WHITE PAPER

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Unleashing the Power of Digital Health: Exploring Modern Advances of Wireless Innovation, Integration, and Compliance

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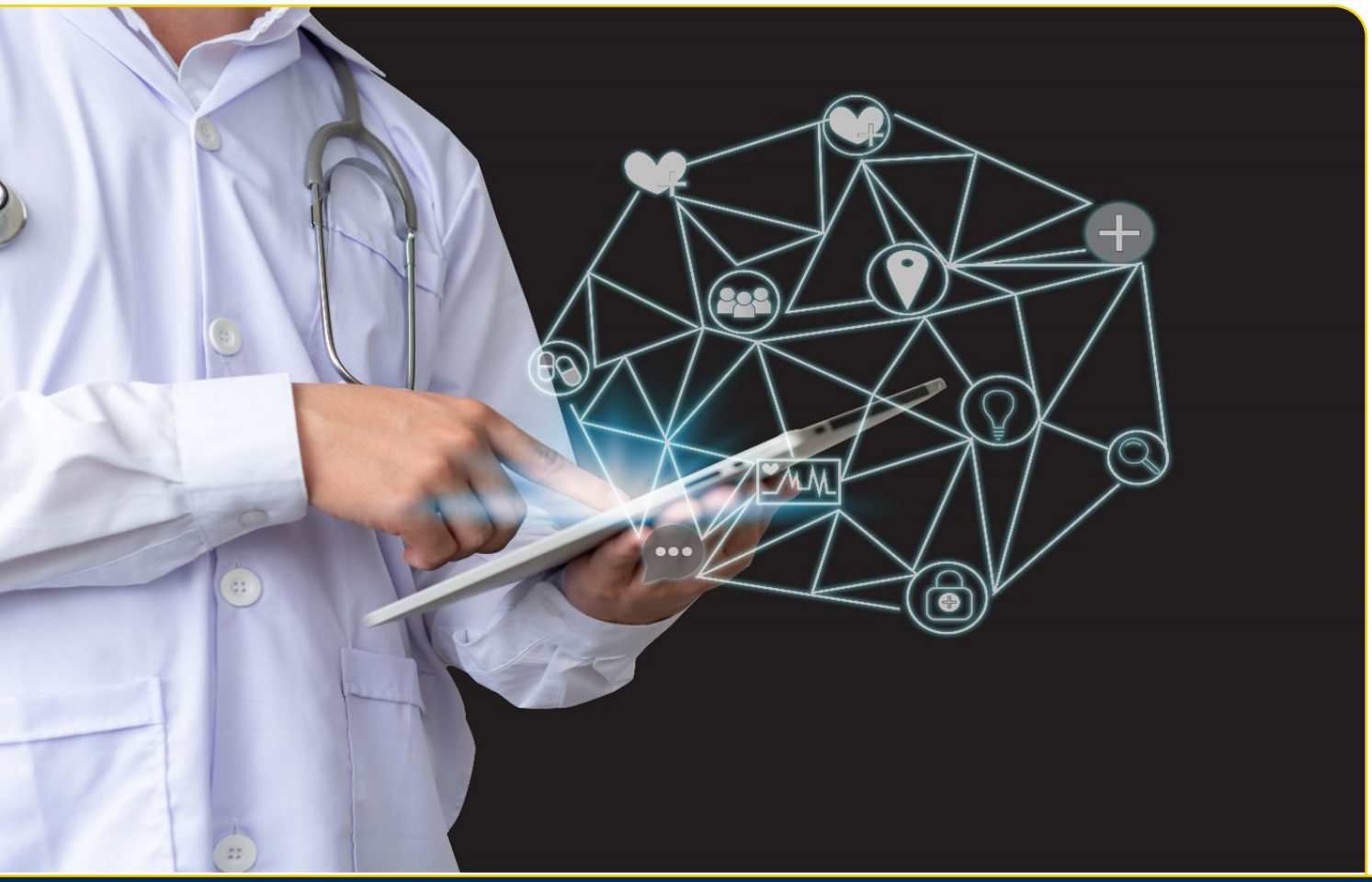

