Public Safety Site Hardening

Site and System Considerations for Public Safety Grade Operations

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Site Hardening Overview

The phrase “public safety grade” aligns with the mission of those who protect and serve. First responders serve the public 24-hours-a-day, seven-days-a-week. Similarly, public safety grade systems are designed and specified to achieve extremely high reliability and availability.

Commercial carriers typically determine service availability and reliability on a site-by-site basis according to business evaluations. Public safety system performance must go beyond this perceived economic balance. Public safety sites and systems are designed to be reliable and available continually and especially under the most severe conditions. In short, long after severe weather or other disaster compromises a commercial site, a site / system providing first responder communications capabilities must remain operational throughout the duration of the event and recovery period. A site that is part of a public safety communications system should exhibit reliability, security, serviceability and performance that exceed those of their commercial counterparts.

Public safety site selection and development have evolved over the years. Today, most public safety sites still utilize government-owned land. However, with the rapid expansion of commercial sites, public safety systems do consider these as potential viable locations in lieu of “greenfield” site development. The use of commercial sites for public safety can provide certain benefits – economic, or to resolve an inability to find suitable land on which to build a new tower structure, or to answer community sentiments against the proliferation of radio towers.

Public safety standards also have evolved over decades to ensure that highly reliable communications are possible. Serving this requirement, consultants have developed specifications that define public safety grade requirements for their customers and manufacturers have implemented procedures to deliver to these consultant/customer requirements. This document will touch upon many of the considerations necessary for establishing a public safety grade infrastructure; provide recommendations for system configuration, hardware and site design, and procedures that, if implemented, will serve to meet the high availability numbers that define a public safety grade communications system. The ability to implement the recommendations that follow will need to be balanced against the cost of implementing such recommendations.
Site Grounding

Site grounding and electrical procedures have been developed by major manufacturers: Harris (AE/LZT 123 4618/1) and Motorola (R56) procedures are recognized as industry standards. These procedures, used by site construction contractors and installation crews, meet high quality electrical and grounding standards beyond compliance to local and state codes or other industry specifications such as Bellcore.

Most site designers and construction experts recognize the benefits of adherence to these standards, and strive to conform to their guidelines and principles. There is little doubt that sites constructed in strict accordance with grounding standards have a much better chance of surviving a lightning strike than those that have not been so constructed. While a site may appear to have been properly constructed (from the grounding perspective), only a careful review of the grounding design will determine that certain key principles have not been violated. Those of particular importance include:

• Single point of ground for the shelter, which eliminates the possibility for voltage potentials to develop between pieces of equipment - a concern related to equipment protection and, under certain circumstances, personnel safety.

• Connection of all site elements to the ground system, including fencing, towers, etc.

• Avoidance of ground loops

A rigorous adherence to site construction standards and diligent enforcement of quality standards ensure that a site is protected to the maximum degree possible. The time and effort invested during the design and construction/equipment installation phase will avoid lightning or other power surge-induced equipment failures, and the resulting downtime. This result is well worth the up-front investment.

Site Security

Site compounds must be secure. Often fencing surrounding the site includes razor wire to prevent intruders from entering. Alarms that monitor the doors typically connect to the public safety network management system to report potential intruders. Security cameras also are used.

Public Safety systems are installed in hardened shelters or secure buildings with Levels 3 and 4 bullet-proof ratings.
Hardened Shelters

Public safety systems are installed in “hardened” shelters or secure buildings in accordance with UL752 (typically Levels 3 and 4) ratings for bullet-proof structures. Shelters are designed with bullet-proof doors and walls. Outdoor cabinets are not utilized. Shelters are also designed to meet wind load specifications. Dual HVAC systems are typical for shelters to ensure that equipment can be maintained in the event of a single HVAC failure and are designed so that either HVAC unit can handle the heat load from the shelter.

