Cellular Coverage Workgroup

A Hotelier's Guide to Cellular Coverage Solutions

Design Considerations

Version 1.00

About HTNG

Hotel Technology Next Generation (HTNG) is a non-profit association with a mission to foster, through collaboration and partnership, the development of next-generation systems and solutions that will enable hoteliers and their technology vendors to do business globally in the 21st century; to be recognized as a leading voice of the global hotel community, articulating the technology requirements of hotel companies of all sizes to the vendor community; and to facilitate the development of technology models for hospitality that will foster innovation, improve the guest experience, increase the effectiveness and efficiency of hotels, and create a healthy ecosystem of technology suppliers.

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1 Introduction

The cellular coverage best practices guide is intended to educate hoteliers and hospitality technology management organizations recommending and supporting hotel properties on the fundamentals of cellular coverage solutions. This guide includes an overview of the wireless technologies supported by the cellular coverage solutions, available solutions and their strengths and weaknesses, as well as design, installation and post-installations considerations.

This guide is intended to provide the hospitality IT or telecom manager with a thorough overview and explains the process that hundreds of hotels have undertaken to select and implement a cellular coverage solution. The information is presented in an uncomplicated manner so that it may be quickly grasped for a high-level understanding, while still providing enough depth to support a comprehensive understanding of the technologies, issues, and concerns.

The contents of this guide are provided on the HTNG website in the following sections:

- Solution Architectures
- Design Considerations
- Installation and Post-Installation Considerations
- Glossary

2 Design Considerations

This section covers design considerations or a cellular coverage solution.

2.1 Summary of Desired Services and Coverage: Planning Ahead

One of the first steps in planning a cellular coverage solution is to take an inventory of which wireless services are required in a facility. Many different wireless services can be implemented using a cellular coverage solution, but different wireless services may have different requirements for the solution itself or for the implementation of the solution by a particular vendor.

For instance, if the primary purpose is to support guest cell-phone and smartphone usage, then a shopping list of Mobile Network Operators (MNOs) should be prepared. Additionally, if the Coverage Solution is needed to support services like Public Safety, paging, or WLAN, then additional requirements should be prepared. For many Coverage Solutions wireless services may include:

- Multiple-MNOs for Cellular Voice and Data, including AT&T, Sprint, T-Mobile, Verizon, etc.
- Public Safety
- Two-Way Radio
- Paging
- WLAN, including 802.11n or legacy 802.11a or b/g.

This list of desired wireless services should be made available to cellular coverage solution vendors before product solutions are presented, allowing vendors and contractors to focus their recommendations on a solution that meets the needs of the hotel facility and avoid discrepancies between vendors.

In addition to specifying the list of wireless services, it is also important to consider the areas in a facility that need coverage. Not all areas of a facility may need every wireless service, a particular wireless service may already have adequate coverage in some areas of a facility and not require additional coverage, and some areas, such as elevators and stairwells – which can provide extreme challenges for cellular coverage solutions – may only need limited coverage. It is also important to note that some vendors will guarantee coverage while others do not. A full set of floor plans with details on which areas do or do not require coverage along with the degree of coverage for each wireless services will greatly improve the process of estimating the cost and complexity of a solution.

2.2 Service Requirements

From a design considerations perspective, one of the biggest impacts on the cost of a cellular coverage solution is the number and types of wireless services. Different wireless services utilize different technologies, different frequencies and have different coverage requirements. To begin, each wireless service may require support of multiple technologies and multiple

frequencies. For instance, a MNO may support 2G/3G/4G across multiple frequencies and require different RF signal sources to provide all cellular data and voice services. From a coverage perspective, the Minimal Signal Strength is key in determining how much antenna infrastructure is required and is a key metric that should be included when discussing wireless service requirements with vendors. Additional information on both RF signal source requirements and Minimal Signal Strength can be obtained from both cellular coverage solution vendors and MNOs.