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In the rapidly advancing landscape of the digital era, healthcare remains a dynamic industry in constant evolution. Digital technology continues to play a significant role in enhancing the efficiency of medical processes and patient care. Technological advancements that have revolutionized patient care over the years include medical telemetry systems with the integration of the Internet of Medical Things (IoMT,) Real Time Location Systems (RTLS), advanced Electronic Health Record systems (EHRs), and more. As digital transformation continues in the medical market, healthcare institutions are adopting cutting-edge technologies to improve the quality of patient care and safety, optimize workflows, and improve operational efficiency. Among these technologies, artificial intelligence (AI) and machine learning (ML) are playing a transformative role in revolutionizing hospital processes and driving innovation across the medical industry. At the heart of these transformative technologies lie various wireless technologies, including Wi-Fi, serving as the backbone that enables seamless communication and empowering connected healthcare.

This article explores the cooperative relationship between these technologies, revealing the transformative impact they have on healthcare delivery. Additionally, it examines the critical nature of healthcare compliance in deploying the network edge devices that support these technologies, especially those situated in or on the ceiling. Moreover, it explores innovative modern ceiling deployment methods aimed at streamlining healthcare regulations.

The Evolution of Medical Telemetry in the Healthcare Market

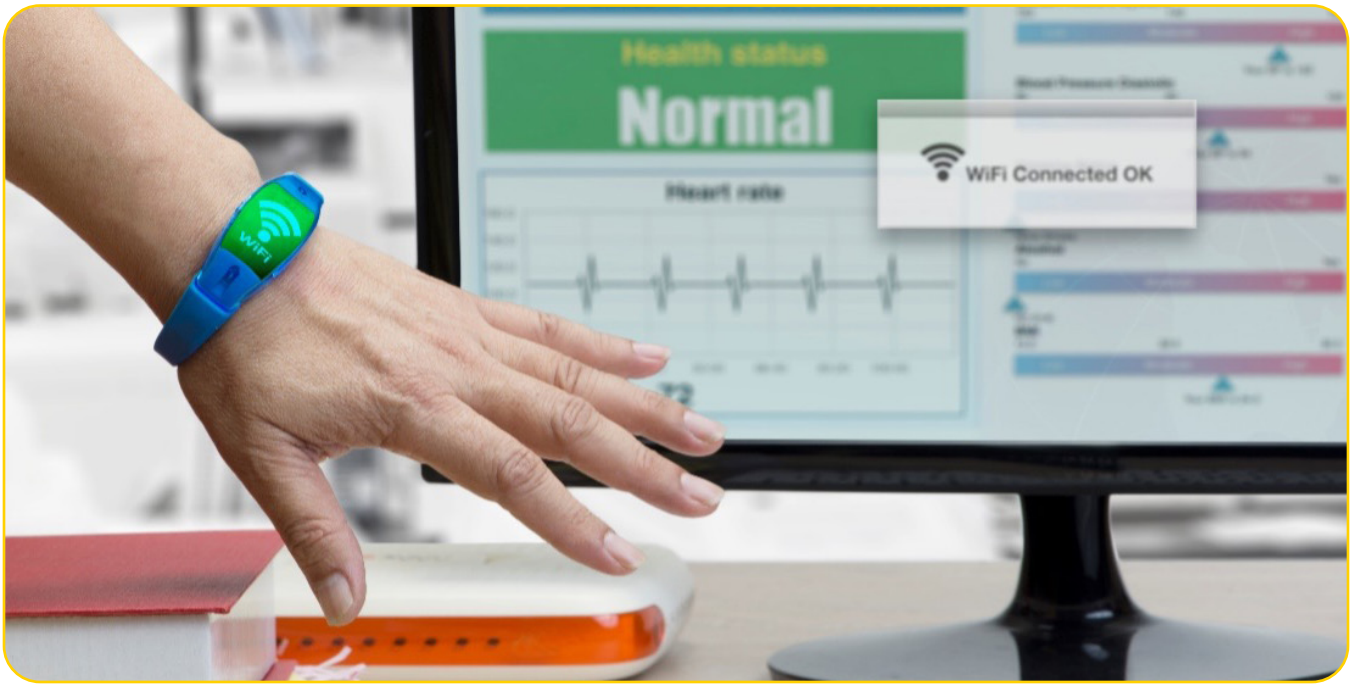
As early as the mid-century era, medical telemetry was prevalent in early cardiac telemetry systems. These systems primarily focused on monitoring patients' heart rhythms and transmitting data to centralized monitoring stations within hospitals. At this time patients were hooked up to bulky machines and wires. However, with rapid advancements in wireless communication and sensor device technology, medical telemetry has undergone significant evolution, expanding its capabilities beyond cardiac monitoring to encompass a wide range of observable and actionable parameters. Today, medical telemetry systems are capable of monitoring various vital signs, including heart rate, blood pressure, temperature, oxygen saturation, and respiratory rate, among others. Medical telemetry systems consist of several key components that work together to monitor and transmit patients' physiological data. These systems use a combination of wearable sensors, electronic health records (EHRs), wireless communication technologies, and advanced data analytics to provide comprehensive and real-time statistics of the status of patients' health.

