



Cellular Coverage Workgroup

A Hotelier's Guide to Cellular Coverage Solutions

Installation and Post-Installation 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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Table of contents

1	INTRODUCTION	4
2	INSTALLATION/FACILITIES CONSIDERATIONS	5
2.1	ACCESS FOR INSTALLATION	5
2.2	SPACE, POWER, AND HVAC.....	5
2.3	MNO INFRASTRUCTURE CONSIDERATIONS	5
2.3.1	BDA	5
2.3.2	BTS and IP Base Stations	6
2.4	SUBSYSTEM REQUIREMENTS	6
2.4.1	Overview	6
2.4.2	Antenna Placement	7
2.5	WI-FI SYSTEM CONSIDERATIONS	8
3	POST-INSTALLATION CONSIDERATIONS.....	9
3.1	ACCEPTANCE TESTING	9
3.2	COVERAGE SOLUTION SYSTEM MONITORING & OWNERSHIP RESPONSIBILITIES.....	9
3.2.1	System Monitoring	9
3.2.2	Ownership Responsibilities for Coverage Solution-Carrier, Owner or Third-Party Vendor	10
4	COVERAGE SOLUTION INSTALLATION CONSIDERATIONS.....	12
4.1	ASSURANCE OF COVERAGE	12
4.2	TRAINING	12
4.3	FINANCING	12
4.4	REFERENCES.....	13
4.5	MNO PARTICIPATION.....	13
4.6	ECONOMICS	14
4.7	THE COVERAGE SOLUTION PROCESS.....	15
4.7.1	Phase 1 - Site Survey	15
4.7.2	Phase 2 - System Design & Engineering	15
4.7.3	Phase 3 - Project Management.....	15
4.7.4	Phase 4 – Installation	16
4.7.5	Phase 5 - Commissioning, Testing, and Verification.....	16
4.7.6	Phase 6 - Ongoing Maintenance Support	17

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 Installation/Facilities Considerations

2.1 Access for Installation

Hotels are unique with regard to cellular coverage solution installation. They do not have down time like public venues, airports, or convention centers. Access may be a challenge, and installation may be restricted due to hotel occupancy or security issues. Night work may be the best option for common areas, but will often not work in the guest areas. Additionally, Mobile Network Operators (MNOs) require access to install and commission the equipment and for ongoing maintenance as discussed in Post-Installation Considerations section below.

Most vendors take this into consideration, but it does not hurt to specify restrictions in the request for quote, including times that certain areas will be open for installation.

While most coverage solutions require only a few workers to deploy, consideration must be given to access for these workers and the typical access restrictions unique to hotels.

2.2 Space, Power, and HVAC

The cellular coverage solution itself requires very little AC power and space and, therefore, generates very little heat. For example, the coverage solution equipment needed to cover a half-million square feet may fit in half of a standard telecom rack in the MDF (head end) and consume less than 200 watts of power; however this may change with multiple MNOs and MIMO.

Remote hubs used in the active and hybrid systems require additional power that can be centralized in the same room as the head end equipment via a remote power feed or provided locally in the IDFs or where the remote equipment is mounted.

The signal sources provided by the MNOs require additional space, power, and HVAC. The amount of resource, including Power and HVAC, required for the MNO depends on the signal source they select for the installation. A BDA may fit into an existing rack while a BTS may require several full racks.

2.3 MNO Infrastructure Considerations

2.3.1 BDA



A BDA off-air interface requires that an antenna be mounted on the roof or comparable location. The roof-mounted antennas tend to be less than five pounds with very little wind loading.

The BDA itself is typically located in the MDF along with all other associated coverage solution equipment. Each BDA employed requires ample power (to include backup power), rack-mount or wall-mount space to comply with manufacturers' space-allocation specifications, environmental,

and cable pathways for access to both the coverage solution head-end equipment and the rooftop antenna. In most cases, short coax cable runs and potentially diplexers are required between the BDA and the coverage solution remote unit. These cables can be easily installed, dressed, and labeled.

