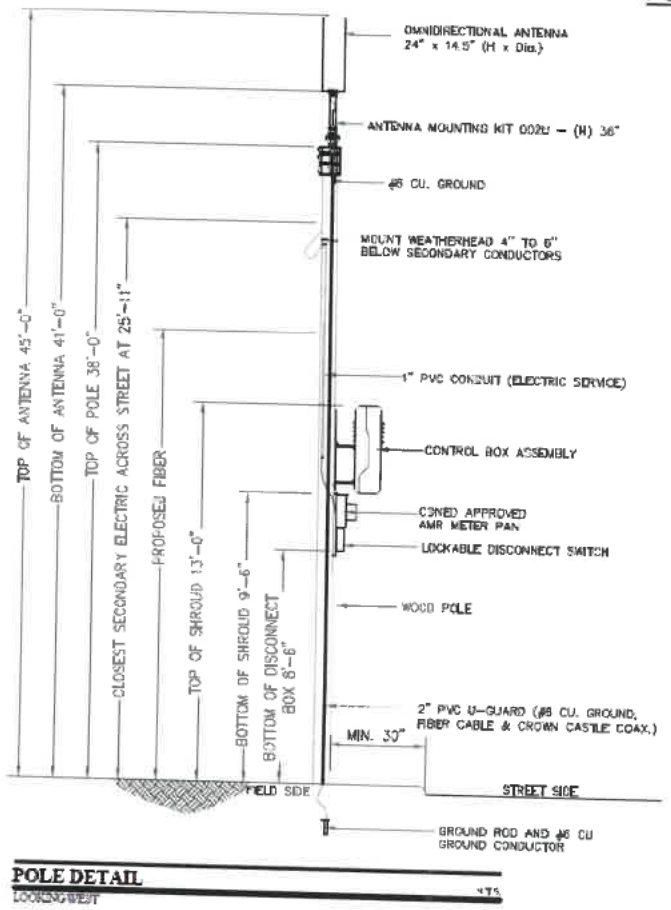
Exhibit B-1:
Pole Attachment Utility Approved Specification for Zones B & C

Exhibit B-1:

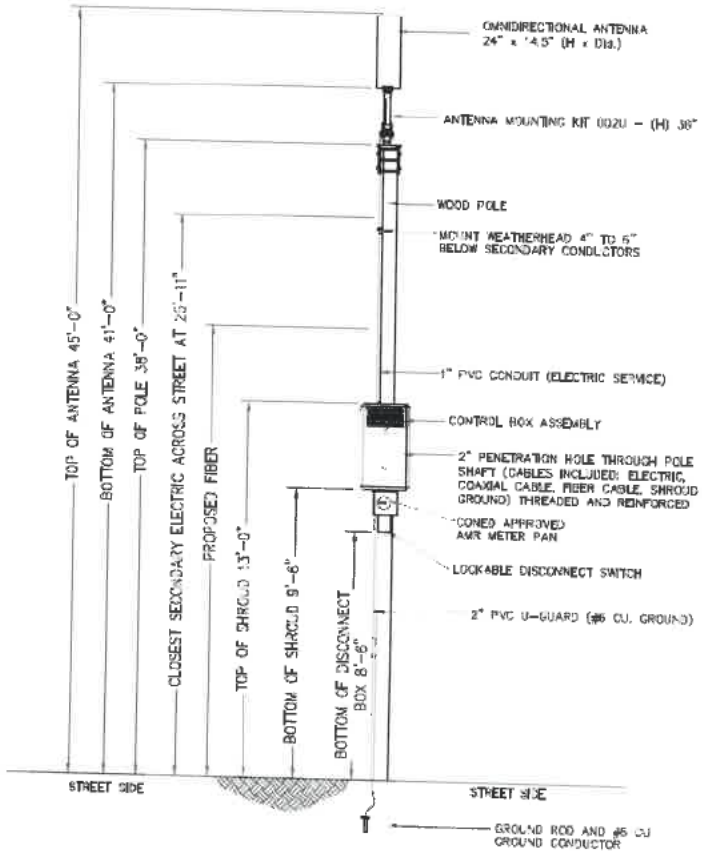
Pole Attachment Utility Approved Specification for Zones B & C

Pole Top Installation on Utility Pole using ConEd Approved Specifications

Pole Elevation



POLE DETAIL
LOOKING WEST



POLE DETAIL
LOOKING SOUTH

Exhibit B-1:

Pole Attachment Utility Approved Specification for Zones B & C

Pole Top Installation on Utility Pole using ConEd Approved Specifications

Mounting Detail

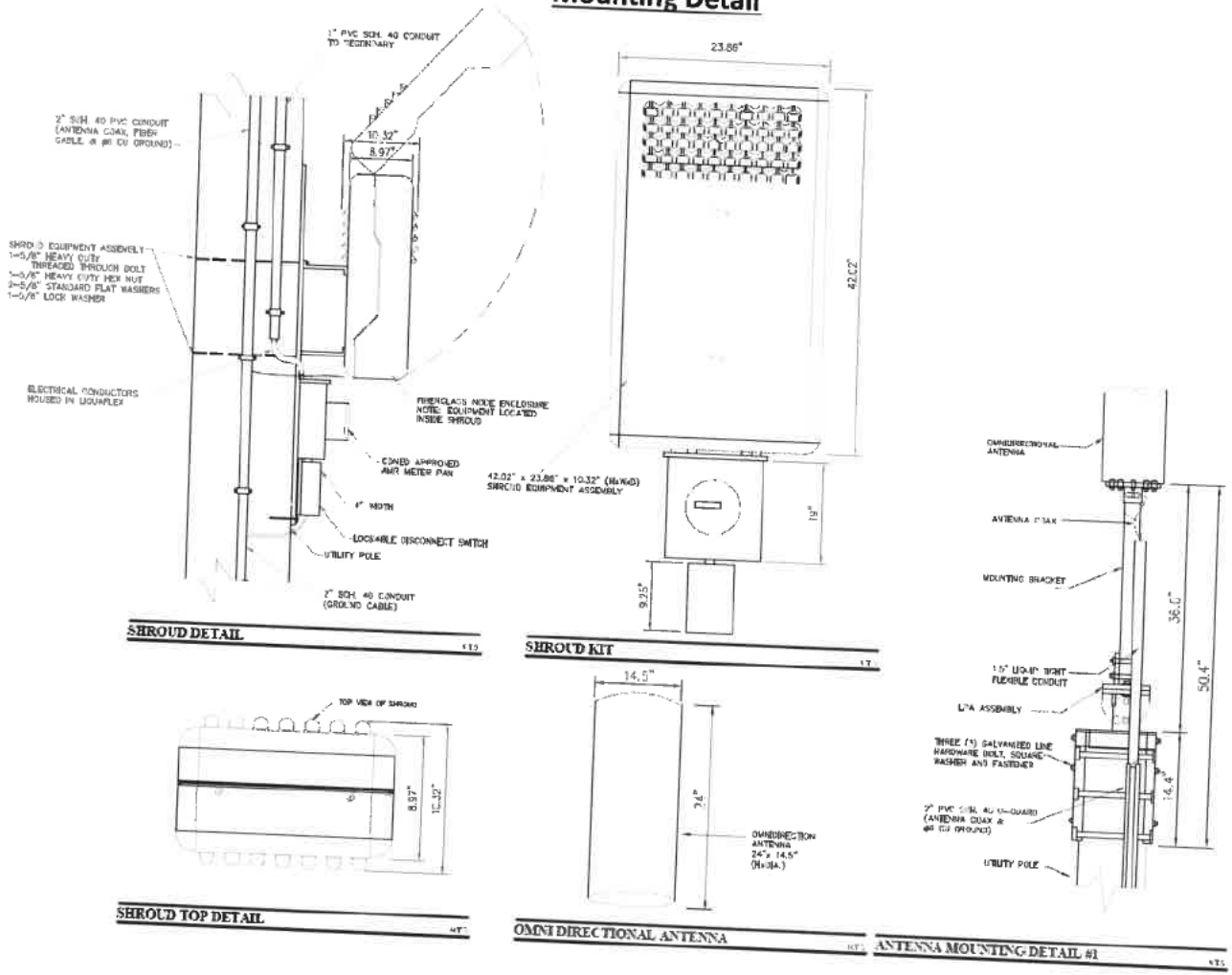


Exhibit B-1:

Pole Attachment Utility Approved Specification for Zones B & C

Pole Top Installation on Utility Pole using ConEd Approved Specifications

Photo Simulations

Current DoITT Approved Spec

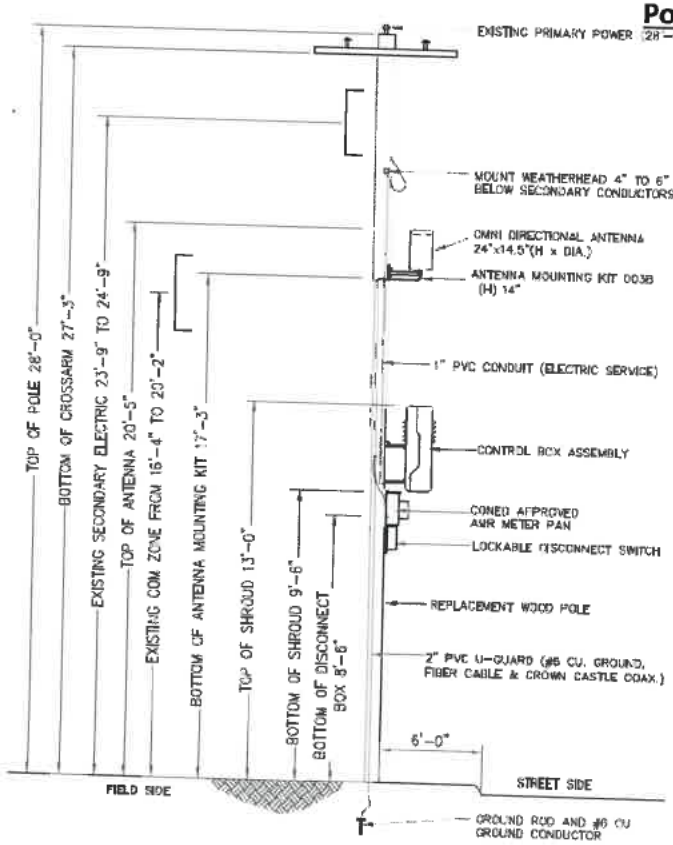
Current ConEd Approved Spec

Exhibit B-1:

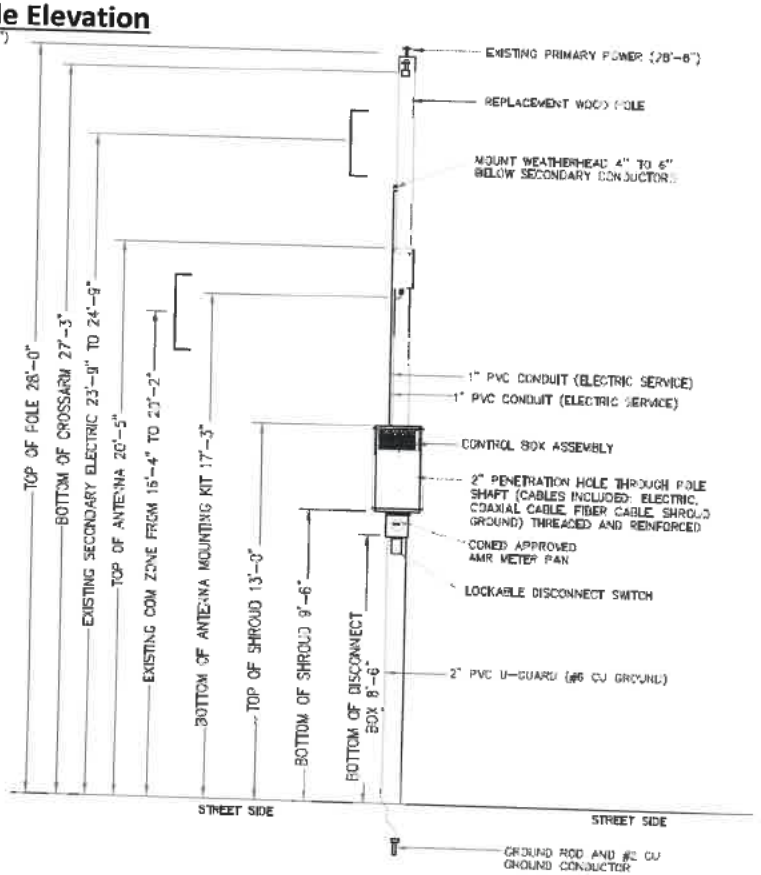
Pole Attachment Utility Approved Specification for Zones B & C

Comm Zone Installation on Utility Pole using ConEd Approved Specifications

Pole Elevation



AS BUILT POLE DETAIL
LOOKING NORTH N.T.S



PROPOSED POLE DETAIL
LOOKING WEST N.T.S

Exhibit B-1:

Pole Attachment Utility Approved Specification for Zones B & C

Comm Zone Installation on Utility Pole using ConEd Approved Specifications

Mounting Detail

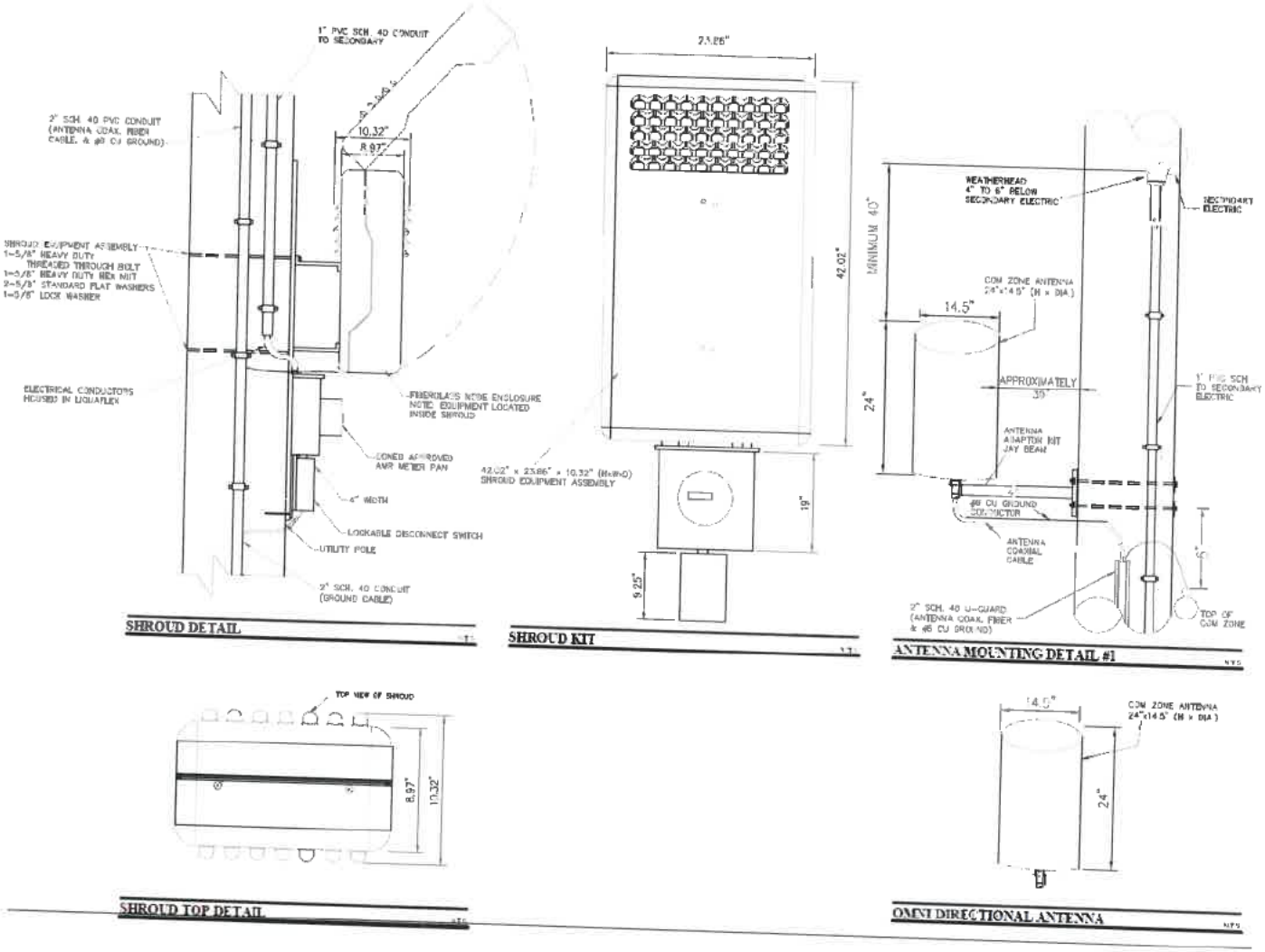


Exhibit B-1:

Pole Attachment Utility Approved Specification for Zones B & C

Comm Zone Installation on Utility Pole using ConEd Approved Specifications

Photo Simulations

Current DoITT Approved Spec

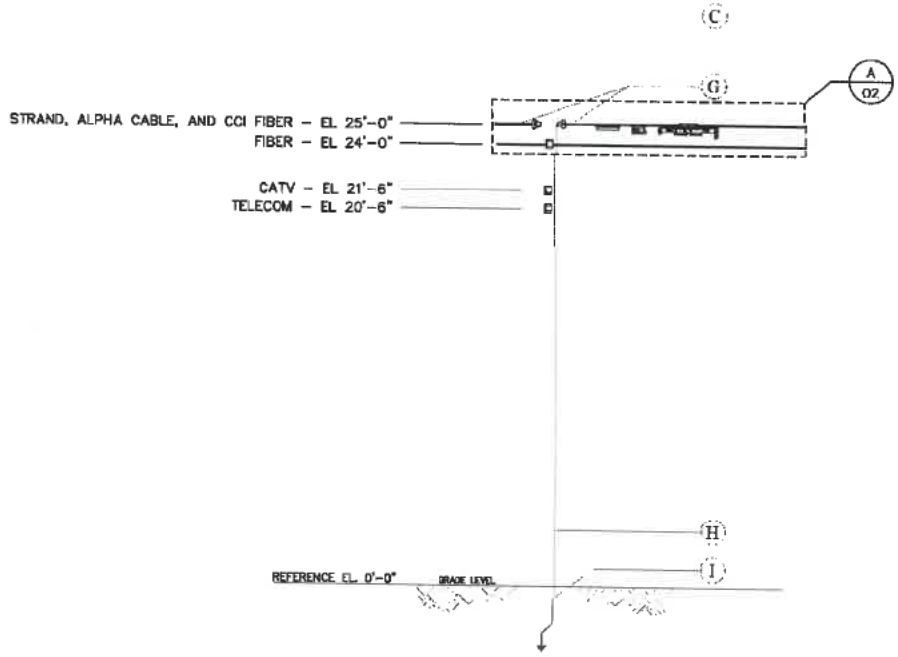
Current ConEd Approved Spec

Exhibit B-2:
Strand Mount Utility Approved Specifications for Zones B & C

- Exhibit B-2 - #1 Two Radios Strand Mounted without Power Supply
- Exhibit B-2 - #2 Two Radio Strand Mounted Solution with Associated SE41 Power Supply
- Exhibit B-2 - #3 SE41 Power Supply Cabinet Mounted on a Utility Pole
- Exhibit B-2 - #4 Two Radio Strand Mounted Solution with Associated TE33 Power Supply
- Exhibit B-2 - #5 TE33 Power Supply Cabinet Mounted on a Utility Pole

Two Radios Strand Mounted without Power Supply - Exhibit B-2 #1

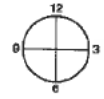
CROWN CASTLE NG EAST
POLE CONFIGURATION



EXISTING POLE DETAIL
LOOKING AT 12:00

TOP VIEW OF POLE

QUADRANT LOCATION
OF EQUIPMENT



Street Side

Note: Equipment quadrant may vary per utility or condition.

NOTE:
STRAND MOUNT

BILL OF MATERIALS:

(A) INSTALL STRAND MOUNT ANTENNA
2 – ERICSSON 6503 ANTENNAS
7.85" x 7.87" x 5.90" (w/mtg) – 15 lbs ea.

(B) INSTALL RADIO 2203 STRAND MOUNT – DUAL PANEL ANTENNA W/ COUNTER WEIGHT AND DIPLEXERS
27.1" x 22.50" x 12.24" (cubed) – 45 lbs

(C) EXISTING POLE TO REMAIN
EXISTING POLE (40' WOOD)
TYPE 1/H2 – CLASS 2
HEIGHT 38'–6" (AGL)

(D) INSTALL REMOTE RADIO UNITS
2 – ERICSSON 2203 UNITS
7.9" x 7.9" x 3.9" (W/Mtg) – WEIGHT INCLUDED IN ITEM B

(E) INSTALL DC CONVERTERS
2 – ALPHA WIRELESS – XP040-150-P00
2.8" x 10" x 5.5" (W/out) – 4.3 lbs ea.

(F) INSTALL 3M BLC AERIAL CLOSURE
MODEL BLC-2.2X10 – 100 PAIR
14" x 2.2" (Hd) – 2.6 lbs

(G) STRAND, 50 PAIR AND ALPHA CABLE AND FIBER CABLE

(H) INSTALL WIRE, #4 SOL. CU GROUND CONDUIT 20
MOUNTING, 1/2" ID x 6" LG. STAPLE, 1/2" x 2", GALV.

(I) INSTALL GROUND ROD, 5/8" x 8' LG CU. PLATED

ENG INFO:
hbk ENGINEERING
HBK ENGINEERING, LLC
[illegible]
STATE OF ILLINOIS DEPARTMENT OF PROFESSIONAL REGULATION
LICENSE NO. 184.007200

CROWN CASTLE

TITLE:
CROWN CASTLE NG EAST
EXISTING POLE WITH STRAND MOUNT
DAS EQUIPMENT

REVISIONS

REV	DATE	DESCRIPTION	BY
02	10-16-17	PER CC COMMENTS	AMW
01	10-11-17	PER CC COMMENTS	AMW
00	10-10-17	PER CC COMMENTS	AMW
00	10-04-17	PER CC COMMENTS	AMW

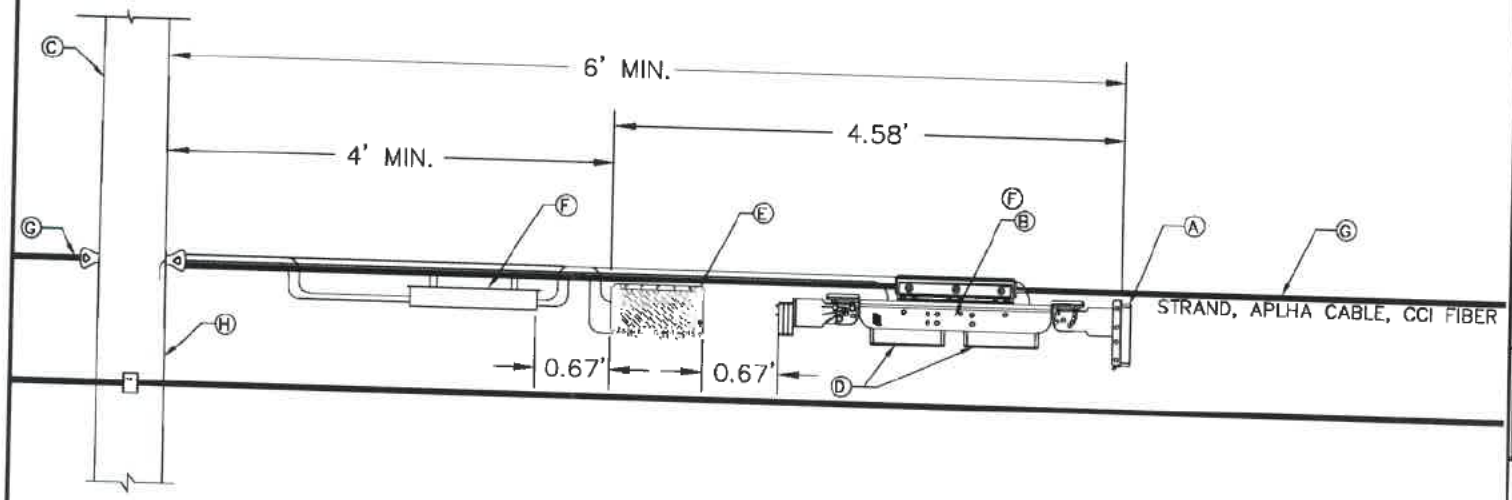
DRAWN BY:	CHECKED BY:	APPROVED BY:
AMW	JFM	MEC

PROJECT NUMBER:	17-5275
FILE NAME:	STRAND MOUNT
DATE STAMP:	10-16-17
SCALE:	AS SHOWN

SHEET: 1 OF: 2

Two Radios Strand Mounted without Power Supply - Exhibit B-2 #1

CROWN CASTLE NG EAST
PROPOSED EQUIPMENT DETAILS



DETAIL 'A'

MODE:
STRAND MOUNT

LIST OF MATERIALS:

(A) INSTALL STRAND MOUNT ANTENNA
2 – ERICSSON 8843 ANTENNAS
7.83" x 7.83" x 0.98" (HxWxD) – 1.0 lbs ea.

(B) INSTALL RADIO 2203 STRAND MOUNT – DUAL PANEL ANTENNA W/ DIPLEXER MOUNT AND DIPLEXERS
37.1" x 15.39" x 12.24" (LxWxD) – 40 lbs

(C) EXISTING POLE TO REMAIN
EXISTING POLE (48' 1600#)
TYPE LINE – CLASS 2
HEIGHT 39'-6" (AGL)

(D) INSTALL REMOTE RADIO UNITS
2 – ERICSSON 2203 UNITS
7.9" x 7.4" x 5.5" (HxWxD) – WEIGHT INCLUDED IN ITEM B

(E) INSTALL DC CONVERTERS
2 – ALPHA WIRELESS – DR48-100-P58
3.8" x 10" x 5.3" (HxWxD) – 4.2 lbs ea.

(F) INSTALL 3M SLIC AERIAL CLOSURE
MODEL: SLIC-2.2ITS – 100 PAIR
14" x 5.3" (HxD) – 3.1 lbs

(G) STRAND, 50 PAIR ARD ALPHA CABLE AND FIBER CABLE

(H) INSTALL WIRE, #4 SOL. CU GROUND COVERED 3D MOLDING, 1/2" D x 8' LG., STAPLE, 1/2" x 2", GALV.

(I) INSTALL GROUND ROD, 5/8" x 8' LG CU. POINTED

hbk ENGINEERING
HBK ENGINEERING, LLC
921 WEST VAN BUREN, SUITE 100
CHICAGO, IL 60607
PHONE: 630-735-0775 LICENSED BUSINESS
STATE OF ILLINOIS DEPARTMENT OF PROFESSIONAL REGULATION
LICENSE NO. 184.010218

OWNER/DEVELOPER:
CROWN CASTLE

TITLE:
CROWN CASTLE NG EAST
EXISTING POLE WITH STRAND MOUNT
DAS EQUIPMENT

REVISIONS

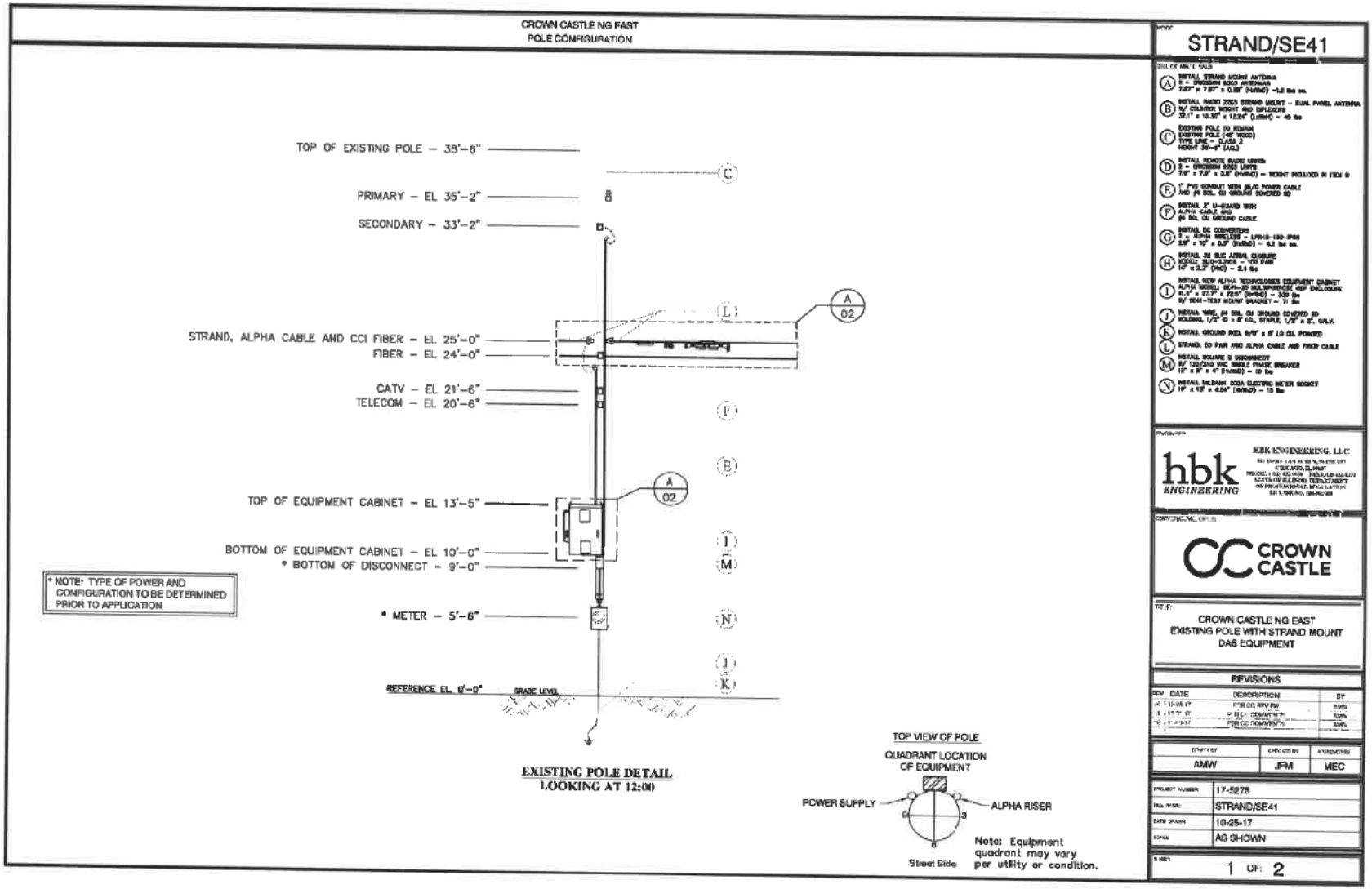
REV	DATE	DESCRIPTION	BY
00	10-16-17	FOR CC REVIEW	AMW
01	10-18-17	[illegible]	AMW
02	10-24-17	PER CCI COMMENTS	AMW
03	10-31-17	[illegible]	AMW

DRAWN BY	CHECKED BY	APPROVED BY
AMW	JFM	MEC

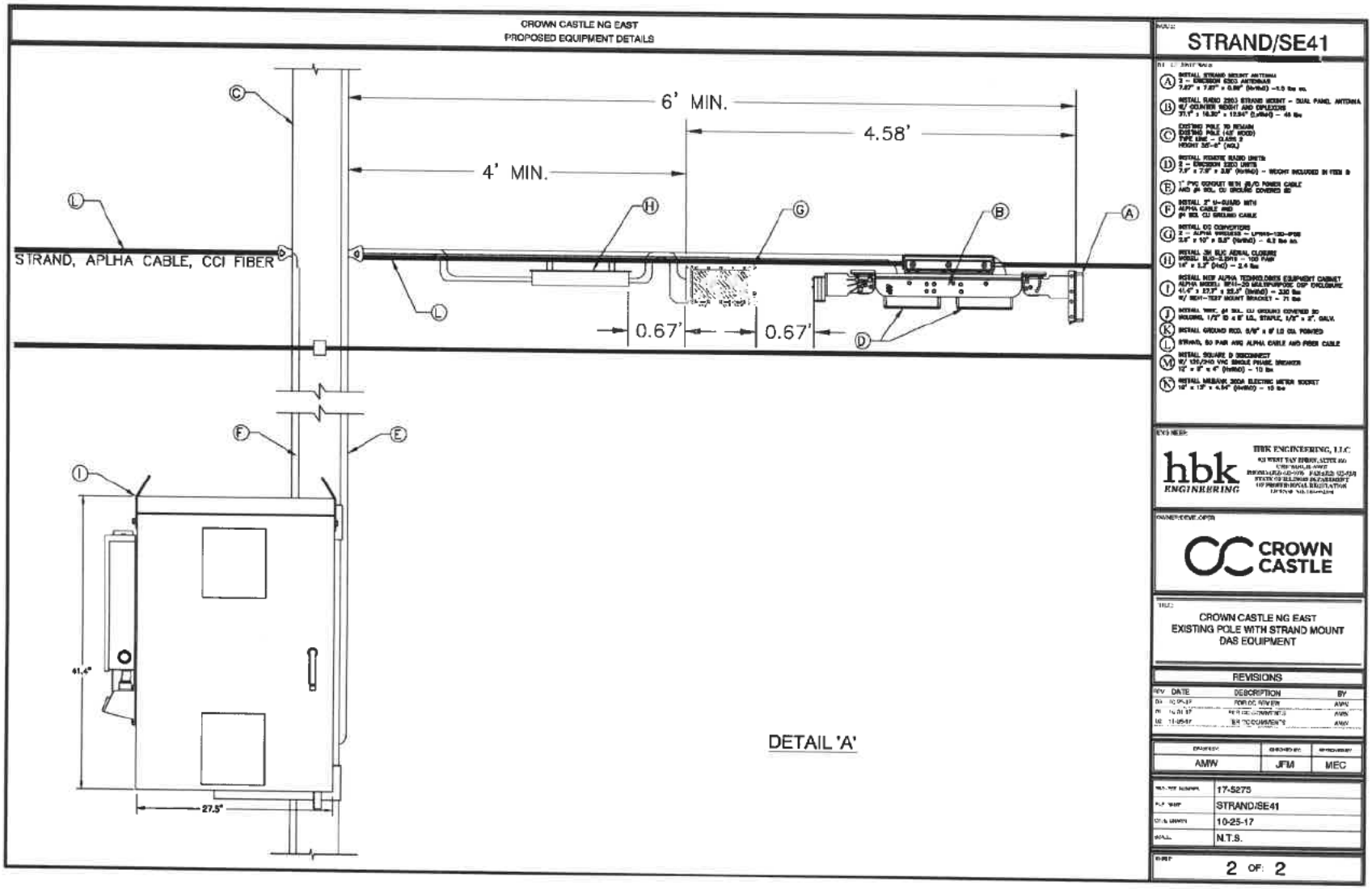
PROJECT NUMBER	17-5275
SHEET NAME	STRAND MOUNT
SHEET SIZE	10-16-17
SCALE	N.T.S.