Key Components and Technology Innovations of Medical Telemetry

Several innovations have elevated the use of medical telemetry making it more detailed, accurate, reliable, and remotely accessible than ever before. Some of the key components include:

- **Internet of Medical Things (IoMT):**
  The Internet of Medical Things revolutionized healthcare through the power of smart components and collective connectivity. IoMT is most commonly referred to as an interconnected network of medical devices and applications that collect, transmit, and analyze hospital related data in real time. These components can range from medical devices which are equipped with IoMT technology such as infusion pumps, medical monitors, wearable sensors and monitors, diagnostic equipment, smart medical appliances, to sensors which are embedded in medical devices that collect data such as vital signs, patient movement, blood glucose levels, and medication observation. Actuators may also be included to perform actions based on data received, such as adjusting medication dosages. IoMT devices provide connectivity through the use of various wireless communication technologies, on-premise networks, or cloud-based platforms.

- **Wireless wearable sensors and monitors:**
  Traditional wired sensors have been replaced by compact and lightweight wireless wearable devices, considered as part of the IoMT ecosystem. These components are comfortably worn by patients for short or extended periods of time. These sensors use advanced biometric technology to accurately measure and transmit vital medical data in real-time. Depending on the parameters being measured, these sensors may be in the form of adhesive patches, wristbands, chest straps, or other wearable medical devices. Monitoring type devices receive data from wearable sensors and process it before transmitting it to the central monitoring station or the clinical device. These devices include bedside monitors, wall or ceiling monitors, or handheld monitors equipped with telemetry software. To view and use this vital data, various types of wireless communication technologies are used to transmit the data to monitoring systems and/or electronic health record (EHR) systems. These integrated systems allow the healthcare staff to remotely monitor patients' health status in real time without the need for constant bedside observation. For the clinical staff, wireless wearable sensors and systems streamline clinical workflows and enable more efficient patient monitoring and continued care.



- **Wireless Communication Technologies:**
  The integration of wireless communication protocols has empowered the transmission of vital data from wearable sensors and other medical devices to central monitoring stations and clinicians' mobile devices. Wireless communication technologies include Bluetooth Low Energy (BLE,) Wi-Fi, Zigbee, cellular, RFID (Radio-Frequency Identification), UWB (Ultra Wide Band,) NFC (Near Field Communication), and other specialized medical telemetry protocols. These may also incorporate the utilization of dedicated services like Wireless Medical Telemetry Service (WMTS). WMTS is an exclusive wireless communication service dedicated to healthcare facilities. It enables the wireless transmission of medical data between monitoring systems and medical devices operating within dedicated radio frequency bands allocated for medical telemetry. WMTS helps to ensure reliable and interference-free transmission of vital patient data. Additionally, wireless technologies allow for remote monitoring of patients that extend beyond the walls of the hospital such as a patients' home or another facility. Wireless communication technologies play a critical role in enabling communication between many medical devices and platforms.

- **Central Monitoring Station:**
  The central monitoring station is where patient data is received, processed, and displayed for the healthcare staff to monitor. It typically includes viewing real-time data, setting alarms for abnormal readings, and historical data analysis.

- **Remote Monitoring Platforms:**
  The development of cloud-based remote monitoring platforms has enabled centralized management and analysis of patient data collected through medical telemetry systems. These platforms offer healthcare providers remote access to comprehensive patient dashboards, real-time alerts, and advanced analytics tools, enabling proactive intervention and personalized care delivery.