Access between the BDA and a rooftop antenna requires ample cable vertical pathways. Cable riser space must be planned and allocated for each BDA employed in the coverage solution. Typically half-inch coax cable is the norm. However, in some cases where RF link budgets may be borderline or exceeded, thicker cables, such as five-eighths-inch coax, may be required. Though not necessary for most installations, various forms of armored cable are available, further protecting the integrity of the cable from damage when required.

Once operational, the BDA will be rebroadcasting a licensed FCC spectrum. Written approval from the MNO is required before the BDA may be activated.

2.3.2 BTS and IP Base Stations

A BTS, a mini-BTS (i.e. micro-cell) require ample power; rack-mount/wall-mount space to comply with manufacturers' specifications; environmental; and cable pathways for access to the coverage solution head-end equipment, telco access facilities, and rooftop access for a GPS antenna.

Like the BDA, short coax cable runs are required between the signal source and the coverage solution head-end. The signal sources are serviced by communication links (T1 or Ethernet) to/from the facility and typically require some form of twisted pair cabling from the building telco demarcation to the signal source. Finally, a GPS antenna may be required on the rooftop or similar location to service the signal source. This, too, requires a half-inch cable via a dedicated or shared vertical pathway from the MDF to the rooftop.

Close coordination with the various MNOs ensures that proper planning has been undertaken to accommodate all cabling requirements as they relate to the wireless operator equipment.

2.4 Subsystem Requirements

2.4.1 Overview

In a perfect environment, building design architects and building owners have allocated appropriate space for MNO signal sources and the cellular coverage solution during design and funding phases. Key locations for space allocation include IDFs and the MDF. Building retrofits may not afford ample or appropriate IDF/MDF space for equipment placement. If MDF/IDF locations are not readily available, great care must be given to determining a secure location for all equipment placement. Consideration must also be given to powering, grounding, servicing space, cable access and dressing, security, access, etc.

Building geometry and wireless application requirements dictate whether coverage solution equipment is required in each IDF, on every floor, or on every other floor. Co-location with other IT equipment within the IDF determines whether dedicated telco racks should be used or if wall-mounting considerations must be made. If IDF space is readily available, one should

consider utilizing a telco rack to properly rack-mount all appropriate coverage solution equipment and power and dressing all appropriate cables (fiber, CAT5/6, coax) ingress/egress to the telco rack. Rack placement must accommodate manufacturers' specifications related to environmental considerations, service space allocation, powering, grounding, cable access, fiber patch panels, Ethernet hubs, etc. If IDF space is a premium, wall-mounting of equipment or deployment of smaller wall-mounted swing racks may be considered. Wall spacing must take into account manufacturers' equipment wall-mounting specifications, cable dressing, fiber patch panels (if required), WLAN access point co-location, CAT5/6 Ethernet hubs, equipment grounding, AC/DC converters (if required), etc. The amount of coverage solution equipment typically located in the MDF may require multiple telco racks to support both the MNO equipment and coverage solution head-end equipment. Consideration for Wireless Service Provider (MNO) BDA and/or BTSs must also be made.

In most cases, dedicated quad AC outlets are adequate to power all equipment to the coverage solution within the IDF. If multiple outlets are not available, then a multi-outlet power strip may be utilized to provide sufficient power to all coverage solution equipment within the IDF. The amount of power required for MDF equipment is determined by the amount of coverage solution equipment and associated MNO head-end equipment to be placed in the MDF. In all cases, proper equipment grounding must be afforded in both the IDF and MDF. In a perfect environment, dedicated building grounding bars are preferred. When grounding bars are not readily available, grounding to building mechanical infrastructure can suffice. In all cases, all coverage solution equipment within the IDF/MDF should be supported by emergency power back-up for the building, as this equipment may be critical for emergency situations. When emergency power is not readily available, independent battery backup subsystems can be employed in each IDF and MDF.