Capacity related considerations should also be taken into account and addressed in two areas: immediate needs and longer term needs (# of channels per band and/or technology, migration to small cells/more sectors, MIMO, adoption of LTE in other frequency bands, etc.). In most cases it's important to make coverage and capacity planning as an integrated part of the same process which will drive antenna density and critical infrastructure related decisions. The table below is an example, but actual Minimum Signal Strength requirements should be provided by the respective MNO for services being covered as some requirements vary by geography.

Wireless Service	Common Technologies	Frequencies	Minimum Signal Strength	Common Names
Public Safety	SMR	150MHz 450MHz 700MHz 800MHz 900MHz	-95dBm	Fire Fighter & Police Radios
Cellular Data and Voice	2G (GSM, EDGE, CDMA, 1XRTT) 3G (EVDO (Rev A), UMTS, HSPA) 4G (WiMAX, HSPA+, LTE)	700MHz 850MHz 900MHz 1700MHz 1900MHz 2100MHz 2600MHz Europe/Asia: (*-indicates different frequency bands) 800 MHz * 900 MHz * 1600 MHz 1800 MHz * 2100 MHz * 2600 MHz *	-85dBm (voice), -75dBm (data)	Cell Phones Smart Phones, Data Cards,

Wireless Service	Common Technologies	Frequencies	Minimum Signal Strength	Common Names
Two-way Radio	iDEN LMR	800MHz 900 MHz	-95dBm	Push to Talk, Two Way Radio
Wireless LAN	802.11 b/g/n 802.11 a/n	2400 MHz 5800 MHz	-70dBm (data), -67 to -60dBm (voice)	Wi-Fi
One-way, Two-way Paging	FLEX	900MHz	-75dBm	Pagers

2.2.1 Public Safety

Public Safety requirements are very localized, often at the municipality level. In the case of cellular coverage solutions, some solutions natively support Public Safety while others may require a separate overlay network that is separate from other wireless services, while others do not support Public Safety. Additionally, Public Safety requirements can range from needing very specific channels inside the Public Safety frequencies to shielded cable and conduit requirements. Care should be taken by the hotelier to work with both the solution vendor and public safety agencies.

2.2.2 Cellular Data and Voice

In the past, the common reason to deploy a coverage solution for cellular was for voice calls. With the dramatic upturn in smartphone usage, data has become the predominant driver. With voice, cellular services could be implemented with a relatively low number of antennas and Minimal Signal Strength. Data is more taxing, especially as data rates increase. With 4G LTE, one of the leading cellular data technologies, data rates are significantly improved over previous generations of cellular data services, but special considerations with respect to signal coverage and quality and even antennas distribution, namely MIMO, should be taken into account. Requirements for 4G LTE can significantly increase the coverage solution infrastructure as well as the number and location of antennas. Hoteliers should consult with a qualified resource to determine hotel and guest needs.

2.2.3 Two-way Radio

Two-way radio can be implemented on many coverage solutions. With some MNOs -- notably Sprint/Nextel's -- the traditional two-way radio infrastructure may be replaced with a multi-functional-based solution that incorporates radio communication. The key hotel departments that rely on two-way radio communications are those with responsibilities for safety and security, including maintenance and security personnel and most department heads.

2.2.4 Wireless LAN

For most hoteliers, Wireless LAN on a coverage solution is an option that can be successfully implemented. Like cellular data services and 4G, implementing WLAN on a coverage solution requires proper engineering to meet WLAN requirements, and higher frequencies, such as 5.8

GHz and 802.11n MIMO, are important considerations when weighing this option as only a few cellular coverage solutions provide 802.11n with MIMO.

2.2.5 Paging

Like two-way radio, paging can be implemented using a specialized wireless services or using MNO technologies, such as Short Message Service (SMS).

2.3 Site Survey and RF Analysis

With the information identified above, a vendor can provide a proposal based on computer-based RF analysis or may choose to do a site survey before RF analysis. The site survey process could be done by a third party prior to requesting proposals or the site survey can be conducted as a group with several vendor/contractors attending.