- **Artificial Intelligence and Machine Learning (AI/ML):**
  Medical telemetry systems have long been instrumental in monitoring and transmitting vital patient data wirelessly. However, the traditional or legacy telemetry approach often faces challenges in managing the massive amounts of data produced, detecting subtle patterns in health conditions, and making timely clinical decisions. This is where AI and ML enter the picture, offering sophisticated algorithms and computer-generated intelligence to analyze data, identify trends, and generate actionable recommendations in real-time. One of the key advantages of incorporating AI and ML capabilities into medical processes is the capability of improving predictive analytics. By comparing patient history records and continuously learning from new information, ML algorithms can quickly analyze complex information from multiple sources such as imaging studies, laboratory results, among others to identify specific patterns of diseases or conditions. This approach can lead to faster and more specific diagnoses, early detection, and better patient management strategies. AI algorithms can also help hospitals streamline operations, as well as allocate resources more effectively and reduce patient wait times by analyzing data on the flow of patients, bed occupancy, staffing levels, and equipment location and usage. This not only improves the patient's experience but also enhances operational efficiency and reduces healthcare costs. Another AI and ML use case that is making its way into the physician office is AI-powered transcription with ambient listening. With permission from the patient, AI will listen to the patient-physician conversation and then organize the notes into the electronic health record. This innovative approach streamlines documentation processes by automatically transcribing and organizing the information captured into the medical health record during the patient consultation and evaluation. This helps to eliminate the requirement of the physician to type the conversation into the system while talking with the patient. By leveraging advanced natural language processing algorithms, AI captures relevant details and flags critical information. Additionally, integrating AI-powered transcription into electronic health records improves accessibility and interoperability, allowing healthcare providers rapid access to comprehensive patient information. Overall, this use-case improves the efficiency and speed of documenting patient-physician conversations.

  There are numerous other applications and use-cases of AI/ML in the healthcare sector which will continue to evolve. The integration of AI and ML into medical systems also raises important considerations related to data privacy, security, and regulatory compliance. Healthcare organizations must ensure that patient data is handled securely, protected against unauthorized access, and compliant with data protection regulations such as the Health Insurance Portability and Accountability Act (HIPAA) in the United States.

  Other medical telemetry components include database storage, alarm systems, security and more.

The Rise of Electronic Health Records (EHR) Systems

Another constantly evolving healthcare innovation is Electronic Health Records (EHRs) systems. EHR systems are equipping healthcare providers with a unified and interconnected ecosystem of software, devices and technology that deliver effective and superior patient records. EHR systems are reshaping how patient data is collected, stored, and accessed.

Telemetry data and real time location systems (RTLS) can now be integrated into EHR systems. By combining real-time physiological data from medical telemetry ecosystems and location services with patient records from EHR systems, healthcare providers gain a complete view of each patient's health status and history, allowing for more informed clinical assessments and treatment decisions. The adoption of EHR systems brings numerous benefits for patients, healthcare providers, and healthcare organizations alike. EHR systems offer patients improved access to their health information, empowering them to actively participate in their care decisions, track their health status, and communicate effectively with their healthcare providers. EHR systems also enable healthcare providers to deliver more coordinated and personalized care by providing a comprehensive view of the patient's medical history and enabling collaboration between interdisciplinary care teams.

From a healthcare provider perspective, EHR systems streamline clinical workflows, reduce administrative burden, and enhance patient safety by eliminating the need for manual documentation and reducing the risk of medication errors or duplicate tests.

EHR systems support evidence-based practice by providing real-time access to clinical guidelines, decision support tools, and health data, enabling the medical staff to deliver more effective and efficient care. Medical telemetry devices send data to EHR system through a combination of wireless communication technologies such as Bluetooth Low Energy (BLE,) Wi-Fi, cellular networks (3G/4G/5G), Zigbee, and proprietary telemetry protocols.

Some common devices that interact with EHR systems include:

- **Medical Monitoring Devices:** A wide range of medical monitoring devices such as cardiac monitors, pulse oximeters, blood pressure monitors, and glucose meters can transmit real-time patient data directly to EHRs. This allows healthcare providers to track patients' vital signs and health metrics without manual data entry. Technologies used to communicate include a variety of options such as legacy wired connections in which the medical device would come equipped with built-in Ethernet port or USB connection that allow them to be directly connected to the hospital network. Another more advanced method is wireless connectivity. For example, many modern infusion pumps and ventilators come equipped with Wi-Fi, BLE or other wireless capabilities. By connecting to the hospital's converged wireless network, these devices can communicate with the EHR system without the need for physical cables, providing greater flexibility and mobility for healthcare providers. Wireless communication enables real-time transmission of patient data, alerts, and alarms directly to the EHR system from anywhere within the facility.