SHEET NO. 2 OF: 2

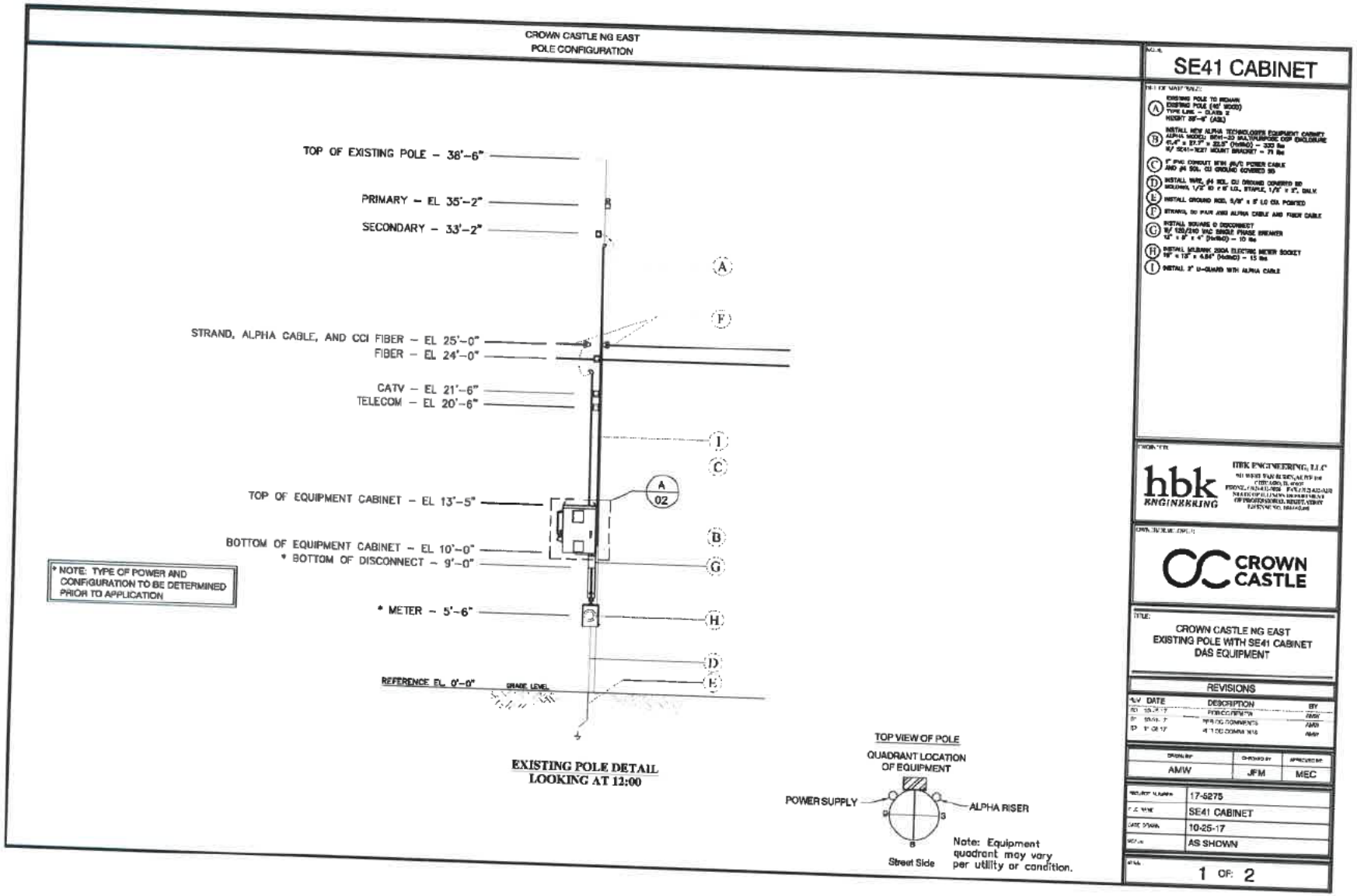
Two Radio Strand Mounted Solution with Associated SE41 Power Supply- Exhibit B-2 #2



Two Radio Strand Mounted Solution with Associated SE41 Power Supply- Exhibit B-2 #2

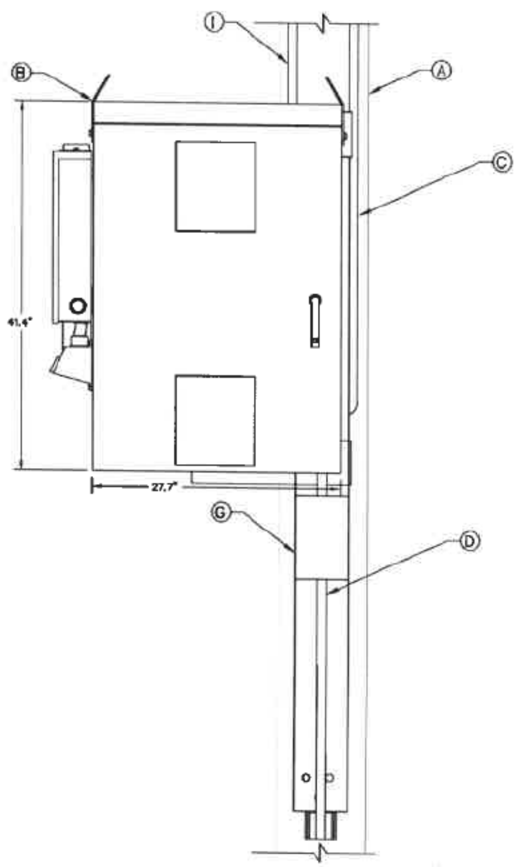


SE41 Power Supply Cabinet Mounted on a Utility Pole - Exhibit B-2 #3



SE41 Power Supply Cabinet Mounted on a Utility Pole - Exhibit B-2 #3

CROWN CASTLE NG EAST
PROPOSED EQUIPMENT DETAILS



DETAIL 'A'
EQUIPMENT CABINET

SE41 CABINET

A EXISTING POLE TO REMAIN
EXISTING POLE (40' WOOD)
TYPE LINE – CLASS 2
HEIGHT 38'-4" (AGL)

B INSTALL NEW ALPHA TECHNOLOGIES EQUIPMENT CABINET
ALPHA MODEL: SE41-30 MULTIPURPOSE OSP ENCLOSURE
41.4" x 27.7" x 22.5" (HxWxD) – 330 lbs
W/ SE41-1027 MOUNT BRACKET – 71 lbs

C 1" PVC CONDUIT WITH #8/C POWER CABLE
AND #4 SOL. CU GROUND COVERED 3D

D INSTALL WIRE, #4 SOL. CU GROUND COVERED 3D
MOLDING, 1/2" ID x 8' LG., STAPLE, 1/2" x 2", GALV.

E INSTALL GROUND ROD, 5/8" x 8' LG CU. POINTED

F STRAND, 50 PAIR AWG ALPHA CABLE AND FIBER CABLE

G INSTALL SQUARE D DISCONNECT
W/ 120/240 VAC SINGLE PHASE BREAKER
12" x 9" x 4" (HxWxD) – 10 lbs

H INSTALL MILBANK 200A ELECTRIC METER SOCKET
16" x 13" x 4.84" (HxWxD) – 15 lbs

I INSTALL 3" U-GUARD WITH ALPHA CABLE

hbk ENGINEERING
HBK ENGINEERING, LLC

CROWN CASTLE

CROWN CASTLE NG EAST
EXISTING POLE WITH SE41 CABINET
DAS EQUIPMENT

REVISIONS

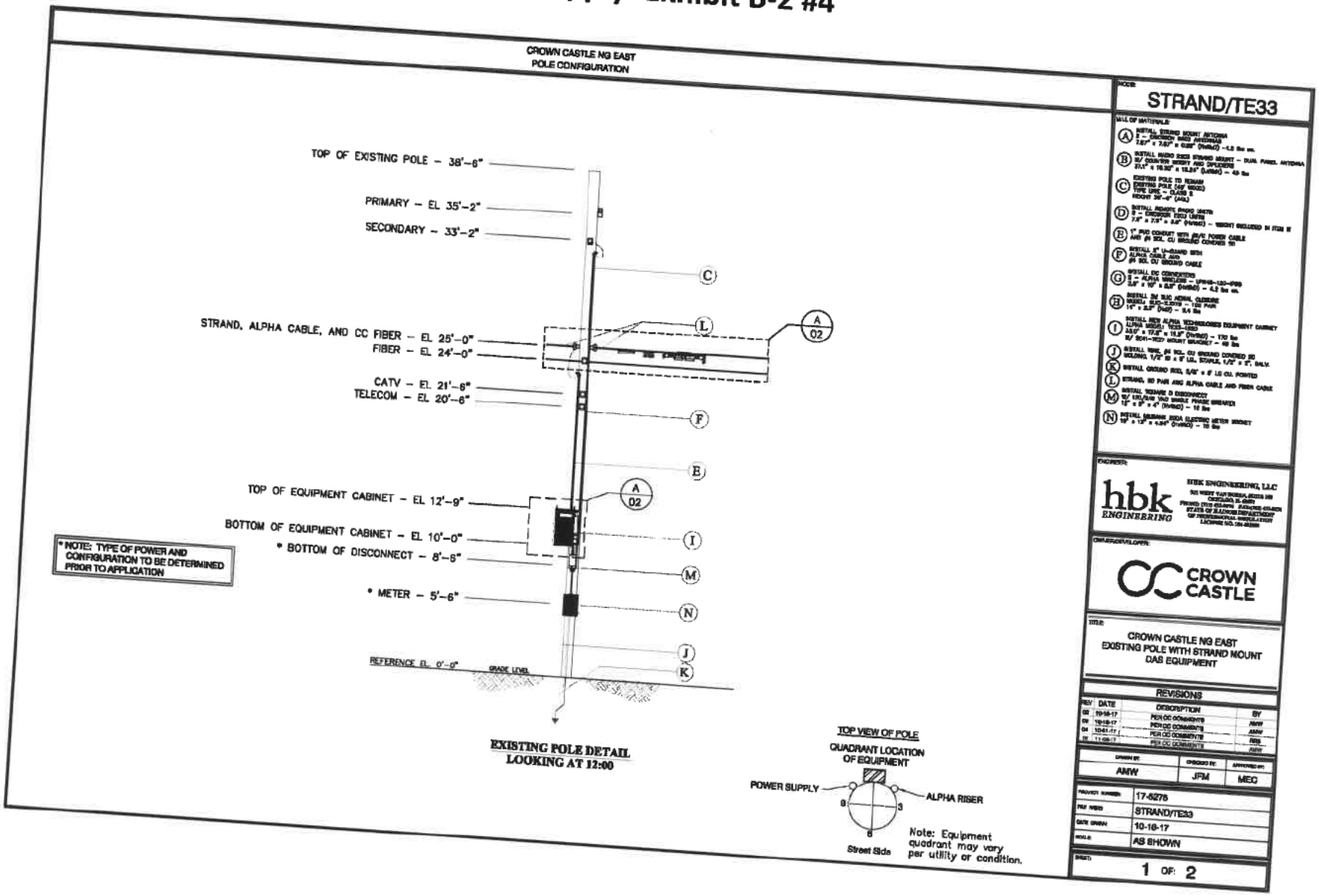
REV	DATE	DESCRIPTION	BY
		FOR CC REVIEW	AMW
		PER CC COMMENTS	AMW
		PER CC COMMENTS	AMW

DRAWN BY	CHECKED BY	APPROVED BY
AMW	JFM	MEC

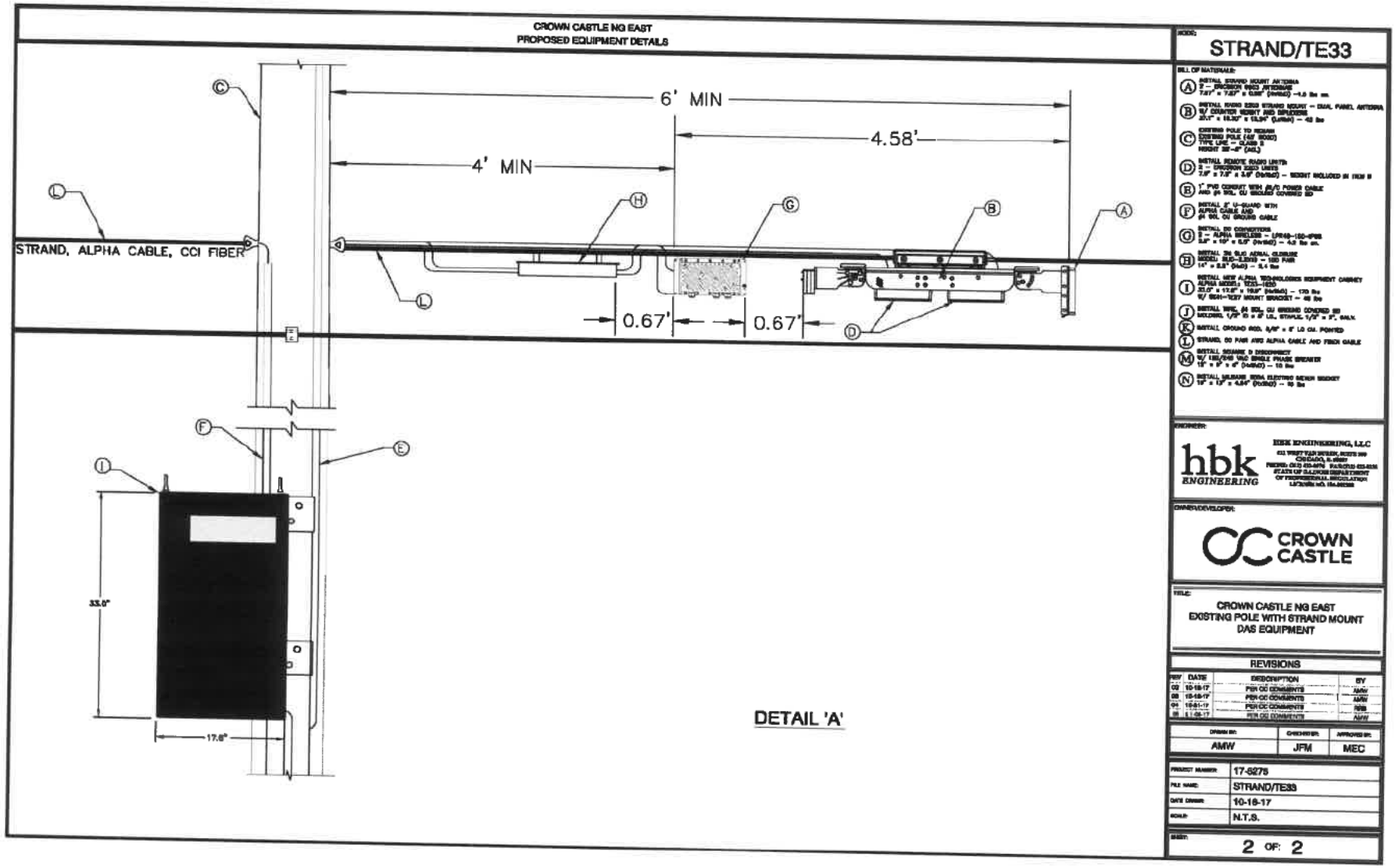
PROJECT NUMBER	17-5275
FILE NAME	SE41 CABINET
DATE DRAWN	10-26-17
SCALE	N.T.S.

2 OF 2

Two Radio Strand Mounted Solution with Associated TE33 Power Supply- Exhibit B-2 #4

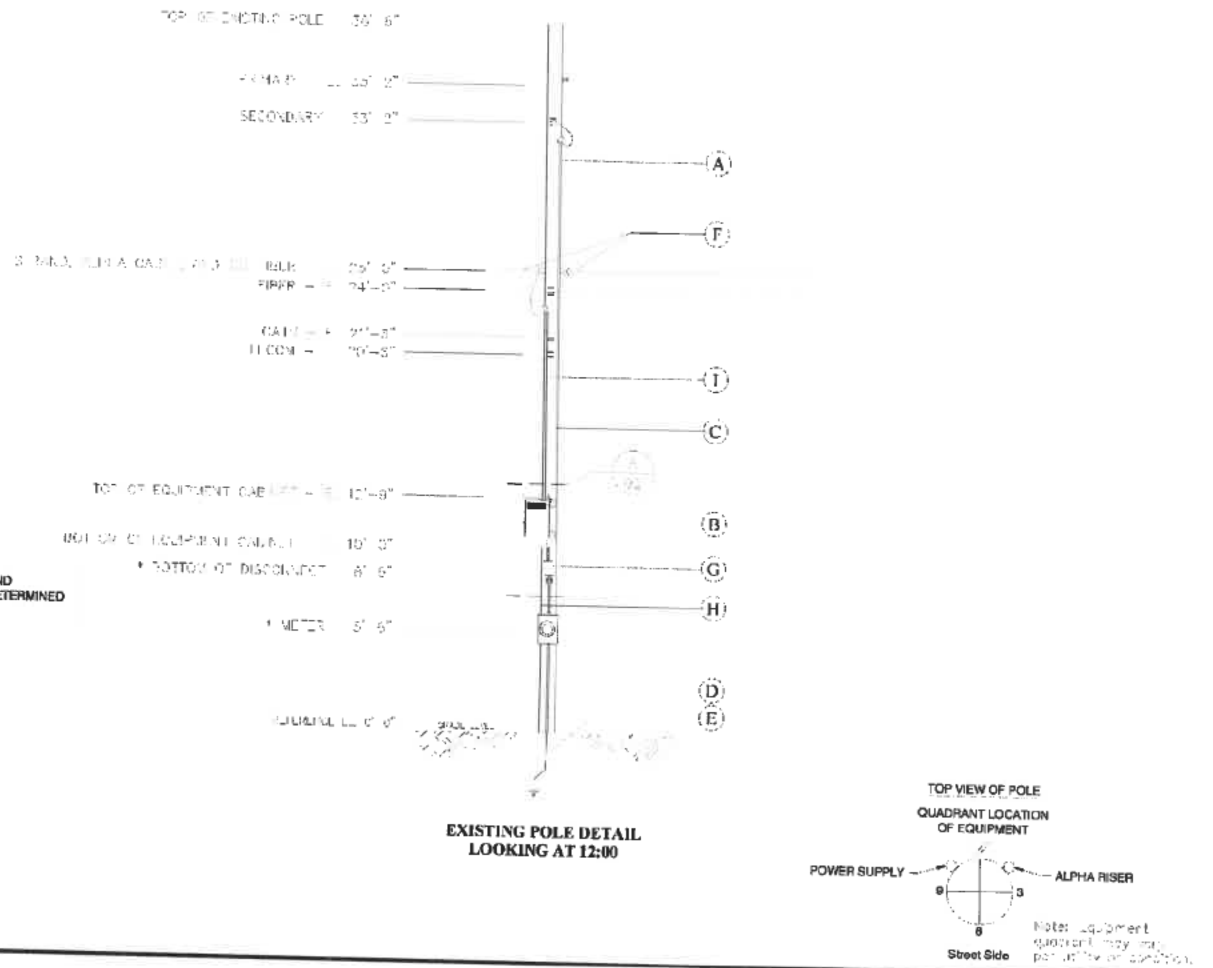


Two Radio Strand Mounted Solution with Associated TE33 Power Supply- Exhibit B-2 #4



TE33 Power Supply Cabinet Mounted on a Utility Pole - Exhibit B-2 #5

CROWN CASTLE NG EAST
POLE CONFIGURATION



* NOTE: TYPE OF POWER AND CONFIGURATION TO BE DETERMINED PRIOR TO APPLICATION

TE33 CABINET

BILL OF MATERIALS:

ENGINEER

hbk ENGINEERING

HBK ENGINEERING, LLC

CROWN CASTLE

CROWN CASTLE NG EAST
EXISTING POLE WITH ALPHA CABINET
DAS EQUIPMENT

REVISIONS

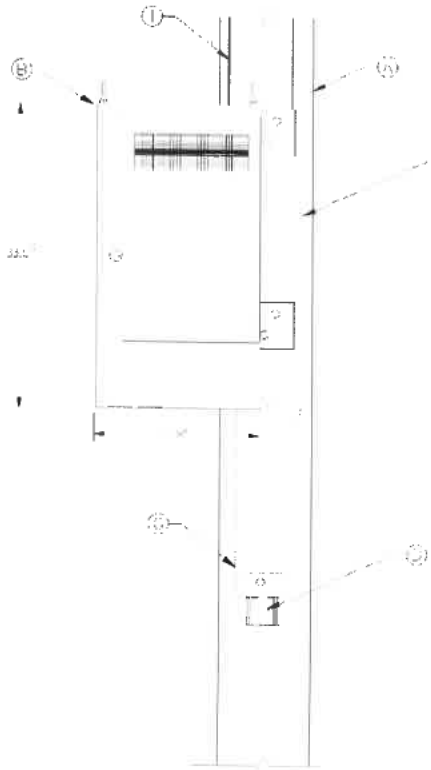
DRAWN BY	CHECKED BY	APPROVED BY
AMW	JFM	MEC

	17-5275
	TE33 CABINET
	10-12-17
SCALE	AS SHOWN

1 OF: 2

TE33 Power Supply Cabinet Mounted on a Utility Pole - Exhibit B-2 #5

CROWN CASTLE NG EAST
PROPOSED EQUIPMENT DETAILS



DETAIL 'A'
EQUIPMENT CABINET

NOTE:
TE33 CABINET

BILL OF MATERIALS:

ENGINEER:
HBK ENGINEERING, LLC

OWNER/DEVELOPER:
CROWN CASTLE

TITLE:
CROWN CASTLE NG EAST
EXISTING POLE WITH ALPHA CABINET
DAS EQUIPMENT

REVISIONS

REV	DATE	DESCRIPTION	BY
03	10-16-17	PER CC COMMENTS	AMW
04	10-18-17	PER CC COMMENTS	AMW
05	10-31-17	PER CC COMMENTS	AMW
06	11-08-17	PER CC COMMENTS	AMW

DRAWN BY:	CHECKED BY:	APPROVED BY:
AMW	JFM	MEC

PROJECT NUMBER:	17-5275
FILE NAME:	TE33 CABINET
DATE DRAWN:	10-12-17
SCALE:	N.T.S.

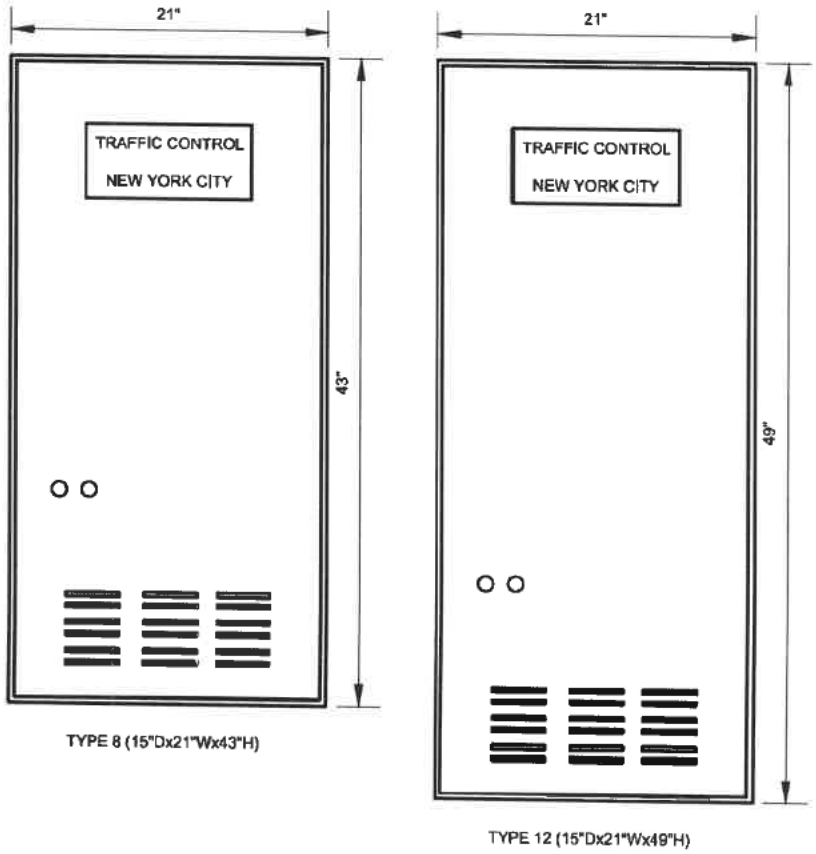
SHEET
2 OF: 2

Exhibit C:
City Approved DOT Control Box
Specification Zone A, B & C

Exhibit C:

City Approved DOT Control Box Specification for Zones A, B & C

This exhibit will show drawings and simulations using Type 8 and Type 12 DOT Control Boxes



Current DOT Control Boxes Approved Spec

Exhibit C: Antenna Option #1
City Approved DOT Control Box Specification for Zones A, B & C

75" H x 2" D

Current Max DoTT Specification is 48" H x 2" D

Phazar Antenna Corp.

1710 – 2155 MHz Omni-Directional Antenna

- Dual Antenna for DAS or LTE Applications
- Frequency coverage for entire AWS band

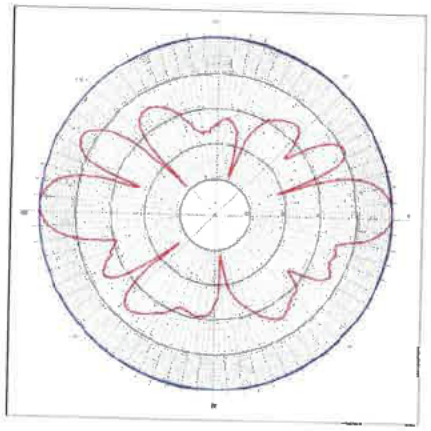
Model AWS360D-1710-7-T0-D

ELECTRICAL SPECIFICATIONS

Frequency Range	1710-2155 MHz
VSWR	1.7:1 VSWR Max
Forward Gain	2 X 7 dBi
Polarization	Vertical
Maximum Power Input	200 Watts
Input Impedance	50 ohms
Vertical -3dB Beamwidth	16° +/- 1° (nominal)
Horizontal -3dB Beamwidth	360°
Azimuth Ripple	+/- .5 dB
Electrical Downtilt	2 and 4° (T2 and T4 for Part Number)
Passive Intermod	-150 dBc

MECHANICAL & ENVIRONMENTAL SPECIFICATIONS

Connector	Type DIN 7/16 (Two connectors)
Mounting	Side mount; clamps provided
Dimension and Weight	48 inches x 2.0 inch O.D. / < 4 lbs 1.82 Kg)
Color	White Standard (Color Options Available)
Wind Survival	130 mph
Lightning Protection	Direct Ground



Current DoITT Approved Spec

[redacted]

Proposed Spec

Exhibit C: Antenna #1

City Approved DOT Control Box Specification Zone A, B & C

Bishops Crook Style Pole – DOT Cabinet Type 8 Sample Drawing

Pole Elevation

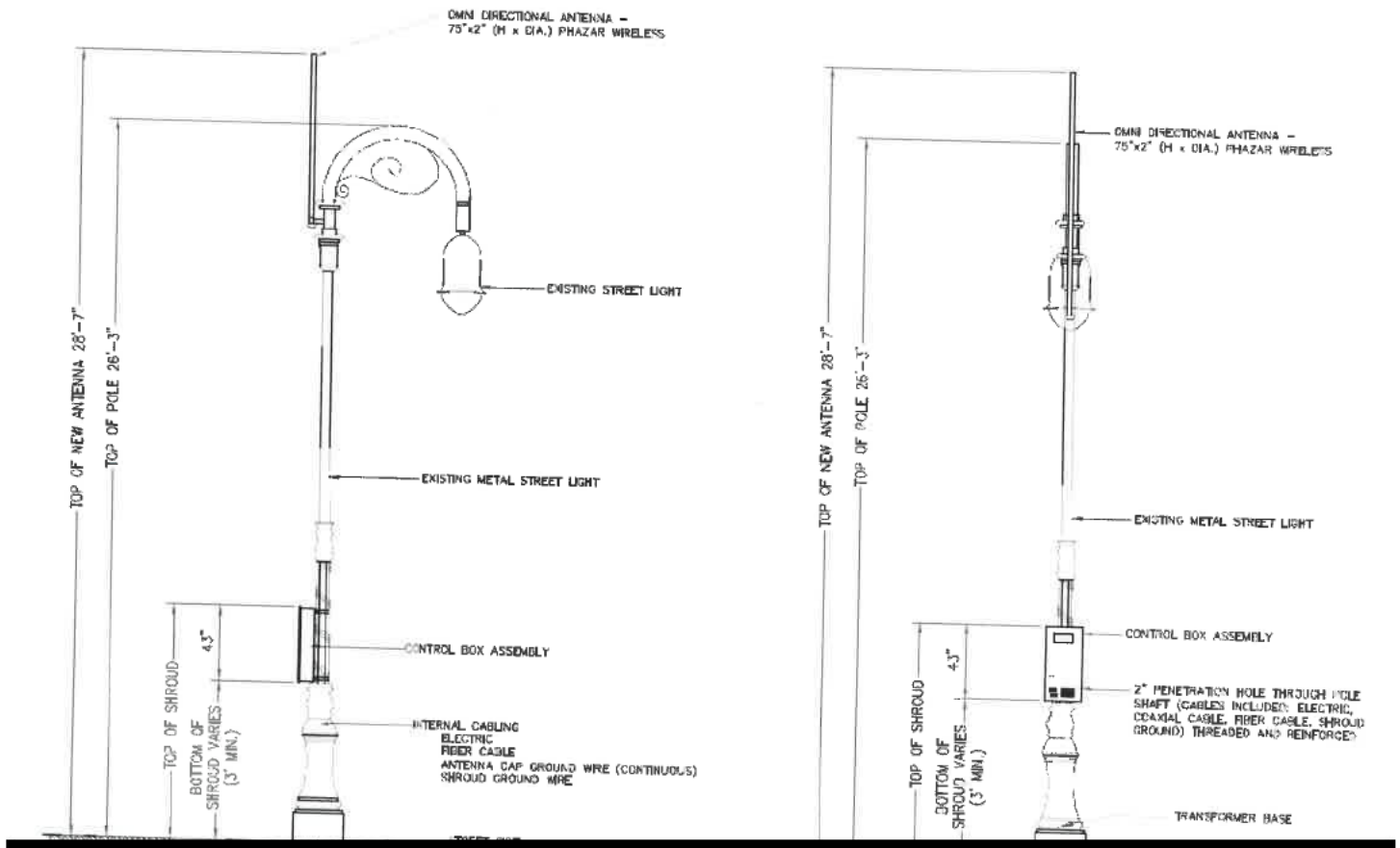
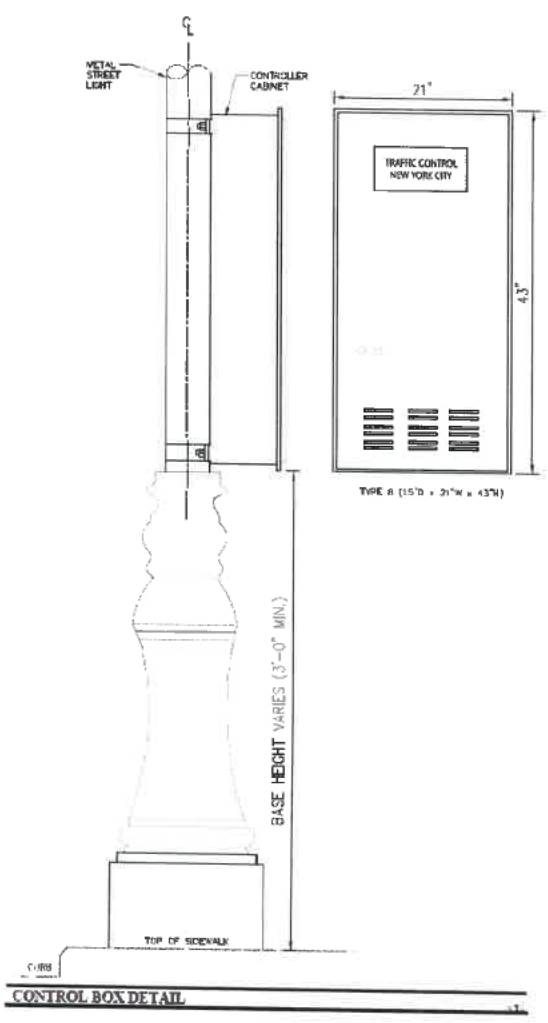