The person(s) doing the survey and analysis looks at building dynamics, existing coverage, which penetrates the building from surrounding exterior macro sites, and/or perhaps how well signals will propagate within the building(s).

From the RF analysis viewpoint, the level of coverage already existing for the desired services can be an important consideration. It is not uncommon to find that a wireless service is already sufficient in some areas and does not need additional coverage. However, this is more likely with cellular voice services and other less demanding services than with newer data services. It is also important to understand that while a facility may have some level of coverage provided by an outdoor network, this coverage may change if/when a MNO makes changes to their macro network.

A coverage solution vendor may also conduct an analysis of how well a test signal distributes (propagates) in some areas. This is usually done with a low-power test transmitter and signal-strength meter. There is no potential danger involved with this process, as the levels are typically less than normal outdoor signal levels.

The output of a site survey should yield detailed notes on the floor plan regarding levels and areas of needed coverage. This coupled with RF analysis is used to provide a proposal as well as engineer a solution.

Naturally, as the size of the property increases, the total cost of the cellular coverage solution increases, but a facility's layouts may also increase costs even in a smaller property. Typically, it is much easier and less expensive to cover small floors that stack than the same amount of square footage on a single level, especially if the telecom closet or IDF is centrally located on the floors.

Long, narrow areas, like hallways and walkways, are more difficult to cover, as well as areas where the ceiling is high and open. Small buildings not physically connected to the main building and/or parking garages may require additional equipment to support. Obstacles like these add to the complexity and cost of the project.

Another factor influencing the cost of the coverage solution will be the MNO's individual system requirements. One requirement in particular is the signal strength generated by the system to meet coverage and capacity requirements. Additional antennas, associated cabling and equipment are required when increased signal strength is desired to meet certain voice and data performance targets. Related to this dynamic is the desire of the MNO's to have the BTS or microcell connected to the coverage solution as the dominant radio source within the building. In this scenario the wireless device will recognize the in-building solution as the strongest signal source and not get 'confused' trying to connect to signals generated from a macro cell site outside the hotel property. This 'confusion' degrades phone performance, impacts overall capacity, and diminishes the customer experience through dropped calls, longer data transmission speeds, etc.

2.4 Equipment, Cabling and Antenna Considerations

Given the fact that all cellular coverage solution architectures solve in-building RF propagation challenges, it is easy to overlook the cable plant design, installation, commissioning, and documentation process necessary to support all wireless applications within a given facility. As indicated earlier in this document, the RF application requirements, coupled with the building size and scope, can easily influence the type of coverage solution architecture employed (e.g. passive, active, hybrid, etc). Likewise, the coverage solution technology employed determines the type of cable plant necessary per manufacturer's equipment specifications. This can include any/all of the following medium: fiber (single mode or multi-mode), coax (various forms), and network/Ethernet cables (CAT5/6).

During the site-survey process, a complete audit of the hotel is necessary to clearly identify both horizontal and vertical cable paths necessary to support the Coverage Solution technology. Frequently, intermediate distribution frames (IDFs) or telecom closets are centrally located on each floor within a facility and become a wiring medium management point between horizontal cable runs to antenna points on the floors and vertical cable runs to the master distribution frame (MDF). The MDF is typically co-located in the basement level of a facility within a telecommunication/server room and becomes the wiring demarcation between multiple IDFs located throughout the facility and the RF signal sources or data application servers.

Floor space and/or wall space must be provisioned in the IDFs/MDF or in other locations to accommodate cable terminations and interconnects. In most cases, and to systematically support and manage the cabling infrastructure, various sizes of telecommunications equipment racks are employed in the IDFs/MDF to support: the various active/passive equipment; AC/DC powering equipment; cable termination hubs; wireless service provider bi-directional amplifier or micro-cells; emergency power backups; telecommunications interfaces, etc. Remote amplification hardware may also be deployed in other areas if IDF locations are not ideal for the targeted coverage area.

