Hospitals & Healthcare Facilities

FALL EDITION

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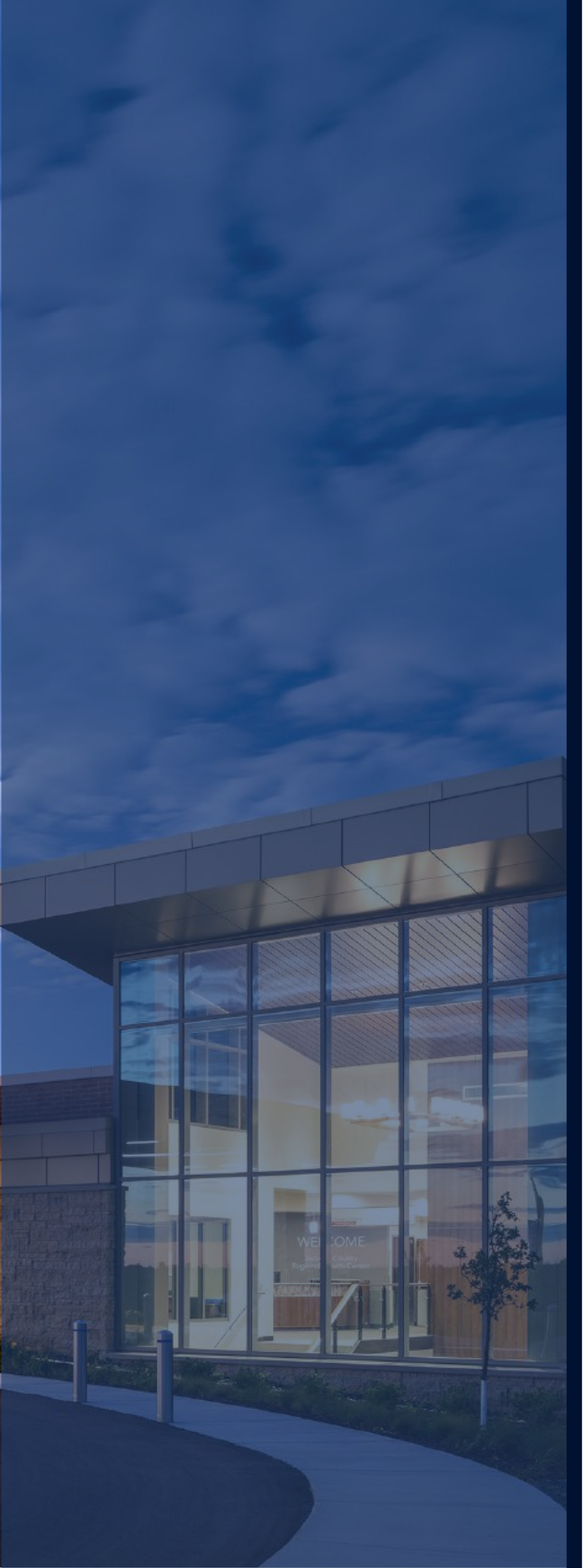

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Navigating hospital ventilation design during COVID-19

COVID-19 has impacted ventilation design considerations in health care settings in a prominent way

In early 2020, the novel coronavirus SARS-CoV-2, also known as COVID-19, caught the world by surprise. As a society, the virus will have lasting impacts among most aspects of life, and it will certainly change the landscape of design in perhaps a permanent way.

Not only will the design concepts in most public and commercial spaces be reconsidered, but this pandemic will be on the forefront of building owners' minds as they progress through hospital designs in the future. Regardless of the length of time that this virus continues to impact our communities, it will not be quickly forgotten and will have long-lasting effects on design considerations in the future.

Standards review, implementation

As engineers across the country started quickly responding to the disaster, it was evident that no singular design standard or code adequately guided the design community. Realizing the deficiency, many organizations such as the Centers for Disease Control and Prevention, the American Society for Healthcare Engineering, and ASHRAE banded together to develop some loose guidance that could be used specifically in the health care setting.

Engineers, hospital owners, and health care experts all over the U.S. quickly formed focus groups to identify design strategies that could both be implemented for not only the influx of the surge of COVID-19 patients, but also permanent concepts that could

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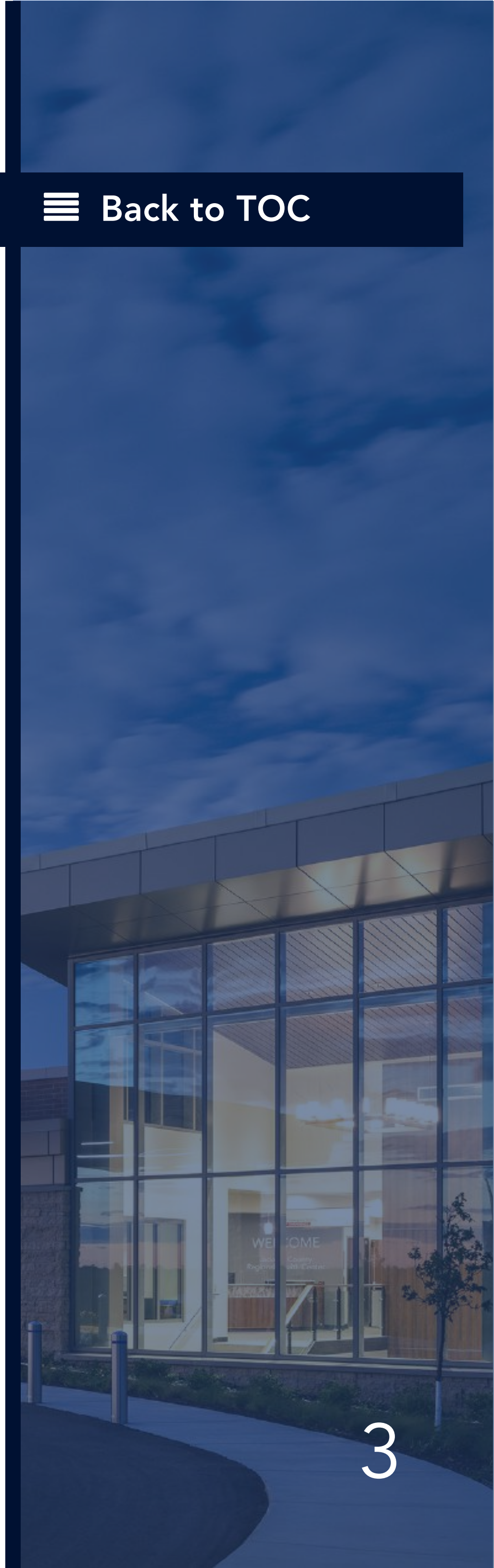