- **Barcode Scanners:** Barcode scanners are used to scan barcoded patient wristbands, medication labels, and other healthcare patient items, enabling healthcare providers to accurately capture and record data in the EHR. Scanning barcodes helps prevent medication errors, ensures proper patient identification, and enhances medication management processes.

- **Diagnostic Equipment:** Imaging devices like X-ray machines, CT scanners, MRI scanners, and ultrasound machines can capture diagnostic images and reports, which can then be uploaded to EHRs for reference by healthcare providers.

- **Smartphones and Tablets:** Hospital clinicians often use smartphones and tablets equipped with specialized applications to access EHRs at the point of care. These mobile devices allow clinicians to view patient records, enter clinical notes, place orders, and review test results in real-time, enhancing productivity and enabling more efficient care delivery.

- **Wearable Devices**: Wearable health monitoring devices, such as smartwatches and fitness trackers, are increasingly being integrated with EHRs to capture and transmit patient-generated health data (PGHD). These devices can monitor various biometric parameters, such as heart rate, activity level, and sleep patterns, providing valuable insights into patients' health status and enabling proactive interventions by healthcare providers.

- **Telemedicine Platforms:** Telemedicine platforms and video conferencing systems enable remote virtual consultations between doctors and patients. These platforms can integrate with EHRs, enabling speedy and accurate documentation of virtual patient conversations and sharing of clinical information between a collaboration of providers.

Real-Time Location Systems (RTLS)

A Real-Time Location System (RTLS) is a technology that tracks and monitors the location of objects, people, or assets within a specified area, using various tracking technologies to locate the exact location of tagged items or individuals. The collected location data is then processed and displayed on a central system, allowing users to monitor and manage the movement and whereabouts of the tracked objects or personnel in real-time. A range of different types of RTLS systems span across a variety of industries including healthcare, manufacturing, logistics, retail, and security, where accurate and timely location information is crucial for operational efficiency, safety, and security.

In healthcare settings, RTLS systems are not typically considered part of the hospital's medical telemetry system. However, advancements in IoT and integration capabilities are leading to increased convergence between these systems. Medical telemetry systems primarily focus on monitoring and transmitting physiological data from patients, such as vital signs for analysis and decision making. These systems regularly involve wearable sensors, monitors, and data transmission devices. On the other hand, real-time location systems (RTLS) are designed to track the location of medical equipment, supplies, patients, and personnel to improve operational efficiency, asset management, and patient flow. RTLS systems share common wireless communication and sensor protocols as medical telemetry such as RFID-based RTLS, Wi-Fi-based RTLS, Bluetooth-based RTLS Ultrasound-based RTLS, Infrared-based RTLS, GPS-based RTLS, Hybrid RTLS and rapidly growing ML-based RTLS. A few ways in which RTLS can relate to and complement medical telemetry:

- **Asset Tracking:** RTLS systems can be used to track the location of medical equipment, such as infusion pumps, wheel chairs,ventilators, and mobile monitoring devices, within a hospital or clinic. By integrating RTLS with medical telemetry systems, healthcare providers
can easily locate essential equipment needed for patient care, reducing search time and optimizing resource utilization.

- **Patient Tracking:** In most all hospital and care facilities, RTLS can be implemented to track the location of patients, particularly those at risk of wandering or those in need of constant supervision, such as dementia patients or infants in neonatal intensive care units (NICUs). Integrating RTLS with medical telemetry allows healthcare providers to monitor patients' movements in real-time while simultaneously tracking their vital signs, enhancing patient safety and security.

- **Workflow Optimization:** RTLS enables hospitals to stay abreast of the movement patterns of staff members, patients, and equipment within their facilities. This data can help healthcare administrators identify bottlenecks, streamline workflows, and optimize resource allocation to improve operational efficiency and patient throughput.

Key Components of an RTLS System

An RTLS system consists of several key components that work together to enable location tracking and management. These components typically include:

- **Tags/Beacons/Transmitters:** These are small devices attached to or embedded within objects, assets, or individuals to track their location. Tags can use various technologies such as RFID, Wi-Fi, Bluetooth, or GPS to transmit signals.