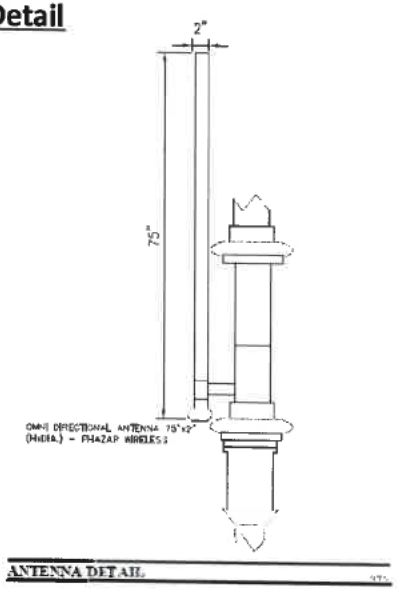
Exhibit C: Antenna #1

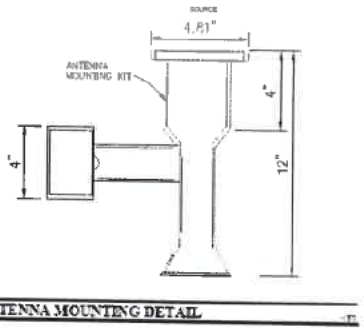
City Approved DOT Control Box Specification Zone A, B & C

Bishops Crook Style Pole – DOT Cabinet Type 8 Sample Drawing



Mounting Detail





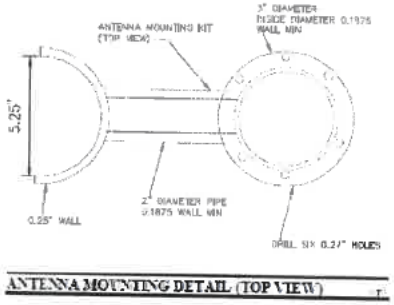


Exhibit C: Antenna #1

City Approved DOT Control Box Specification Zone A, B & C

Bishops Crook Style Pole – DOT Cabinet Type 12 Sample Drawing

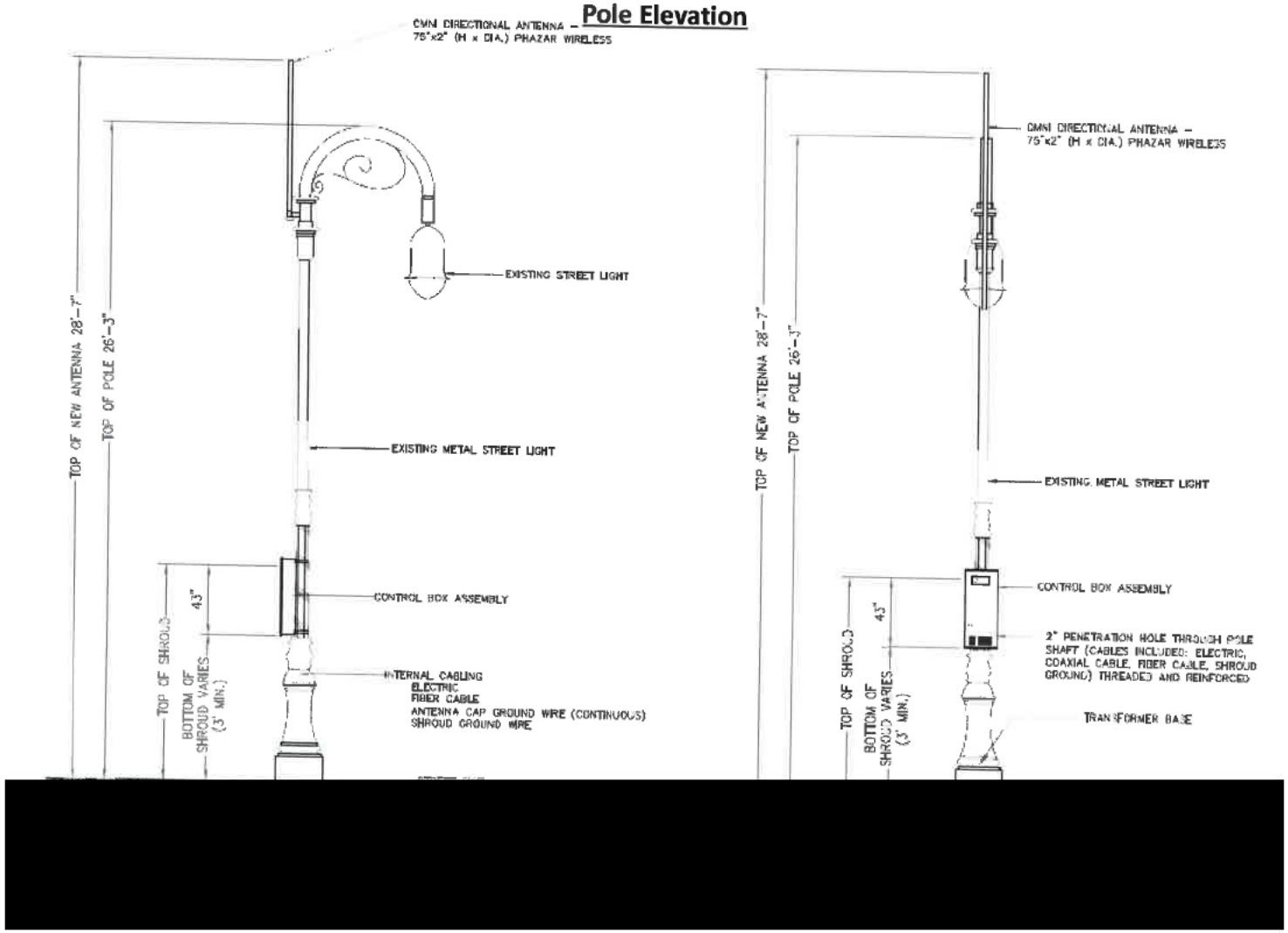


Exhibit C: Antenna #1

City Approved DOT Control Box Specification Zone A, B & C

Bishops Crook Style Pole – DOT Cabinet Type 12 Sample Drawing

Mounting Detail

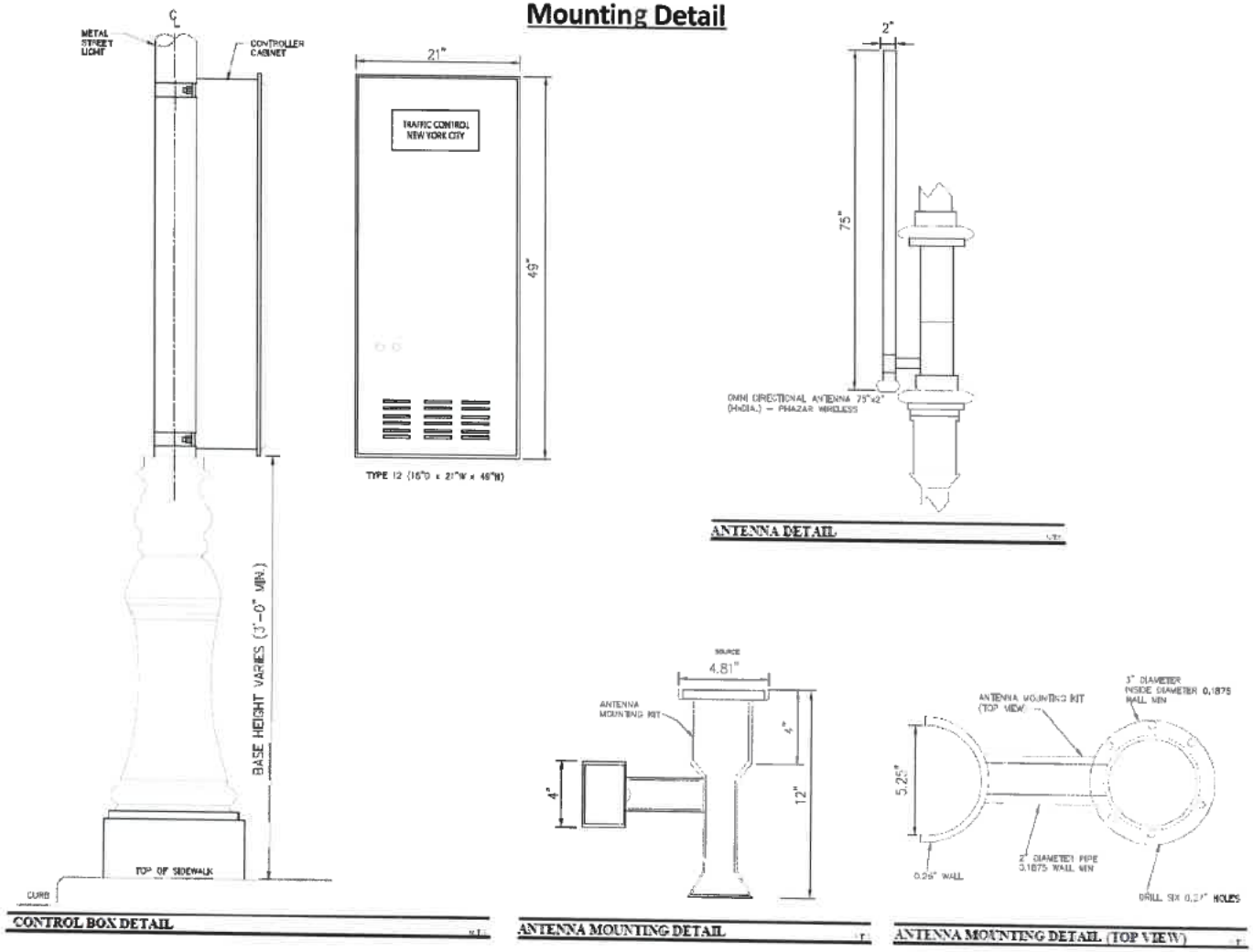


Exhibit C: Antenna #1
City Approved DOT Control Box Specification Zone A, B & C
Bishops Crook Style Pole – Photo Simulations

DOT Cabinet Type 8

DOT Cabinet Type 12

Exhibit C: Antenna #1
City Approved DOT Control Box Specification Zone A, B & C
FS Style Pole – DOT Cabinet Type 8 Sample Drawing

Pole Elevation

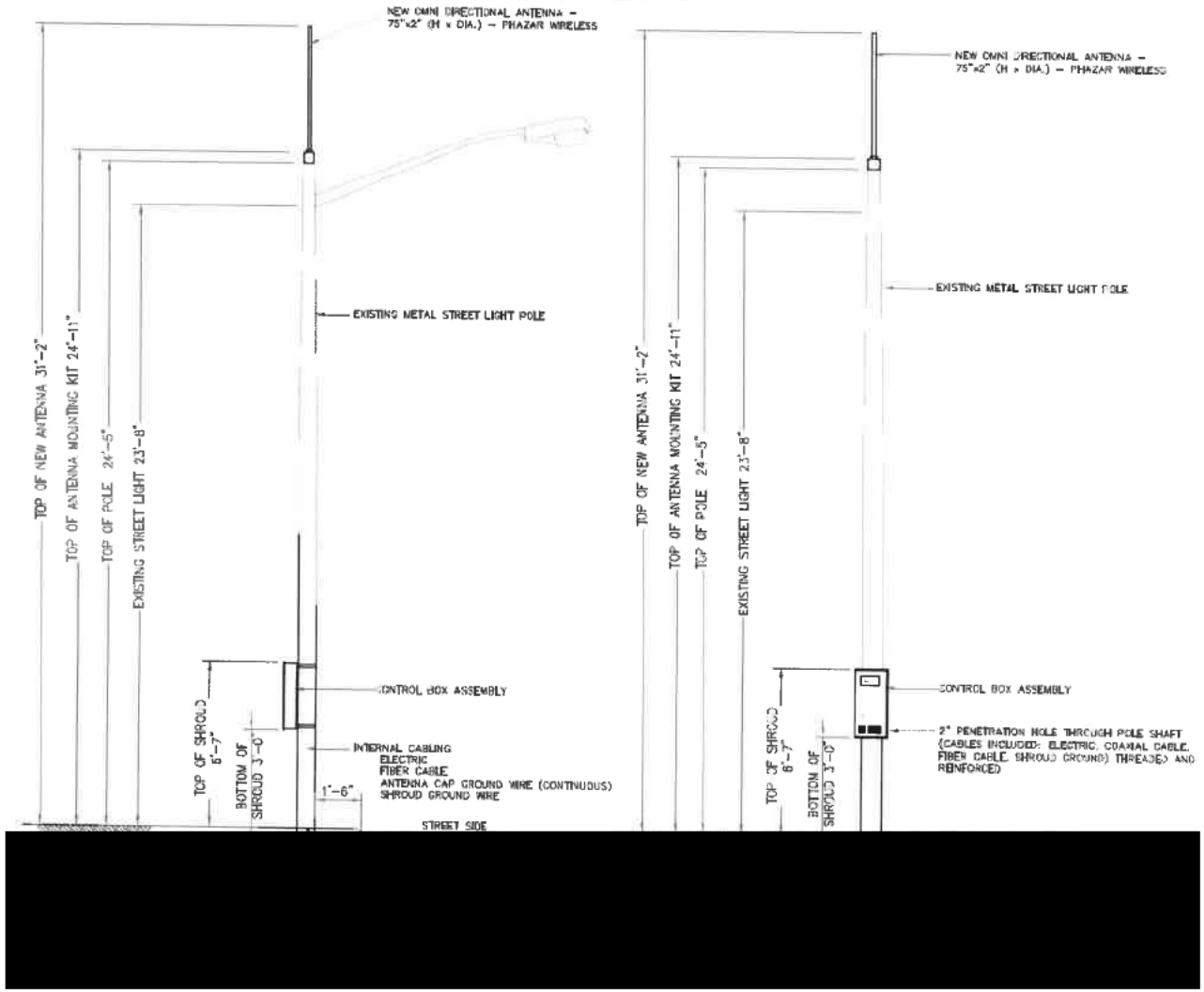
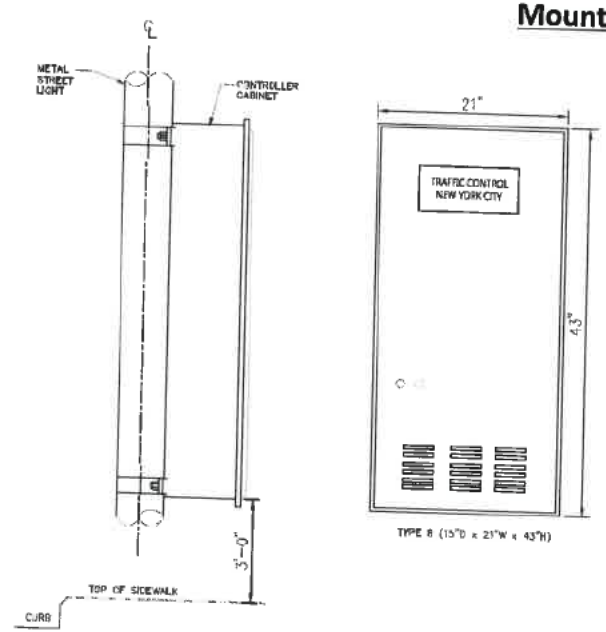


Exhibit C: Antenna #1

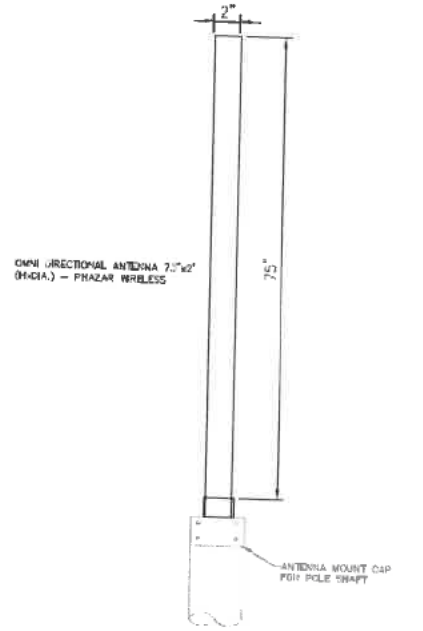
City Approved DOT Control Box Specification Zone A, B & C

FS Style Pole – DOT Cabinet Type 8 Sample Drawing

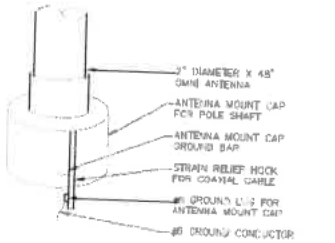
Mounting Detail



CONTROL BOX DETAIL



ANTENNA DETAIL



ANTENNA MOUNTING DETAIL

Exhibit C: Antenna #1

City Approved DOT Control Box Specification Zone A, B & C

FS Style Pole – DOT Cabinet Type 12 Sample Drawing

Pole Elevation

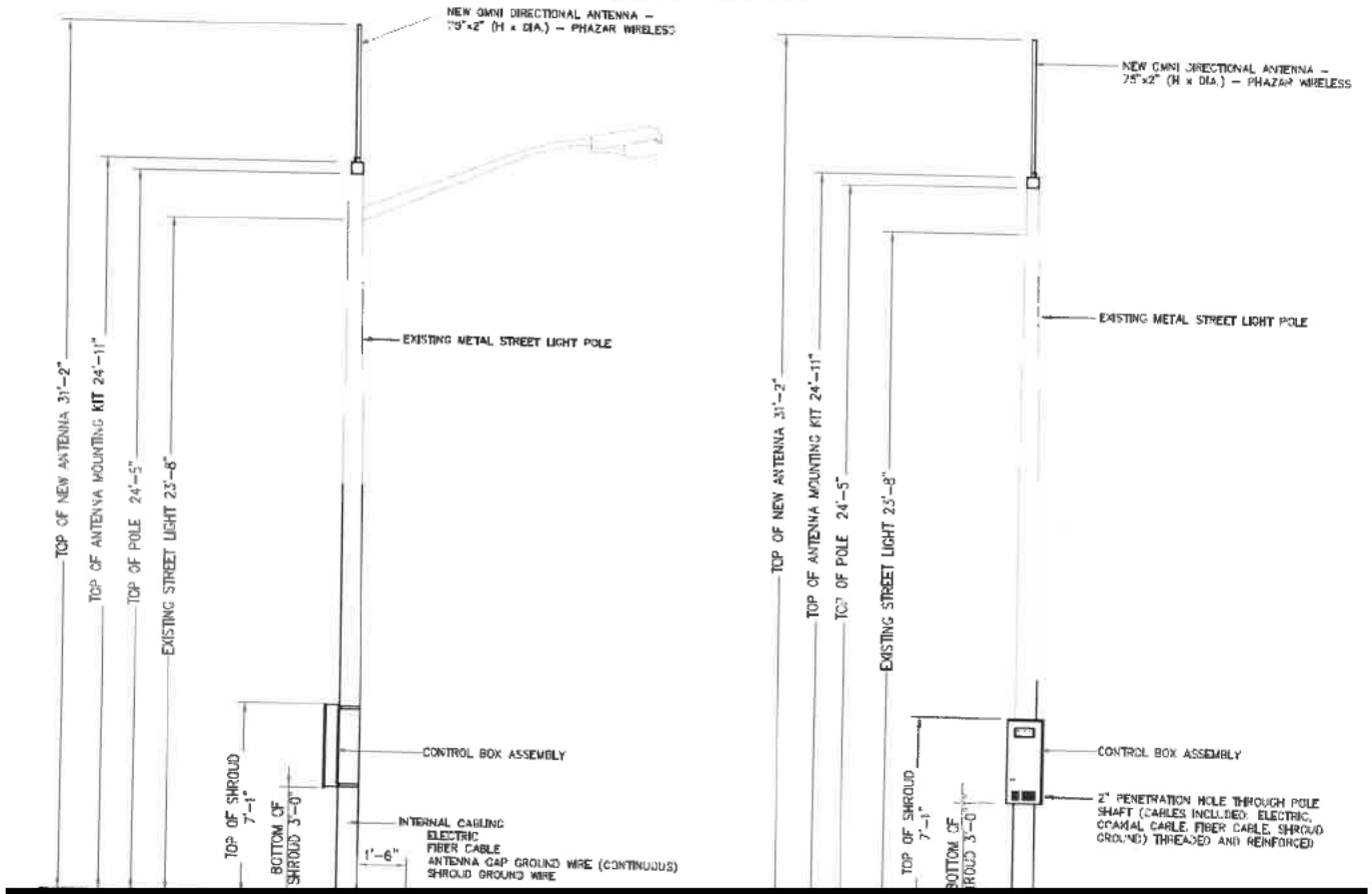
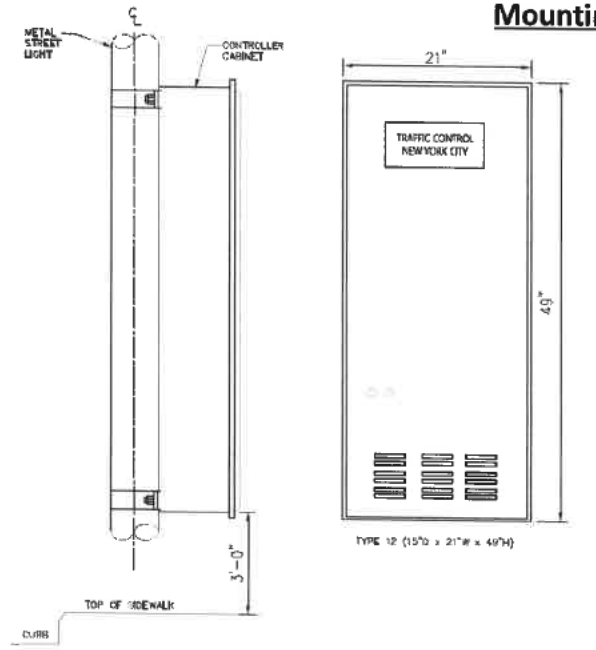


Exhibit C: Antenna #1

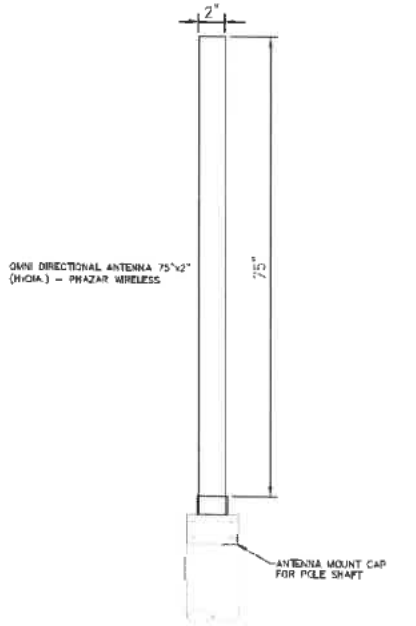
City Approved DOT Control Box Specification Zone A, B & C

FS Style Pole – DOT Cabinet Type 12 Sample Drawing

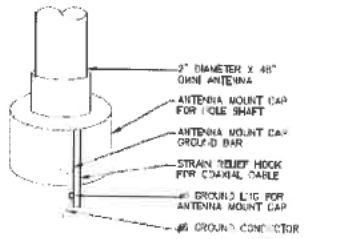
Mounting Detail



CONTROL BOX DETAIL



ANTENNA DETAIL



ANTENNA MOUNTING DETAIL

Exhibit C: Antenna #1
City Approved DOT Control Box Specification Zone A, B & C
FS Style Pole – Photo Simulations

DOT Cabinet Type 8

DOT Cabinet Type 12

Exhibit C: Antenna #1

City Approved DOT Control Box Specification Zone A, B & C

M2 Style Pole – DOT Cabinet Type 8 Sample Drawing

Pole Elevation

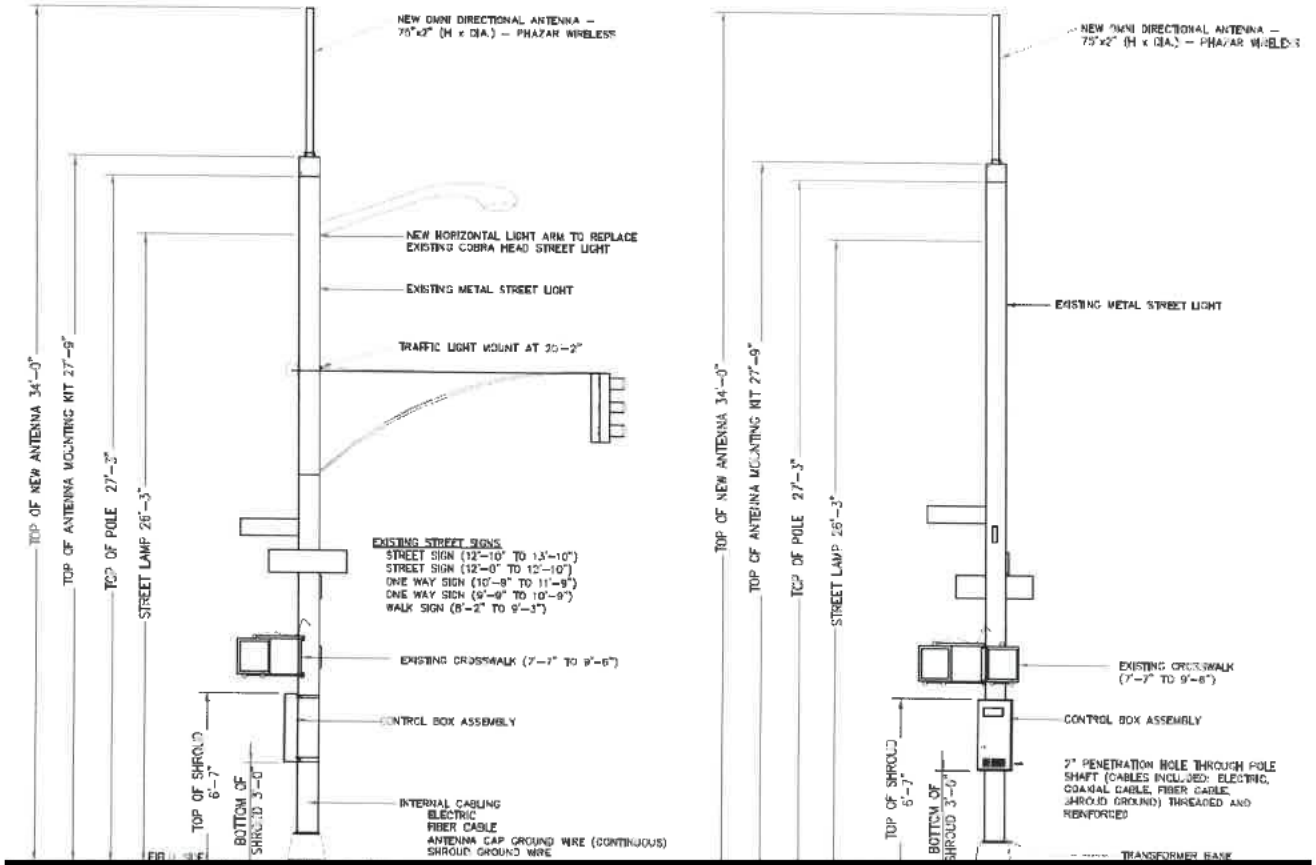
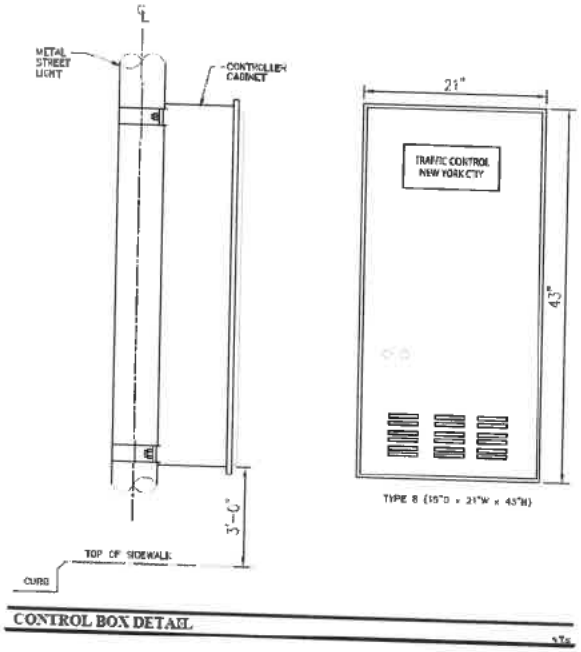


Exhibit C: Antenna #1

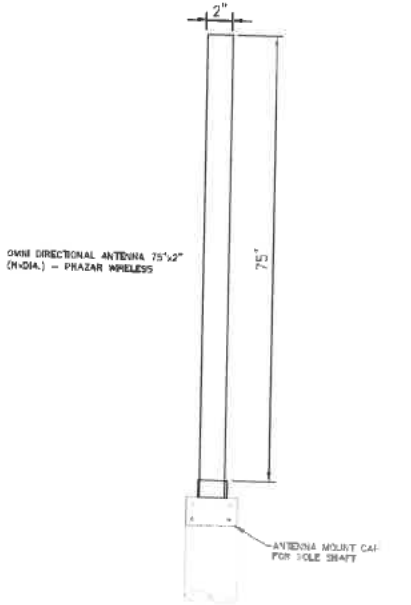
City Approved DOT Control Box Specification Zone A, B & C

