WHITE PAPER

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Deploying Wireless Solutions in Today's Advanced Healthcare Environments

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Over the past two decades, wireless technology has emerged as an essential means to provide internet connectivity and transmit voice, data, and video to and from people and devices. According to Statista, the number of wireless LAN (WLAN)-connected devices is estimated at more than 22 billion globally.[1] The evolution of wireless is having a profound impact on the healthcare industry, driving significant efficiencies and going a long way toward improving patient care and reducing cost. It's no wonder that the global wireless health market alone is projected to grow at an annual rate of 16.2% over the next five years and reach $355.78 billion by 2028, according to Verified Market Research.[2]

To reap the benefits of the increasing breadth and diversity of wireless healthcare technologies and deliver the coverage and capacity to support more users and devices, today's hospitals and healthcare facilities need to deploy wireless access points (APs) in more locations. They also need to ensure higher reliability due to the often critical nature of the applications. At the same time, these environments must comply with stringent data security regulations and ensure infection control measures during wireless network deployment and maintenance. Designers, integrators, and installers servicing healthcare environments therefore need to ensure that APs and their underlying infrastructure don't just provide the required coverage and capacity—they also need to ensure that they protect patient data and health.

Ever-Increasing Use Cases and Technology

Wireless technology has been used in healthcare for the past two decades, initially used primarily for clinicians to digitally record and access patient information via handheld tablets. Now advancements in Wi-Fi technology and the emergence of the Internet of Things (IoT), combined with the need to cut costs and improve productivity, are giving rise to a broad range of wireless applications in the healthcare environment that include the following:

- **Patient Monitoring**
  Wireless telemetry systems provide clinicians with real-time access to patient vital signs and alert significant changes in a patient's condition to prevent complications in intensive care and pre- and post-operation settings. These systems increasingly rely on wireless bedside, wearable, and implantable sensors that wirelessly transmit critical information and integrate with other systems (e.g., nurse call) via portable tablets and smartphones. These systems are especially beneficial for monitoring patients in transport, and they can even continue to remotely monitor certain aspects of a patient's health from their own home to enable shorter-length hospital stays and reduce admissions.
- **Medical Device Connectivity**
  Today's medical equipment such as electrocardiograms, X-ray machines, ultrasounds, and radiology equipment connect to Wi-Fi networks to quickly transfer information to patient health information systems. Wireless connectivity is especially beneficial for mobile medical equipment that moves around the hospital to wherever it is needed.
- **Location and Tracking**
  Wi-Fi location services allow hospitals and healthcare facilities to identify and know where patients, staff, medical equipment, and other assets are located at any time. This helps to streamline operations in complex healthcare environments by reducing wait times and error rates, increasing response time, improving workflow, and enhancing patient and staff safety.

- **Inventory Management**
  Wireless IoT sensors on shelves and inside refrigerated cabinets enable tracking and management of medications and other medical supplies, preventing stockouts, reducing theft, and enabling automatic reordering for streamlined supply chain logistics.
- **Internet Access and Entertainment**
  Wi-Fi networks provide patients, visitors, contractors, and other guests with internet access and the ability to communicate with friends, family, and colleagues. Wi-Fi networks also support patient engagement platforms for everything from on-demand content and video games to meal ordering and health information—all of which improves patient care and satisfaction.
- **Facility Operations**
  Wireless technology is rapidly moving into the facilities management realm with smart building automation that features wirelessly-connected platforms and sensors, enabling advanced analytics and controls for HVAC, lighting, and security systems. These systems help hospitals and healthcare facilities increase energy efficiency, streamline maintenance, and improve air quality and safety to reduce operation costs and enhance occupant health and well-being.

With so many healthcare applications relying on wireless connectivity, and more being introduced every day, today's hospitals and healthcare facilities need to deploy APs in more locations to ensure ample coverage and capacity. Thankfully, Wi-Fi technology has advanced significantly over the past two decades based on the IEEE 802.11 set of wireless application standards that specify communication protocols, speeds, transmission ranges, and operating frequency, as shown in Figure 1.

The latest Wi-Fi 6 and Wi-Fi 6E protocols support higher throughput, greater capacity, improved performance in dense environments, and better support for IoT applications via longer reach and battery life performance—all of which allows hospitals and healthcare facilities to support an increasing range of wireless applications. For more information on Wi-Fi 6 and Wi-Fi 6E, refer to the white paper "Optimizing Next-Generation Wireless Deployments for the Digital World."