Integrated 802.11a/b/g. may also be included with the coverage solution. The 802.11 access points may be distributed throughout the facility or centralized within IDF closets. This former

distribution approach will typically employ ceiling enclosures to house the access points for security.

For cable installation purposes, adequate horizontal and vertical cable pathways, or risers, must be clearly identified and readily available to support the targeted coverage solution technology. It is common practice to use vertical cable conduit or plenum rated cabling between floors to support the interconnection and homing of multiple IDFs to a single MDF location. Depending on the cable medium utilized, ample space must be readily available via conduits to support the vertical cable plant. Further, if fiber is being employed in the conduit between the MDF and IDFs in support of the coverage solution technology, additional innerduct within the conduit to protect the fiber against future potential cabling installation damage must be considered.

Likewise, horizontal cable runs must be clearly identified in order to obtain precise antenna locations for optimal RF propagation. Horizontal cable pathways must be clearly identified and unobstructed in order to ensure cost-effective installation of the cable plant from the IDF to the antennas on the various floors.

It is important to consider the unique requirements of analog RF distribution over fiber optic cable during cable plant planning. Most manufacturers transmit RF in analog format vs. digital. In general, fusion splices and APC connectors are encouraged and patch panels are discouraged.

In all cases, thorough RF analysis must be performed to ensure adequate signal strength to all appropriate end points for both uplink and downlink within the respective coverage solution technology solution. Throughout the cable plant installation process, fiber/coax/copper cable sweeps should be performed on all cable to ensure appropriate performance to validate propagation characteristics. Various forms of handheld telemetry equipment are readily available to perform these sweeps and guarantee the integrity of the cable plant.

Cabling should be designed and installed by someone certified by the following organizations and understand how design objectives impact cellular coverage solution design. For example, new BICSI standards require cable to be run along ceiling grids which increases the amount of cable required and also increases the cost of the cellular coverage solution:

- Building Industry Consulting Services, Inc. (BICSI)[1]
- Registered Communications Distribution Designers (RCDD)

Whenever possible, it is recommended that design engineers and installers provide evidence that the current best practices are employed for a cable plant and coverage solution technology

[1] BICSI (Building Industry Consulting Service, Inc.) is a professional association supporting the information transport systems (ITS) industry with information, education, and knowledge assessment for individuals and companies.

installation. Contractors must ensure that all cabling is appropriately labeled and that a complete set of cable plant documentation ('as-builts') is made available to the hotel as a permanent record and for future reference. As-Built drawings will also denote the location of antennas and radio equipment located in the IDF and MDF spaces as well as in the head-end equipment room. If multiple MNOs attach to the in-building coverage solution with multiple technologies, there may be significant floor space and power requirements. It is best to identify these needs and, where possible, consider these requirements in initial building design.

Any federal/state/local regulations must be recognized and incorporated into the design to ensure compliance.

Finally, the expense of site survey, design/engineering, installation, and commissioning of a Coverage Solution can vary dramatically between an existing facility (retrofit) and a new building ("greenfield"). If planned well in advance and in conjunction with building construction, a greenfield installation is the most cost effective, especially regarding cable plant installation. Typically, existing and experienced onsite construction trades can be engaged to physically install the cable plant at appropriate, scheduled times during the infrastructure build-out. Installation personnel should be certified to work with the medium type being installed. Close coordination and schedule flexibility with the building general contractor and building trades is vital and can result in cost savings during cable plant installation.