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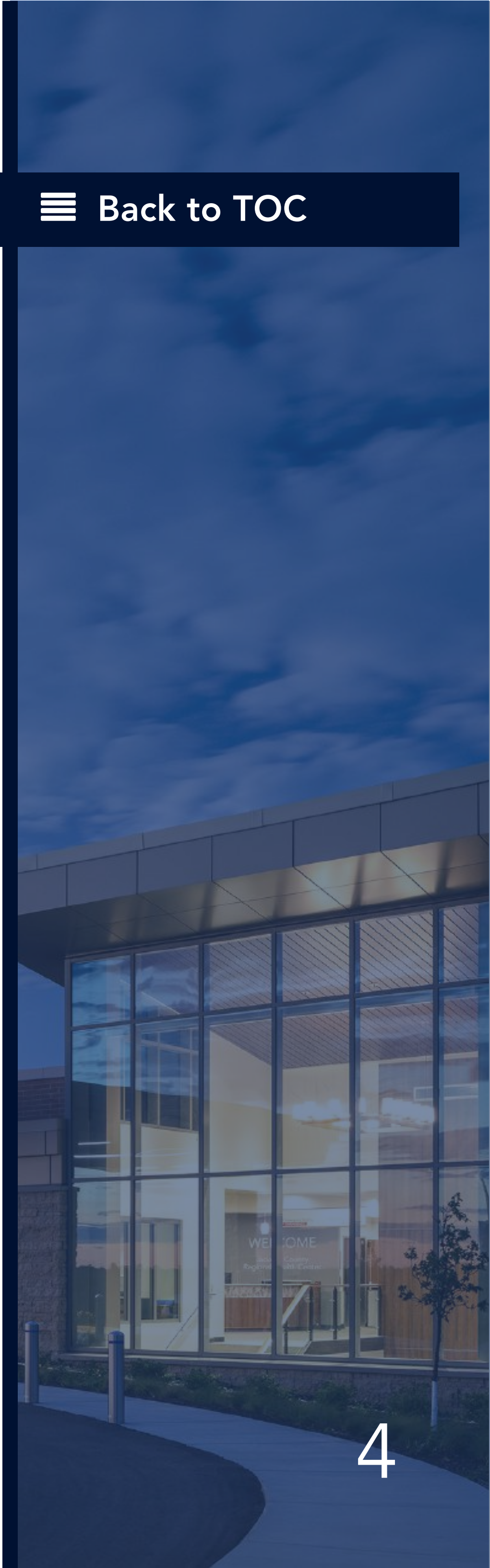
be executed for pandemic scenarios in the future. As more information has been realized regarding the virus, these recommendations have continued to evolve and will eventually lead to changes in future publications and addenda in current standards.

To help assist with advancing the current standards to include guidance around the design and installation of heating, ventilation and air conditioning systems, ASHRAE created an epidemic task force and position documents to address the challenges of the current pandemic as it relates to the disease transmission in multiple public and private environments, including in health care facilities.

One of the prominent ASHRAE standards that is used for most health care projects, ASHRAE Standard 170: Ventilation of Health Care Facilities, is continuing to be evaluated by the committee for formal guidance and possible revisions to include provisions required for pandemic solutions. As these recommendations were continually being clarified, the ASHRAE website was updated to keep the design community abreast with the most up-to-date information. Other resources such as webinars and local chapter presentations have also proved to be useful for distribution of recommendations.

At this time, it is unknown when permanent standards will be written or enforced. The current effort of the epidemic task force is focused on building readiness to allow for reopening of buildings in general, and not code-required specifics yet for modifications to permanently installed ventilation systems in health care facilities. Many of the schematics demonstrated throughout this article are based on previous recommendations for highly infectious disease units per the CDC and other notable resources, as well as requirements as enforced by the local authorities having jurisdiction.