M2 Style Pole – DOT Cabinet Type 8 Sample Drawing

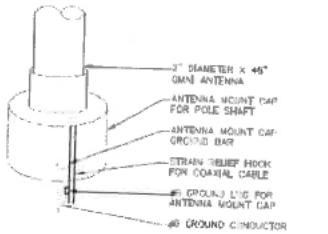
Mounting Detail



CONTROL BOX DETAIL



ANTENNA DETAIL



ANTENNA MOUNTING DETAIL

Exhibit C: Antenna #1

City Approved DOT Control Box Specification Zone A, B & C

M2 Style Pole – DOT Cabinet Type 12 Sample Drawing

Pole Elevation

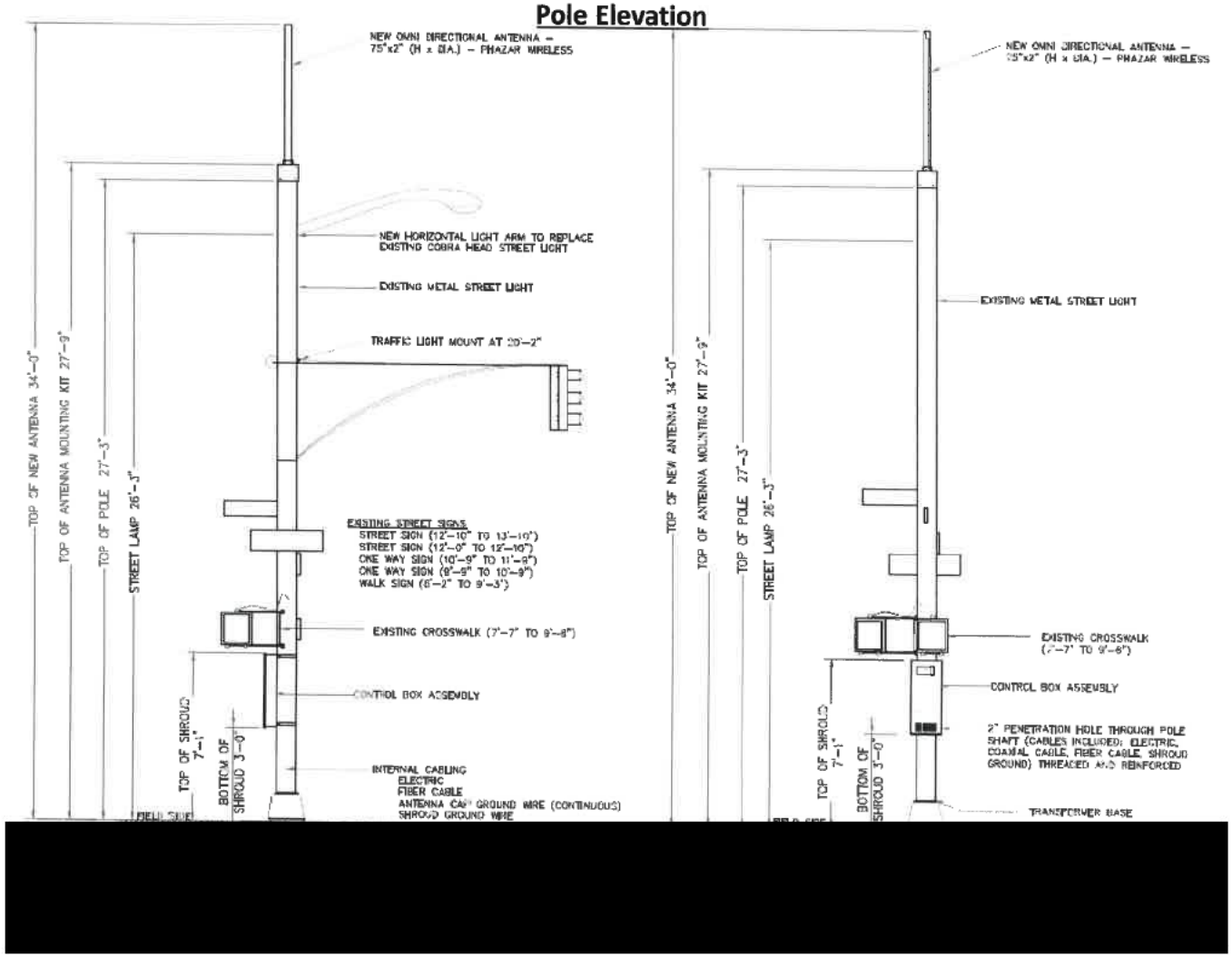
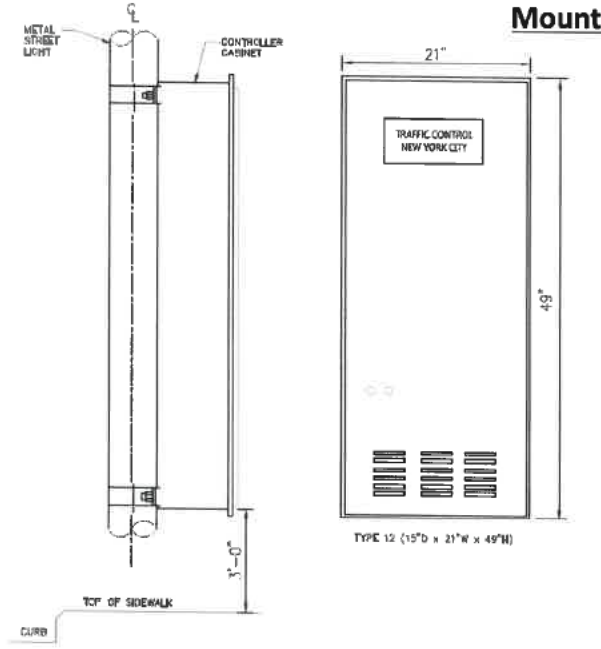


Exhibit C: Antenna #1

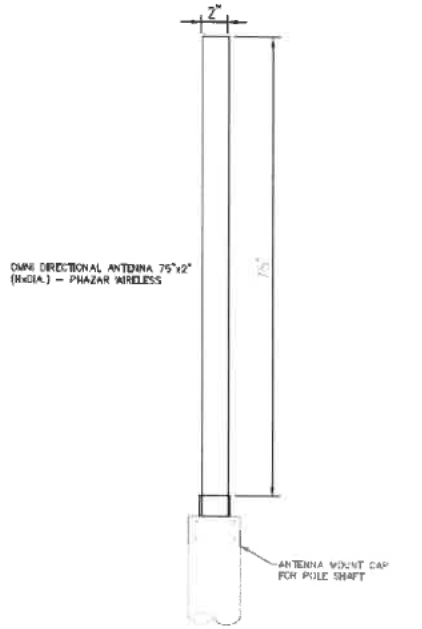
City Approved DOT Control Box Specification Zone A, B & C

M2 Style Pole – DOT Cabinet Type 12 Sample Drawing

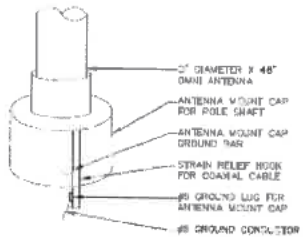
Mounting Detail



CONTROL BOX DETAIL



ANTENNA DETAIL



ANTENNA MOUNTING DETAIL

Exhibit C: Antenna #1
City Approved DOT Control Box Specification Zone A, B & C
M2 Style Pole – Photo Simulations

DOT Cabinet Type 8

DOT Cabinet Type 12

Exhibit C: Antenna Option #2
City Approved DOT Control Box Specification for Zones A, B & C

60" H x 4" D

Current Max DoTT Specification is 48" H x 2" D

Phazar Antenna Corp.

1710 – 2155 MHz Omni-Directional Antenna

- Dual Antenna for DAS or LTE Applications
- Frequency coverage for entire AWS band

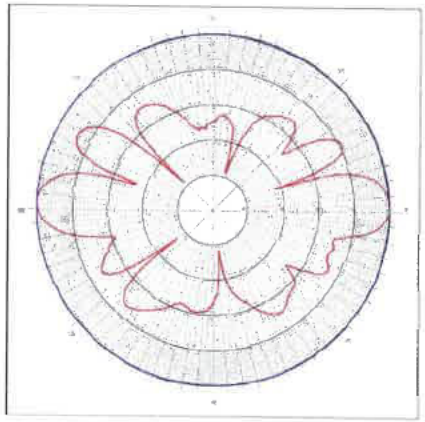
Model AWS360D-1710-7-T0-D

ELECTRICAL SPECIFICATIONS

Frequency Range	1710-2155 MHz
VSWR	1.7:1 VSWR Max.
Forward Gain	2 X 7 dBi
Polarization	Vertical
Maximum Power Input	200 Watts
Input Impedance	50 ohms
Vertical -3dB Beamwidth	18° +/- 1° (nominal)
Horizontal -3dB Beamwidth	360°
Azimuth Ripple	+/- .5 dB
Electrical Downtilt	2 and 4° (T2 and T4 for Part Number)
Passive Intermod	-150 dBc

MECHANICAL & ENVIRONMENTAL SPECIFICATIONS

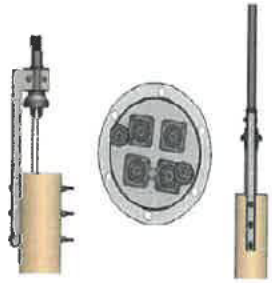
Connector	Type DIN 7/16 (Two connectors)
Mounting	Side mount: clamps provided
Dimension and Weight	48 inches x 2.0 inch O.D. / < 4 lbs. (1.82 kg)
Color	White Standard (Color Options Available)
Wind Survival	120 mph.
Lightning Protection	Direct Ground



Current DoITT Approved Spec

- Current Design: 2" OD
  - Housing designed for 2" OD antenna
  - MK-06766 designed for 2in OD antenna
  - 6 ports – 2 on pigtails
  - Base Mount OD: 4.81in

- Current Design: 2" OD
  - Housing designed for 2" OD antenna
  - MK-06696 designed for 2in OD antenna
  - 6 ports – 2 on pigtails
  - Base Mount OD: 4.81in



[redacted]

Proposed Spec

Exhibit C: Antenna #2

City Approved DOT Control Box Specification Zone A, B & C

Bishops Crook Style Pole – DOT Cabinet Type 12 Sample Drawing

Pole Elevation

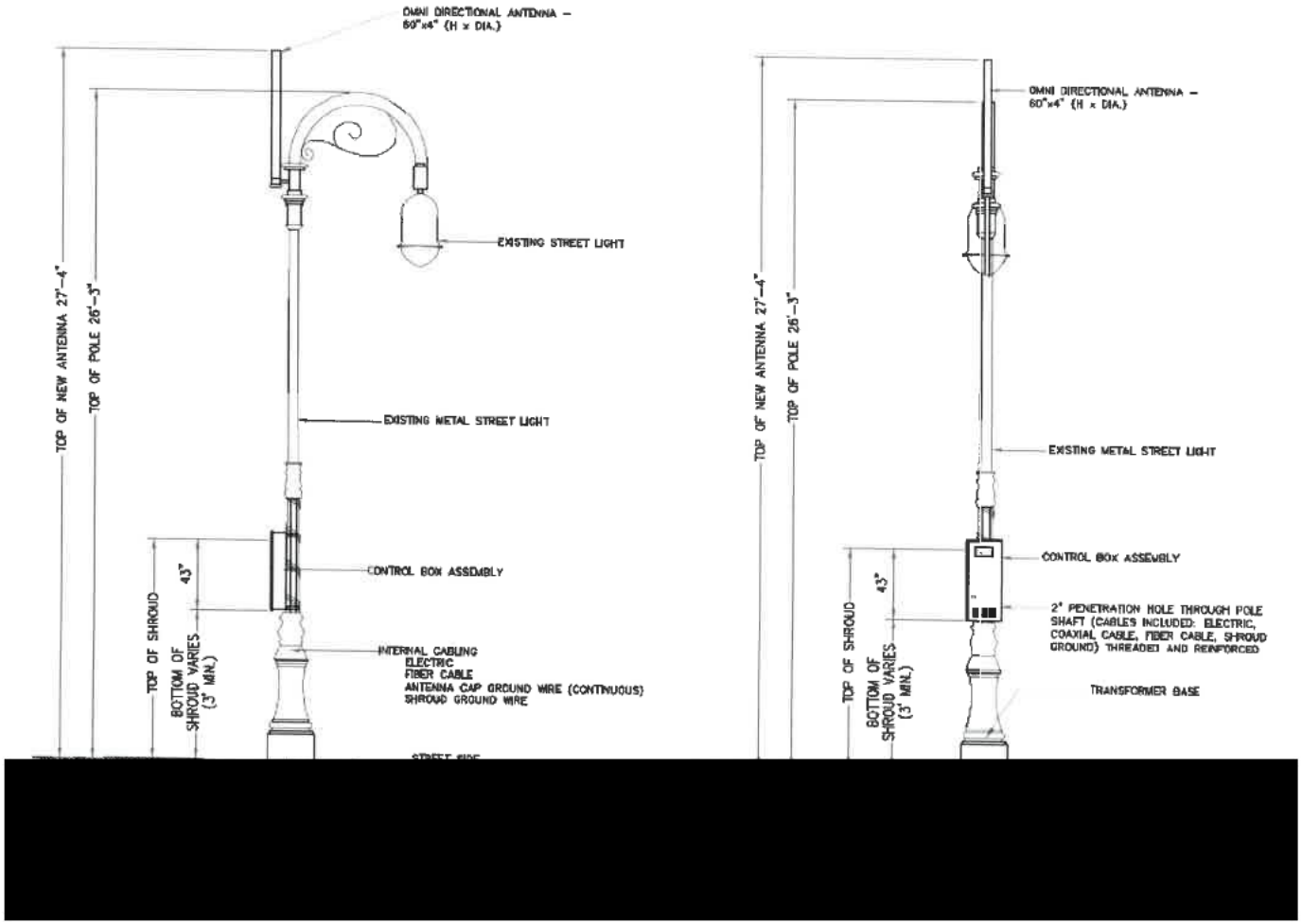


Exhibit C: Antenna #2

City Approved DOT Control Box Specification Zone A, B & C

Bishops Crook Style Pole – DOT Cabinet Type 12 Sample Drawing

Mounting Detail

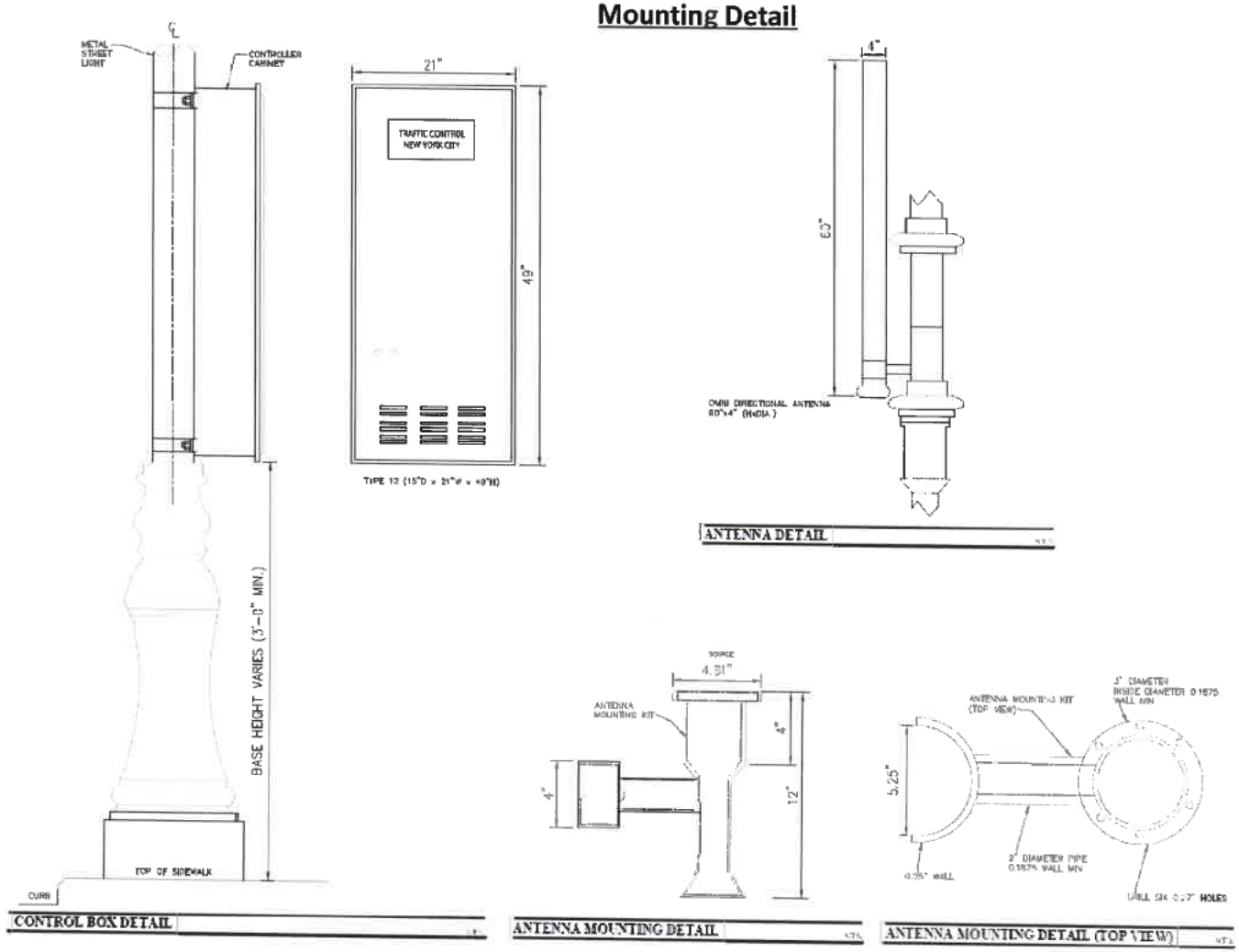


Exhibit C: Antenna #2
City Approved DOT Control Box Specification Zone A, B & C
Bishops Crook Style Pole – Photo Simulation

DOT Cabinet Type 12

Exhibit C: Antenna #2

City Approved DOT Control Box Specification Zone A, B & C

FS Style Pole – DOT Cabinet Type 12 Sample Drawing

Pole Elevation

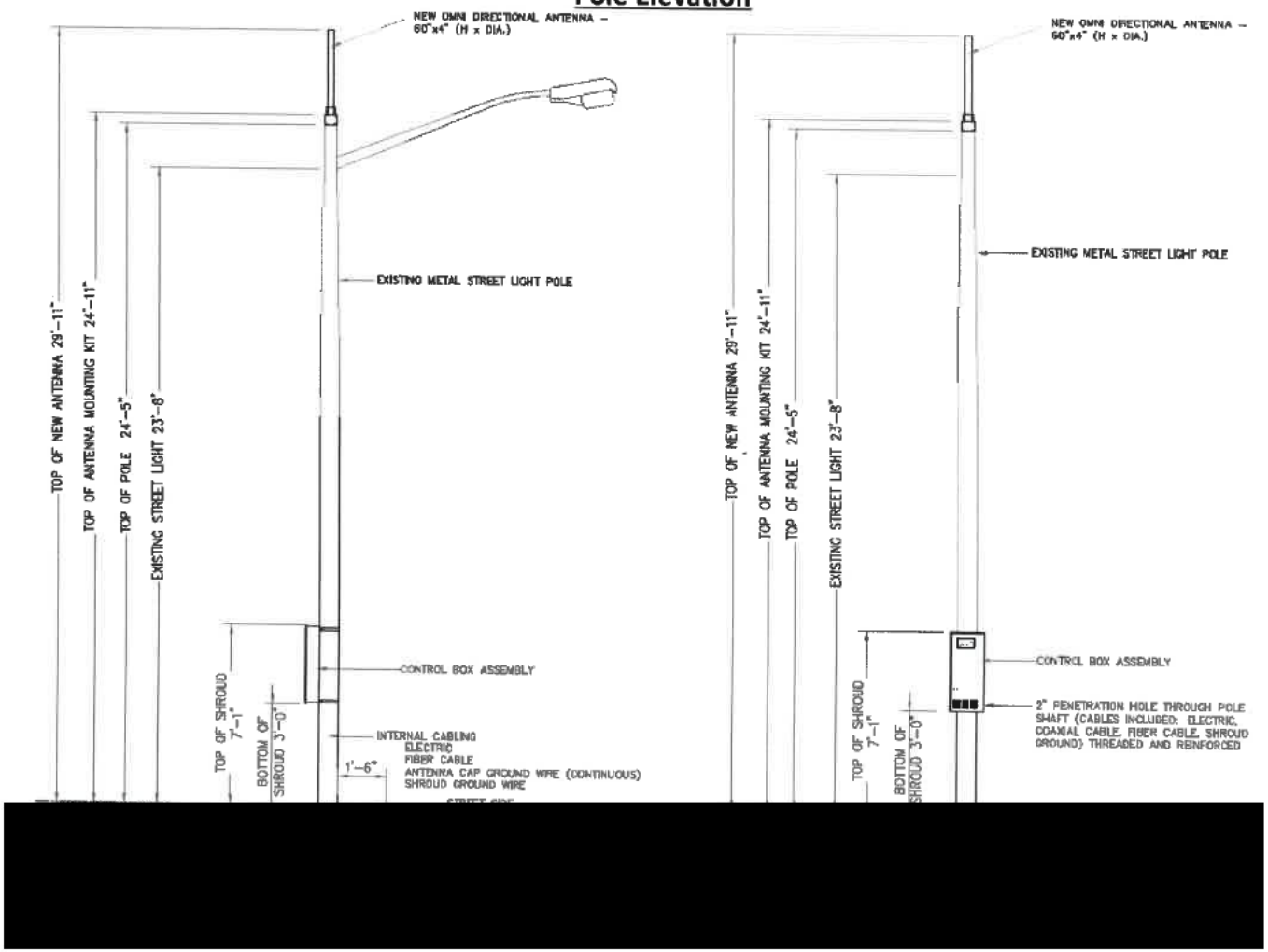
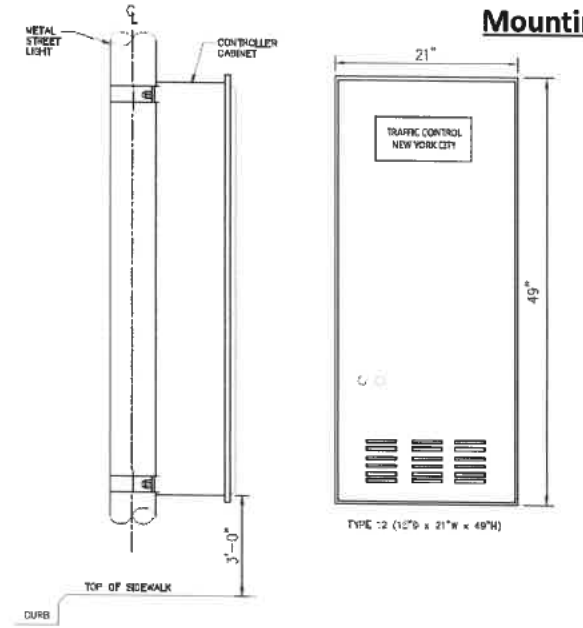


Exhibit C: Antenna #2

City Approved DOT Control Box Specification Zone A, B & C

FS Style Pole – DOT Cabinet Type 12 Sample Drawing

Mounting Detail



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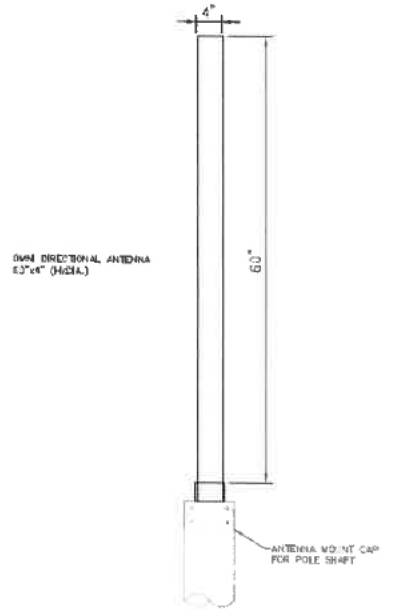
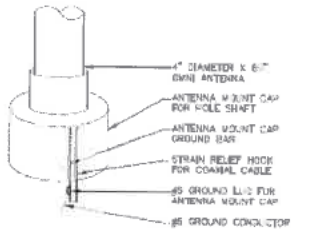


ANTENNA DETAIL



ANTENNA MOUNTING DETAIL

Exhibit C: Antenna #2
City Approved DOT Control Box Specification Zone A, B & C
FS Style Pole – Photo Simulation

DOT Cabinet Type 12

Exhibit C: Antenna #2

City Approved DOT Control Box Specification Zone A, B & C

M2 Style Pole – DOT Cabinet Type 12 Sample Drawing

Pole Elevation

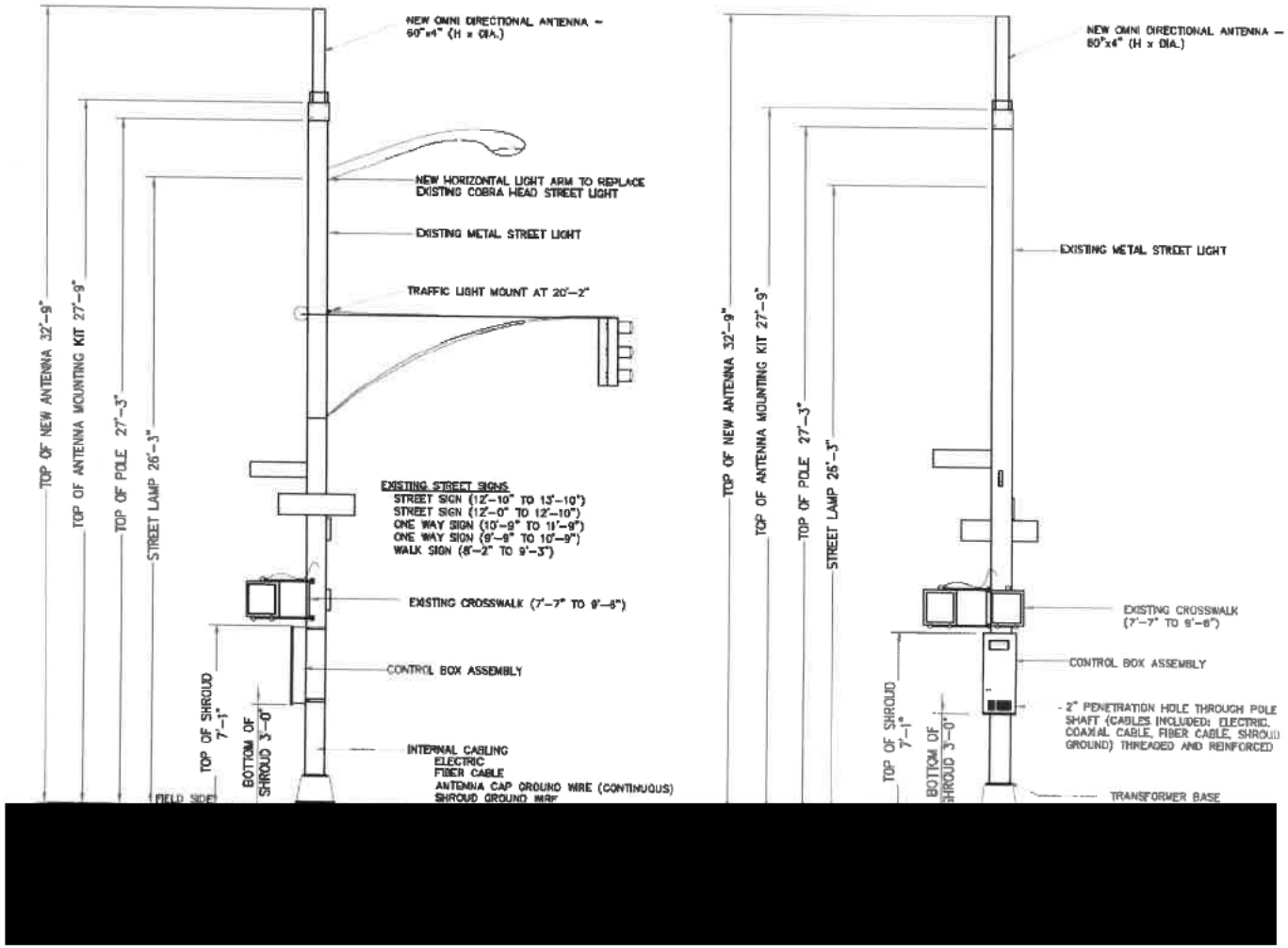
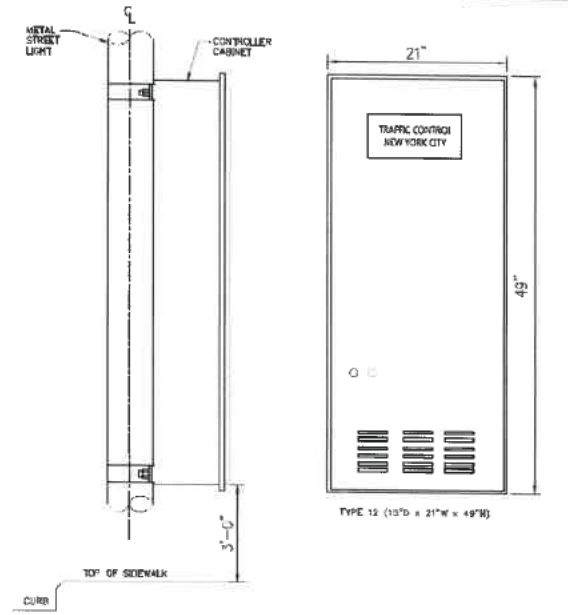


Exhibit C: Antenna #2

City Approved DOT Control Box Specification Zone A, B & C

M2 Style Pole – DOT Cabinet Type 12 Sample Drawing

Mounting Detail



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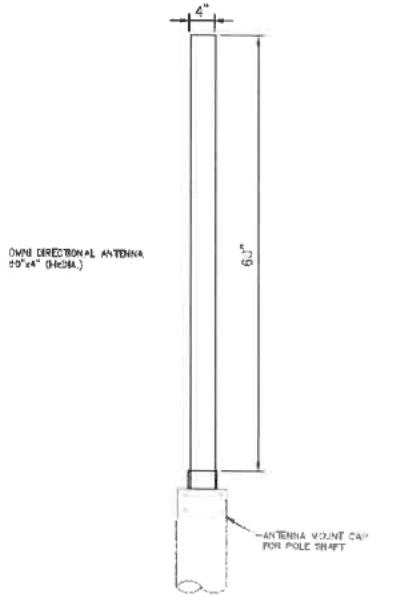
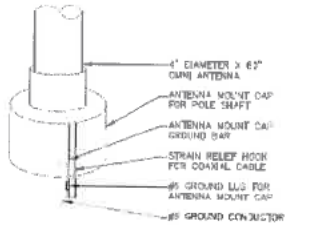


ANTENNA DETAIL



ANTENNA MOUNTING DETAIL

Exhibit C: Antenna #2

City Approved DOT Control Box Specification Zone A, B & C

M2 Style Pole – Photo Simulation

DOT Cabinet Type 12

Exhibit C: Antenna Option #3
City Approved DOT Control Box Specification for Zones A, B & C

24" H x 14.5" D

Current Max DoTT Specification is 48" H x 2" D

Phazar Antenna Corp.