Building retrofits can offer some unique cable plant challenges from a design/engineering and installation perspective, such as:

- Lack of adequate riser facilities between floors to support vertical cable plant
- Lack of adequate horizontal pathways from IDFs to antenna locations
- Drywall or ornate ceilings with little to no access panels
- Lack of adequate space, AC/DC power, and cooling in IDF/MDF to support active equipment
- Lack of grounding in equipment rooms. In particular, may be required when feeding from a roof mounted antenna to BDA
- Fire-rated partitions
- Outdated, inaccurate, or non-existent blueprints depicting potential cable pathways and potential obstacles
- Elaborate trim and hallway/room decorum requiring re-establishment after cable plant installation
- General lack of facility knowledge/history with current staff and construction trades
- Coordinating rolling room/floor blocks for system installation
- Union versus non-union labor
- Standard versus non-standard work hours

Building retrofits also present challenges when determining the MDF and IDF spaces. Whether the hotel is a historic property or built 10 years ago, space always seems to be at a premium. If

the design of a hotel did not allow for the addition of future technologies, then finding adequate space for equipment may become a challenge.

While a thorough site survey, peer review, construction trade review, and detailed project plan can help minimize the aforementioned challenges, contingency plans and change orders should be expected with cable plant installations in building retrofits.

2.5 Redundancy Requirements

Redundancy most often takes the form of a battery backup or backup generator for the system. All vendors can support redundancy, even to the point of two fully functional systems, but rarely do the benefits justify the cost. At minimum a backup generator, should be utilized as the emergency backup system, since a generator can provide continuous backup for an extended period of time. Additionally, some MNOs suggest having additional battery backup of two hours as well. The coverage solution vendor will often inquire if the hotel has an emergency generator and, if so, whether the cellular coverage solution can access it for emergency backup. In these cases, the additional electrical loads from the cellular coverage solution system need to be determined along with an evaluation of whether the existing generator can accommodate this additional load.

Additionally, reliability of the system should be considered. Passive components, splitters, coax, and antennas tend to have very high reliability. For active components reliability is quantified by industry standard as MTBF, or mean time between failures. The higher the MTBF, the less likely a component will fail over time. The industry standard for MTBF used by most manufacturers is the Bellcore Reliability Prediction Model B332 –Issue 6. While a high MTBF does not guarantee a system will not have service interruptions, it tends to be a good indicator.

2.6 Additional Design Considerations

Building Codes – Local codes dictate cabling requirements for a building. Items such as fire stops, plenum locations, and cable loading vary by locale. Coverage Solution designs and associated costs may differ accordingly.

FCC Compliance – All equipment included in the Coverage Solution design must comply with FCC regulations for the equipment type. RF sources must be certified for use on the carrier network and not pose an operational hazard for other frequencies.

Link Budget – The link budget for each carrier must provide sufficient signal for satisfactory user service levels. Coverage Solution system gain/loss should be carefully documented and periodically checked to ensure consistent performance. Link budget should be considered for both uplink and downlink transmissions.

Frequency – Where multiple frequencies will be utilized, specification of filters must be sufficient to prevent interference from neighboring channels.

Power Levels – The aggregate power emanating from any antenna should not exceed levels recommended in the FCC OET Bulletin 65 Standards for Maximum Permissible Exposure for the

safety of those in close proximity. RSSI minimum requirements should be clearly documented for all covered areas.

Plenum Locations – Any equipment or cables installed in a plenum location should be manufacturer-rated for that purpose.

Inter-modulation – When multiple frequencies are passed through a non-linear device, such as an antenna, additional harmonic waves are generated. The third harmonic generated is so close to the original frequencies that in-band RF noise and interference levels are significantly raised. This can create a multitude of operational problems, including "cell deafness" for the RF carrier equipment if not properly mitigated. When operating at power levels of 1 watt and below, which is common for in-building designs, inter-modulation problems are infrequent, but the potential issue should not be disregarded. Mitigation techniques for intermodulation include spatial separation of antennas and robust filters and amplifiers tested in carrier interoperability labs.

IDF (and other types of maintenance closets/locations where equipment can be deployed) – Each of these locations must account for wall space and cooling requirements. IDF's should be specified on every floor for new construction.