Backup Power

Public safety systems include electrical protection systems within the shelter to prevent damage to the RF equipment from electrical surge. Systems may include Uninterruptible Power Supply (UPS) or DC Plant battery/rectifier systems. UPS is typically used for smaller loads and shorter runtimes, and DC Plants for larger loads and longer runtimes. These systems also provide the first line of electrical coverage in the event of main power loss until such time that an emergency stand-by generator comes online. Electrical systems should include the ability to connect to a generator whether that generator is on-site or must be “rolled in”. It is common practice for a Land Mobile Radio (LMR) system to equip the site with a fixed installation generator sized to accommodate all equipment at the site, including HVAC. Generator run times and fuel storage tank capacity are sized in accordance with system response requirements, site criticality, and site accessibility. It is not atypical to size fuel storage capacity that will allow the site to run for four or more days before having to refuel. Alternatively, shelters may be provisioned with an exterior electrical port to allow connection to a temporary (roll-up) generator on wheels. This design approach, while understood to be common practice for commercial systems, would be considered for public safety design as a cost-efficiency measure.

In-Shelter Design

While it may be considered to be common practice in any communications system design, in-shelter design should conform to well-established standards for the layout of equipment. Commonality of design from one shelter to the next enhances serviceability. Attention to the details of cable layout, and strict quality control in the installation of equipment and interconnecting cabling will not only enhance serviceability, but also minimize possibility of RF or other harmful forms of interference.

Backhaul networks represent an area of considerable vulnerability in maintaining full site operations during adverse conditions.

Backhaul

Backhaul networks – in whatever form or media to establish connectivity of the site to its core – can represent vulnerability to maintaining full site operation during adverse conditions. Microwave systems in particular are susceptible to failure or service interruptions due to radio hardware failure or path outages from excessive precipitation or high winds that cause dish mis-orientation.
Microwave and network systems must be designed to very high standards of path reliability - 99.9999% availability is not an uncommon design standard. Paths designed to such a high standard deliver protection against path outages related to excessive rates of rainfall. To protect against hardware failure, redundant RF hardware such as Monitored Hot Standby Equipment (MHSB) is quite commonly used for critical links. In lieu, or in combination with, the use of MHSB equipment, path/route diversity, which is the practice of serving a site with two links is a very common practice. This means that the failure of the primary route would result in an automatic and immediate re-routing through the secondary route.

Alternatively, the use of fiber optic networks is well-accepted in public safety system design, due to their relatively high levels of availability, as well as the high bandwidth that such connectivity provides at relatively low cost. However, the single point of failure that a single fiber-served site represents is still an issue, requiring that, similar to a design that employs microwave as a means of connectivity, the site is served with more than a single fiber feed. For those sites employing a dual fiber feed, a “dual fiber entrance” into the facility is attractive, such that excavation activity at a single location (i.e. – a single swipe of a backhoe bucket) would not sever both feeds.

For those sites that demand the highest levels of reliability, a combination of fiber as a primary means of backhaul, combined with an alternate microwave link as a backup, ensure against a common failure that could impact one or the other of these systems on a wide-spread scale. Such a configuration is said to employ “media diversity” (also a form of route diversity). For remote regions where high reliability is desirable, but where there would be a high cost associated with the establishment of the techniques discussed above, satellite connectivity may provide alternate path routing.

Antenna Support Structures

Towers are designed and constructed in accordance with TIA/EIA-222-G. Rev G is the latest revision of the TIA-222 Standard “Structural Standards for Antenna Supporting Structures and Antennas”. Rev G is based on a 3-second gust wind speed while the preceding Rev F is based on a fastest mile wind speed. Rev F is based on a fastest mile wind speed. The wind speeds are not directly comparable and it is very important to define the basis of a wind speed when specifying wind loading requirements. For a given location, the 3-second gust wind speed represents the peak gust wind speed whereas the fastest-mile wind speed represents the average wind speed over the time required for one mile of wind to pass the site.

A Rev G 3-second basic wind speed map defines the wind speed specified for all regions within the United States and US territories. Rev G presents additional factors to be considered in the design of new structures and for the modification of existing structures. The reliability requirements of a structure can now be accounted for by assigning a classification to a structure (Class I, II or III). Public safety will be a class III, whereas a carrier or a utility may only require a class II rating. The wind speed can also be adjusted based on the type of terrain surrounding the site and if the site is located on a hill or ridge.