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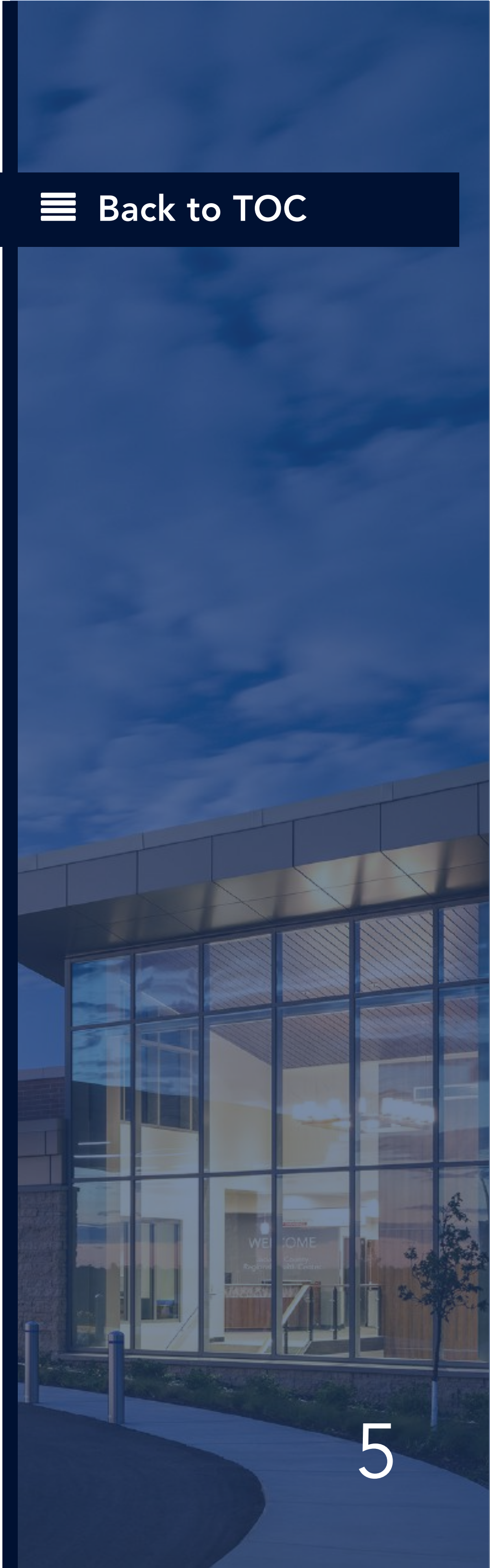
COVID-19 ventilation concepts

Although there are several unique design considerations that need to be considered in relation to the COVID-19 crisis, most notably and impactful to the HVAC world is the need for negatively pressurized spaces and careful consideration to airflow relationships with adjoining spaces and departments. This requires special consideration with regards to the ventilation system.

While the term “ventilation air” can suggest many meanings, the ASHRAE Fundamentals 2017 defines it simply as “air used to provide acceptable indoor air quality.” Ventilation is the primary strategy in limiting the spread of infectious diseases through an air system and includes an array of control mechanisms including dilution, filtration, source capture and exhaust components. These functions can occur either at the base air handling unit system or at the room itself and carry a varying weight of effectiveness and cost.

While there are many strategies that can mitigate the transmission of disease, arguably the most effective as it relates to the transfer within the HVAC system is intercepting the return air and diverting it to the exterior to prevent recirculation of the virus back throughout the hospital air system. This captures the contaminated air at the source and eliminates the ability for infected air to find its way back into the spaces and potentially infect other patients or staff.

However, this solution may not be as feasible depending on the system configuration and the ease of routing exhaust ductwork to the exterior. This is especially true in retrofit applications where air systems were designed in a traditional manner that did not include diverting return air paths. Depending on the complexity of the air distribution systems and physical location of the source equipment, this strategy can become a burdensome and costly solution.



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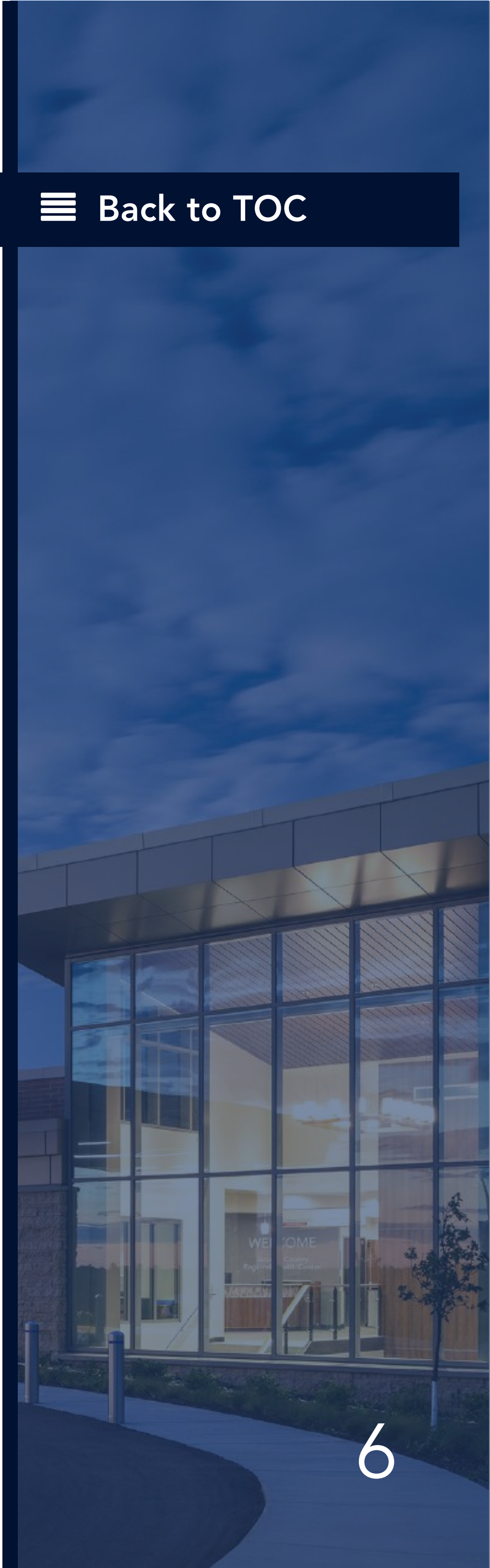
Easing the surge

Many of the early concepts that were created at the start of the COVID-19 crisis included simplistic temporary solutions to help assist during the surge, but were not meant for permanent applications. This included creating temporary negative pressure rooms from existing patient rooms using direct exhaust through high-efficiency particulate air filtration or installing temporary ante rooms at each patient room to create a sealed air barrier.