- **Receivers/Nodes/Access Points:** These are devices installed throughout the designated area to receive signals from tags and determine their location. Receivers may also perform signal processing and transmit data to a central server. Receiver/nodes capture the signals emitted by the tags/beacons and transmit them to the central server for processing. The nodes are typically mounted on the ceiling tile grid or walls.

- **Network Infrastructure:** The network infrastructure is another critical component of RTLS technology. The receiver nodes communicate with the central server over an Ethernet or Wi-Fi connection. The network must be designed and installed with redundancy and fault tolerance in mind to maximize uptime and reliability. This includes the network of antennas, Wi-Fi access points, and other hardware required to support the transmission and reception of signals within the RTLS environment.

- **Software/Application:** The software or application functions as the interface for managing and monitoring the RTLS system. It runs on a dedicated server or cloud-based service that can handle the volume of data generated by the tags and receivers and allows users to view real-time location data, set up zones, and generate reports. The software also provides a dashboard that displays the location and status of all assets in real time. The dashboard can be accessed from any internet-enabled device such as a laptop, tablet, or phone.

Other components include central server/cloud platform, user interface, PoE power or batteries, location engine and more.

Modernizing and Simplifying Infection Control for the Physical Deployment of RTLS Ceiling Mounted Devices

The ongoing development and integration of healthcare technologies are set to enhance the capabilities of medical systems. Advancements in technology and the requirement for a dense amount of network component installations will require robust and widespread network performance. Network professionals face the challenge of optimizing network performance while ensuring compliance with healthcare facility codes and processes, especially during installation or upgrades of ceiling mounted network components. Following is a list of hospital wireless related polices and procedures to take into consideration during the planning stages of ceiling mounted RTLS node installations:

Standards, Codes, Recommendations and Best Practices

BICSI Guide to Medical Grade Wireless Utility (MGWU) BICSI International

Supplemental Information
"The implementation of a wireless infrastructure should not require costly and disruptive above ceiling change management." "They should be installed in a cabinet flush with or below the ceiling, or wall mounted."

ANSI/TIA-1179-A Healthcare Facility Telecommunications Infrastructure Standard
"It is recommended that the wireless environment be characterized prior to design and installation of cabling."
"Policies and procedures to mitigate Airborne Infectious Disease."

HIPAA—§ 164.310 Physical Safeguards.
A covered entity must, in accordance with § 164.306: (a)(1) Standard Facility access controls. Implement policies and procedures to limit physical access to its electronic information systems and the facility or facilities in which they are housed, while ensuring that properly authorized access is allowed.

ICRA 2.0
ICRA procedures are called for by the Facilities Guidelines Institute (FGI), wherein the procedures are implemented throughout project planning, design, and construction. A set of the ICRA procedures are intended to protect patients from airborne infectious diseases that can spread from above ceiling spaces when work is being performed in these areas (i.e. ceiling tiles being lifted). ICRA procedures are to be used for new product installation, routine maintenance procedures, renovation, and construction projects.

NEC Code
Hospitals strictly adhere to the National Electric Code. Ceiling mounted enclosures or cabinets should be UL listed for in-ceiling installation and should be clearly labeled as "UL Listed." Additionally, enclosures or cabinets with metal back boxes should come with Fire-Rated grommets for cable egress.

ANSI/BICSI 008-2024 Wireless Local Area Network (WLAN) Systems Design and Implementation Best Practices.

Chapter 7 - Wireless System Design and Implementation

7.6 Access Points and Enclosures

7.6.1 Design Considerations

- The wireless access point infrastructure physical design should consider consistency, compatibility, and ease of operational support while lowering overall cost.
- Wireless access point infrastructure design costs should consider both initial installation costs as well as operational costs." Ease of operational support and consistency.
- Wireless antennas and access points be placed within enclosures or surface mounted that provide physical security. APs and related enclosures should be selected and installed so they are accessible for servicing and troubleshooting.
- Mounting methods should minimize the time required to maintain and change access points. Possible methods include, but are not limited to, ceiling enclosures and wall brackets that offer rapid serviceability and migration to new access points using interchangeable doors and trims on the housing.