1710 – 2155 MHz Omni-Directional Antenna

- Dual Antenna for DAS or LTE Applications
- Frequency coverage for entire AWS band

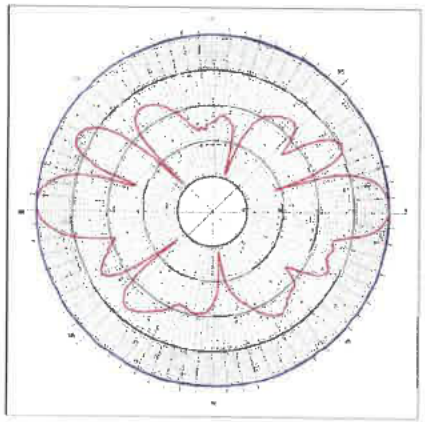
Model AWS360D-1710-7-T0-D

ELECTRICAL SPECIFICATIONS

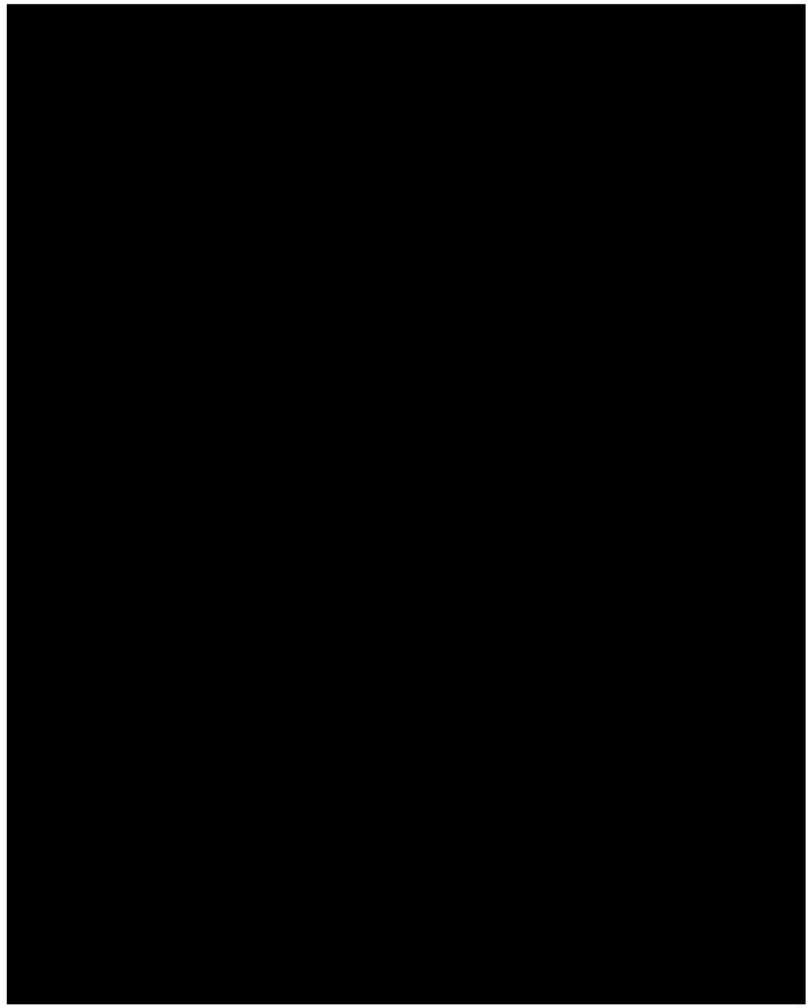
Frequency Range	1710-2155 MHz
VSWR	1.7:1 VSWR Max
Forward Gain	2 X 7 dBi
Polarization	Vertical
Maximum Power Input	200 Watts
Input Impedance	50 ohms
Vertical -3dB Beamwidth	16° +/- 1° (nominal)
Horizontal -3dB Beamwidth	360°
Azimuth Ripple	+/- .5 dB
Electrical Downtilt	2 and 4° (T2 and T4 for Part Number)
Passive Intermod	-150 dBc

MECHANICAL & ENVIRONMENTAL SPECIFICATIONS

Connector	Type DIN(7/16 (Two connectors)
Mounting	Side mount; clamps provided
Dimension and Weight	48 inches x 2.0 inch O.D. / < 4 lbs.1.82 kg)
Color	White Standard (Color Options Available)
Wind Survival	120 mph.
Lightning Protection	Direct Ground



Current DoITT Approved Spec



Proposed Spec

Exhibit C: Antenna #3

City Approved DOT Control Box Specification Zone A, B & C

FS Style Pole – DOT Cabinet Type 12 Sample Drawing

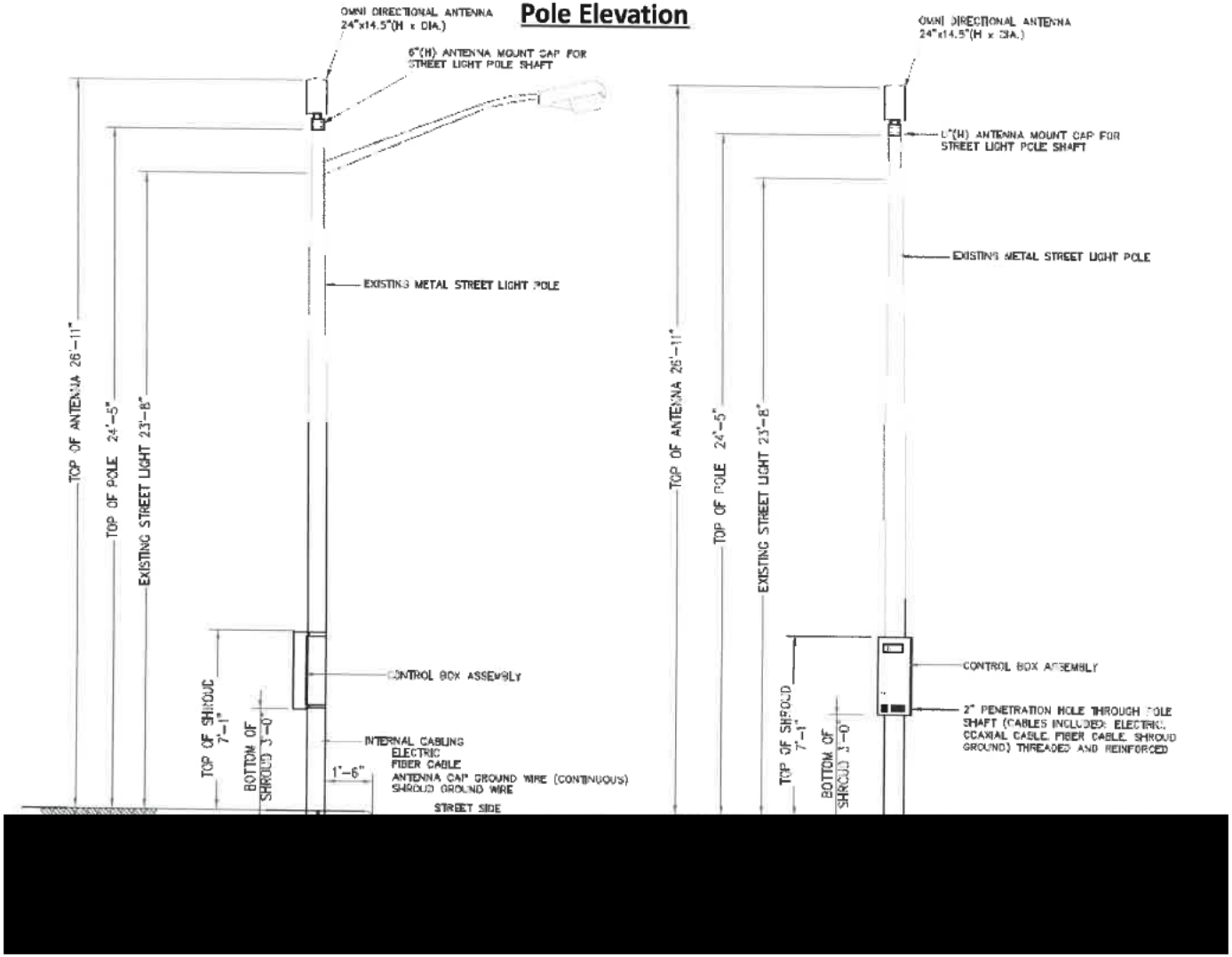
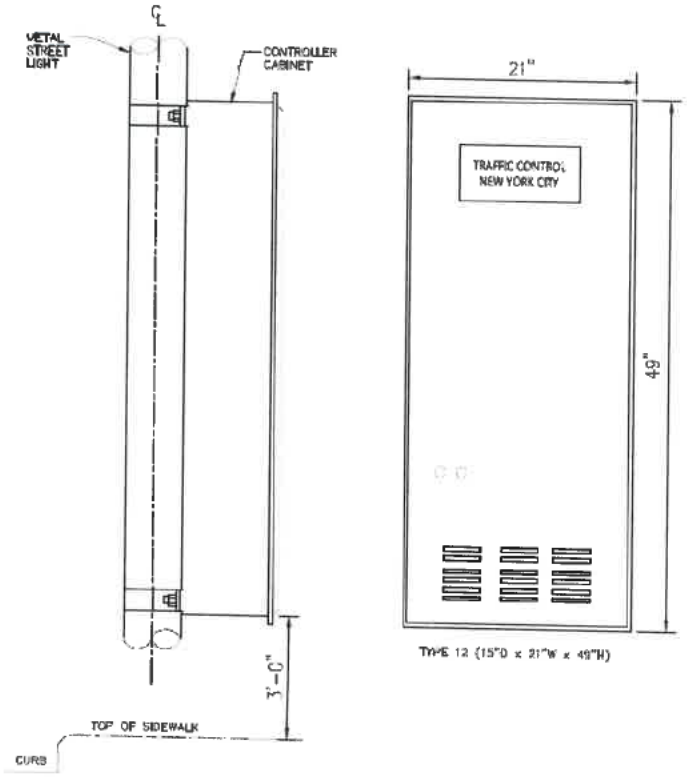
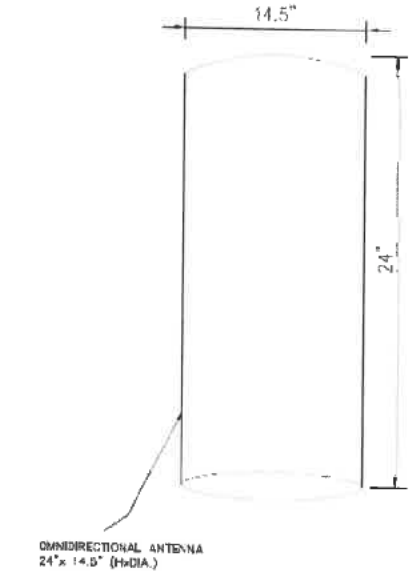


Exhibit C: Antenna #3
City Approved DOT Control Box Specification Zone A, B & C
FS Style Pole – DOT Cabinet Type 12 Sample Drawing

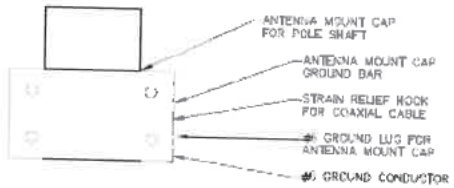
Mounting Detail



CONTROL BOX DETAIL



OMNI DIRECTIONAL ANTENNA



ANTENNA MOUNTING DETAIL

Exhibit C: Antenna #3
City Approved DOT Control Box Specification Zone A, B & C
FS Style Pole – Photo Simulation

DOT Cabinet Type 12

Exhibit C: Antenna #3

City Approved DOT Control Box Specification Zone A, B & C

M2 Style Pole – DOT Cabinet Type 12 Sample Drawing

Pole Elevation

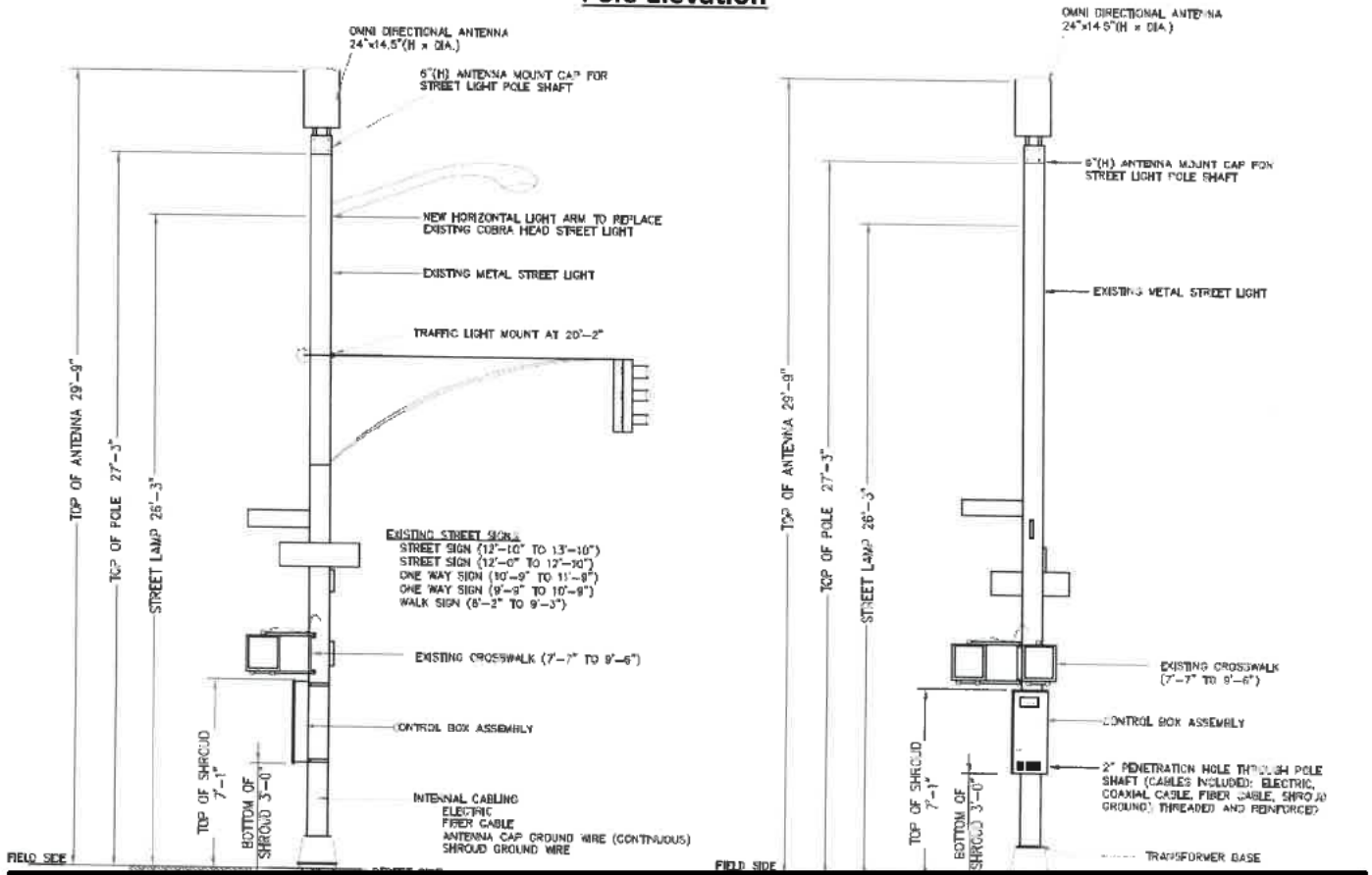


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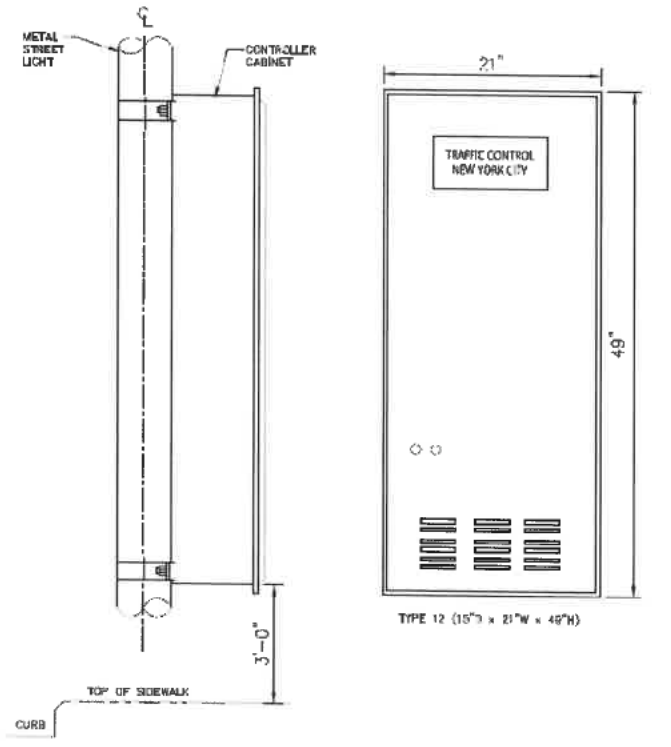
Exhibit C: Antenna #3

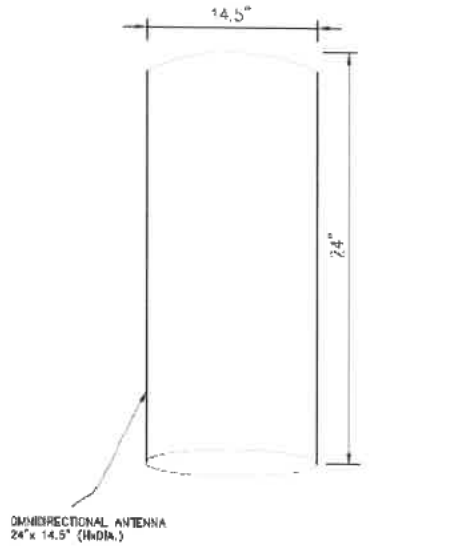
City Approved DOT Control Box Specification Zone A, B & C

M2 Style Pole – DOT Cabinet Type 12 Sample Drawing

Mounting Detail



CONTROL BOX DETAIL



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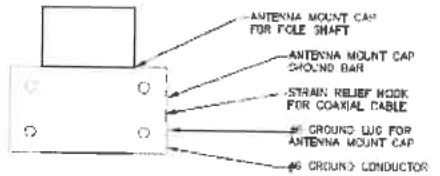
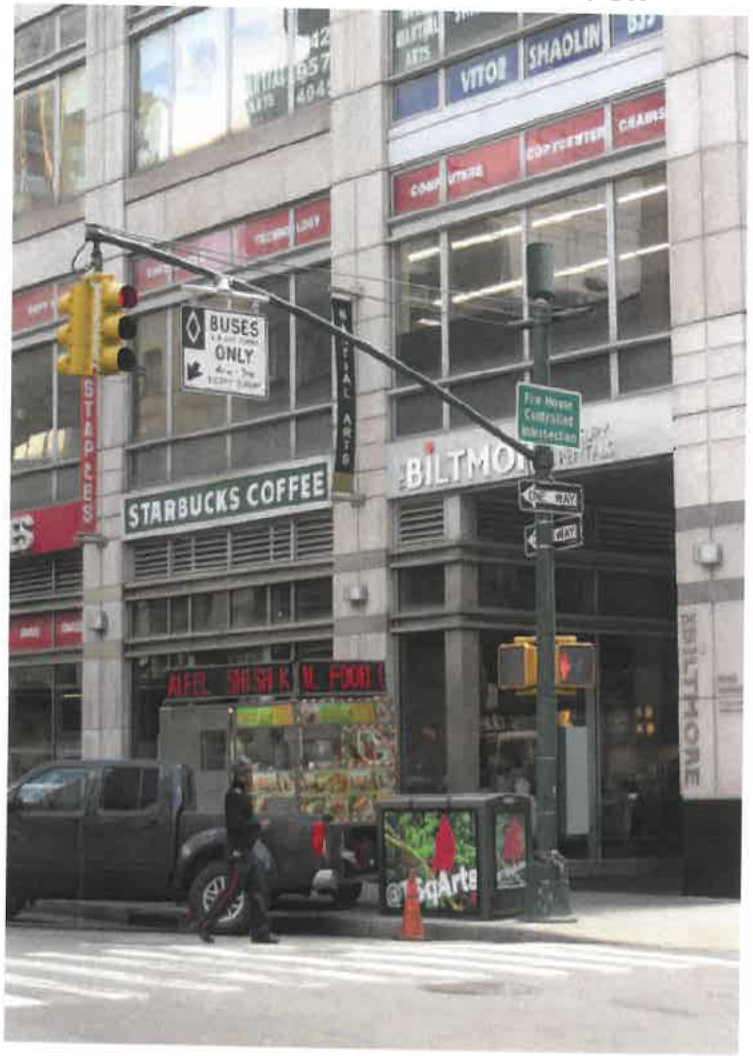


ANTENNA MOUNTING DETAIL

Exhibit C: Antenna #3
City Approved DOT Control Box Specification Zone A, B & C
M2 Style Pole – Photo Simulation

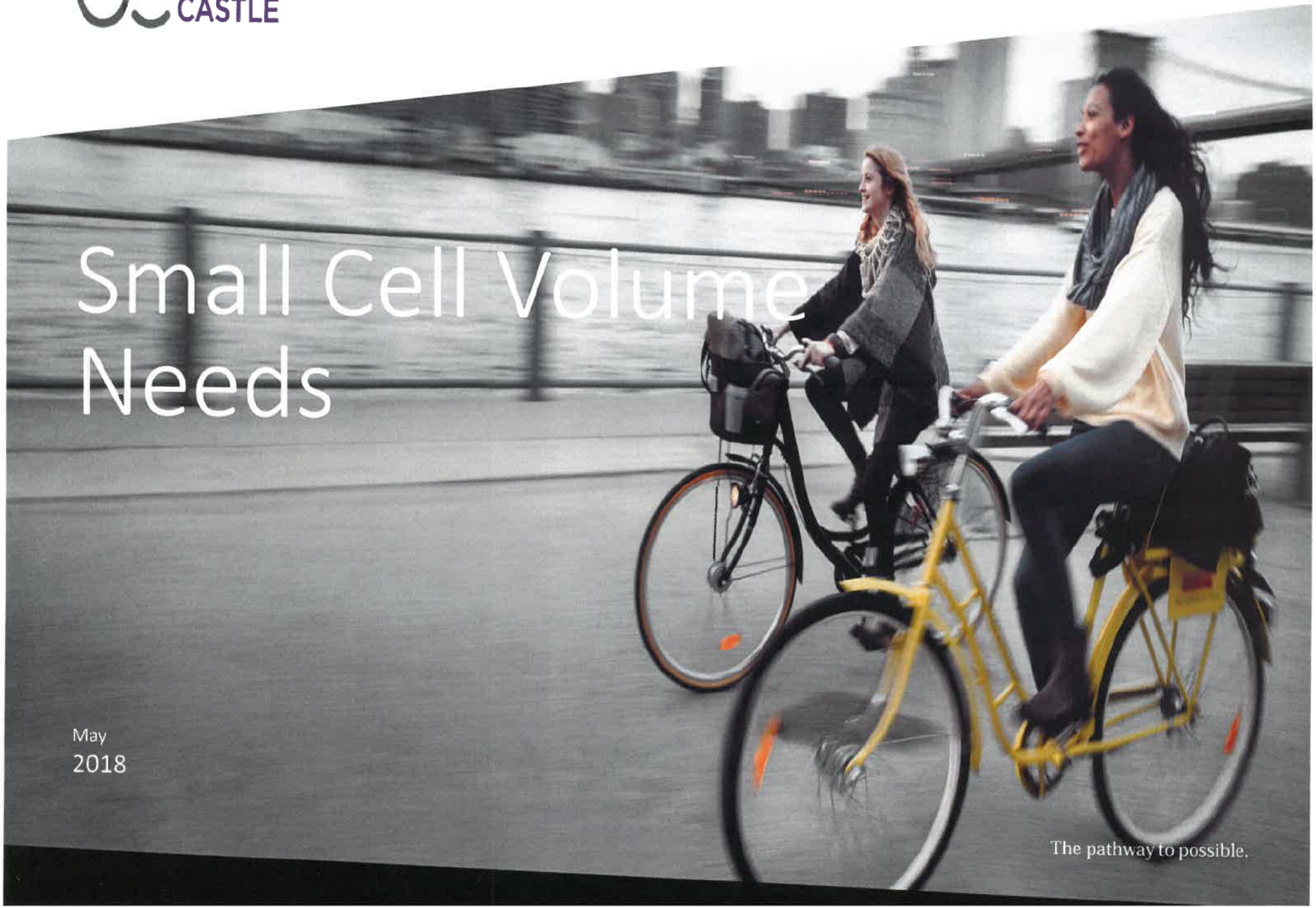


DOT Cabinet Type 12

Exhibit D:
Optimal 5G/IoT Deployment Configuration
Zone A, B & C

CROWN CASTLE

Small Cell Volume Needs



May
2018

Multiple Customers, Bands, Technologies

Colocation

- Small cells are expensive to deploy, shared infrastructure provides a significant economic benefit
  - Allows for faster growth due to less capital outlay for all parties
- Reduces the overall amount small cell infrastructure needed – less poles and antennas

Necessary to plan for multiple bands

- Typically each band requires its own radio, its own box
  - 600, 700, 850, PCS, AWS, Band 41 (2600), CBRS, Band 46 (LAA), mmWave (28GHz),
  - Carriers can easily plan for 4 (or more) Sub 6GHz bands and possibly mmWave
- Radios are not necessarily low power
  - Higher powers are still needed to capture enough traffic and also penetrate buildings

Multiple Customers, Bands, Technologies

Necessary to plan for both technologies when thinking about small cell deployment

- 4G and 5G will coexist long into the future
  - Early 5G deployments will actually depend on 4G and require dual connectivity
- 5G is not just mmWave, it will cover all frequency bands, including all current Sub 6GHz 4G LTE bands
  - Lower band equipment mostly employs separate radios and external antennas
  - mmWave requires integrated radios and antennas which can not be shrouded and need mounting higher up on the pole
  - 5G and advanced 4G technology rely on aggregating and using multiple bands together to achieve higher broadband speeds – thus requiring multiple bands deployed

Massive MIMO Integrated Form Factors

28GHz
128x128 Tx/Rx
6 kg
5L volume
8" x 4.7" x 8"

39GHz
512x512 Tx/Rx
14 kg
18L volume
~ 24" x 4" x 12"

Fully integrated Tx/Rx branches to dedicated antenna elements

Allows for beamforming and higher order MIMO

Place footnote text here

Adding new technology

Traditional equipment will need to co-exist with new integrated equipment

[redacted]

CROWN CASTLE

Volume Drivers: “new” Integrated Radio Equipment

Equipment Enclosures / Shrouding

Optimal Antenna Preferences

Volume Drivers: MIMO

MIMO Technology

- 5G and advanced 4G technology rely on using multiple transmit and receive paths or MIMO for higher broadband speeds – thus multiple paths for each multiple band (radio) deployed
- Sub 6GHz radios are either 2x2 MIMO or 4x4 MIMO
  - The trend is 4x4
  - More MIMO paths require more cable connections and space for cable management
  - Each path requires a cable connection to an individual port on antenna, which drives increased antenna dimensions

Volume Drivers: Antennas

Antennas

External antennas need to be multiband

- 7 different bands between the 4 national carriers
- Note lower bands drive larger volume requirements

External antennas need multiple ports per band

- For MIMO and multicarrier
- Note more ports drive increased volume requirements

Ideally all in the same enclosure for aesthetic reasons

An appropriate range of bands and number of ports for MIMO and colocation can be supported with < 6 cubic foot volume.

Smaller volumes must tradeoff either bands, colocation, or even performance ie < 3 cubic feet

Volume Drivers: Antennas

Volume Drivers: Antennas

Exhibit E:
Radio Frequency Emissions Report

Pinnacle Telecom Group

Professional and Technical Services

Antenna Site FCC RF Compliance Assessment and Report

prepared for

Crown Castle

Pole-mounted DAS Operations
New York Market

October 14, 2014

14 Ridgedale Avenue - Suite 209 • Cedar Knolls, NJ 07927 • 973-451-1630

Contents

Executive Summary

At the request of Crown Castle, Pinnacle Telecom Group has performed an independent expert assessment of radiofrequency (RF) levels and related FCC compliance for "distributed antenna system" (DAS) operations in the New York Market. The DAS antennas are to be mounted on poles, and will be capable of supporting transmission in the 700, 1900 and 2100 MHz frequency bands, facilitating the provision of commercial wireless services.

The FCC requires antenna operators to perform an assessment of the RF emissions from their antennas, and to ensure compliance with the FCC's Maximum Permissible Exposure (MPE) limit. That limit, described in some detail in Appendix A, has been set in such a manner that continuous exposure to RF levels up to and including 100 percent of the MPE limit is safe for humans of either sex, any size, any age, and under any conditions.

The analysis described herein examines FCC compliance for the Crown Castle antenna operation for three possible exposure situations: (1) for people standing at street level below the antenna installation; (2) for antenna technicians or other workers climbing the pole; and (3) for people in buildings adjacent to and at the same general height as the antennas.

The analyses for each area of interest employ standard FCC formulas for calculating the RF effects of the antennas in a very conservative manner, in order to ensure "safe-side" (i.e., intentionally overstated) results and thus great confidence in conclusions regarding compliance with the applicable MPE limit.

The results of compliance analyses can be described in layman's terms by expressing the calculated RF levels as simple percentages of the applicable FCC MPE limit. If the reference for that limit is "normalized" to 100 percent, then calculated RF levels higher than 100 percent indicate the MPE limit is exceeded and there is a need to mitigate the potential exposure. On the other hand, calculated RF levels consistently below 100 percent serve as a clear and sufficient demonstration of compliance with the MPE limit. Because of the conservatism encouraged by the FCC, calculations showing RF levels up to and

even including 100 percent of the applicable MPE limit serve as proof of compliance.

The results of the RF compliance assessment in this case are as follows:

- ***For People Standing at Street Level around the Antenna:*** The conservatively calculated maximum RF level from the Crown Castle antenna operation is 0.9490 percent of the FCC MPE limit – a result that is less than one percent, and which is clearly well below the 100-percent reference for compliance.
- ***For Workers Close to the Antenna:*** The near-field analysis shows that that the applicable FCC occupational MPE limit is satisfied at all same-height distances, and the general population MPE limit is satisfied at a same-height distance of four feet. We recommend that an "Notice-type" RF alert sign be posted at the antenna location, with a specified stand-off distance of four (4) feet for purposes of controlling potential exposure of the general public.
- ***For People in an Adjacent Building:*** For someone inside a building at a distance of as little as 10 feet away from the antenna and at the same height as the antennas, the conservatively calculated RF level is 28.8 percent of the FCC general population MPE limit – well below the 100-percent reference for compliance. At distances greater than 10 feet from the antennas, or in positions lower or higher than the antennas, the RF levels are even less significant.

The results of the analyses of RF levels, along with the recommended RF alert signage, combine to satisfy the FCC's regulations and associated guidelines concerning the control of potential RF exposure. Moreover, because of the conservative methodology and assumptions incorporated in the analysis, RF levels actually caused by the antennas in each area of interest will be even less significant than the calculation results indicate.

The remainder of this report provides the following:

- relevant technical data on the Crown Castle DAS antenna operation;
- a description of the applicable FCC mathematical models for assessing compliance, and application of the technical data to those models; and
- the results of the analysis, and the compliance conclusion for the proposed Crown Castle DAS operation.

In addition, two Appendices are included. Appendix A provides background on the FCC MPE limit, as well as a list of key FCC references on compliance. Appendix B provides a summary of the qualifications of the expert certifying RF compliance for the described Crown Castle DAS operations.

Antenna and Transmission Data

Transmission parameters for the DAS antenna operation are provided below.

General Data	
Antenna Type	Omnidirectional
Antenna Model	Phazar AWSBRS360T-698/1710-7/2/9-T0
Antenna Length	72 in.
Antenna Mounting Height AGL	10 meters (32.8 ft.)
700 MHz Transmission Data	
Tot. Available RF Power	20 watts
Antenna Line Loss	1.0 dB
Max. Antenna Input Power	15.89 watts
Max. Antenna Gain	2.0 dBi
1900 MHz Transmission Data	
Tot. Available RF Power	20 watts
Antenna Line Loss	1.0 dB
Max. Antenna Input Power	15.89 watts
Max. Antenna Gain	9.0 dBi
2100 MHz Transmission Data	
Tot. Available RF Power	80 watts
Antenna Line Loss	1.0 dB
Max. Antenna Input Power	63.55 watts
Max. Antenna Gain	9.0 dBi

The vertical-plane emission pattern of the antenna is used in the analysis of street-level compliance. Figures 1 and 2 that follow show the manufacturer-specified vertical-plane pattern for the proposed antenna model in each frequency band.

Note that the use of a decibel scale to describe the relative pattern at different angles incidentally serves to significantly understate the actual focusing effects of the antenna. Where the antenna pattern reads 20 dB, for example, the relative RF energy emitted at the corresponding downward angle is 1/100th of the maximum that occurs in the main beam (at 0 degrees); at a 30 dB point, the level is 1/1,000th of the maximum.

Note, finally, that the automatic pattern-scaling feature of our internal software may skew side-by-side visual comparisons of different antenna models, or even different parties' depictions of the same antenna model.

Figure 1. AWSBRS360T-698/1710-7/2/9-T0 – 700 MHz Vertical-plane Pattern

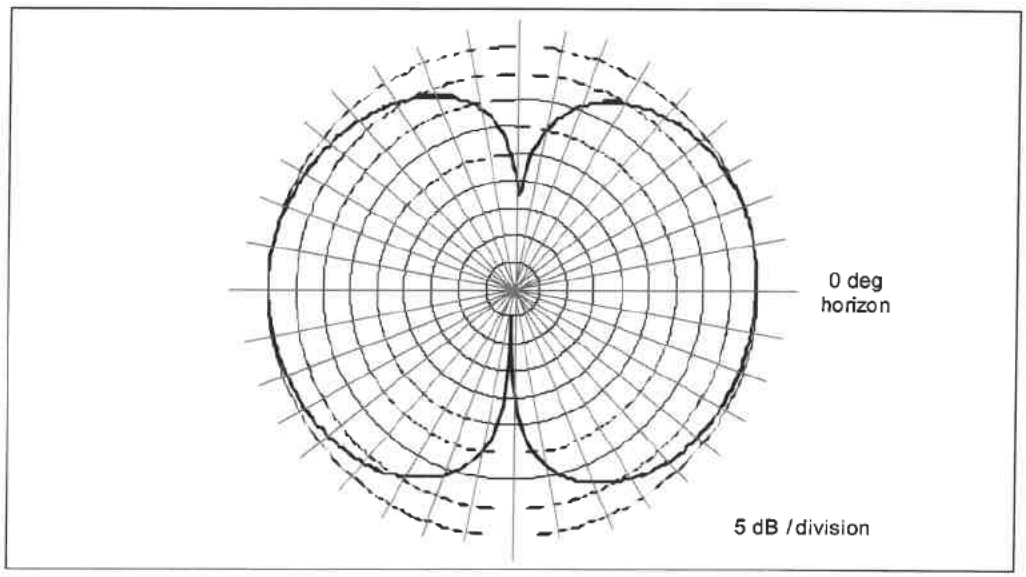


Figure 2. AWSBRS360T-698/1710-7/2/9-T0 – 1900 MHz Vertical-plane Pattern

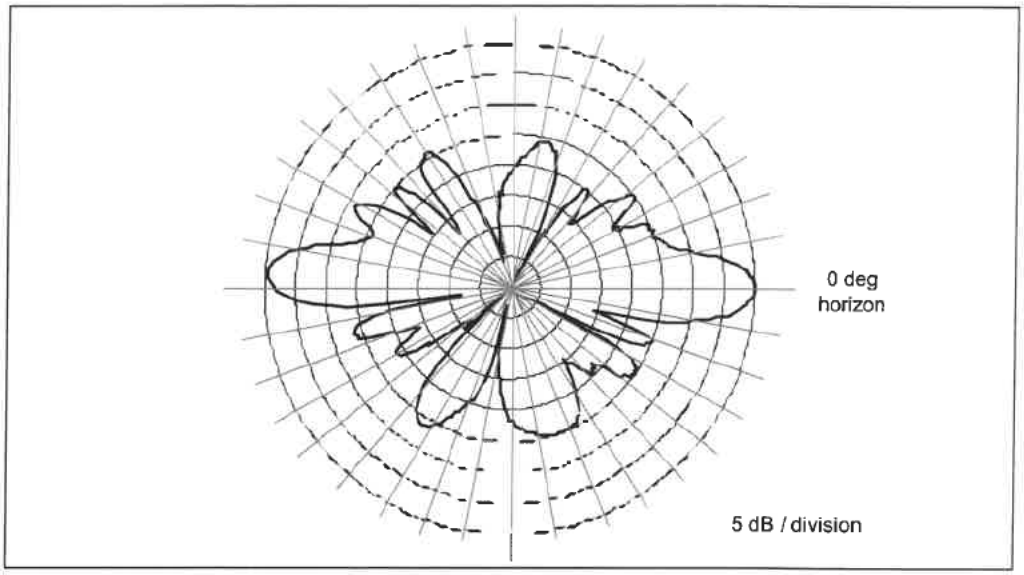
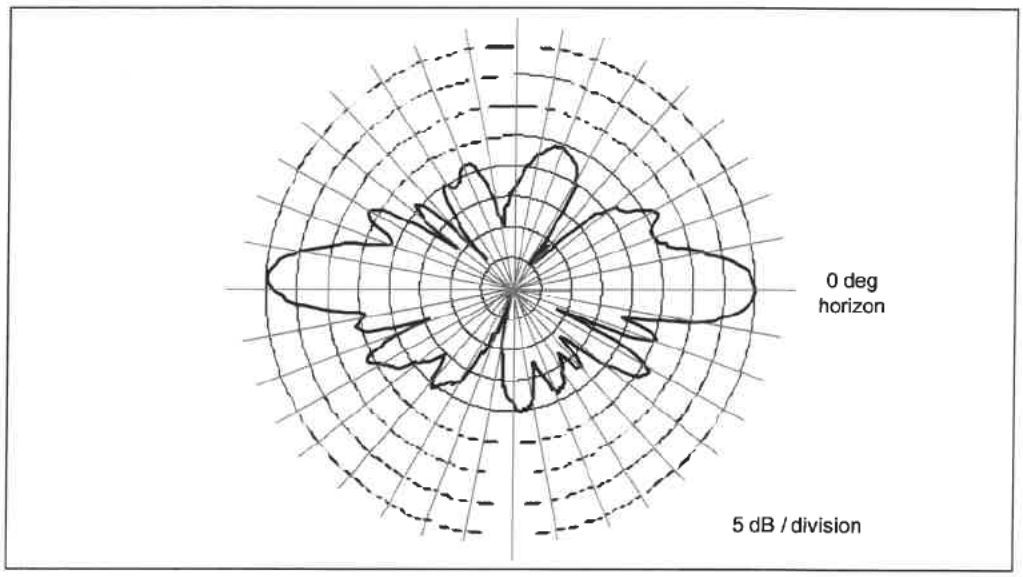


Figure 3. AWSBRS360T-698/1710-7/2/9-T0 – 2100 MHz Vertical-plane Pattern



Compliance Analysis

FCC Office of Engineering and Technology Bulletin 65 ("OET Bulletin 65") provides guidelines for mathematical models to calculate the RF levels at various points around transmitting antennas.