2.4.2 Antenna Placement

The least complicated coverage solution design provides separate in-building distribution and antenna systems for each carrier/frequency being deployed. Though simple, this can lead to the property's having an undesirable and unsightly "antenna farm" appearance. To reduce both the cost and number of antennas, a common alternative design broadcasts multiple frequencies on a single coverage solution infrastructure. Antenna placement for multi-frequency systems is normally designed based on the "worst-case" propagation, usually the highest frequency to be transmitted. Multiple methods can be employed to make in-building antenna installations more aesthetically pleasing. Antennas can be colored to blend with surrounding areas or located above suspended ceilings, for example. Electronic down-tilt antennas are frequently specified for mounting above ceiling tiles.

Additionally, if the system is designed as a MIMO solution then a second antenna is required in the same coverage area. The distance between the two antennas is a function of the design, but approximately four to six feet of separation between the two antennas is a 'Rule of Thumb' distance. Many of the MNOs are requiring MIMO for 4G services. Some solutions are available

which integrate the two antennae into a single form factor, eliminating the need for a second cable and antenna.

2.5 Wi-Fi System Considerations

As mentioned earlier, not all coverage solution vendors' equipment is architected to support 802.11 a/b/g/n. During the site survey phase of the project, incremental applications for the enablement of Voice over IP (VoIP), wireless point of sale, wireless data (hotel staff, back office, guests), etc. need to be uniquely specified and considered, as they may add incremental costs to the coverage solution. As an example, best engineering practices dictate a stronger Receive Signal Strength Indicator (RSSI) level in support of VoIP versus best-effort wireless data services. In effect, the antenna density and associated prerequisite equipment, labor, cabling, etc. in support of VoIP may increase, as well. Further, various WLAN applications may only require coverage within certain locations of the facility. Most traditional cellular coverage solutions do not support integration of 802.11n and a parallel solution for 802.11n is often deployed. With that said, some cellular coverage solutions do support 802.11n on the antenna infrastructure and others can allow 802.11n and cellular to coexist on the same LAN structured. The hotel should work with the manufacturer to determine the impact of cabling infrastructure when 802.11n is deployed with cellular coverage solutions.

Security is yet another consideration in the design of a coverage solution to ensure that all property and guest data is secure and free from vulnerabilities. As such, each wireless application has a prerequisite cause/effect on design considerations for the coverage solution.

3 Post-Installation Considerations

3.1 Acceptance Testing

Acceptance testing usually consists of injecting a signal (from a test transmitter) into the coverage solution and measuring the level of the signal at several areas in the property. Most vendors or coverage solution contractors propose an acceptable method of testing in their quote. A key consideration here is to include MNO commissioning in the coverage solution quote. An independent group should do the Acceptance Test Plan (ATP) to show the best- and worst-case readings. The installation vendor or contractor who sells and installs the coverage solution should be present, so they can be reached quickly if there are issues with coverage for a specific MNO.

3.2 Coverage Solution System Monitoring & Ownership Responsibilities

Troubleshooting, Support and Preventive Maintenance

3.2.1 System Monitoring

In today's enterprise environment, cellular, wireless, and applications services from the multi-service coverage solution have become mission critical and require real-time monitoring. A coverage solution today must effectively monitor:

- its own health
- signals from each of the services it handles
- service-provider signal
- amplifier status
- physical cable connectivity (all the way out to the antennas in the ceiling)