In both applications, the return air grille is sealed to eliminate air transfer back to the main air handling unit and the HEPA filtered negative air machines creates the pressure relationship required to reduce contaminant spread. Pressure monitors, via digital or mechanical means, are provided to ensure continuous monitoring occurs and that the correct pressure relationship is maintained. While these solutions allow for temporary conversion of the spaces during surge applications, they are not suitable or practical for long-term operations of ongoing or recurrent pandemics.

If possible, operating the AHUs that serve the pandemic area in 100% outside air with full exhaust is the most preferred method, although careful consideration should be taken before activating this sequence to ensure that the AHUs, coils, humidifiers and associated outside air ductwork and louver sections have been sized appropriately based on the seasonal duration of use. Potentially lowering the leaving supply water temperature at the chilled water plant can be investigated if capacity at the coils are deficient. Individual spaces would still need to be balanced to ensure that negative pressure relationships are maintained, but this strategy does ensure that contaminated air is not reentrained back into clean spaces.

Additional protection either in the AHU or in the ductwork of HEPA filtration, use of ultraviolet-C lights, and/or ionic purification strategies could all be implemented in any



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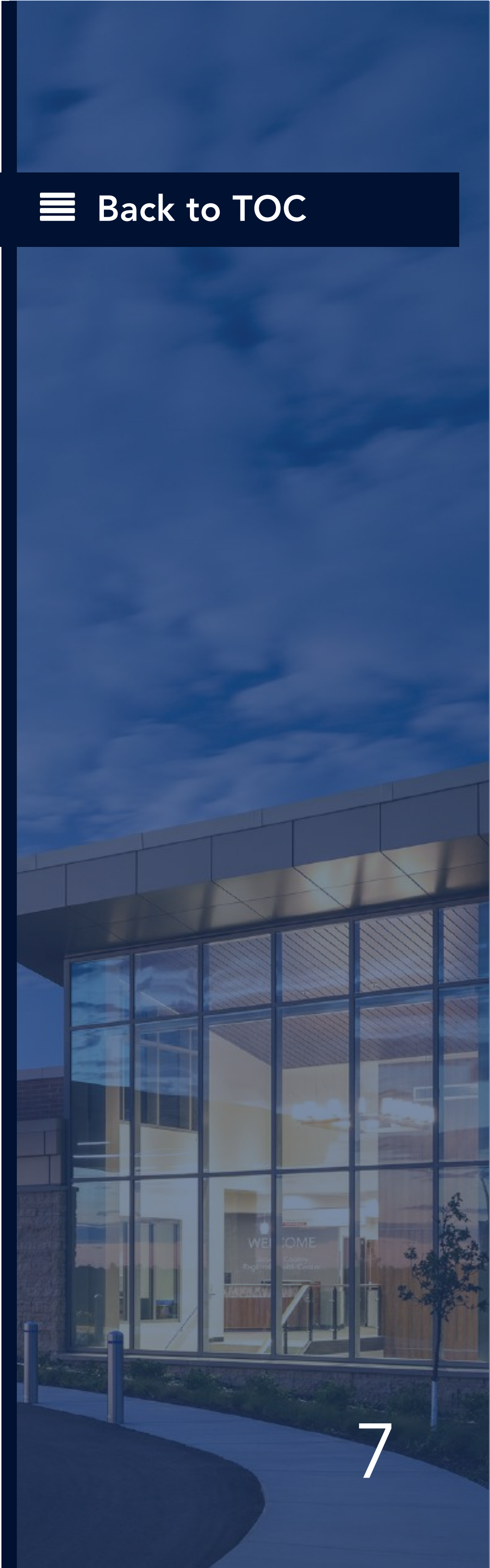
of these strategies; however, the most effective strategy remains removal of the contaminated air from the spaces in conjunction with providing negative pressure spaces.

Permanent pandemic solutions

While these temporary conversion concepts of existing areas into intensive care units has been required to quickly adapt to the surge capacity needs, many hospital owners have seized the moment during existing construction projects to make crucial modifications to the mechanical systems to allow for conversion to fully negative pressure wings or suites. While each design solution is unique to the complexities of the individual project, the most overwhelmingly effective strategy is to divert the airstream to be a fully exhausted system. By carefully sequencing motorized dampers at strategic locations within the system, the dampers can be automated to divert the return airstream to be fully exhausted so no air from the contaminated area returns to the AHU.

This allows the AHU to operate in a more traditional mode during nonpandemic operation and reduce the additional energy penalties. If the air was designed to be permanently exhausted rather than returned to the AHU, the additional outside air would be required during all hours of the year, resulting in significantly higher energy costs.

Still, in this strategy, careful consideration needs to be taken to ensure that the outside air is properly balanced to make up for the additional exhaust that is removed from the building to maintain an overall positively pressurized building during pandemic mode. This increase of outside air could have impact on the overall size of the cooling coils, preheating coils and humidifiers within the central AHU system and the central energy plant that should be considered and evaluated.