In this case, there are two general areas of potential exposure interest: (1) at street level below and around the antenna installation; and (2) at the same relative height as the antenna. The FCC's "far-field" model applies to the street-level analysis. The FCC's "near-field" model applies to the analyses of RF levels closer to and at the same general height as the antennas, such as applies to utility pole workers and people in buildings adjacent to the antenna installations.

Each area of interest is addressed in the subsections that follow.

Street-Level Compliance Analysis

The areas at street level around an antenna installation are clearly open to unrestricted public access, and are subject to the FCC MPE limit for "uncontrolled" exposure, commonly called the "general population" limit.

At street-level, the RF levels from antennas are directly proportional to the total antenna input power and the relative antenna gain in the downward direction of interest – and the RF levels are otherwise inversely proportional to the square of the straight-line distance to the antenna.

Conservative calculations also assume the potential RF exposure is enhanced by reflection of the RF energy from the intervening ground. Our calculations will assume a 100% "perfect" ground reflection, the absolute worst-case approach.

The formula for street-level RF compliance calculations for any given wireless antenna operation is as follows:

$$MPE\% = (100 * InputPower * 10^{(Gmax-Vdisc/10)} * 4) / (MPE * 4\pi * R^2)$$

where

MPE%	=	RF level, expressed as a percentage of the MPE limit applicable to continuous exposure of the general public
100	=	factor to convert the raw result to a percentage
InputPower	=	maximum net power into antenna, in milliwatts, a function of the number of RF channels, the transmitter power, and line loss
$10^{(Gmax-Vdisc/10)}$	=	numeric equivalent of the relative antenna gain in the downward direction of interest; data on the antenna vertical-plane pattern is taken from manufacturer specifications
4	=	factor to account for a 100-percent-efficient energy reflection from the ground, and the squared relationship between RF field strength and power density ($2^2 = 4$)
MPE	=	FCC general population MPE limit
R	=	straight-line distance from the RF source to the point of interest, centimeters

We will conservatively perform the MPE% calculations out to a distance of 500 feet from the facility to points six feet off the ground, with the latter figure representing human standing height. The calculation geometry is illustrated in Figure 4 on the next page.

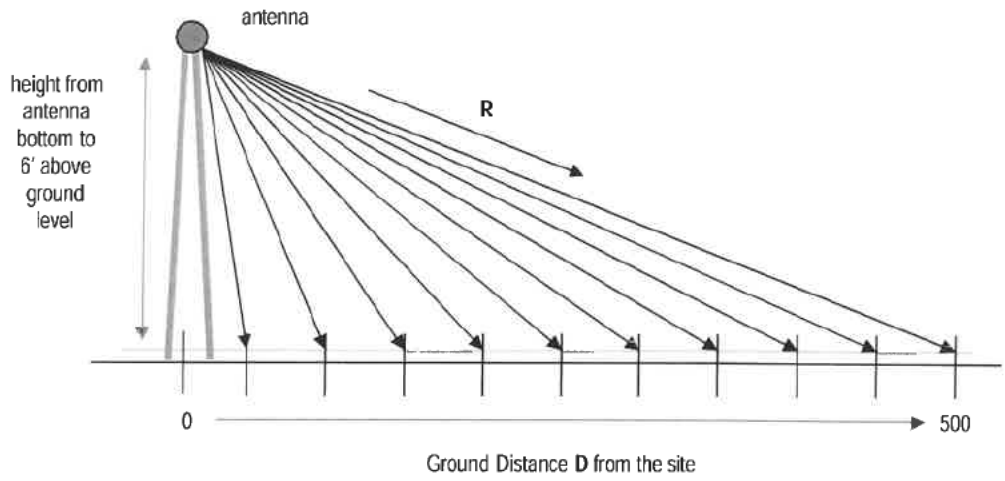


Figure 4. Street-level MPE% Calculation Geometry

It is popularly understood that the farther away one is from an antenna, the lower the RF level – which is generally but not universally correct. The results of MPE% calculations fairly close to the base of the pole will reflect the variations in the vertical-plane antenna pattern as well as the variation in straight-line distance to the antennas. Therefore, RF levels may actually increase slightly with increasing distance within the range of zero to 500 feet from the site. As the distance approaches 500 feet and beyond, though, the antenna pattern factor becomes less significant, the RF levels become primarily distance-controlled, and as a result the RF levels generally decrease with increasing distance, and are well understood to be in compliance.

Street-level FCC compliance for a multiple-band antenna operation is assessed in the following manner. At each distance point along the ground, an MPE% calculation is made for the RF effect in each frequency band, and the sum of the individual MPE% contributions at each point is compared to 100 percent, which serves as the normalized reference for the FCC MPE limit. We refer to the sum of the individual MPE% contributions as "total MPE%", and any calculated MPE% total MPE% result exceeding 100 percent is, by definition, higher than the FCC

limit and represents non-compliance and a need to mitigate the RF levels. If, on the other hand, all results are below 100 percent, that set of results serves as a demonstration of compliance with the MPE limit.

The following conservative methodology and assumptions are incorporated into the MPE% calculations on a general basis:

1. The antennas are assumed to be operating continuously at maximum power.
2. The power-attenuation effects of shadowing or other obstructions to the line-of-sight path from the antenna to the point of interest are ignored.
3. The calculations intentionally minimize the distance factor (R) by performing the calculations from the bottom (rather than the centerline) of the antenna.
4. The potential RF exposure at ground level is assumed to be enhanced (increased) via a "perfect" mirror-like 100-percent field reflection from the intervening ground.

The net result of these assumptions is to significantly overstate the calculated RF exposure levels relative to the levels that will actually occur – and the purpose of this conservatism is to allow very "safe-side" conclusions about compliance.

The table on the next page provides the results of the street-level MPE% calculations for each frequency band and the total, with the maximum (worst-case) calculated total MPE% effect highlighted in bold in the last column.

Ground Distance (ft)	700 MHz MPE%	1900 MHz MPE%	2100 MHz MPE%	Total MPE%
0	0.0009	0.0811	0.1596	0.2416
20	0.7873	0.0153	0.0329	0.8355
40	0.6019	0.0511	0.2960	**0.9490**
60	0.3543	0.0148	0.0027	0.3718
80	0.2199	0.0104	0.0741	0.3044
100	0.1461	0.0011	0.0142	0.1614
120	0.1060	0.0118	0.0402	0.1580
140	0.0788	0.0250	0.1362	0.2400
160	0.0609	0.0336	0.1687	0.2632
180	0.0495	0.0339	0.1593	0.2427
200	0.0403	0.0422	0.1809	0.2634
220	0.0334	0.0412	0.1933	0.2679
240	0.0281	0.0347	0.1628	0.2256
260	0.0246	0.0396	0.1748	0.2390
280	0.0212	0.0342	0.1509	0.2063
300	0.0185	0.0298	0.1316	0.1799
320	0.0163	0.0318	0.1248	0.1729
340	0.0144	0.0282	0.1107	0.1533
360	0.0129	0.0252	0.0988	0.1369
380	0.0116	0.0226	0.0887	0.1229
400	0.0104	0.0219	0.0938	0.1261
420	0.0095	0.0199	0.0851	0.1145
440	0.0086	0.0181	0.0775	0.1042
460	0.0079	0.0166	0.0710	0.0955
480	0.0073	0.0152	0.0652	0.0877
500	0.0067	0.0140	0.0601	0.0808

As indicated, the overall maximum calculated RF level is 0.9490 percent of the FCC MPE limit – less than one percent, and obviously well below the 100-percent reference for compliance with the FCC limit.

A graph of the overall calculation results, provided on the next page, probably provides a clearer *visual* illustration of the relative insignificance of the calculated RF levels. As might be expected with such low calculated RF levels, the results line barely rises above the graph's baseline, and shows an obviously clear and consistent margin to the FCC MPE limit.

Therefore, we recommend that the RF alert sign shown in Figure 6, below, be posted at the antenna location, with a specified distance of four feet for purposes of controlling potential exposure of the general public.

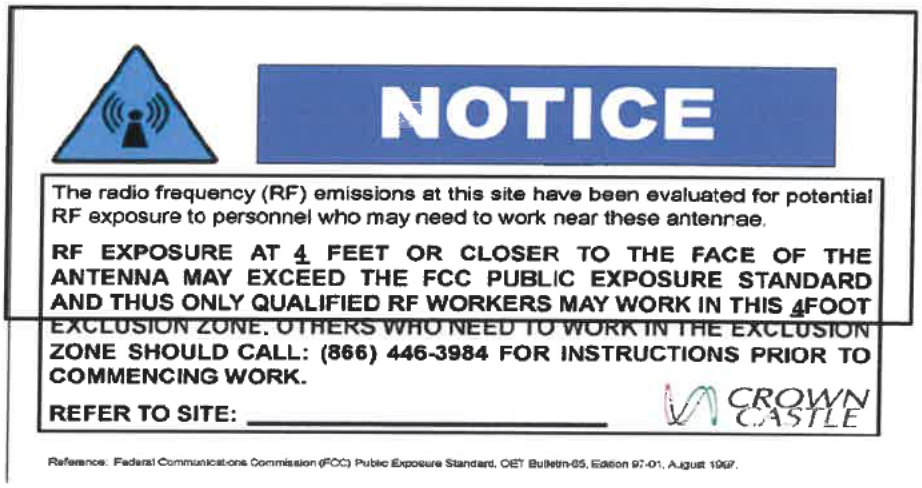


Figure 6. Recommended RF Alert Signage

Compliance Conclusion

The results of the analyses of RF levels, along with the recommended RF alert signage, satisfy the FCC's regulations concerning the control of potential RF exposure. Moreover, because of the conservative methodology and assumptions incorporated in the analysis, RF levels actually caused by the antennas in each area of interest will be even less significant than the calculation results indicate.

Certification

It is the policy of Pinnacle Telecom Group that all FCC RF compliance assessments are reviewed, approved, and signed by the firm's Chief Technical Officer, who certifies as follows:

1. I have read and fully understand the FCC regulations concerning RF safety and the control of human exposure to RF fields (47 CFR 1.1301 *et seq*).
2. To the best of my knowledge, the statements and information disclosed in this report are true, complete and accurate.
3. The analysis of site RF compliance provided herein is consistent with the applicable FCC regulations, additional guidelines issued by the FCC, and industry practice.
4. The results of the analysis indicate that the subject antenna operations will be in compliance with the FCC regulations and applicable MPE limits.

Daniel J. Collins

Chief Technical Officer
Pinnacle Telecom Group, LLC

10/14/14

Date

Appendix A. Background on the FCC MPE Limits

FCC Regulations

As directed by the Telecommunications Act of 1996, the FCC has incorporated into its Rules and Regulations a set of limits for maximum continuous human exposure to RF emissions from antennas.

The FCC maximum permissible exposure (MPE) limits represent the consensus of federal agencies and independent experts responsible for RF safety matters. Those agencies include the National Council on Radiation Protection and Measurements (NCRP), the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), the American National Standards Institute (ANSI), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA). In formulating its guidelines, the FCC also considered input from the public and technical community – notably the Institute of Electrical and Electronics Engineers (IEEE).

The FCC's RF exposure guidelines are incorporated in Section 1.301 *et seq* of its Rules and Regulations (47 CFR 1.1301-1.1310). Those guidelines specify MPE limits for both occupational and general population exposure.

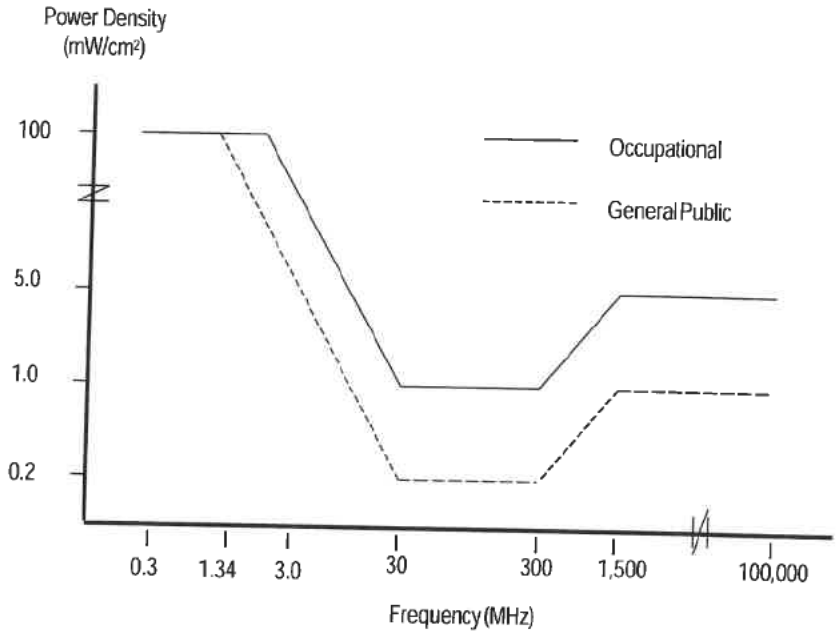
The specified continuous exposure MPE limits are based on known variation of human body susceptibility in different frequency ranges, and a Specific Absorption Rate (SAR) of 4 watts per kilogram, which is universally considered to accurately represent human capacity to dissipate incident RF energy (in the form of heat). The occupational MPE guidelines incorporate a safety factor of 10 or greater with respect to RF levels known to represent a health hazard, and an additional safety factor of five is applied to the MPE limits for general population exposure. Thus, the general population MPE limit has a built-in safety factor of more than 50. The limits were constructed to appropriately protect humans of both sexes and all ages and sizes and under all conditions – and continuous exposure at levels equal to or below the applicable MPE limits is considered to result in no adverse health effects or even health risk.

The reason for *two* tiers of MPE limits is based on an understanding and assumption that members of the general public are unlikely to have had appropriate RF safety training and may not be aware of the exposures they receive; occupational exposure in controlled environments, on the other hand, is assumed to involve individuals who have had such training, are aware of the exposures, and know how to maintain a safe personal work environment.

The FCC's MPE limits are expressed in two equivalent forms, using alternative units of field strength (expressed in volts per meter, or V/m), and power density (expressed in milliwatts per square centimeter, or mW/cm^2). The table on the next page lists the FCC limits for both occupational and general population exposures, using the mW/cm^2 reference, for the different radio frequency ranges.

Frequency Range (F) (MHz)	Occupational Exposure (mW/cm^2)	General Public Exposure (mW/cm^2)
0.3 - 1.34	100	100
1.34 - 3.0	100	$180 / F^2$
3.0 - 30	$900 / F^2$	$180 / F^2$
30 - 300	1.0	0.2
300 - 1,500	F / 300	F / 1500
1,500 - 100,000	5.0	1.0

The diagram below provides a graphical illustration of both the FCC's occupational and general population MPE limits.



Because the FCC's RF exposure limits are frequency-shaped, the exact MPE limits applicable to the instant situation depend on the frequency range used by the systems of interest.

The most appropriate method of determining RF compliance is to calculate the RF power density attributable to a particular system and compare that to the MPE limit applicable to the operating frequency in question. The result is usually expressed as a percentage of the MPE limit.

For potential exposure from multiple systems, the respective percentages of the MPE limits are added, and the total percentage compared to 100 (percent of the limit). If the result is less than 100, the total exposure is in compliance; if it is more than 100, exposure mitigation measures are necessary to achieve compliance.

Note that the FCC "categorically excludes" all "non-building-mounted" wireless antenna operations whose mounting heights are more than 10 meters (32.8 feet) from the routine requirement to demonstrate compliance with the MPE limit, because such operations "are deemed, individually and cumulatively, to have no significant effect on the human environment". The categorical exclusion also applies to *all* point-to-point antenna operations, regardless of the type of structure they're mounted on. Note that the FCC considers any facility qualifying for the categorical exclusion to be automatically in compliance.

FCC References on RF Compliance

47 CFR, FCC Rules and Regulations, Part 1 (Practice and Procedure), Section 1.1310 (Radiofrequency radiation exposure limits).

FCC Second Memorandum Opinion and Order and Notice of Proposed Rulemaking (FCC 97-303), *In the Matter of Procedures for Reviewing Requests for Relief From State and Local Regulations Pursuant to Section 332(c)(7)(B)(v) of the Communications Act of 1934 (WT Docket 97-192), Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation (ET Docket 93-62), and Petition for Rulemaking of the Cellular Telecommunications Industry Association Concerning Amendment of the Commission's Rules to Preempt State and Local Regulation of Commercial Mobile Radio Service Transmitting Facilities*, released August 25, 1997.

FCC First Memorandum Opinion and Order, ET Docket 93-62, *In the Matter of Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation*, released December 24, 1996.

FCC Report and Order, ET Docket 93-62, *In the Matter of Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation*, released August 1, 1996.

FCC Office of Engineering and Technology (OET) Bulletin 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition 97-01, August 1997.

FCC Office of Engineering and Technology (OET) Bulletin 56, "Questions and Answers About Biological Effects and Potential Hazards of RF Radiation", edition 4, August 1999.

Appendix B. Summary of Expert Qualifications

Daniel J. Collins, Chief Technical Officer, Pinnacle Telecom Group, LLC

Synopsis:	• 40+ years of experience in all aspects of wireless system engineering, related regulation, and RF exposure • Has performed or led RF exposure compliance assessments on more than 17,000 antenna sites since the new FCC rules went into effect in 1997 • Has provided testimony as an RF compliance expert more than 1,400 times since 1997 • Have been accepted as an expert in New Jersey and more than 40 other states, as well as by the FCC
Education:	• B.E.E., City College of New York (Sch. Of Eng.), 1971 • M.B.A., 1982, Fairleigh Dickinson University, 1982 • Bronx High School of Science, 1966
Current Responsibilities:	• Leads all PTG staff work involving RF safety and FCC compliance, microwave and satellite system engineering, and consulting on wireless technology and regulation
Prior Experience:	• Edwards & Kelcey, VP – RF Engineering and Chief Information Technology Officer, 1996-99 • Bellcore, Executive Director – Regulation and Public Policy, 1983-96 • AT&T (Corp. HQ), Director – Spectrum Management Policy and Practice, 1977-83 • AT&T Long Lines, Group Supervisor – Microwave Radio System Design, 1972-77
Specific RF Safety/ Compliance Experience:	• Involved in RF exposure matters since 1972 • Have had lead corporate responsibility for RF safety and compliance at AT&T, Bellcore, Edwards & Kelcey, and PTG • While at AT&T, helped develop the mathematical models later adopted by the FCC for predicting RF exposure • Have been relied on for compliance by all major wireless carriers, as well as by the federal government, several state and local governments, equipment manufacturers, system integrators, and other consulting / engineering firms
Other Background:	• Author, *Microwave System Engineering* (AT&T, 1974) • Co-author and executive editor, *A Guide to New Technologies and Services* (Bellcore, 1993) • National Spectrum Managers Association (NSMA) – former three-term President and Chairman of the Board of Directors; was founding member, twice-elected Vice President, a long-time member of the Board of Directors, and was named an NSMA Fellow in 1991 • Published more than 35 articles in industry magazines

Exhibit F: About Crown Castle Solutions LLC

Exhibit F:
Crown Castle Investor Presentation

CROWN CASTLE

June 2018

Crown Castle

Investor Presentation

Cautionary Information

This presentation contains forward-looking statements and information that are based on management's current expectations. Such statements may include projections, Outlook and estimates regarding (1) carrier network investment, densification, and capital expenditures, and potential benefits derived therefrom, (2) shareholder returns, (3) our strategic and competitive position, (4) potential benefits and returns which may be derived from our business, our investments and our acquisitions, (5) dividends, including potential growth and dividend yields, (6) demand for our sites and services, (7) leasing activity and tenant additions, (8) our growth, (9) capital allocation and capital expenditures, including sustaining capital expenditures, (10) our balance sheet, (11) U.S. mobile data traffic, growth, demand, usage and speed, (12) cash flows, (13) revenues, including site rental revenues, (14) AFFO, and (15) margins, including site rental gross margin. The term "including", and any variation thereof, means "including, without limitation."

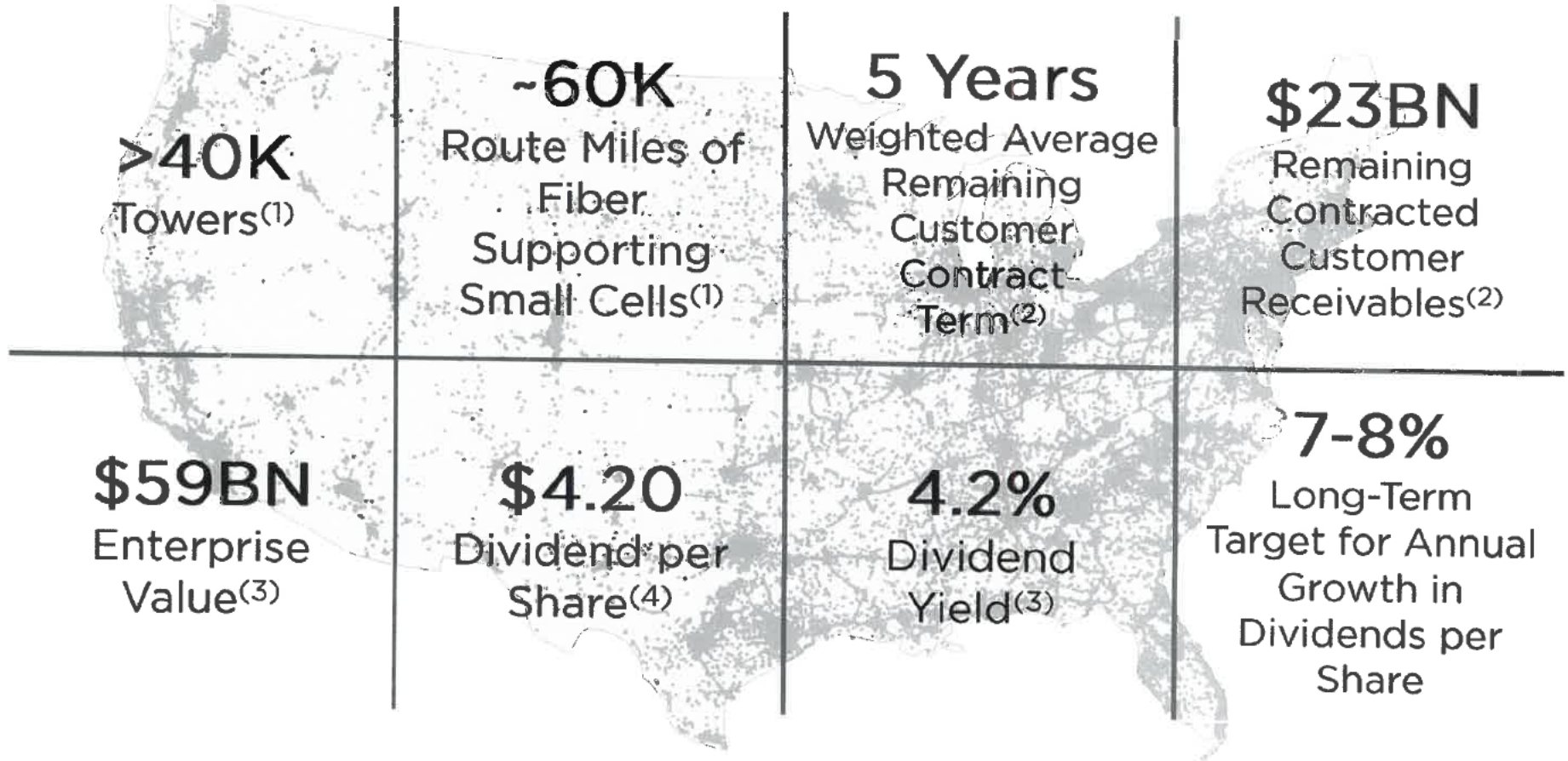
Such forward-looking statements are subject to certain risks, uncertainties and assumptions, including prevailing market conditions and other factors. Should one or more of these risks or uncertainties materialize, or should any underlying assumptions prove incorrect, actual results may vary materially from those expected. More information about potential risk factors which could affect our results is included in our filings with the Securities and Exchange Commission. The Company assumes no obligation to update publicly any forward-looking statements, whether as a result of new information, future events or otherwise.

This presentation includes certain non-GAAP financial measures. Tables reconciling such non-GAAP financial measures are set forth in the Supplemental Information Package posted in the Investors section of Crown Castle's website at http://investor.crowncastle.com.

Company Overview

Crown Castle at a Glance

The Foundation for a Wireless World



>40K Towers[1]	**~60K** Route Miles of Fiber Supporting Small Cells[1]	**5 Years** Weighted Average Remaining Customer Contract Term[2]	**$23BN** Remaining Contracted Customer Receivables[2]
$59BN Enterprise Value[3]	**$4.20** Dividend per Share[4]	**4.2%** Dividend Yield[3]	**7-8%** Long-Term Target for Annual Growth in Dividends per Share

1. As of 3/31/18
2. As of 3/31/18 excludes renewal terms at customers' option
3. As of 6/15/18 close
4. Q1 2018 declared dividend per share annualized

1 **40,000**

Towers

Provide the critical foundation for coverage and capacity

2 **60,000**

Small Cells[1]

Enable additional network densification by offloading traffic and bolstering capacity in the areas of the network where data demand is the greatest

3 **60,000**

Route Miles of Fiber

Increase returns on fiber investments by sharing the same fiber assets across thousands of fiber solutions customers

1. Number of nodes on air or under contract

Maximizing Shareholder Value by Focusing on Growing Long-Term, High Quality Dividends

- ✓ Drive organic growth by leasing our existing portfolio of >40K well-located towers and 60K route miles of high capacity fiber
- ✓ Allocate capital to accretive discretionary investments that further grow and enhance our long-term dividends per share
- ✓ Maintain a strong investment grade balance sheet to ensure consistent access to capital

Combination of Stability and Growth Provides Compelling Total Return Opportunity

Attractive Dividend Yield

- ✓ Dividends supported by high quality, long-term contracted lease payments
- ✓ Weighted average 5-years of contracted lease payments totaling $23 billion[1]
- ✓ Provider of mission critical shared communication infrastructure assets
- ✓ Investment grade balance sheet
- ✓ 100% focused on attractive U.S. wireless market

Long-Term Growth Tailwinds

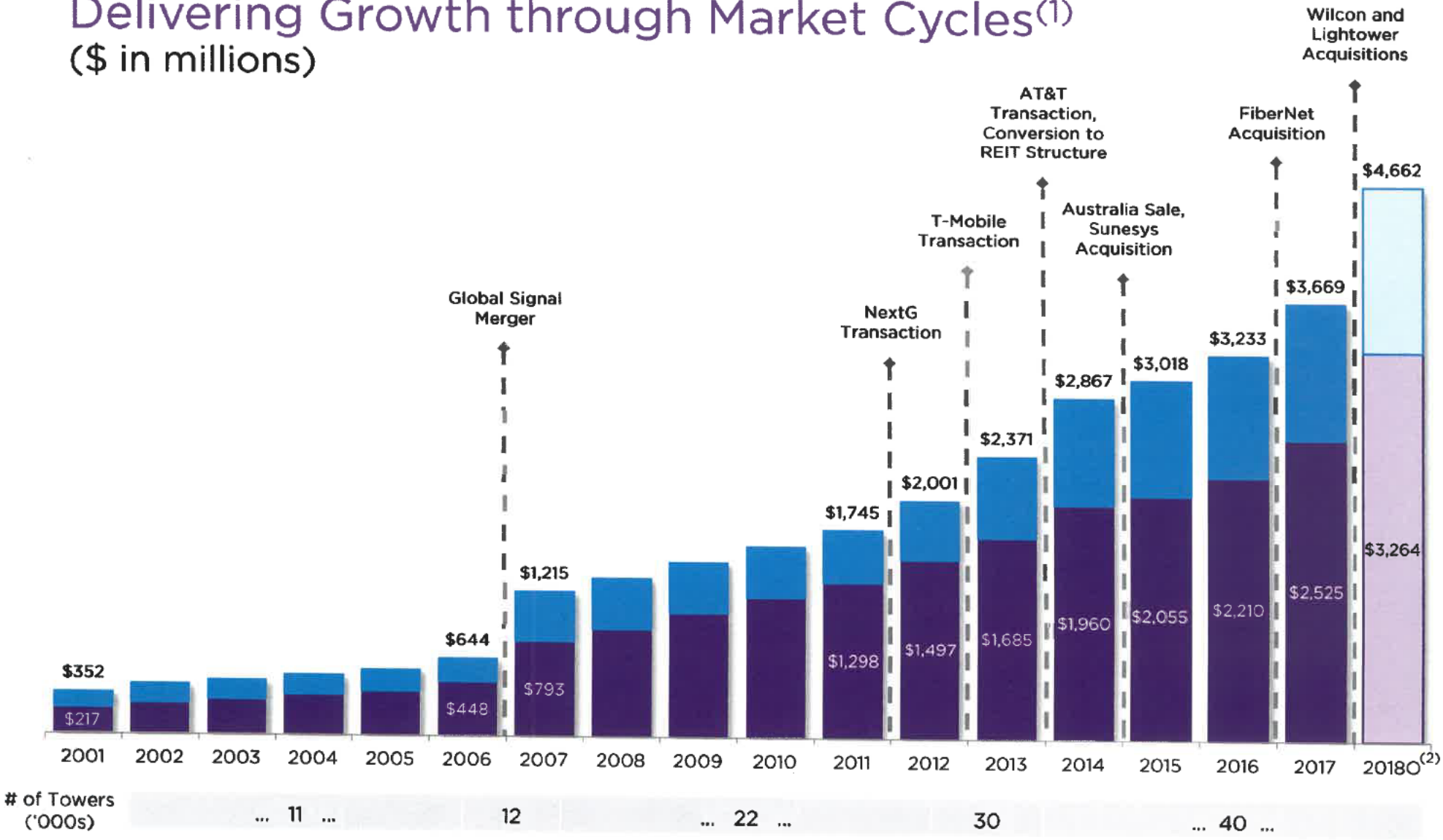
- ✓ Embedded growth tied to contracted escalators
- ✓ Data growth expected to drive continued network investment
- ✓ Well positioned to capture network densification with portfolio of towers and fiber fed small cells
- ✓ Proven track record of generating growth through execution and capital allocation

CROWN CASTLE

1. As of 3/31/18; excludes renewal terms at customers' option

Proven Operating Track Record, Consistently Delivering Growth through Market Cycles[1]

($ in millions)