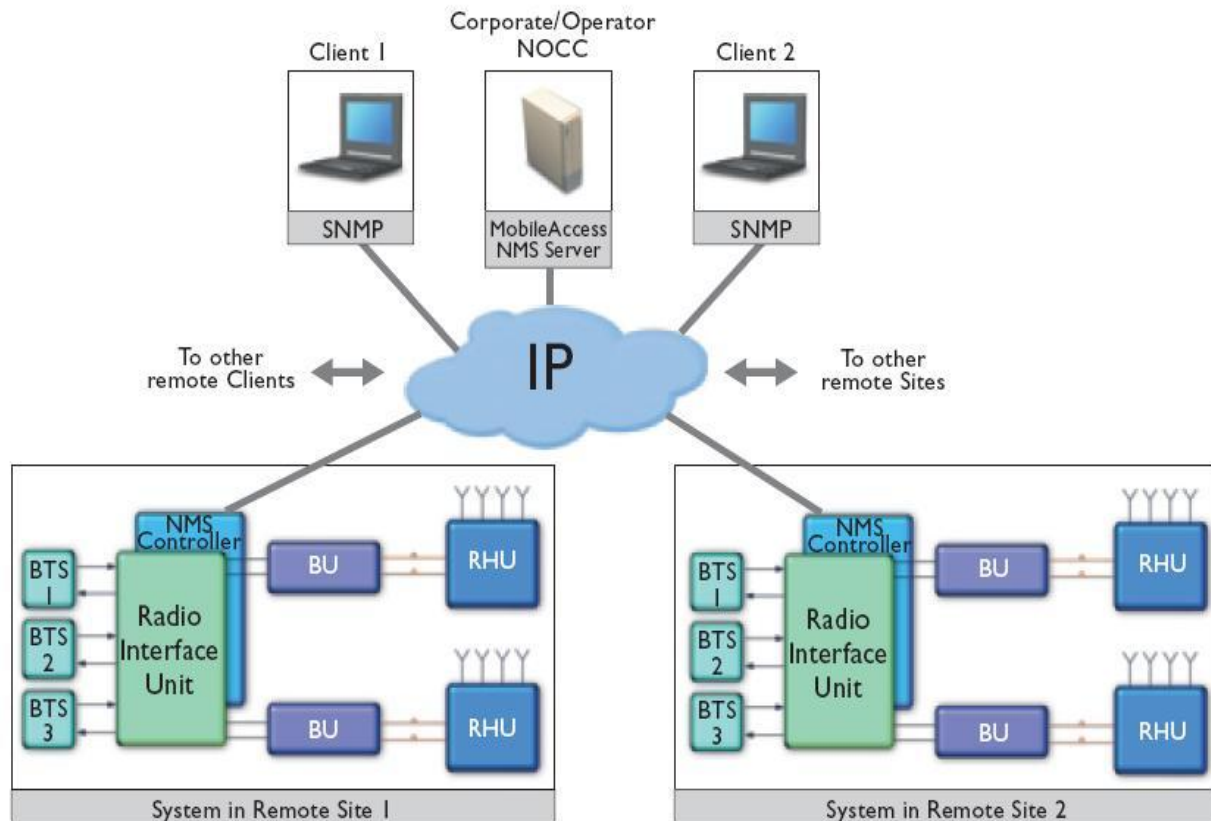
Since enterprises today have many locations, the coverage solution must be capable of real-time monitoring of multiple sites from a Web-based terminal. The components of the coverage solution should also provide flexible connectivity options that align with the demands of a dynamic enterprise network environment, including Ethernet IP, dial-up, and local connectivity. The coverage solution must be able to proactively send alerts out when faults are detected, as IT personnel are typically too busy to monitor the system proactively.

All technologies should be monitored, ideally to the antenna. However, active and hybrid systems also require management capability to set up and optimize the system. Cellular coverage solution vendors offer integrated or add-on system management elements and software that vary somewhat in capability but provide the essentials for good system management.

From a network-level perspective, enterprise cellular coverage management systems offer an application that enables the user to monitor all of the remote system controllers simultaneously via IP connectivity. This server is typically Web based, allowing equipment monitoring to be done locally by the hotel or remotely by a provider so that when system failures are detected, service and maintenance personnel may be automatically dispatched.

On the individual site level, the enterprise cellular coverage management systems monitor provider signal levels on a per-provider basis. The systems also monitor equipment health, including the status of the amplifier, fiber, and antenna connectivity. Generally, this functionality is handled in-band over the same fiber as the coverage solution, so no additional network infrastructure is needed.