For remote regions where high reliability is
Network Operations Center

To provide continuous, high-performance communications capability, it is essential to establish a 24/7/365 Network Operations Center (NOC). A NOC provides several necessary capabilities and services, including (among others):

- Performance monitoring
- Event logging
- Trouble-ticketing
- User Point-of-Contact (for reporting service issues, user problems, etc.)
- Service the needs of multiple agencies

The NOC will be required not only to be a 24/7/365 operation, but also must have the ability to be relocated to a completely redundant facility that will allow NOC operations to be restored in the event of loss of the primary NOC.

Fall-Back Coverage

Under normal conditions, site operation is reliant upon a connection to the system core. Without such a connection, site operation may be curtailed or severely compromised because such an outage may impact more than just a single site, and in fact may impact a wide area (e.g. – an earthquake) and take out many sites reducing communications capability to zero. For such occasions, and keeping in mind the mission that the communications system is intended to support, it would be prudent to account in the overall system design for such possibilities. Such system design considerations may vary from region to region and would be designed on a case-by-case basis. Examples for consideration are

- Reduced levels of coverage (portable in-door reduced to mobile coverage [key sites kept on the air])
- Standalone operation (sites severed from the core operating as autonomous sites; users served within the footprint of that site) Establishing fallback sites (site not normally used except under defined circumstances – e.g. mountain-top sites that are capable of providing mobile coverage to large geographic areas)
- Roll-up sites (commonly employed in both public safety and commercial systems to quickly restore communications or to provide enhanced service for “special events” or other circumstances)
During the design phase of the system in a particular region, the engineers and other planning personnel would need to determine likely failure scenarios unique to that region, and establish planning and equipment configurations that would be able to put in place should such failures materialize.

**Autonomous Site Operations**

Equipment that relies upon a connection to a system core is vulnerable to being severed from that core, rendering the site inoperative until core connectivity can be reestablished. Because core connectivity may take many hours to reestablish, it would be useful to provide a means by which a site could operate in an autonomous mode, allowing users to intercommunicate within the coverage footprint of the severed site.

**Maintenance Procedures**

To ensure that sites/systems maintain the high states of readiness during their life-cycles, it will be necessary to establish a rigorous and regularly performed program of planned maintenance. Well maintained sites will operate at peak performance throughout their life cycles; problems will be uncovered early, and will be able to be resolved in the most cost-effective manner. Site run-times under failed commercial power situations will be able to be sustained as designed (through regular battery maintenance); RF Interference (e.g.- intermod) will be able to be avoided through proper site maintenance procedures and monitoring of all site activity (if shared with other tenants).

**Service Level Agreements**

It is not enough to have established a high level of performance at a site during site commissioning. Those levels of performance at the time of acceptance must be reliably maintained over time, and guarantees of such performance by those responsible for maintaining them should be given. Service Level Agreements (SLAs) must be established with the service provider; agreements that have sufficient incentive (or penalties) to support the degree of rigor necessary to maintain performance and availability year after year.

**System Spares**

To allow service level agreements to be maintained, it will be necessary to have access to equipment spares that will allow site operation to be quickly reestablished. In accordance with the SLAs, the ability to obtain the necessary replacement parts in a timely manner is critical. To accomplish that, well-equipped spare parts depots must be provided and the procedures established that will allow maintenance and service organizations to obtain the parts necessary to reestablish site operation within SLA-defined timeframes.

Well maintained sites will operate at peak performance throughout their life cycles.
Service Crews

Throughout the service area, it is essential to have established a relationship with organizations capable of providing well-qualified and readily available crew(s) to perform regular maintenance or, more importantly, to respond in the timeliest fashion possible when site-related work must be performed. Such crews must be both available and capable of performing in-shelter related work to the high standards set during initial installation, and must operate with the understanding of the priority of the work that must be done to re-establish site operation after a failure – for whatever reason – has occurred. It is essential that the service organization selected to perform regular maintenance and timely restoration of service after failure be thoroughly familiar with the equipment being serviced, be properly equipped with the tools necessary to perform the required work, be located in areas that will allow response within the SLA established time-frames, work within established procedures identified in the SLA, and be completely familiar with the standards of work expected.