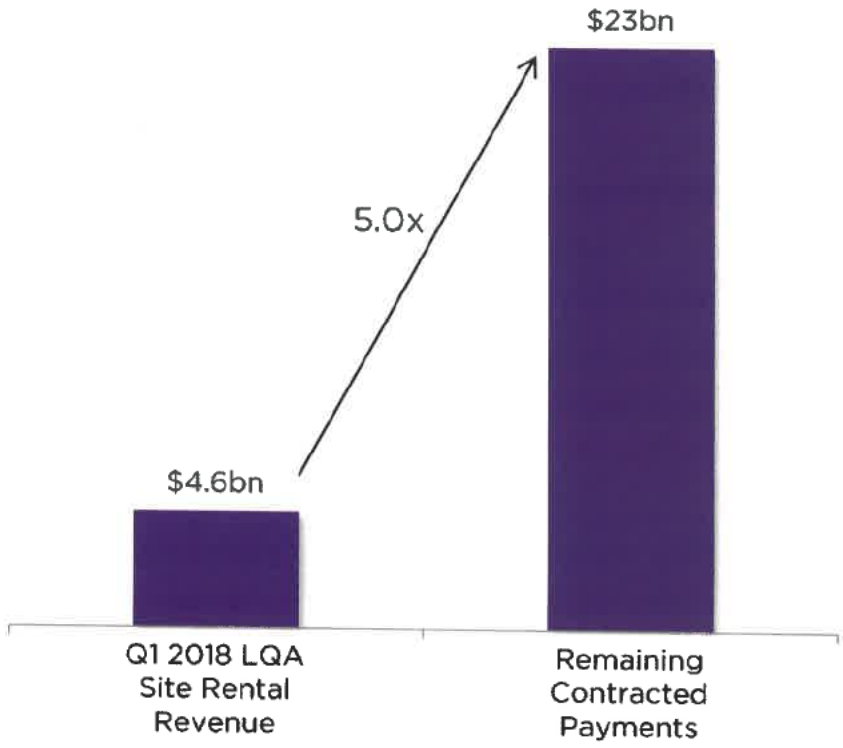
1. Exclusive of results from discontinued operations
2. Mid-point of outlook as issued on April 19, 2018

Long-Term, High-Quality Cash Flows

Long-Term Contracted Revenues

- Long-term, recurring revenues provide stability and embedded growth from contracted escalators
  - $23 billion in contracted lease payments predominantly from the top U.S. wireless carriers[1]
  - 5 years weighted average current term remaining[1]
- High quality revenue stream
  - Shared communication infrastructure provides cost effective network deployments on mission critical infrastructure
  - Big 4 wireless carriers represent approximately 84% of site rental revenues[2]

Remaining Contracted Payments[1]



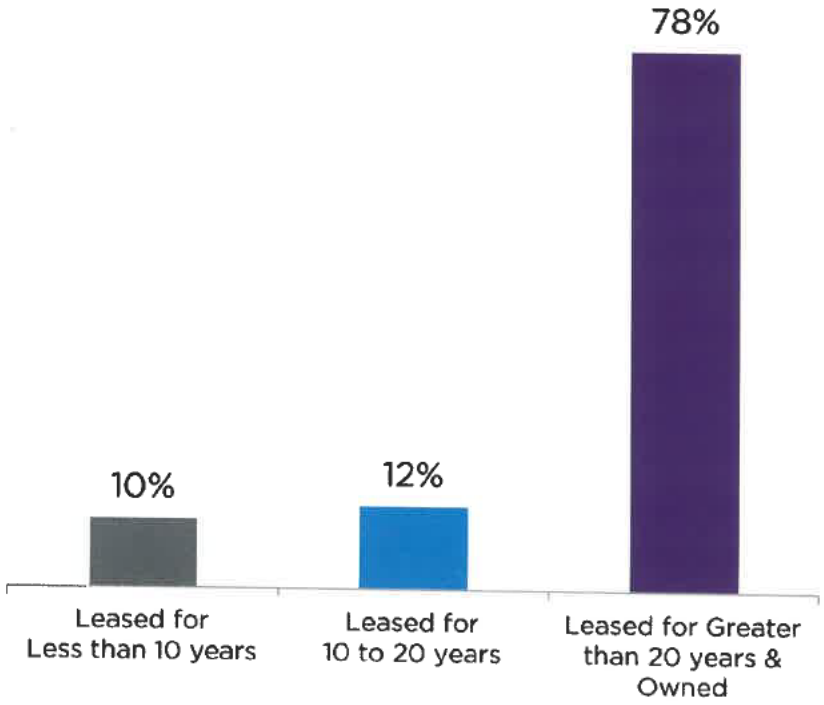
1. As of 3/31/18; excludes renewal terms at customers' option, weighted by site rental revenues
2. Expressed as percentage of last quarter annualized "LQA" Q1 2018 site rental revenues

Long-Term Control of Assets

Ground Interest Overview

- Crown has long-term control of the majority of the land interests under its towers:
  - Completed over 26,000 land transactions
  - Own or control for more than 20 years the land under towers representing 78% of site rental gross margin[1]
  - Approximately 38% of site rental gross margin is generated from towers on land owned by the company[1]
  - Existing ground leases have an average remaining term of approximately 34 years[1]

Ground Interest by Percentage of LQA Site Rental Gross Margin[2]



CROWN CASTLE

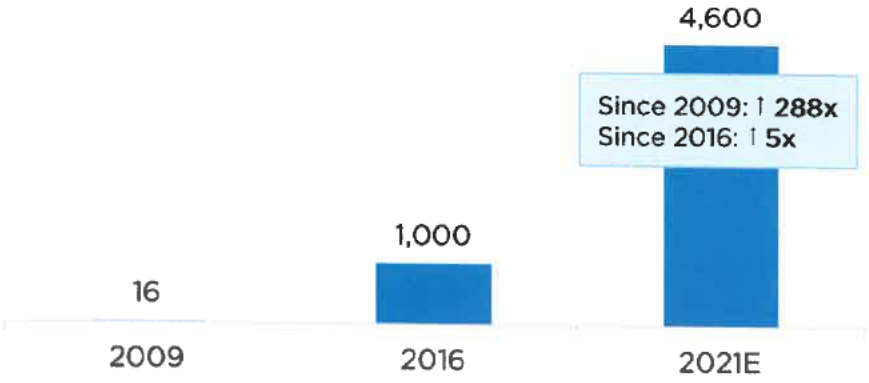
1. As of 3/31/18; includes renewal terms at the Company's option; weighted by site rental gross margin
2. Expressed as a percentage of LQA Q1 2018 site rental gross margin

Industry Overview

Growth in Mobile Data Expected to Drive Continued Network Investment

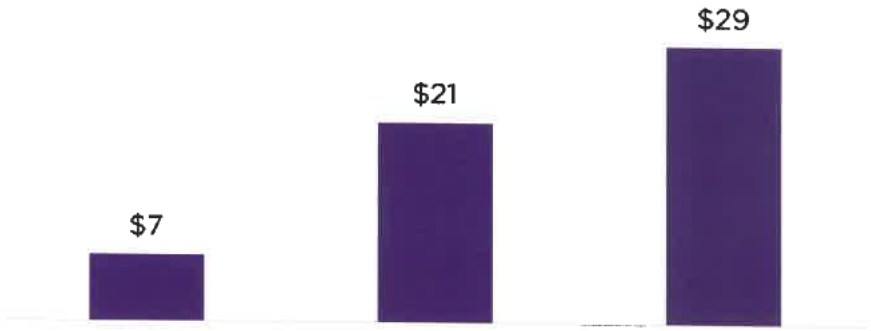
Strong Consumer Demand for Data...

Forecasted U.S. Mobile Data Usage ("PB" per month) [1]



...Has Historically Driven Carrier Network Investment...

Average Annual U.S. Wireless Capex [2] ($ Bn)



...And is Expected to Continue – Carrier Commentary on 1Q 2018 Earnings Calls

"We remain confident in our strategy and priorities, led by investing in our networks."

-Matthew D. Ellis, Verizon EVP & CFO
April 24, 2018

"With FirstNet, 5G and fiber build, our network development has never moved at a faster pace."

-John Stephens, AT&T Senior EVP & CFO
April 25, 2018

"Together, we [T-Mobile + Sprint] will build a network with historic capabilities that will have the breadth and depth to reach every person across the country..."

-John Legere, T-Mobile CEO
May 1, 2018

"The combined company [T-Mobile + Sprint] will put America first and force the competition to invest and do better for consumers."

-Marcelo Claure, Sprint CEO
May 2, 2018

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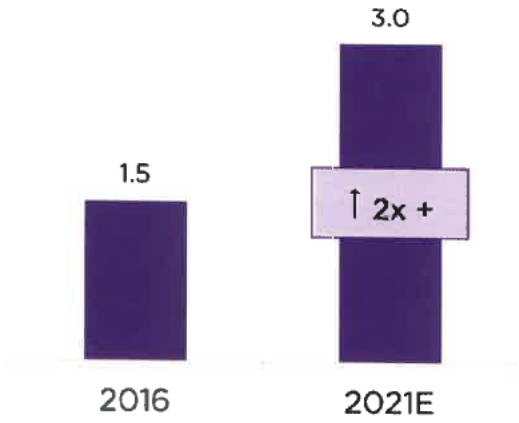
1. Cisco VNI, 2017; Petabyte ("PB") equivalent to 1 million Gigabytes
2. CTIA Report

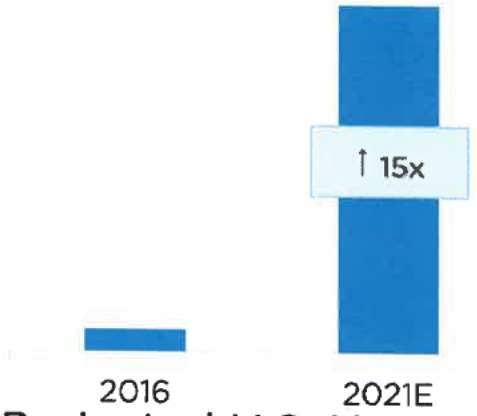
Mobile Data Growth Expected to Continue

Projected Connected Devices per Capita in the U.S.



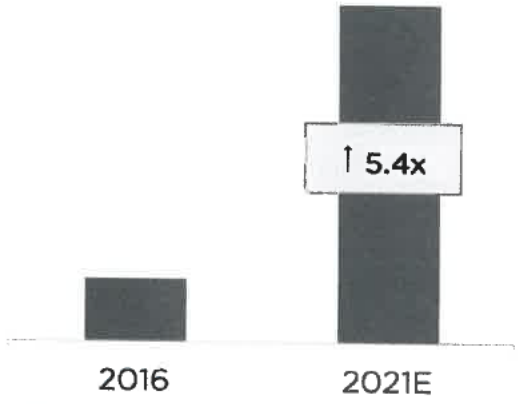
1Bn+...
Total projected connected devices in the U.S. by the end of 2021 (1)

Projected M2M Traffic in the U.S.



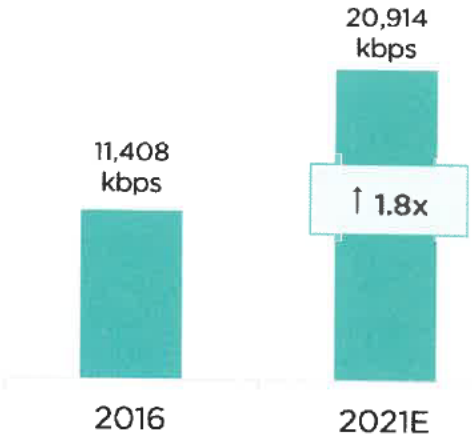
8%...
of total Mobile data traffic in 2021 is projected to be M2M, up from 2% in 2016 (1)

Projected U.S. Mobile Video Traffic



76%...
Of total mobile data traffic in 2021 is projected to be mobile video, up from 64% in 2016 (1)

Projected U.S. Network Connection Speed



13%...
Annual increase in mobile connection speed in the U.S. through 2021 (1)

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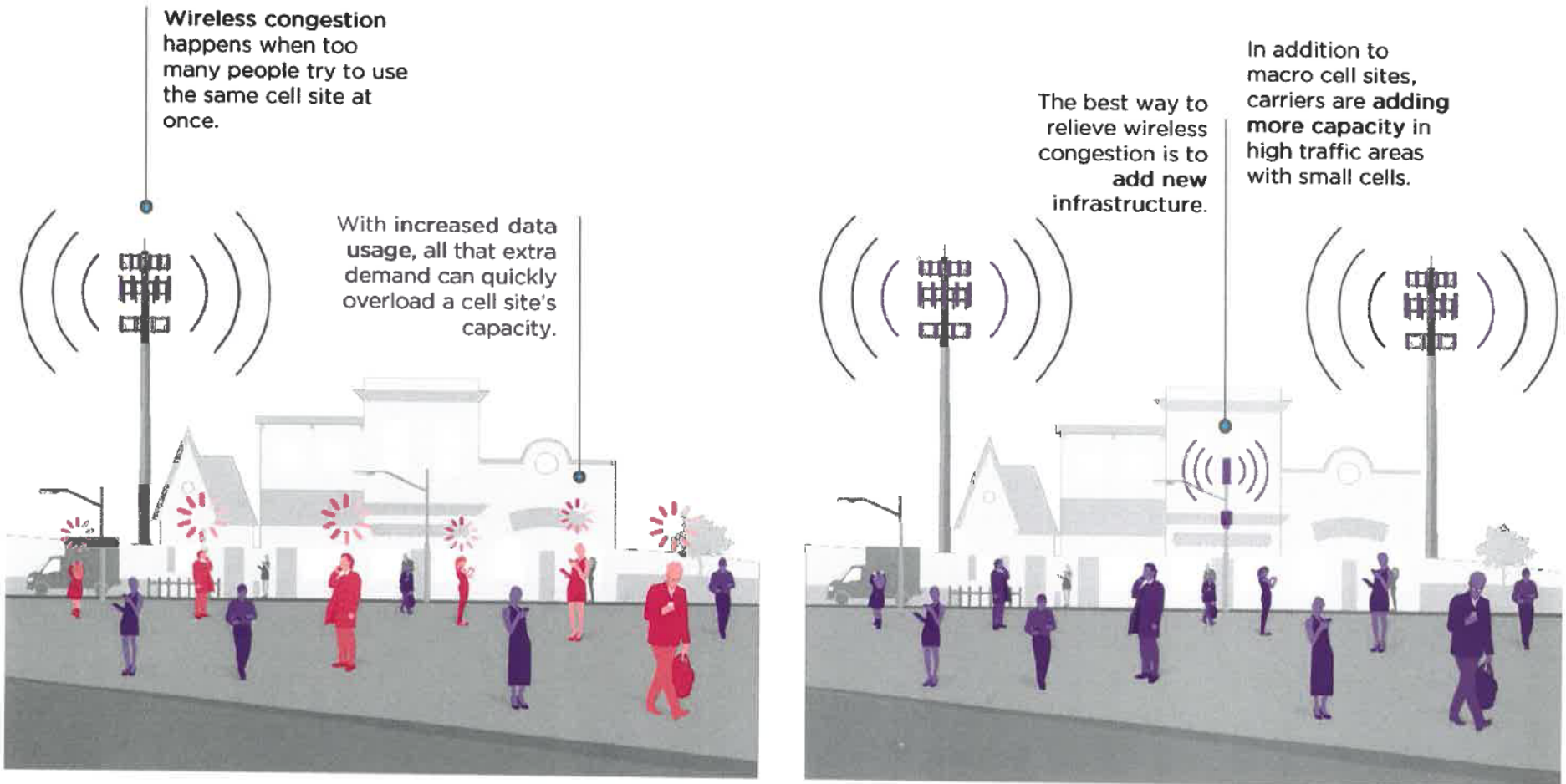
1. Cisco VNI, 2017

Increasing Data Consumption is Driving the Need for Denser Networks of Towers and Small Cells



CONGESTION vs. **CAPACITY**

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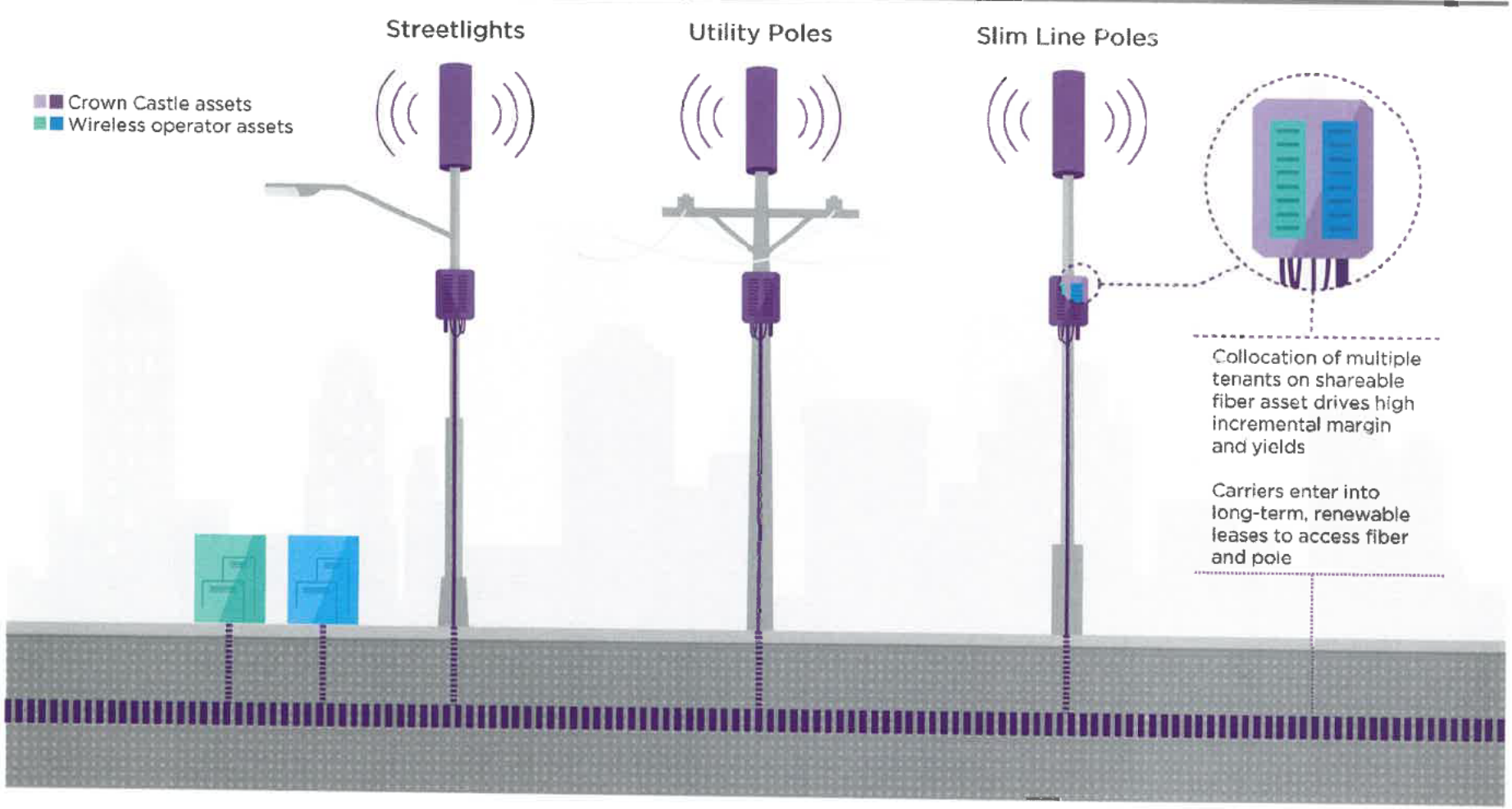
What Are Small Cells?

Fiber fed small cells enable wireless carriers to add much needed coverage and capacity to relieve congestion on their networks

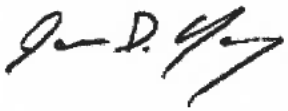


CROWN CASTLE

Exhibit F:
Supplier Diversity & How to Become a Supplier

Our commitment to diversity

At Crown Castle, we are committed to conducting our business with the highest standards and integrity. It's part of our guiding principles and the basis on which we interact with our customers, suppliers, shareholders, and fellow employees. To make a positive difference in the communities where we serve, we work hard to ensure our own foundation is continually strengthened. That's why diversity is such a key component of our business. We believe that partnering with minority-, women-, and disabled-owned businesses gives us a competitive advantage in the marketplace, and is essential to the strength of both our supply chain and our business.



James D. Young
Chief Operating Officer

Building the foundation

Mobile technology is everywhere. It's become an inseparable part of our lives. As the nation's largest provider of shared wireless infrastructure, we're building the foundation that enables our customers to keep expanding and improving their networks. The people who make it possible include our 4,500 employees in offices throughout the country, whose high standards and dedication to service set the standard in the industry. But we can't do it alone. We rely on a network of suppliers and contractors who share our values and standards, and who can assist us in delivering the best results for our customers.

Certified diverse suppliers may include:

- Minority Business Enterprises (MBE)
- Women Business Enterprises (WBE)
- Service-Disabled Veteran-Owned Business Enterprises (SDVOBE)

Building strong partnerships through supplier diversity

The process of becoming qualified to do work for Crown Castle differs depending on the products or services your company provides. Our Supply Chain Management Department, located in Canonsburg, Pennsylvania, will work directly with diversity suppliers during the qualification phase. They will help facilitate introductions to our district offices, located nationally, where project decisions are made. We outline the basics below, but be sure to visit our website for more information.

How to apply

Site-related products and contracted services

The process to provide site-related products requires your company to accept our Terms and Conditions of Purchase and submit a W-9. To obtain a copy of our Terms and Conditions, contact Supply Chain Management at Supplier.Diversity@crowncastle.com.

To work at our sites for construction, maintenance, antenna installation, site acquisition, civil work, fiber work, utility work, lawn care, engineering, and regulatory services, you'll need to send information about your company to Supplier.Diversity@crowncastle.com.

Company information can include:

- Capabilities Statement
- Certificates
- Contact Information

Non-site-related products & services suppliers

The process to apply for qualification to provide non-site-related products and services simply requires your company to accept our Terms and Conditions of Purchase and submit a W-9. To obtain a copy of our Terms and Conditions of Purchase, contact Supply Chain Management at Supplier.Diversity@crowncastle.com.

Special requirements for contracted services

Invoicing payment terms

Our standard payment term is net 45 days. You will be required to 1) accept electronic payments from Crown Castle, 2) comply with the Release and Waiver of Lien documents, and 3) prepare and electronically submit invoices that meet Crown Castle's invoice requirements.

Release and Waiver of Lien (RWOL)

If you are providing construction services subject to a lien, we require that you pay all subcontractors and obtain an unconditional waiver of lien prior to sending an invoice to Crown Castle.

How we award business

The vast majority of business is awarded through our district offices throughout the United States. Vendors who demonstrate successful business performance may be invited to perform additional work in other districts.

Areas of opportunity

Crown Castle purchases the following products and services:

SERVICES

Construction

- Access Roads
- Antenna and Line Installation
- Collocation Site Construction
- Electrical
- Fiber Work
- Foundations
- Grounding
- Microwave Path Alignment
- Raw Land Site Construction
- Rooftop Site Construction
- Small Cell Network Construction (IDas/oDas)
- Tower Erection
- Tower Reinforcement
- Waveguide/Sweep Testing

Construction Management

- Design/Build
- Materials Specification
- Permitting
- Pre-Construction Consultation
- Site Visit, Feasibility, Budget Analysis

Consulting Services

- AM Detuning
- Drive Testing
- EME and NIR Studies
- Environmental Assessment: NEPA, Phase I & II, SHPO
- FAA 2C & 1A Certification
- Interference/ Inter-Modulation Studies
- RF Emissions
- Site Acquisition: Leases, Title, Regulatory Compliance, Site Identification
- Surveying

Engineering

- Certified Welding Inspections
- Construction Drawings
- Geo-Technical Reports
- Materials Analysis
- Modification Drawings
- Non-Destructive Testing: Dye Testing, Level II Ultrasonic Testing (UT), Magnetic Testing (MT)
- Post-Construction Inspections
- Site Plans
- Structural Analysis
- Tower Mapping
- Zoning Drawings

Repair & Maintenance

- Generator Maintenance
- Grounds Keeping
- HVAC Maintenance
- Lighting Service: System Repair and Replacement
- Site Maintenance: Compound Repair and Improvement
- Tower Audits/Inspections
- Tower Maintenance

PRODUCTS

Towers

- Accessories
- Antennas
- Antenna Mounts
- Grounding Products
- Ice Bridges
- Jumpers
- Transmission Lines

Small Cell Network Construction (IDas/oDas)

- Antennas
- Conduits
- Enclosures
- Fiber Optic Cables
- Hand-Holes
- Lightning Protection
- Underground Electrical Vaults
- Wireless Networking Equipment

Repair & Maintenance

- Batteries
- Concealed Communication Towers
- Electrical Supplies
- Equipment Shelters
- Flags
- Generators
- Hand Tools
- Locks
- Paint/Coatings
- Replacement Lamps
- Safety Equipment
- Signage
- Standard Communication Towers
- Testing Equipment
- Tower Construction
- Tower Lighting: Dual, Medium Intensity, High Intensity, Red Systems, White Systems

Exhibit F:
Our Role In Your World

Our role in your world.

We own and operate the nation's most unique and comprehensive portfolio of communications infrastructure. It all works together to meet unprecedented demand—connecting people, businesses, and communities and erasing life's conventional boundaries.

Our infrastructure transforms everything around us.

People

We connect people to the devices, apps, and data they rely on to communicate, stay informed, and live their lives to the fullest.

Businesses and organizations

We make sure businesses and other large organizations have secure access to the essential data and applications they need to embrace new technologies and stay ahead.

Communities

We provide connections that improve safety and efficiency and that make communities better places to live.

Schools and universities

Our fast, secure fiber networks support new learning technologies in the classroom and promote groundbreaking research in higher education.

First responders

We give police officers, firefighters, and EMTs secure access to the information they need to react quickly to emergencies.

Venues

We give stadiums, convention centers, amusement parks, and other venues the wireless coverage and capacity to accommodate large crowds.

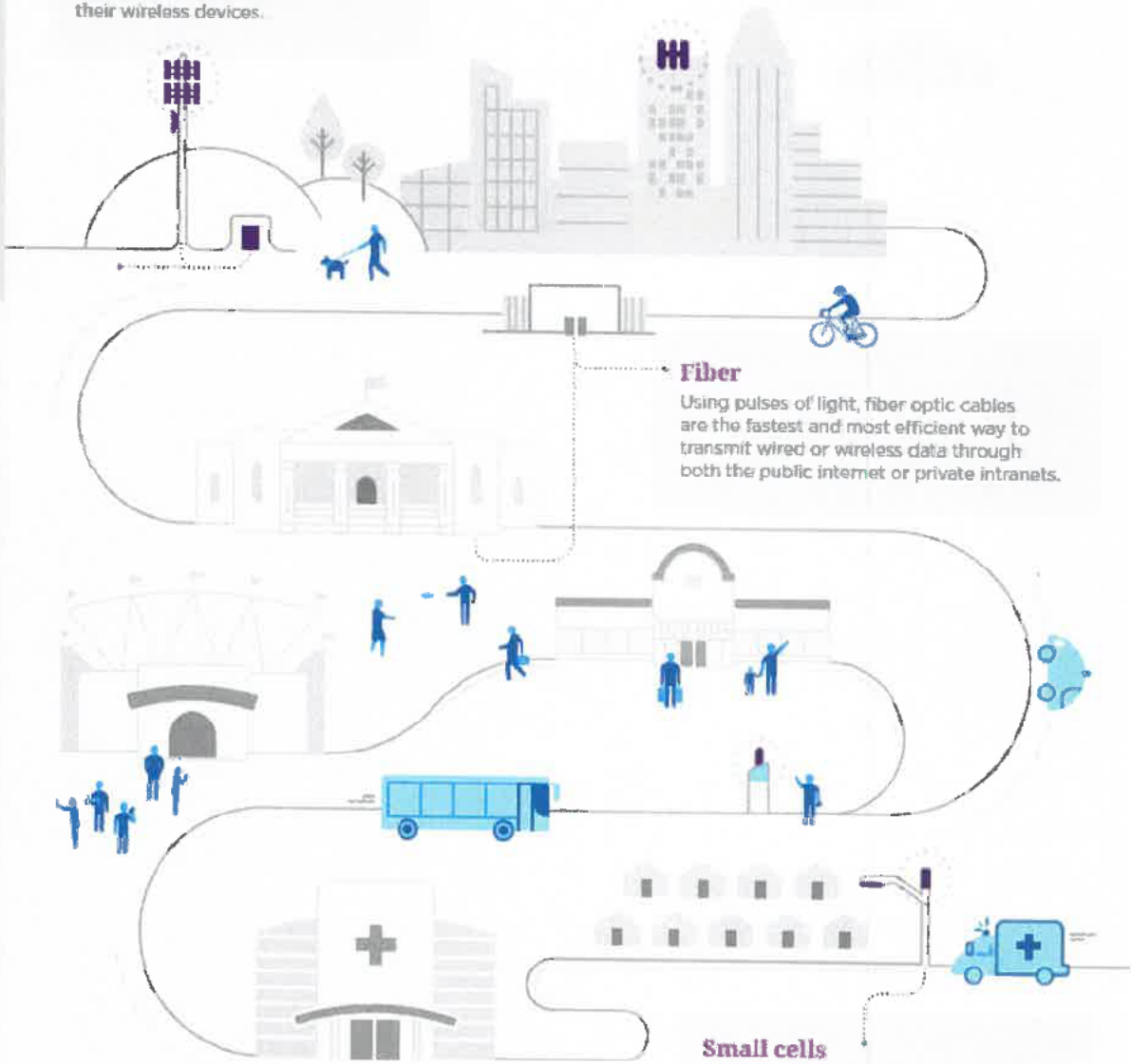
Innovators

We help deploy exciting new technologies that build smarter communities and create new opportunities for cities and technology companies alike.

CROWN CASTLE
The pathway to possible.

Cell towers

Towers receive and transmit cellular signals over a large geographic area—carrying the voice and data that people send and receive on their wireless devices.



Fiber

Using pulses of light, fiber optic cables are the fastest and most efficient way to transmit wired or wireless data through both the public internet or private intranets.

Small cells

Lower to the ground, and often attached to streetlights or utility poles, small cells add additional wireless coverage and capacity—or bring new coverage where towers aren't feasible.

The wireless world is changing.

And so is your community.

CROWN CASTLE


The phones, tablets, and wearable devices we take for granted today were unimaginable just a few years ago. At the rate broadband technology is changing, we're seeing increasing demand being put on the infrastructure that supports it. We've helped communities like yours deal with this changing world.
Let's work together to understand what growing data demand means for your community.

Increased data use is driving big changes.

As data usage increases, so does network congestion. Think of it as cars trying to crowd onto a busy interstate. At some point, traffic comes to a standstill. In the wireless world, adding new infrastructure is the equivalent of building more lanes—it gives all that extra data someplace to go.

OVER

50%

of households rely exclusively on their mobile phones.[3]

MOBILE VIDEO

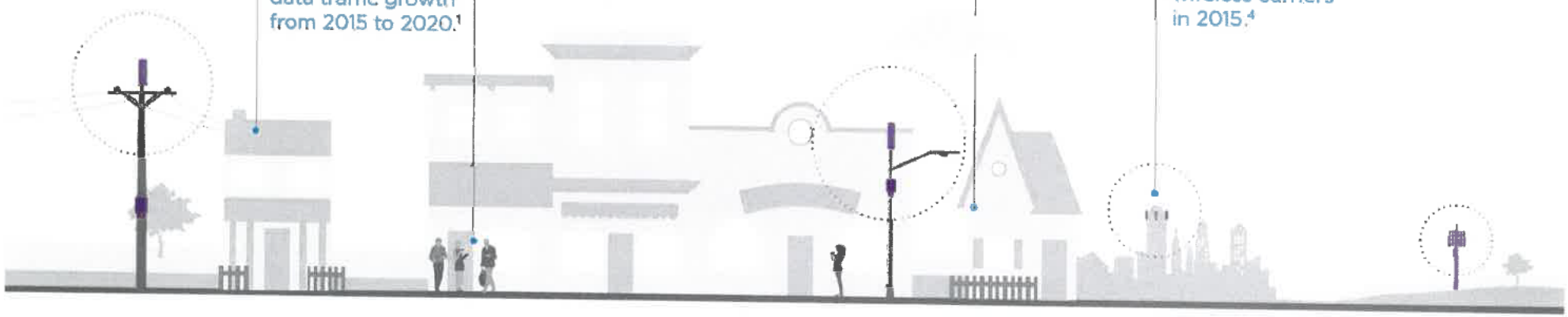
is projected to be 77% of cellular data traffic by 2020.[2]

6X

projected mobile data traffic growth from 2015 to 2020.[1]

9.6 BILLION GIGABYTES

of data traffic was facilitated by US wireless carriers in 2015.[4]



Your community's safety is dependent on reliable service.