The following diagram is an example of one vendor's Network Management System (NMS):



3.2.2 Ownership Responsibilities for Coverage Solution-Carrier, Owner or Third-Party Vendor

As previously discussed, multiple options are available for funding, management, and control of cellular coverage solutions. However, ownership of the coverage solution does carry certain responsibilities, regardless of the business model. Primary among these are spectrum stewardship, interference mitigation, performance monitoring, and network protection. As network carrier diversity increases, so, too, does the complexity of coverage solution management.

Spectrum stewardship is taking responsibility for the RF sources that are being distributed within the building. When multiple RF sources are broadcast, certain frequency parameters must be adhered to by each source. Frequency, filtering, power levels, channel usage, and guard-band requirements should be clearly defined for each source. Identification of such violations and proper remediation are the responsibility of the coverage solution owner. With neutral host systems, carrier demarcation occurs at the RF source.

Interference mitigation is required when the performance of one or more RF sources is negatively impacted by external sources. With neutral host systems, the most common interference sources are other carriers and inter-modulation generated at the antennas. Identification of interference sources and corrective action are the responsibility of the coverage solution owner.

Performance monitoring involves verifying that all RF signals are being distributed throughout the building(s) at a sufficient level to provide adequate service to users. Reduced signal strength may be the result of interference, coverage solution component failure, environmental changes, or problematic RF sources. Identification of performance failures, issue resolution, and notification of affected carriers are the responsibility of the coverage solution owner.

Network protection normally involves providing physical security for RF source equipment and electrical isolation, if required. Any coverage solution component failure that negatively impacts carrier equipment is the owner's responsibility.

Access – Carriers will typically require 24/7/365 access to their signal source equipment. This is done to ensure their ability to quickly remedy any unexpected network performance issue that may arise due to changing conditions in the network or changing performance of the cellular coverage solution.

4 Coverage Solution Installation Considerations

4.1 Assurance of Coverage

As established earlier in the document, a vendor that provides a comprehensive site survey and design document usually renders a comprehensive and complete solution that exceeds the performance criteria established in the initial requirements document. A good coverage solution provider commonly samples system performance measurements as the solution is being installed to ensure that RF coverage requirements are being adequately met. RF sources can be easily injected into the cable plant and associated antennas (on a sample basis) and verified via RF measurement equipment as the solution is being built out. Typically, one can quickly hone in on challenging coverage areas within the property and determine if adequate coverage can be provided for all wireless applications.

Once the solution is completely installed, activated, and “tuned” appropriately, similar measurements can be easily ascertained to ensure that adequate coverage exists throughout the targeted coverage areas for all wireless applications. Results of the measurements should be documented and stored for future reference purposes.

4.2 Training

Like any Information Technology (IT) solution in operation at the property, training is paramount to handle day-to-day operational requirements that may arise. In many cases, after the initial system turn-up and final documentation of the solution is rendered, basic hands-on and/or formal classroom training should be considered. While it is not necessary to thoroughly understand all aspects of the system, basic system surveillance and management techniques, level-one troubleshooting scenarios, and ongoing periodic maintenance procedures should be well understood by a number of members on the staff. Likewise, good system documentation and reference guides should be provided with the solution and be readily available to reinforce any information covered in a training curriculum. Most cellular coverage solutions have various forms of remote management capabilities that can enable remote assistance from either the solution provider and/or original equipment manufacturer should the need arise. Training for use of the system-management tool should also be provided.

4.3 Financing

If a hotel property’s client satisfaction scores indicate a strong demand for ubiquitous wireless coverage, and their planning and budget cycles do not support a capital purchase such as a coverage solution at the time, various financing options are available from many reputable industry institutions that can tailor a financial package to coincide with your funding requirements and minimize the impact of a capital purchase such as a coverage solution to your business. Depending on the total expense of the project, it is conceivable to obtain financing packages that range anywhere from a one- to five-year term. While financing a project such as this may not be appropriate for every situation, it can be used as a tool to parlay a capital cost into an operating expense that can coincide with the operating cash flow of the property. It is imperative to ensure that the financing company is reputable, possesses excellent references, and has the financial staying power to withstand changes in market and other unforeseeable

conditions. It is of utmost importance to ensure that the financial institution regularly deals in the hospitality marketplace and thoroughly understands the business.