ANSI/BICSI 004 - Information Communication Technology Systems Design and Implementation Best Practices for Healthcare Institutions and Facilities

- "Offering design and implementation of IT systems used within healthcare facilities."
- "This standard is intended primarily for healthcare facilities such as hospitals, skilled nursing homes, re-habilitation, psychiatric facilities, ambulatory clinics, surgical centers, outpatient clinics."
- "Discrete antenna systems are unlicensed radio deployments such as WLAN (IEEE 802.11) and smaller personal area networks (IEEE 802.15)."
- "Placement of equipment - Specifies that wireless antennas and access points be placed within enclosures or surface mounted in locations that provide access without disturbing the environment."

Key Challenges of Deploying Wireless Devices on the Ceiling in Healthcare Environments

Infection Control Risk Assessment (ICRA) procedures are necessary and vital for the protection of patients during construction or MAC work. In some cases, ICRA procedures will require construction of negative air pressure barriers or tents around the work area, adding significantly to cost. However, it is necessary to pull a network cable from the ceiling to the device which is positioned below the ceiling tile on the ceiling's grid structure. This process may lead to permanent holes and gaps in the ceiling which are not permitted in many spaces throughout the hospital, particularly and including patient areas. ICRA 2.0 revision from American Society for Health Care Engineering of the American Hospital Association (ASHE,) has equipped healthcare professionals with a more advanced Matrix of Precaution which essentially extends the requirement to more spaces in the medical facility potentially requiring the implementation of ICRA processes. Better installation methods can simplify these procedures and help reduce cost while also protecting the safety of patients.

The installation method should aim to eliminate the need for a hole in the ceiling for cable egress. By code, holes are not permitted in the ceiling throughout most of the hospital, particularly and including patient areas. By avoiding the necessity of creating an opening in the ceiling, avoids the extra cost and time to seal the hole. Additionally, a modern approach to installing wireless devices on the ceiling simplifies the installation process. Additionally, eliminating the need for a ceiling hole enhances the aesthetics of the environment, maintaining a clean and unobtrusive installation. Overall, by streamlining cable egress without compromising functionality, an enhanced installation method offers a more efficient and visually pleasing solution for deploying wireless devices on ceiling grid structures.

The installation method must adhere rigorously to stringent healthcare facility codes and standards for ceiling-mounted equipment. Compliance with these regulations ensures the safety, reliability, and functionality of the installed equipment within the healthcare environment. Additionally, adherence to codes and standards is essential for maintaining accreditation, upholding patient safety, and mitigating liability risks for the healthcare facility. By following these guidelines carefully, the installation method should guarantee that ceiling-mounted equipment meets the highest quality and safety standards, providing peace of mind to healthcare professionals and patients alike.

The installation approach should offer a designated secure storage area above the ceiling for surplus cable service loops and connectivity components for each wireless device. Installation should provide full access to wireless network devices and cabling components for maintenance or upgrades after initial installation. The goal is to have access to these components without lifting the ceiling tile which would eliminate the need for infection control procedures.

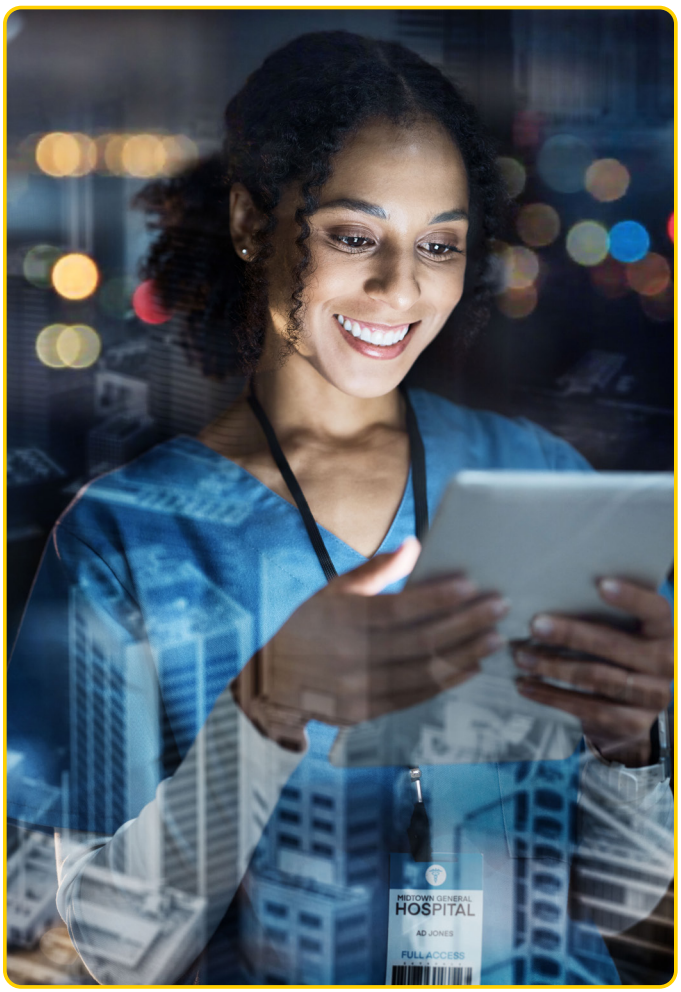
Additionally, physical security is critical during installation to eliminate tampering of the wireless device and associated cabling. A polished, professional finish for the installation should be considered to meet aesthetic standards while also delivering superior wireless performance.