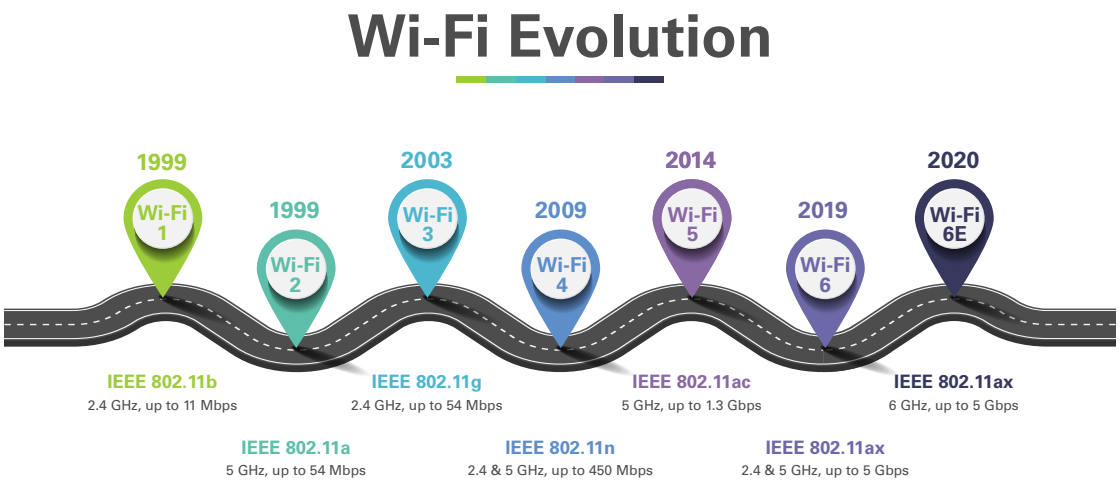


Figure 1: The Evolution of Wi-Fi generations and IEEE 802.11 Standards

While Wi-Fi is the primary wireless protocol to support wireless applications in healthcare environments, it is not the only wireless technology available. Other proprietary and non-proprietary wireless protocols operate within various licensed and unlicensed frequency bands to support application-specific deployments, cellular communications, or a variety of short- and long-range low-power wireless protocols. For example, The Federal Communications Commission (FCC) has allocated specific frequency bands for wireless medical telemetry service (WMTS) and requires that all WMTS transmitters be registered with a frequency coordinator, currently the American Society of Health Care Engineering (ASHE). Some wireless protocols can coexist within a single AP. It's not unusual for an AP to support 802.11 Wi-Fi in conjunction with other wireless technologies, enabling the AP to also function as a gateway for collecting and transmitting data from local sensors or other devices within the healthcare environment.

A Highly Regulated Environment

Healthcare is a highly regulated industry that requires adherence to an extensive range of standards and regulations that aim to protect patients, provide safe working environments, and ensure public health and welfare. Highly regulated and complex healthcare environments pose several challenges when it comes to deploying advanced wireless technologies—from complying with Infection Control Risk Assessment (ICRA) procedures and healthcare-specific design and installation standards, to ensuring FDA-approved wireless devices and compliance with HIPAA data security and privacy regulations.

Designers, integrators and installers working in the healthcare space need to understand the following specific regulatory and standard-based requirements that relate to wireless network implementation and the installation and cabling of APs.

Infection Control Risk Assessment (ICRA) procedures

Hospitals and healthcare facilities are required to protect patients. Dust, mold, and fungal spores found in the space above a suspended ceiling, or within walls, are contributors to airborne infectious disease that is a threat to patients, especially surgical and immuno-compromised patients. Healthcare environments therefore require ICRA procedures per the Facility Guidelines Institute's (FGI) Guidelines for Design and Construction of Hospital and Healthcare Facilities, which covers infection prevention requirements during construction, renovation, and maintenance. In 2022, the American Society for Health Care Engineering (ASHE) published an updated reference toolkit and process guide for ICRA assessments, ASHE ICRA 2.0, which improves clarity and provides more precise recommendations compared to previous versions via expanded descriptions, categorization of spaces, and classes of precautions. The following ICRA 2.0 step-by-step process assesses the impact of construction activities on surrounding areas:

- **Step 1: Identify the Construction Project Activity Type**
  The type of construction is identified as either Type A inspection and non-invasive activities; Type B small-scale, short duration activities that create minimal dust and debris; Type C large-scale, longer duration activities that create a moderate amount of dust and debris; or Type D major demolition and construction activities.