89%

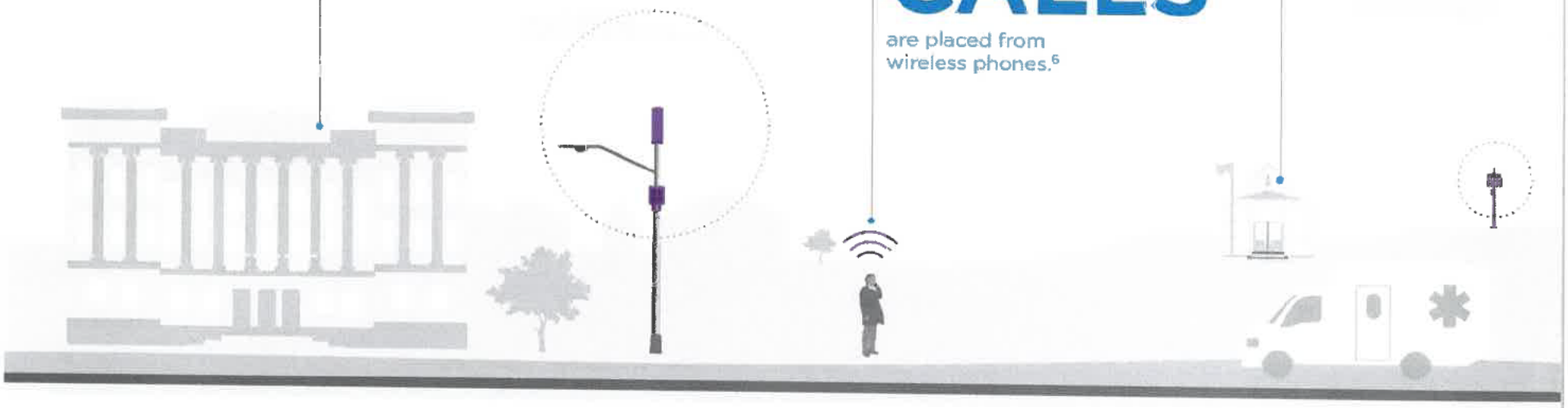
of public safety decision makers say wireless data is just as important as voice.[5]

80% OF 911 CALLS

are placed from wireless phones.[6]

50%

of school administrators prioritize mobile access when updating emergency response plans.[7]



Your community needs more wireless infrastructure. Now what?

Additional infrastructure translates into more convenience for residents, more efficiency for businesses, and greater safety and peace of mind for the community at large.

Before you get upgraded, this is what you can expect:

1. ASSESSMENT

After considering the needs of residents, business owners, and first responders, a determination is made as to where additional infrastructure is needed.

2. PLANNING

Our engineers will design a network that supports the community's need. We gather input and work closely with municipal planners to come up with a solution that best serves everyone's needs.

3. CONSTRUCTION

Our construction managers oversee every aspect of the project to ensure safe and proper installation with as little disruption as possible.

A small cell node in Central Park, NYC.

A small cell node in a residential community.

Small cell solutions get big results.

While towers and rooftop antennas are still widely used, small cell solutions are often most practical in places where capacity is an issue. They are small, low-powered, and sit near to the ground, so we can place more of them closer together. They increase capacity and the likelihood that you'll get a direct line-of-sight signal—while preserving the aesthetics of their surroundings. In addition, each node is connected by fiber optic cable, allowing it to handle large amounts of data and making future upgrades simple.

What makes up an SCS network?

Small cell solutions networks can vary significantly in the way they look, but have a few things in common. As their name implies, they are smaller and more discreet than other forms of infrastructure. Typically they include the components shown on the right.

NODES

These are the small radio frequency transmitters that send and receive radio signals to and from your mobile device.

HIGH-SPEED CONNECTION

This is the connection from the node to a base station—usually fiber optic.

GROUND EQUIPMENT

The radio transreceivers that send and process the wireless signals are usually located out of the way in a central location.

FIBER-OPTIC CABLE

This routes the signals through the network and on to its destination.

SHOULD I BE WORRIED ABOUT RADIO FREQUENCY EMISSIONS?

There are no adverse affects from cellular signals.

At ground level, cellular RF levels are not significantly different from TV and radio signals, and fall within FCC guidelines.

More resources are available online.

For more information or links to reputable studies, visit the websites of the American Cancer Society, the Federal Communications Commission (FCC), the International Commission on Non-Ionizing Radiation Protection (ICNIRP), and the World Health Organization.

The benefits of working with Crown Castle.

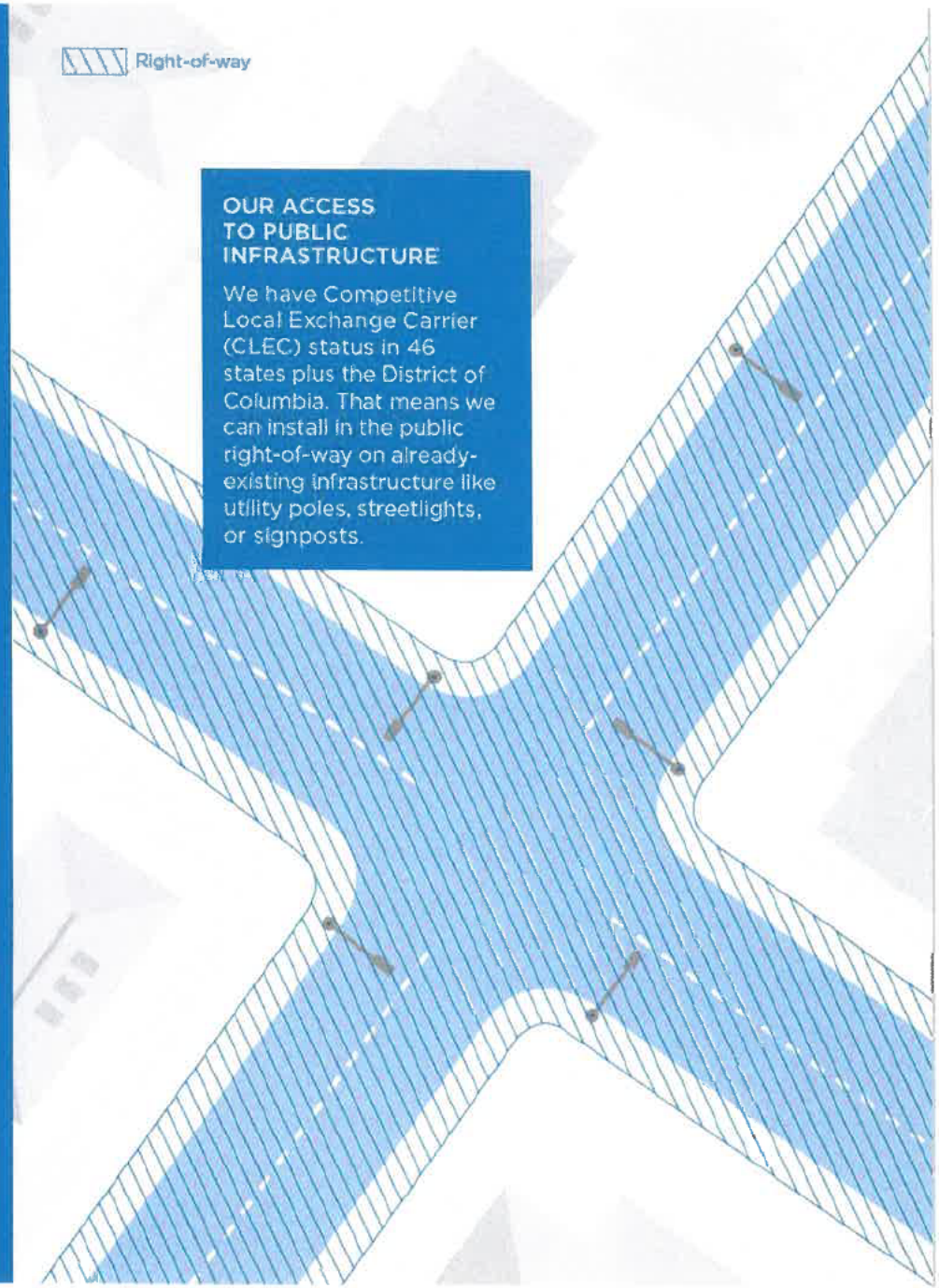
Wireless infrastructure has been our core business since 1994—before most people even had mobile phones. When we build and maintain a small cell network, you can be sure we're in it for the long haul. Other benefits include:

OUR SHARED INFRASTRUCTURE MODEL

Multiple carriers can use the networks we build, which reduces the need for redundant infrastructure in your community.

OUR COMMITMENT TO AESTHETICS

We take special care to place nodes in the most discreet way possible. In cases where we need to add additional slimline poles, we design them to blend in and fit the style of your community.



OUR ACCESS TO PUBLIC INFRASTRUCTURE

We have Competitive Local Exchange Carrier (CLEC) status in 46 states plus the District of Columbia. That means we can install in the public right-of-way on already-existing infrastructure like utility poles, streetlights, or signposts.

LEARN MORE

We hope you're as excited about improving your community as we are. If you'd like to learn more about how we can help, contact your local Crown Castle representative or visit CrownCastle.com

ABOUT CROWN CASTLE

- Our national reach includes more than 40,000 towers and 50,000 small cell nodes on air or under contract supported by approximately 60,000 route miles of fiber.
- We have more than 15 years of experience building and maintaining small cell networks in venues and communities, including dense urban centers and residential neighborhoods.
- We have offices nearby with people who understand your community—and its network needs.
- We're an S&P 500 company listed on the NYSE.

1. "Visual Networking Index," *Cisco*, 2016.
2. "Visual Networking Index," *Cisco*, 2016.
3. "Wireless Snapshot, 2017," *CTIA*, 2017.
4. "Annual Wireless Industry Survey," *CTIA*, 2016.
5. "Building Safer, More Resilient Communities in a New Era of LMR Intelligence," *Motorola*, 2014.
6. "2016 National 911 Progress Report," *911.gov*, 2017.
7. "Study Shows Mobile-Enabled Emergency Plans Are a Top Safety Priority for Schools," *CampusSafety*, 2014.

Exhibit F:
A More Connected Life – How Technology Is Driving Wireless Demand

A more connected life.

How technology is driving wireless demand.

Where we are: today

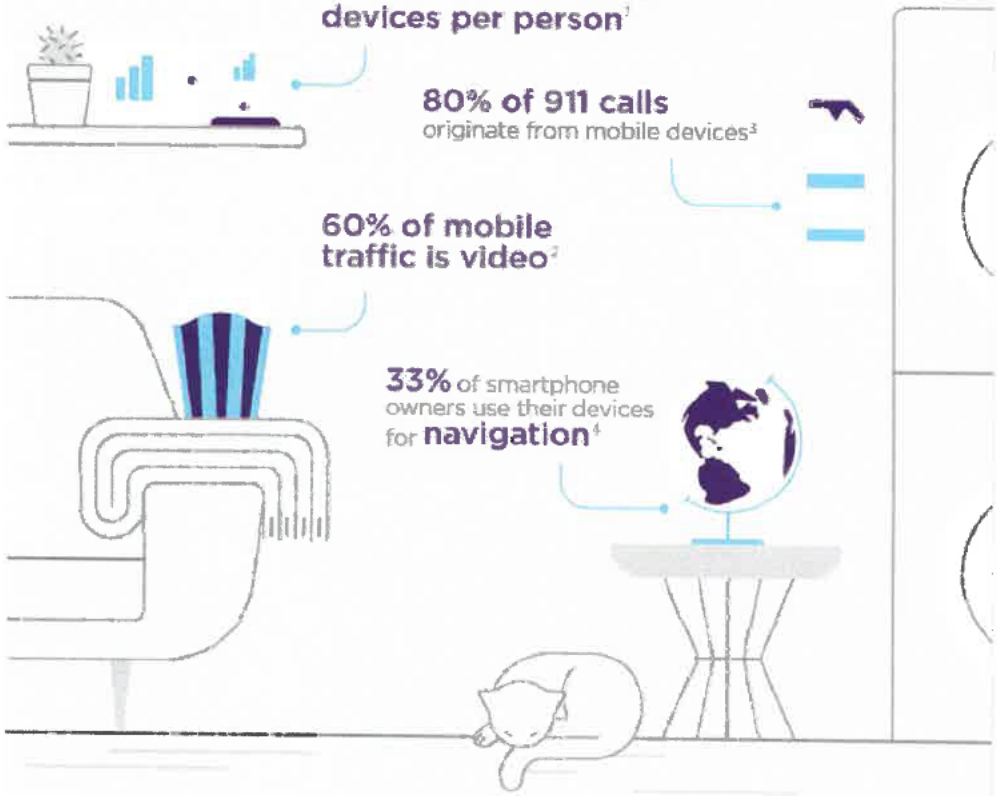
We rely on mobile data now more than ever. Smarter devices, bigger screens, and faster data have led to a dramatic shift in the way we consume information and media—leading to a significant increase in mobile traffic.

2.3 internet-connected devices per person[1]

80% of 911 calls originate from mobile devices[3]

60% of mobile traffic is video[2]

33% of smartphone owners use their devices for **navigation**[4]



Where we're going: 2021

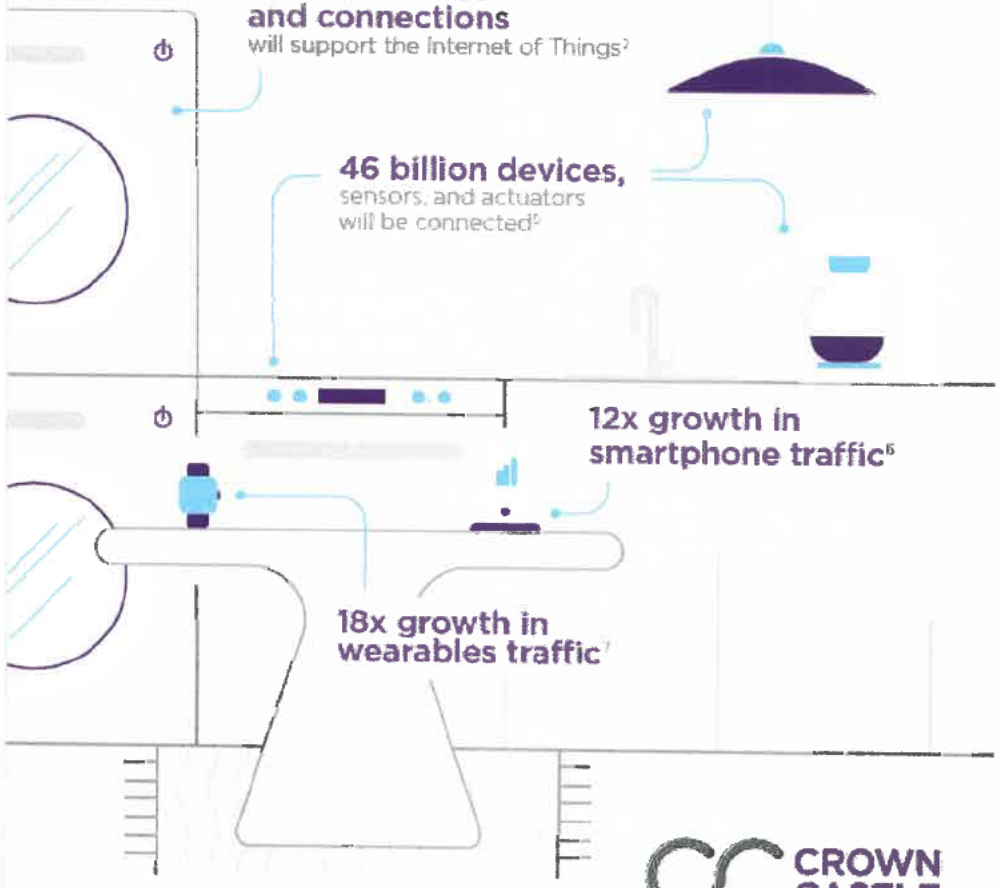
In the next 5 years, new developments like 5G and the Internet of Things (IoT) will drive even more of our lives—and things—online. This new technological growth is projected to bring about even greater data demand and usage.

50% of devices and connections will support the Internet of Things[2]

46 billion devices, sensors, and actuators will be connected[5]

12x growth in smartphone traffic[6]

18x growth in wearables traffic[7]



1. "The Zettabyte Era: Trends and Analysis," Cisco, June 2017. 2. "Visual Networking Index," Cisco, June 2017. 3. "2016 National 911 Progress Report," National 911 Program, December 2016. 4. "U.S. Smartphone Use in 2015," Pew Research Center, April 2015. 5. "The Internet of Things: Consumer, Industrial & Public Services 2016-2021," Juniper Research, December 2016. 6. "Mobility Report," Ericsson, June 2016. 7. "Visual Networking Index," Cisco, February 2015.

CROWN CASTLE

Exhibit F:
Multi-Point Annual Operations Checklist

Exhibit F:
Multi-Point Annual Operations Checklist

Operations Multi-Point Inspection Checklist

Node General

- ☐ Inspect equipment wirings. Ensure all wiring is properly secured.
- ☐ Grounding. Ensure grounding is intact and that cove molding is connected and secure.
- ☐ Secure equipment. Ensure equipment is locked.
- ☐ Ensure all shroud openings are closed with duct seal.
- ☐ Thoroughly clean internal components and fans with compressed air.
- ☐ Check for any post installation equipment from other entities that would interfere with operations.
- ☐ Inspect structural integrity.
- ☐ Inspect node for general condition, including shroud, meter pan and disconnect box. Insure that all these parts are intact and not damaged in any way.
- ☐ Inspect Remote Unit mounting brackets. Ensure that all mounting brackets are well secured. Inspect for external hazards to the site (i.e. loose structures near antennas, leaning pole, bare cables, etc.)
- ☐ Bottom Status light : led light green
- ☐ Check fiber jumper properly routed and weatherproofed
- ☐ Required Signage Posted
- ☐ Record Latitude and Longitude
- ☐ Record Meter Number
- ☐ Meter Number
- ☐ Visually check ground.

Node - RF Cable Contacts and Adaptors

- ☐ Note and record any corrosion
- ☐ Contacts and Adaptors Tightly screwed
- ☐ Confirm node is weatherproof
- ☐ Check for bends
- ☐ Check for breaks
- ☐ Cleaned Fiber (NY ONLY)

Antenna Node

- ☐ Visually inspect weatherproofing
- ☐ Properly fastened
- ☐ Proper orientation
- ☐ Ensure that there is no vegetation within 5ft of Cable and Antenna
- ☐ Sweep Test with RL Label (NY ONLY)
- ☐ Node - VSWR
- ☐ Perform VSWR command to confirm return loss
- ☐ VSWR Return Loss

Metal Pole

- ☐ Metal fatigue due to cyclic loading (such as wind induced vibration and damage
- ☐ Design related issues.
- ☐ Weld failures on the base plate, pole seams and access openings.
- ☐ Defects in the pole foundation, concrete, anchor bolts and supporting structures.
- ☐ Internal and external corrosion
- ☐ Improper drainage of any moisture buildup on the interior of pole.
- ☐ Loose anchor bolt nuts.
- ☐ Visual observation of pole vibration.
- ☐ Ensure that hatch door is present and securely locked
- ☐ Visually check ground.
- ☐ Check for keep-off tags

Wood Pole

- ☐ General Condition-The pole should be inspected for buckling at the ground line and for an unusual angle with respect to the ground. Buckling and odd angles may indicate that the pole has rotted or is broken.
- ☐ Cracks-The pole should be inspected for cracks. Horizontal cracks perpendicular to the grain of the wood may weaken the pole. Vertical ones, although not considered to be a sign of a defective pole, can pose a hazard to the climber, and the employee should keep his or her gaffs away from them while climbing.
- ☐ Holes-Hollow spots and woodpecker holes can reduce the strength of a wood pole
- ☐ Shell Rot and Decay-Rotting and decay are cutout hazards and are possible indications of the age and internal condition of the pole.
- ☐ Knots -various fastenings formed by looping and tying a rope (or cord) upon itself or to another rope or to another object. One large knot or several smaller ones at the same height on the pole may be evidence of a weak point on the pole.
- ☐ Depth of Setting-Evidence of the existence of a former ground line substantially above the existing ground level may be an indication that the pole is no longer buried to a sufficient extent.
- ☐ Soil Conditions-Soft, wet, or loose soil may not support any changes of stress on the pole
- ☐ Burn Marks-Burning from transformer failures or conductor faults could damage the pole so that it cannot withstand mechanical stress changes
- ☐ Visually check ground.
- ☐ Check down guy and hi/low guy attachments and strands
- ☐ Check for Utility company keep-off tags

Ariel Fiber

- ☐ Is the fiber strand sagging too much or too stretched from pole to pole?
- ☐ Is fiber sheath properly lashed?
- ☐ Is the fiber conduit properly secured to the pole and weatherized?
- ☐ Is fiber slack properly secured with correct hardware?

☐ Does fiber cable have appropriate clearance from roadway?

Underground Fiber

☐ Is the fiber conduit properly secured to the pole and weatherized?
☐ Is micro trench or traditional trench in good condition?

Exhibit G:
RFP REQUIRED FORMS

RFP EXHIBIT C - ACKNOWLEDGEMENT OF RELEASE & ADDENDUM

EXHIBIT C
ACKNOWLEDGMENT OF RELEASE DATE AND ADDENDUM

APPLICANT'S NAME: Crown Castle Solutions LLC

RFP RELEASE DATE: June 12, 2018

NUMBER OF ADDENDA RECEIVED: Four (4)

ISSUE DATE(S) OF ADDENDA: 06/27/18; 06/29/18; 07/11/18; 07/25/18

RFP EXHIBIT D – AFFIRMATION

EXHIBIT D
AFFIRMATION

The undersigned proposer or bidder affirms and declares that said proposer or bidder is not in arrears to the City of New York upon debt, contract, or taxes and is not a defaulter, as surety or otherwise, upon obligation to the City of New York, and has not been declared not responsible, or disqualified, by any agency of the City of New York, nor is there any proceeding pending relating to the responsibility or qualification of the proposer or bidder to receive public contracts except

---

Full name of Proposer or Bidder
Crown Castle Solutions LLC

Address
1220 Augusta Drive, Suite 600

City Houston State Texas Zip Code 77057

CHECK ONE BOX AND INCLUDE APPROPRIATE NUMBER:

□ A - Individual or Sole Proprietorship*
SOCIAL SECURITY NUMBER _____

□x B - Partnership, Joint Venture or other unincorporated organization
EMPLOYER IDENTIFICATION NUMBER [redacted]
(Limited Liability Company)

□ C - Corporation
EMPLOYER IDENTIFICATION NUMBER _____

By Bruce Hamburg
Signature

VP Legal
Title

If a corporation, place seal here:

Must be signed by an officer or duly authorized representative.

* Under the Federal Privacy Act the furnishing of Social Security Numbers by bidders on City contracts is voluntary. Failure to provide a Social Security Number will not result in a bidder's disqualification. Social Security Numbers will be used to identify bidders, proposers, or vendors to ensure their compliance with laws, to assist the City in enforcement of laws as well as to provide the City a means of identifying of businesses which seek City contracts.

RFP EXHIBIT F – DOING BUSINESS DATA FORM

NYC Mayor's Office of Contract Services

Doing Business Data Form

To be completed by the City agency prior to distribution Agency_____ Transaction ID_____

Check One ☐ Proposal ☐ Award

Transaction Type (check one) ☐ Concession ☐ Economic Development Agreement ☐ Franchise ☐ Grant ☐ Pension Investment Contract ☐ Contract

Any entity receiving, applying for or proposing on an award or agreement must complete a Doing Business Data Form (see Q&A sheet for more information). Please **either type responses directly into this fillable form or print answers by hand in black ink, and be sure to fill out the certification box on the last page. Submission of a complete and accurate form is required for a proposal to be considered responsive or for any entity to receive an award or enter into an agreement.**

This Data Form requires information to be provided on principal officers, owners and senior managers. The name, employer and title of each person identified on the Data Form will be included in a public database of people who do business with the City of New York, as will the organizations that own 10% or more of the enitity. No other information reported on this form will be disclosed to the public. **This Data Form is not related to the City's PASSPort registration or VENDEX requirements.**

Please return the completed Data Form to the City office that supplied it. Please contact the Doing Business Accountability Project at DoingBusiness@mocs.nyc.gov or 212-788-8104 with any questions regarding this Data Form. Thank you for your cooperation.

*If you are completing this form by hand, **please print clearly.***

Entity Information

Entity EIN/TIN [redacted] Entity Name Crown Castle Solutions LLC

Filing Status

***NEW:** Data Forms submitted now must include the listing of **organizations**, as well as individuals, with 10% or more ownership of the entity. Until such certification of ownership is submitted through a change, new or update form, a no change form will not be accepted.*

(Select One)

■ Entity has never completed a Doing Business Data Form. Fill out the entire form.

☐ Change from previous Data Form dated _____. *Fill out only those sections that have changed, and indicate the name of the persons who no longer hold positions with the entity.*

☐ No Change from previous Data Form dated _____. *Skip to the bottom of the last page.*

Entity is a Non-Profit ☐ Yes ■ No

Entity Type ☐ Corporation (any type) ☐ Joint Venture ■ LLC ☐ Partnership (any type) ☐ Sole Proprietor ☐ Other (specify) _____

Address 1220 Augusta Drive, Suite 600

City Houston State TX Zip 77057

Phone [redacted] E-mail [redacted]@crowncastle.com

Provide your e-mail address in order to receive notices regarding this form by e-mail.

Principal Officers

Please fill in the required identification information for each officer listed below. If the entity has no such officer or its equivalent, please check "This position does not exist." If the entity is filing a Change Form and the person listed is replacing someone who was previously disclosed, please check "This person replaced..." and fill in the name of the person being replaced so his/her name can be removed from the *Doing Business Database*, and indicate the date that the change became effective.

Chief Executive Officer (CEO) or equivalent officer ☐ This position does not exist

The highest ranking officer or manager, such as the President, Executive Director, Sole Proprietor or Chairperson of the Board.

First Name Jay MI A. Last Brown Birth Date (mm/dd/yy) [redacted]

Office Title President and Chief Executive Officer Employer (if not employed by entity) Crown Castle USA Inc.

Home Address [redacted]

☐ This person replaced former CEO _____ on date _____

Chief Financial Officer (CFO) or equivalent officer ☐ This position does not exist

The highest ranking financial officer, such as the Treasurer, Comptroller, Financial Director or VP for Finance.

First Name Daniel MI K. Last Schlanger Birth Date (mm/dd/yy) [redacted]

Office Title Senior Vice President and Chief Financial Officer Employer (if not employed by entity) Crown Castle USA Inc.

Home Address [redacted]

☐ This person replaced former CFO _____ on date _____

Chief Operating Officer (COO) or equivalent officer ☐ This position does not exist

The highest ranking operational officer, such as the Chief Planning Officer, Director of Operations or VP for Operations.

First Name James MI D. Last Young Birth Date (mm/dd/yy) [redacted]

Office Title Senior Vice President and Chief Operating Officer - Fiber Employer (if not employed by entity) Crown Castle USA Inc.

Home Address [redacted]

☐ This person replaced former COO _____ on date _____

Principal Owners

Please fill in the required identification information for all individuals or organizations that, through stock shares, partnership agreements or other means, own or control 10% or more of the entity. If no individual or organization owners exist, please check the appropriate box to indicate why and skip to the **Senior Managers** section. **If the entity is owned by other companies that control 10% or more of the entity, those companies must be listed. If an owner was identified on the previous page, fill in his/her name and write "See above." If the entity is filing a Change Form, list any individuals or organizations that are no longer owners at the bottom of this section.** If more space is needed, attach additional pages labeled "Additional Owners."

There are no owners listed because (select one):

☐ The entity is not-for-profit ☐ The entity is an individual ☐ No individual or organization owns 10% or more of the entity

Other (explain) _____

Individual Owners (who own or control 10% or more of the entity)

First Name _____ MI ___ Last _____ Birth Date (mm/dd/yy) _____

Office Title _____ Employer (if not employed by entity) _____

Home Address _____

First Name _____ MI ___ Last _____ Birth Date (mm/dd/yy) _____

Office Title _____ Employer (if not employed by entity) _____

Home Address _____

Organization Owners (that own or control 10% or more of the entity)

Organization Name Crown Castle Operating Company

Organization Name Crown Castle International Corp.

Organization Name _____

Remove the following previously-reported Principal Owners

Name _____ Removal Date _____

Name _____ Removal Date _____

Name _____ Removal Date _____

Senior Managers

Please fill in the required identification information for all senior managers who oversee any of the entity's relevant transactions with the City (e.g., contract managers if this form is for a contract award/proposal, grant managers if for a grant, etc.). Senior managers include anyone who, either by title or duties, has substantial discretion and high-level oversight regarding the solicitation, letting or administration of any transaction with the City. At least one senior manager must be listed, or the Data Form will be considered incomplete. If a senior manager has been identified on a previous page, fill in his/her name and write "See above." If the entity is filing a Change Form, list individuals who are no longer senior managers at the bottom of this section. If more space is needed, attach additional pages labeled "Additional Senior Managers."

Senior Managers

First Name James MI D. Last Young Birth Date (mm/dd/yy) _____

Office Title See Above Employer (if not employed by entity) _____

Home Address _____

First Name Robert MI ___ Last Ackerman Birth Date (mm/dd/yy) [redacted]

Office Title SVP and COO - Towers and Small Cell Employer (if not employed by entity) Crown Castle USA Inc.

Home Address [redacted]

First Name Cathy MI ___ Last Piche Birth Date (mm/dd/yy) [redacted]

Office Title Area President Employer (if not employed by entity) Crown Castle USA Inc.

Home Address [redacted]

Remove the following previously-reported Senior Managers

Name _____ removal date _____

Name _____ removal date _____

Certification

I certify that the information submitted on these two pages and ____ additional pages is accurate and complete. I understand that willful or fraudulent submission of a materially false statement may result in the entity being found non-responsible and therefore denied future City awards.

Name Lewis Kessler Title VP General Manager

Entity Name Crown Castle Solutions LLC Work Phone # [redacted]

Signature _____ Date 07/31/18

Please return this form to the City agency that supplied it to you, not to the Doing Business Accountability Project. **Standard Form**

NYC Doing Business Data Form (continued)

Senior Managers:

Lewis Kessler, Vice President, General Manager – East Area

DOB: [redacted]

Appendix

Equipment Exhibit Matrix

Proposal + Exhibit	Equipment Cabinet/Shroud	Antenna(s)	Pole Type	Tennant Capacity	Areas of Deployment	Exhibit (Refer to RFP)	Technology
Proposal (Exhibit A) : Existing Approved Equipment Specification	DoITT Cabinet: 9"D x 35"H x 15.5"W 2.8 cubic ft	26"H x 2"D 48"H x 2"D 60"H x 2"D 72"H x 2"D	Metal Street Light Wood Utility Pole	1 to 2	Zones A, B, C	Exhibit A	4G
Wooden Utility Poles (Exhibit B-1) : (Equipment Approved by ConEd)	Utility Approved Larger Cabinet, DoITT Style: 12"D x 42"H x 23.9"W 7 cubic ft	24"H x 14.6"D 48"H x 8"D 26"H x 8"D	Wood Utility Poles	3 to 4	Zones B, C	Exhibit B-1	4G, Enhanced 4G, 5G, Milimeter Wave
DOT Control Box Type 8 (Exhibit C) : (DOT Cabinet Deployed Throughout the City)	DOT Control Box Type 8: 15"D x 43"H x 21"W 7.8 cubic ft	75"H x 2"D- Antenna Option #1	Metal Street Light	3 to 4	Zones A, B, C	Exhibit C	4G, Enhanced 4G, 5G, Milimeter Wave
DOT Control Box Type 12 (Exhibit C) : (DOT Cabinet Deployed Throughout the City)	DOT Control Box Type 12: 15"D x 49"H x 21"W 8.9 cubic ft	75"H x 2"D - Antenna Option #1 60"h x 4"D - Antenna Option #2 24"H x 14.5"D - Antenna Option #3	Metal Street Light	3 to 4	Zones A, B, C	Exhibit C	4G, Enhanced 4G, 5G, Milimeter Wave
Optimal 5G/IoT Deployment Configuration for Zones A, B & C (Exhibit D)	See Exhibit D (Small Cell Volume Needs)	See Exhibit D (Small Cell Volume Needs)	Metal Street Light Wood Utility Pole	3 to 4	Zones A, B, C	Exhibit D	4G, Enhanced 4G, 5G, Milimeter Wave

Description of Figures in Response

- Figure 1 – Photos of Existing Installations
- Figure 2 – Equipment Matrix for Exhibits B-1 and C
- Figure 3 – Utility Pole Installations, Current City Spec on Top Two Photos and ConEd Spec on Bottom Two Photos
- Figure 4 - Large Utility Equipment on Utility Poles In the Outer Boroughs by Others
- Figure 5 – Photo Simulation of Current DoITT Spec and Specs proposed in Equipment Matrix
- Figure 6 – Photos of Existing Ground Furniture
- Figure 7 – Wireless Technology Matrix
- Figure 8 – National Operations Center Monitoring Matrix
- Figure 9 – National Operations Center Target Response Times
- Figure 10 – National Operations Center Troubleshooting Levels
- Figure 11 – Crown Castle Acquisitions Timeline
- Figure 12 – Picture of the National Operations Center
- Figure 13 – Breakdown of Crown Castle Assets Nationwide
- Figure 14 – Graph of Desktop Internet Consumption vs Mobile Internet Consumption