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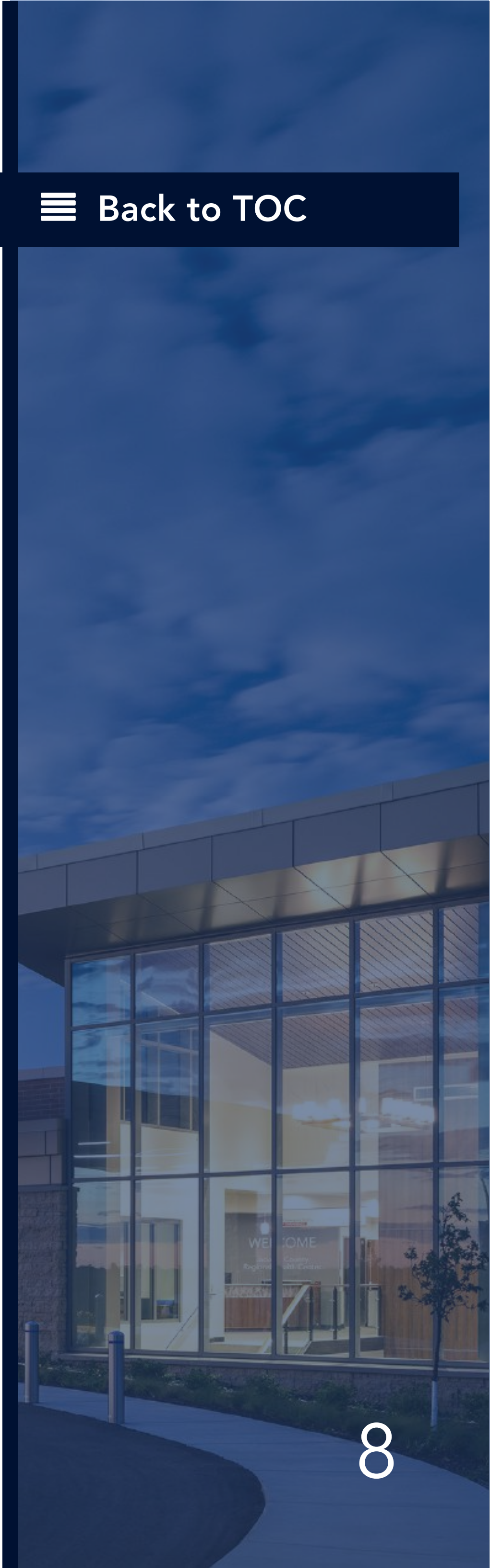
In addition, individual space pressurization needs to be assessed. While the motorized dampers will allow for an entire area or floor to become negative if additional air is removed above the existing return airflow values, the energizing of the exhaust fan and damper control will not alone create negative rooms without another means of rebalance at the space level. This rebalance can be accomplished either through a manual rebalance of each space or through the activation of independent air valves provided on the supply and return systems. The air valves can be programmed with two distinct airflow setpoints: one for normal mode of operation and one for the pandemic mode and would operate in conjunction with the motorized dampers.

While changing the pressurization from positive/neutral to negative pressure at the space level can be a challenge, perhaps one of the most debated topics is the quantity of airflow that is required to be delivered and exhausted from the space. To modify a room from an ICU airflow to meet that of an airborne infection isolation room requires an increased airflow and total air quantity required to meet that of an airborne infection isolation room above a medical/surgical patient room is even higher.

Depending on the type of pandemic, a patient room designed as a true airborne infection isolation room may not be required. As with COVID-19, which the main route of transmission is through respiratory droplets, the additional air change rate to turn over the air in the space may not be needed. Per the World Health Organization, these droplets are heavy enough that they cannot travel or linger in the air as long as other airborne viruses, such as the measles.

Therefore, providing protection in a room with 12 air changes per hour of exhaust volume is not the governing factor and instead, the pressure relationship becomes the key driver to minimizing virus transmission in adjacent spaces. Airflow patterns as



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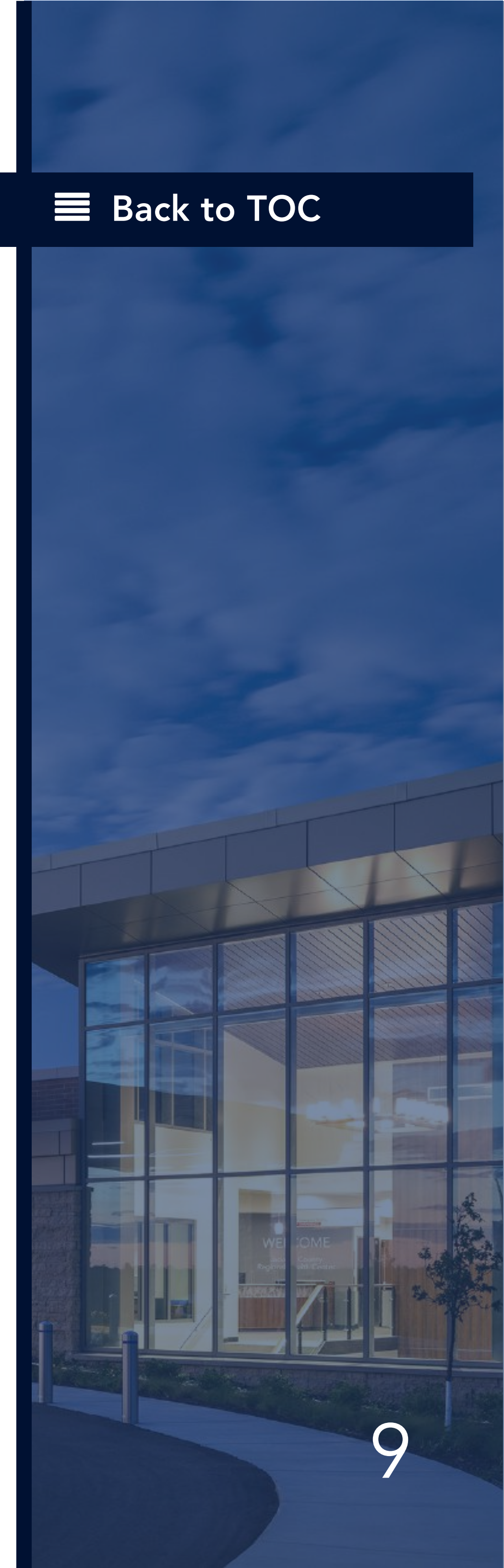


they relate to the patient and caregiver relationship should be considered to limit the spread within the space as well. To maintain a negative pressure relationship, either a reduction in the supply air or an increase in the return/exhaust airflow is required to achieve negative pressurization.