- **Step 2: Identify Patient Risk Group**
  The level of patient risk is identified as Low Risk, Medium Risk, High Risk, and Highest Risk based on the type of location and its procedures. For example, Low Risk includes spaces such as public hallways, office areas, breakrooms, and bathrooms not located within clinical units. Medium Risk includes areas such as waiting areas, cafeterias, and gift shops. All patient care areas fall under High Risk, including patient rooms, acute care units, emergency departments, pharmacies, and diagnostic suites. The Highest Risk level includes any invasive patient care activity, such as intensive care units (ICUs), operating rooms, transplants and transfusion services, invasive imaging, and all oncology units.
- **Step 3: Identify Class of Precautions**
  In this step, the Class of Precaution is identified as Class I, Class II, Class III, Class IV, or Class V by mapping the Construction Project Activity Type in Step 1 and Patient Risk Group in Step 2, as shown in the Table 1 below. Note that infection control permit and approval is required for all Class IV and Class V Precautions, as well as for any Type C project activity that falls under Class III Precaution. In addition, environmental conditions that could affect human health, such as sewage, mold, asbestos, gray water, and black water, require Class IV Precaution for Low and Medium Risk Groups and Class V Precaution for High and Highest Risk Groups. All construction and renovation activities fall under Class III, IV, or V.

Patient Risk Group	Construction Project Activity Type			
	Type A	Type B	Type C	Type D
Low	I	II	II	III
Medium	I	II	III	IV
High	I	III	IV	V
Highest	III	IV	V	V

Table 1: Class of Precautions based on Patient Risk Group and Construction Project Activity Type

- **Step 4: Assess Potential Risk to Areas**
  New in ICRA 2.0 is a table for identifying the surrounding areas that could be affected by a project. It includes checklists for impacts such as noise, vibration, dust control, ventilation, pressurization, vertical shafts, and elevators/stairs, as well as impacts to systems such as data, mechanical, and medical gases for all adjacent areas. The table also includes a checklist of mitigation strategies for these impacts. If more than one risk group will be affected in an adjacent area, the highest Patient Risk Group must be used. This can greatly increase the number of projects that are identified as Class III, IV, and V Precaution.

For each Class of Precautions, ICRA 2.0 includes minimum required infection control precautions for before and during project activity, as well as precautions upon completion of activity. These precautions have a significant impact on work that takes place in the space above the ceiling (i.e., plenum space), such as pulling cable and AP installation, moves, adds, and changes. For example, there are restrictions on removing ceiling tiles and penetrating fire- and smoke-rated ceilings. For any construction or renovation projects that require Class III, Class IV, or Class V Precaution, the workspace must also be negatively pressurized, and the exhaust must be high-efficiency particulate air (HEPA) filtered or conducted away to prevent spreading dust and spores throughout the facility. These precautions even cover such details as sealing doors and all penetrations, containing all trash and debris in the work area, and requirements for worker clothing. For detailed information on ICRA 2.0 and required infection control precautions, visit https://www.ashe.org/icra2.

Industry Cabling Standards and Best Practices

In addition to ICRA requirements, there are industry cabling standards specific to healthcare. Developed by the Telecommunications Industry Association (TIA), ANSI/TIA-1179-A is the latest telecommunications infrastructure standard for healthcare, which includes recommendations for cabling wireless APs.[4] Much of this standard refers to, and synchronizes with, the latest ANSI/TIA-568 standards for commercial building telecommunications and references additional standards such as ANSI/TIA 862 for intelligent building systems and ANSI/TIA 5017 for security.