4.4 References

Taking the time and energy to call and/or meet a cross section of a vendor's previous clients is paramount and can possibly save a lot of project aggravation in the long run. Based on hotel companies in similar projects, the following are questions that may be useful to ask:

- Is the vendor's equipment approved for connection by the Wireless Service Providers? MNOs maintain a list of approved cellular coverage solution products that they will connect to. These products have undergone lab testing by the MNOs to ensure no damage will occur to their network and the cellular coverage solution will perform to the standards required by the carrier when properly designed and implemented.
- Does the vendor commonly provide solutions such as this to other hospitality venues? Has the vendor proven to be accommodating in working around daily facility operational challenges?
- Does the vendor issue a high number of project-change orders after the project is underway? If so, this could be a warning sign that the lowest bid may not be the best (or lowest cost) bid.
- Does the vendor provide complete turnkey and life-cycle maintenance support or do additional contracting specialties (and costs) need to be considered?
- In the past, did the vendor keep all trade payables current with any/all participating trades on the project?
- Have previous projects come in on time and on budget? If not, what were some of the lessons learned?
- Were jobsites kept orderly and safe? Were local safety regulations and building codes adhered to during the project?
- How thorough was the initial site survey and did the end solution meet the design goals stated in the initial design document?

It is ideal to verify bank references and check with major suppliers to anticipated vendors. Visiting one or two clients for whom the vendor installed a solution similar in size and scope is also a good idea. Not only will this provide relevant feedback from a current client but can assimilate many "lessons learned" for the project, as well.

4.5 MNO Participation

Deployment of a coverage solution does not automatically guarantee signal source from Wireless Services Providers (MNOs) that operate. In many cases, if the property is capitalizing the cost of the coverage solution, there is a higher probability is very high that signal source will be provided by the MNO. However, to increase the probability of MNO participation, the selected coverage solution provider should be able to assist in contacting the appropriate local MNO resources to ascertain their ability and willingness to provide signal source to the coverage solution. This should be performed after the design phase and prior to the contracting

phase. Many times, MNOs reserve the right to thoroughly review the coverage solution design plan to ensure that their signal source is managed appropriately on the coverage solution and that it adheres to each MNO's operating standards. Naturally, it is advantageous to utilize a coverage solution vendor that has an excellent working relationship with all MNOs and has a proven record in gaining a high degree of MNO participation on past projects. Hoteliers should also take into consideration whether or not they want to take on the responsibility of obtaining MNO participation. This is typically not part of a hotelier's core skills, and many clients prefer to use an experienced, independent third party who already has a good working relationship with the MNOs.

4.6 Economics

While coverage solution economics are beyond the scope of this section of the guide, it is recommended that adequate time be devoted to ascertaining general pricing guidelines for capital planning purposes in support of a turnkey coverage solution installation. This information can be obtained through qualified turnkey coverage solution contractors whom possess expertise and past performance in venues similar to targeted property. They should be able to render price ranges on a per square foot basis for planning purposes.

It is important to note that each property is unique in nature and must be individually qualified in order to provide an accurate capital cost. If necessary, a formal site survey and design can be undertaken by a qualified contractor in order to render a more accurate and precise cost structure.

Additional factors that may affect costs include, but are not limited to:

- Post turn up operating costs including Equipment Failure Rate, Extended Warranty, Monitoring and Operations and Maintenance
- Property occupancy levels
- RF signal source designation
- Number of frequency signals requiring coverage
- Designated work hours
- Building geometry, construction material, furniture, fixtures
- Legal agreements
- Building age and ability to support structured wiring
- Specialized cabling requirements
- Campus with outdoor coverage requirement
- International standards/compliance (where applicable)
- Local building standards
- Union versus non-union labor
- MNO participation
- IDF/MDF space considerations
- System powering/backup power requirements
- Wireless applications supported
- Emerging wireless standards/frequencies

4.7 The Coverage Solution Process

Qualified coverage solution vendors will have developed and implemented time-tested and proven Methods of Procedure (MOPs) for the design, engineering, project management, installation, testing and certification, and ongoing maintenance of various forms of wireless/mobility solutions, including cellular coverage solutions. These MOPs ensure measurable, manageable, and repeatable steps necessary for a successful project. The following sections outline the various phases necessary for a successful, converged wireless implementation.