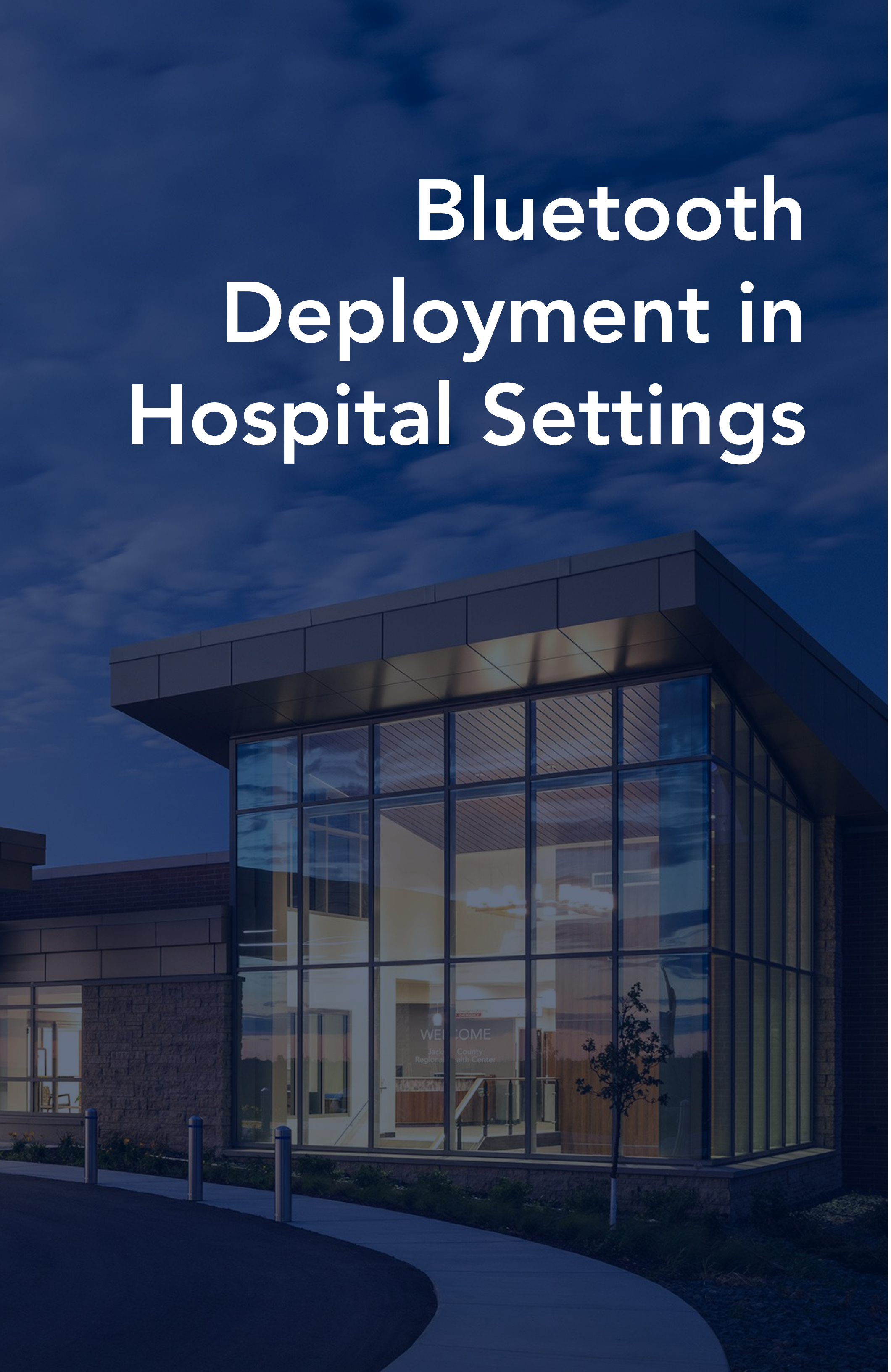
The approach to simply change the airflow and not necessarily increase total airflow to the requirements of 12 ACH of exhaust was evident in the beginning of the COVID-19 crisis, as most authorities having jurisdiction would accept air balance modifications as necessary to become negative pressure, rather than enforcing a higher air change rate. This greatly reduced the burden on existing infrastructure systems that were already in operation or in construction to become more reasonably modified. However, total ACH is continuing to be evaluated by the ASHRAE 170 committee for guidance on future pandemics.

COVID-19 has forever changed our world and the lens through which we design through will continue to evolve. The ASHRAE epidemic task force and standards committees will continue to evaluate design requirements that will be adopted in formal standards in the forthcoming years to help direct engineers how to best design and prepare health care facilities, nursing homes and outpatient facilities during these difficult, unprecedented times.

April Woods

***April Woods** is a vice president with WSP USA. Woods has played a key role in engineering mechanical solutions for major health care projects over the past decade and is particularly passionate about sustainable building design and overall impact of energy efficiencies in building systems. She is a member of the Consulting-Specifying Engineer editorial advisory board.*

Bluetooth Deployment in Hospital Settings



Introduction

There is no argument that the global rise of wireless connectivity continues to increase and at a rapid pace. The majority of the world population is now connected to the internet. Business Insider (BI) Intelligence estimated years ago that by 2020, 24 billion devices would be connected to the IoT or Internet of Things. As connectivity increases, so does our reliance on it which reinforces its use in a wide range of environments and situations.

Hospitals and other healthcare settings are not immune to this trend. Between the sky-rocketing use of personal monitoring devices and the fact that actual medical equipment is increasingly going wireless, healthcare in general has become far more mobile than ever before. With this mobility comes ever increasing pressure for consistent and reliable wireless connectivity to effectively manage and support patient care.