For example, in alignment with TIA-568 standards, TIA-1179 recommends installing a minimum of two Category 6A connections to each Wi-Fi 6/6E AP to effectively achieve redundancy and support high throughput. It also recommends a minimum of a 25 Gbps uplink capacity within the fiber backbone infrastructure to support the increased amount of traffic and higher speeds that come with Wi-Fi 6/6E and more connected devices. It's important to consider that while Wi-Fi APs are often refreshed every 3 to 5 years, the underlying cabling infrastructure should have a typical lifecycle of 10 to 15 years. Replacement of the cabling infrastructure is far more disruptive than refreshing an AP and can impact multiple areas of a hospital or healthcare facility since cables traverse multiple locations. From an ICRA perspective, this has the potential to impact multiple Patient Risk Groups and increase the number of Class III, IV, and V Precaution projects. It is therefore vital to follow the latest industry cabling standards in addition to ICRA requirements.

Wireless designers, integrators, and installers working in the healthcare environment should also follow industry best practices per ANSI/BICSI 004, ICT Systems Design and Implementation Best Practices for Healthcare Institutions and facilities.[5] BICSI 004 refers to ICRA guidelines and the need to control environmental contaminants and pollutants and specifically states that "wireless antennas and access points should be placed within enclosures or surface mounted in locations that provide access without disturbing the surrounding environment." The standard also includes an informative ICRA Appendix A that covers various materials required to fulfill ICRA requirements, such as protective clothing, HEPA vacuums and filters, dust catching devices, and construction barriers, as well as recommendations surrounding infection control training, work scheduling, access to occupied areas, and proper material storage.

For wireless systems in a healthcare facility, BICSI 004 classifies three grades, including Medical Grade for clinical devices and applications that collect and share life-critical medical information, Enterprise Grade for devices and applications that are intended to "inform and direct" and are therefore considered mission critical but not life critical, and Consumer Grade for devices and applications that are not medical related, such as Wi-Fi intended for general use by the public. For each grade, BICSI 004 recommends minimum levels of coverage, signal quality, capacity, security, and certainty (i.e., performance), as shown in Table 2.

	Coverage	Signal	Capacity	Security	Certainty
Medical	100%	100%	100%	Maximum	100%
Enterprise	95%	95%	95%	High	95%
Consumer	90%	90%	Best Effort	Limited	90%

Table 2: BICSI 004 recommended assurance and performance levels for wireless systems within healthcare facilities.

Another best practice to follow for wireless deployments in healthcare is ANSI/BICSI 008, WLAN Systems Design and Implementation Best Practices.[6] This standard provides specific wireless design considerations for diverse types of environments, including healthcare facilities. This document is useful in that it covers non-clinical areas that may need to be considered for hospitals and healthcare facilities, such as parking areas and garages. BICSI 008 also mirrors TIA cabling standards in that it recommends a minimum of two Category 6A cables be installed to support each wireless AP.

Information Privacy Regulations

In addition to protecting patient health, all healthcare entities must comply with HIPAA, the Health Insurance Portability and Accountability Act to protect sensitive patient information from being disclosed without the patient's consent or knowledge.[7] Applicable to all healthcare institutions, providers, and health plans, HIPAA requires both physical and cyber safeguards. Cybersecurity enabled via antivirus and antimalware, data encryption, segmentation, and other practices is outside the scope of this paper. However, designers, integrators, and installers should be familiar with HIPAA's physical safeguard requirements to prevent unauthorized access and avoid theft or tampering.

HIPAA defines physical safeguards as "policies and procedures to protect a covered entity's electronic information systems and related buildings and equipment, from natural and environmental hazards, and unauthorized intrusion." Section 164.310 specifically requires limiting physical access to electronic information systems and the facility or facilities in which they are housed, while ensuring that proper authorized access is allowed. This includes all workstations (i.e., connections) that access protected health information, which encompasses APs that wirelessly transmit protected health information and any outlets that connect APs to the network.

Optimizing Wireless Healthcare Deployments

It is important to remember that every wireless healthcare application needs an AP (e.g., wireless AP, gateway, or antenna) to send and receive information to and from devices. Given the breadth of life-critical, medical-critical, and general-use wireless technologies being leveraged in the healthcare environment, APs are deployed across all hospital and healthcare facility spaces. For each space, it is imperative to deploy these devices in a manner that complies with ICRA 2.0, industry standards, and HIPAA requirements. At the same time, deployments must optimize coverage, ensure protection, and meet aesthetic requirements.