4.7.1 Phase 1 - Site Survey

A detailed site survey should be conducted and typically includes the following tasks:

- Evaluate building construction and proposed equipment location
- Evaluate equipment closet and riser
- Validate coverage objectives of client
- Set up test transmitter to collect signal-strength data
- Optimize propagation predictions
- Identify potential problem areas
- Generate guidelines for installation of cabling
- Pre-qualify subcontractor(s)
- Prepare subcontractor's scope of work
- Update cost estimates
- Update project scheduling
- Develop CAD drawings
- Complete site survey report

4.7.2 Phase 2 - System Design & Engineering

System design documentation should be prepared per customer specification and typically includes the following information:

- Description of design methodology and assumptions
- Carriers and Bands supported
- Description of the demarcation point
- RF plots
- Equipment locations
- Cabling runs
- Power-system design
- Alarm-monitoring design
- Proposed-to-build drawings

4.7.3 Phase 3 - Project Management

A detailed project plan should be generated for the management of all the associated tasks to ensure project objectives are met. The project plan typically incorporates the following details:

- Coordination building access, work-area access, security checks, and safety training with facility management
- Coordination of receiving and staging logistics with facility management
- Assessment of work area's adherence to safety standards
- Review and signoff of proposed-to-build-drawings
- Review and signoff of proposed project schedule
- Management of coverage solution equipment shipping logistics
- Management of third-party equipment shipping logistics
- Quality assessment of incoming coverage solution materials
- Management of wiring subcontractors
- Management of system commissioning
- Confirmation and implementation of selected sparing option
- Coordination of system acceptance and signoff

4.7.4 Phase 4 – Installation

The wireless system should be installed in accordance with proposed-to-build drawings, taking into account the following:

- Broadband coaxial cabling attached per manufacturer's specification and in accordance with all EMR (occupational health and safety) and EMC/EMI standards
- Broadband coaxial connectors installed per manufacturer's specification
- Single-mode fiber cabling attached per manufacturer's specification and in accordance with all EMR (occupational health and safety) and EMC/EMI standards
- SC/APC fiber connectors attached per manufacturer's specification
- All cabling labeled
- All cabling tested
- All racks installed in accordance with local standards
- All equipment rack- or wall-mounted in accordance with the installation guidelines
- All fire stops repaired in accordance with local regulations
- All antennas installed in accordance with manufacturer's specification
- Power connectivity (local or central)
- As-built cabling documentation
- Optional: power drops, core drilling, or conduit runs installed in accordance with local regulations

4.7.5 Phase 5 - Commissioning, Testing, and Verification

The wireless system should be tested to confirm that the design requirements are met. Typical design requirements include coverage, received signal strength (RSSI), maximum power level, and signal "roll-off" outside the building. The commissioning, testing, and verification typically consists of the following:

- Final configuration of integration module (i.e., attenuation) and measurement of incoming power level
- Measurement of EIRP at remote hub unit antenna port
- Antenna orientation, if applicable
- Comprehensive “walk test” to measure received signal strength at pre-determined locations, including perimeter window, building core/elevator, basement/garage, and street-level outside building
- Handoff into and out of in-building network
- Talk-in and talk-out testing, if applicable
- Closeout documentation, such as coverage maps, as-built drawings, and acceptance results
- Signoff/customer acceptance

4.7.6 Phase 6 - Ongoing Maintenance Support

A comprehensive maintenance plan should be designed and implemented based on the hotel’s specific needs. Considerations for the plan typically includes:

- Technical-assistance center/help-desk function
- Network Operations Center (NOC) monitoring function
- Dispatch and troubleshooting function
- Sparing program
- Extended Warranty program