Even more critical than consistency and reliability is the need for secure wireless connectivity. According to a 2022 IBM Security study, healthcare data breaches cost the industry, on average, $10.1 million per incident, up 41.6% from 2020. If compromised, healthcare facilities can face not just legal expense, but costs related to patient notifications, breach detection, and the cost of responding to and fixing the breach. Adding to these financial expenses, they can also suffer the expense of downtime while the problem is repaired, damage to their reputation, and the loss of patient trust.

There are currently three primary wireless connectivity methods that are used for IoT within hospital settings – Wi-Fi, Bluetooth, and (increasingly) ultra-wideband or UWB – a short-range, very high frequency wireless technology). With the rapid pace of innovation and the increasing growth of IoT, healthcare providers experience more and more pressure to adopt these wireless technologies (individually or as part of a multi-technology network) for both improved patient care and a reduction in cost (a priority of both for-profit and non-profit organizations alike). Added to this pressure are the challenges (and headaches) that accompany the proper deployment of an effective wireless network.

This white paper focuses on Bluetooth technology. The reason for this focus

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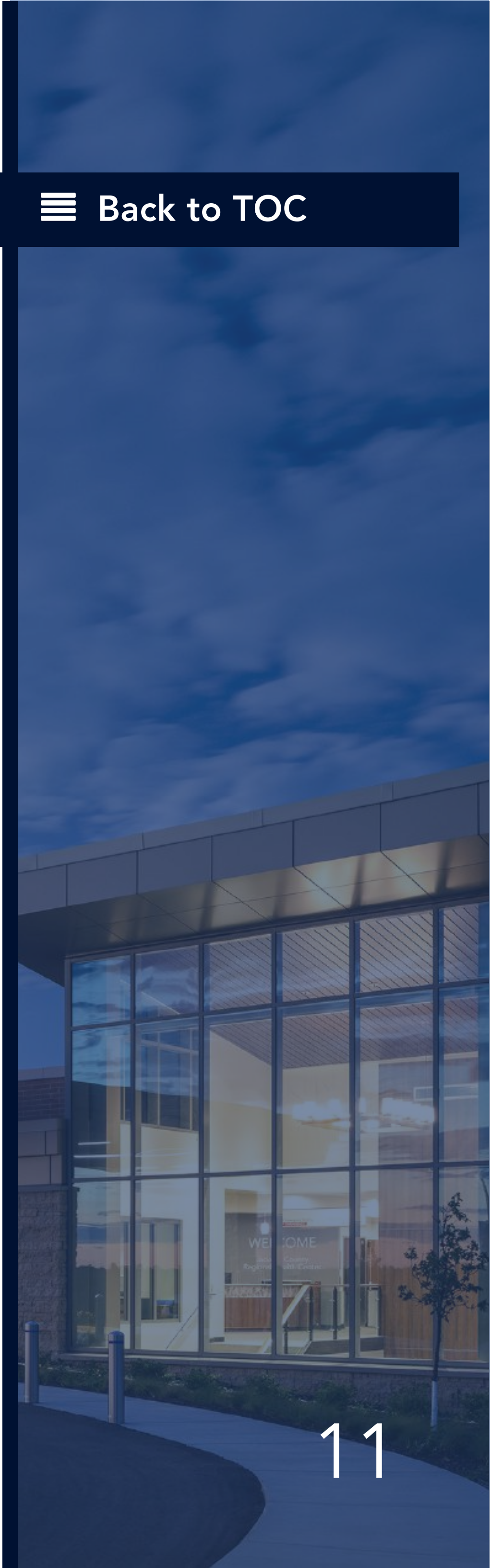

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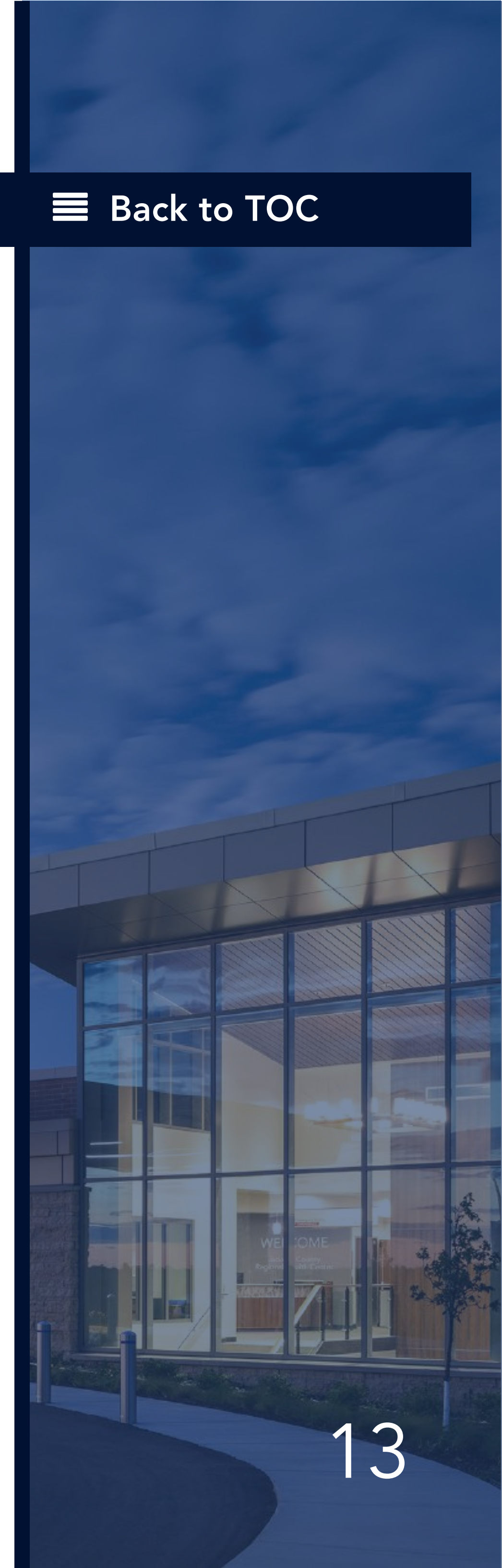
is to counter the fact that, traditionally, healthcare organizations have typically avoided relying on Bluetooth due to concerns about performance and security. Adding Bluetooth devices to hospital settings was simply adding yet one more RF technology in an already-congested wireless space. But, because the security aspect of Bluetooth is greatly improved and newer technologies counter the RF interference often caused by wireless overcrowding, Bluetooth is becoming a much more trustworthy connectivity solution even in hospitals and other healthcare facilities.