While meeting all of these requirements can seem overwhelming, choosing the right wireless enclosure or mounting solution can help wireless designers, integrators, and installers optimize compliance, coverage, protection, and aesthetics when deploying APs in the healthcare environment. Following are some considerations for various healthcare spaces and key features to look for when choosing wireless enclosures and mounting solutions.

Patient Care Areas

In the highest risk procedural, invasive, ICU, and oncology areas and in high risk areas such as patient floors, emergency departments, and imaging suites that require the most stringent infection control precautions to protect vulnerable patients from airborne contaminants, wireless enclosures should permit secure access to APs without exposing the above-ceiling plenum space. Whether dome style or AP-specific, key features to look for in a suspended ceiling AP enclosure include the following, as identified in Figure 2:

1. An all-metal back box large enough to stow excess cable and provide an effective dust barrier to simplify ICRA compliance during AP installation and maintenance
2. Firestop grommets for cable egress to maintain ceiling fire and smoke ratings
3. UL listed for the type of ceiling (i.e., suspended), installation (in-ceiling), and space (i.e., plenum)
4. Interchangeable doors support installation or migration to any vendor's AP
5. Locking keyed-alike doors to meet HIPAA physical security requirements, while enabling access for authorized personnel and simplifying key management
6. Aesthetic features such as textured, powder-coat finishes and opaque white or clear frosted domes to blend seamlessly into the ceiling
7. Fire-rated plastic domes that are virtually transparent to wireless signals to maintain proper coverage
8. Simplified tool-less AP installation and swing-down mounting features
9. Cut-outs for leading AP models in AP-specific enclosures

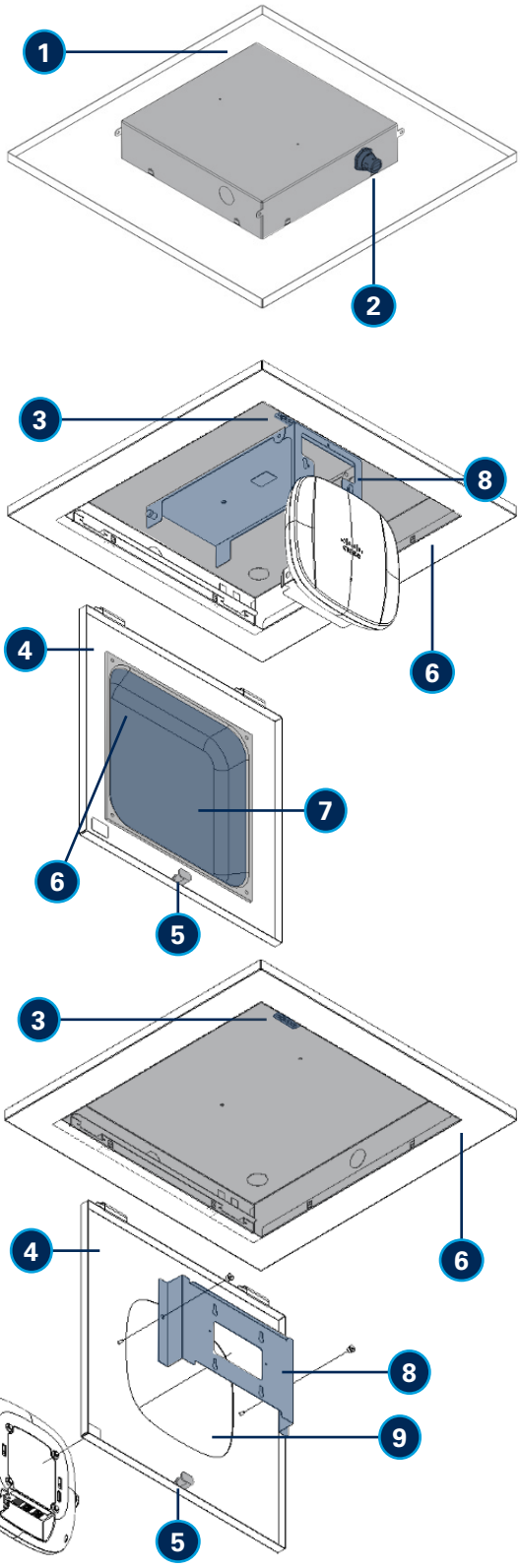


Figure 2: Key features to look for in a suspended ceiling AP enclosure for healthcare environments