Oberon delivers leading-edge ceiling mounting solutions. Industry preferred; customer approved.

Oberon Healthcare-Ready RTLS Infrastructure Solutions

In the dynamic landscape of healthcare, efficient and accurate tracking of assets, patients, and personnel within healthcare facilities is paramount. Therefore, the successful implementation of RTLS systems relies heavily on the effective installation of the edge devices such as the RTLS nodes, receivers, and access points. This is where Oberon can help, revolutionizing RTLS device deployment that optimizes performance, security and critical post-installation support.

Oberon brings a wealth of expertise and experience to the table, specializing in the design, deployment, and maintenance of wireless infrastructure solutions tailored to the unique needs of healthcare environments. With a deep understanding of healthcare environments, compliance and best practices, Oberon offers wireless installation mounting solutions designed specifically for integration of edge components into healthcare environments, facilitating compliance with healthcare regulations and procedures.



Oberon™ Wi-Tile™ Ceiling Enclosures 1047 Series: A Modern Approach to Ceiling Mounting Equipment

Model 1047-DOME:

- The 1047-DOME enclosure is a 2′ x 2′ ceiling tile enclosure offering an ABS Hemisphere Dome Door
- This sophisticated modern design enables the installation of wireless devices, including RTLS nodes, receivers, and access points, which require antennas to be positioned beneath the ceiling while also ensuring physical protection
- The ABS plastic dome has little to no effect on the wireless signal
- Solid back-box fills opening behind AP in the ceiling creating an effective fire-resistant, smoke and dust barrier simplifying ICRA compliance.
- Firestop grommet to properly seal cable egress in the backbox
- UL listed for low voltage applications. Designed to meet NEC300-22 and 300-23 for plenum installations. OSHPD approved, OPM-0110-13
- Constructed to be compliant with City of Chicago Environmental Air (CCEA) plenum requirements

Features:

- Mounts device flush to the ceiling, with a DOME for optimal wireless coverage
- Attractive, textured, powder-coat finish blends seamlessly with most 2′ x 2′ ceiling structures
- Larger back-box designed for securing most vendors' network edge devices
- Lockable drop-down doors permit easy access to equipment and cabling WITHOUT the need to open the above ceiling space.
- The lockable doors are interchangeable simplifying migration to next-generation devices
- Enclosure back-box is an effective dust barrier to simplify ICRA procedure compliance

Looking for more Oberon Healthcare-Ready solutions? Visit us at oberonwireless.com for more information and essential planning for your healthcare solutions!

Need a customized solution? Contact us at sales@oberonwireless.com or 877-867-2312

About Us

Oberon has been at the forefront of pioneering innovative wireless mounting solutions since 1999. We collaborate with top technology innovators to meet the pressing demands of modern business today. From Wi-Fi and 5G cellular to DAS antennas and medical wireless nodes/access points, Oberon delivers mounting solutions that streamline technology transitions, enhance physical security, meet codes and regulations, enable seamless authorized access for maintenance, and optimize performance/aesthetic standards.

Visit oberonwireless.com to learn more about how Oberon can help you optimize your next-generation wireless deployments.

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