Tower Crews

Throughout the service area, it is essential to have established a relationship with organizations capable of providing well-qualified and readily available crew(s) to perform regular maintenance or, more importantly, respond in the timeliest fashion possible when tower-related work must be performed. Such crews must be both available and capable of performing tower-related work to the high standards set during initial installation, and must operate with the understanding of the priority of the work that must be done to re-establish site operation after lightning strikes, windstorms or other tower equipment damaging events.

Public Safety System Coverage

While not strictly an issue related to site hardening, public safety grade coverage is a topic that is always worthy of mention when discussing system design because it is the key driving force behind any Public Safety communications system design. There indeed are many other aspects of a system design that, if not providing the desired level of functionality, will cause the users to balk at system acceptance, but none more so than coverage. If the system does not provide a coverage footprint that encompasses the users’ service area, and provide the appropriate levels of reliability and voice quality (i.e. – DAQ 3.4), the question of functionality will not even arise.

Invariably, Public Safety design specifications, whether issued directly by the customer or by a consultant, will put the on us onto the vendor to meet the coverage needs of the users of the system (which, by the way, may vary from user to user on a multi-tenant system). It is incumbent on the system designers to fully understand in all aspects the details of the system coverage design requirement prior to embarking on system design / site selection exercise.

Failure on the part of the vendor to fully comprehend such requirements (and user expectations – unwritten requirements), runs the grave risk of unmet or mismatched expectations as the system comes to completion. It is well worth the effort on the part of the vendor, and in everyone’s best interest, to hammer out the coverage design details at the front end of the project, as it is very difficult and costly to resolve discrepancies at late stages of the project.
Coverage design details that must be well understood include:

- Service area boundary(s)
- Voice quality objective
- Area coverage reliability Confidence level
- Type of service required (mobile only, portable outdoor, portable in-door)
- Level of portable in-door coverage required (building attenuation level specified) Bounded areas where portable in-door coverage requirements apply
- Specific buildings / tunnels, etc. that must be covered
- Coverage Acceptance Test Plan (CATP) methodology (extremely important to have in place “up-front” and well-detailed. This can be a very costly and time-consuming exercise, one on which overall system acceptance is highly dependent.)

Standards

List of standards that have been cited in public safety grade specifications:

- American National Standards Institute (ANSI)
- American Society of Testing Materials (ASTM)
- Electronics Industry Association (EIA)
- Federal Communications Commission (FCC)
- Institute of Electrical and Electronic Engineers (IEEE)
- National Electric Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Telecommunications Industry Association (TIA)
- Underwriters Laboratories (UL)

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Fire Protection

The information that follows is illustrative of certain standards of typical Public Safety concerns in the industry. These concerns are normally not encountered in commercial designs. NFPA 1221 requires the following when developing a Communications System:

**Procedures for various methods of communication**

- Public reporting
- Telephoning
- Dispatching
- One-way and two-way radios

**Description of functions of the communication system**

- Communication between the public (including automatic alarms) and emergency response agency
- Communication within the emergency response agency
- Communication among emergency response agencies

**General requirements for a communications center**

- Location
- Wiring and cables
- Construction
- General requirements for the operations of a communication center
- Utilities
- Fire Protection
- Management qualifications and training
- Security
- Staffing procedures
- Power
- Time recording
- Lighting
Learn More

NPFA web site – http://www.nfpa.org

NFPA 1500 – Standard on Fire Department Occupational Safety and Health Program

NFPA 1561 – Standard on Emergency Services Incident Management System

NFPA 1620 – Recommended Practice for Pre-Incident Planning

About the Author

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About Harris Corporation

In public safety and professional communications, Harris is a leading supplier of assured communications® systems and equipment for public safety, federal, utility, commercial, and transportation markets – with products ranging from the most advanced IP voice and data networks, to next-generation, secure public safety-grade LTE (Long-Term Evolution) solutions for voice, video, and data applications, to industry leading multiband, multimode radios. Harris has more than 80 years of experience in public safety and professional communications and supports over 500 systems around the world.