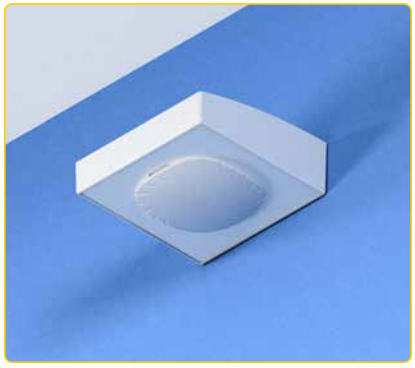
Note that for non-suspended ceiling deployments, enclosures should have many of these same key features but with fasteners that enable installation in almost any type of hard wall or ceiling and a shallow back box for mounting flush to the ceiling.

Harsh Environments

Certain healthcare environments are subject to liquid wipe, spray, or wash down such as Operating Rooms, Emergency Departments, burn -units and isolation rooms. The National Electric Manufacturers Association (NEMA) has a rating system that provides guidance to the protection provided. When deploying APs in these areas, enclosures should have a NEMA-PW ancillary rating, which provides protection from high pressure sprays or washdowns. The enclosures should also maintain physical protection, optimized coverage, and aesthetics.

Wall-Mounting Requirements

To optimize coverage, APs, by their very nature, must be exposed to provide best line of sight and avoid obstruction. In general, APs are best mounted to ceilings. However in healthcare spaces where ceiling mounting is not practical such as cafeterias and auditoriums, AP manufacturers recommend mounting APs in a horizontal orientation using right angle wall brackets. As with other enclosure and mounting solutions in the healthcare environment, right-angle wall mounts should still provide physical protection via locks and ensure optimum coverage via covers that do not block wireless signals.



General-Use Areas

Lobbies, waiting rooms, office areas, public hallways, gift shops, and other low- and medium-risk areas not located within clinical units still need a convenient way to mount and conceal APs into drywall ceilings and walls. Many of these areas have aesthetic requirements where the AP needs to virtually disappear without compromising coverage. Features to look for in wireless enclosures for these spaces include recess mounting and paintable, low-loss plastic covers that are low profile and yet have minimal impact on wireless signal performance.

Outside Spaces

It's important to remember that hospitals and healthcare facilities can include outdoor spaces such as ambulance bays, parking garages, courtyards, and other spaces that require weather protection and where there may be no feasible option for ceiling or wall mount. Wireless bollards are a cost effective and secure way to mount APs and maintain coverage in these spaces, especially where mounting on buildings or light poles is aesthetically unacceptable. Bollards should be rugged, weather proof, and tamper resistant, while being large enough to accommodate outdoor APs and any required equipment to extend network connectivity to the AP (i.e., edge switches, media converters, and Power over Ethernet injectors). The bollard cover should be constructed of a low loss material to minimize impact on the wireless signal. Bollards that are available in custom colors and custom heights are ideal for these environments.

Getting it Right

The proliferation of wireless healthcare technologies and the need to deploy APs in every hospital and healthcare facility space, while complying with regulations and standards and maintaining coverage, protection, and aesthetics, requires careful consideration about how APs are installed in healthcare environments. Optimizing wireless deployments for healthcare is easier with the right partner and solutions.

Oberon has a long history of working with hospitals and healthcare facilities—and the designers, integrators, and installers that work in this space—to develop wireless enclosures and mounting solutions that simplify ICRA, HIPAA, and code and standard compliance. Major healthcare entities consistently rely on Oberon's comprehensive range of enclosures, mounting solutions, and accessories that include:

- Suspended and hard ceiling wireless AP enclosures specifically designed to facilitate ICRA, HIPAA, and code compliance in healthcare environments
- NEMA-PW wireless AP enclosures designed to offer maximum protection in power washing environments and outdoor locations
- Right-angle wall-mount and ceiling-mount solutions for suspended ceiling, hard ceiling, open ceiling, warehouse, and high-bay environments to ensure optimum wireless coverage
- Secure locking ceiling and wall-mount wireless AP enclosures to prevent tampering and unauthorized access
- Low-profile and recessed wall- and ceiling-mount solutions and vanity covers that allow wireless APs to blend into the surrounding décor for superior aesthetics and improved security
- Free-standing bollards for mounting outdoor wireless APs in parking areas, courtyards, and other outdoor open spaces

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