And this is good news! Bluetooth technology brings with it a variety of benefits to these environments:

- It's widely used, especially with its integration with smart phones, tablets, and personal monitoring devices;
- It's a low power technology which, with the addition of Bluetooth Low Energy, significantly extends battery life;
- It's a relatively low-cost solution for wireless connectivity;
- With newer technologies, it operates or cooperates well in noisy or crowded RF environments;
- New Bluetooth 5.2 features like LE Coded and 2M PHY yield higher throughput and longer range;
- With greater adoption in medical devices, Bluetooth LE is becoming common in healthcare environments, such as in surgical sensors, patient monitor peripherals. And asset/patient tracking Additionally, healthcare can extend to the patients' home, such as in as fitness trackers, blood pressure and glucose monitoring sensors. This decreases the length of hospital stays, increasing the comfort level of patients, and greatly reducing costs for both the hospitals and the patients.

Bluetooth is an innovative way to improve patient care, make healthcare operations more efficient (and quicker with the aid of AI processing the generated data), decrease clinical errors, and reduce the overall costs. This white paper describes several Bluetooth technologies that enable its reliability and efficiency in hospital settings.



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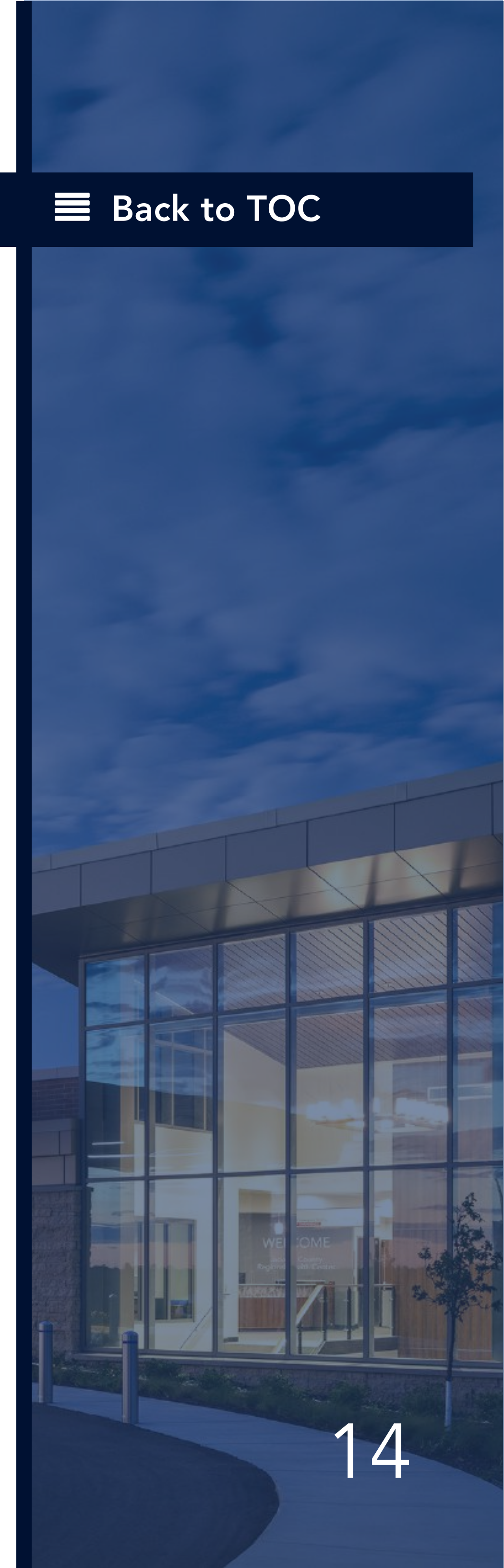

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In other words, Bluetooth is an innovative way to improve patient care, make healthcare operations more efficient (and quicker with the aid of AI processing the generated data), decrease clinical errors, and reduce the overall costs.

This white paper describes several Bluetooth technologies that enable its reliability and efficiency in hospital settings. We also provide a brief overview of Bluetooth security and its impact on reliability in hospital settings as well as counter the myth that Bluetooth and Wi-Fi cannot coexist in a medical environment.

Hospital Settings And Its Effect On Connectivity

Hospital settings are both hectic and fast-paced. Yet, in the midst of this seemingly chaotic environment, hospitals provide critical, life-saving services on a daily basis to hundreds of thousands of patients. The evolution of connectivity technologies greatly enhances a hospital's ability to successfully deliver these vital services but the fact remains… there are a multitude of RF obstacles inherent to a hospital or other medical setting. The following are just a few of these obstacles.

Challenging Physical Environment

The challenging physical environment of hospital settings is brutal when it comes to the wireless connectivity that is required for RF technologies. Fundamentally, hospitals are made up of walls, electronic equipment, and a lot of people. Each of these components are obstacles to efficient and reliable wireless communication.

- Walls are often made of extremely dense materials such as concrete which can block radio-frequency signals

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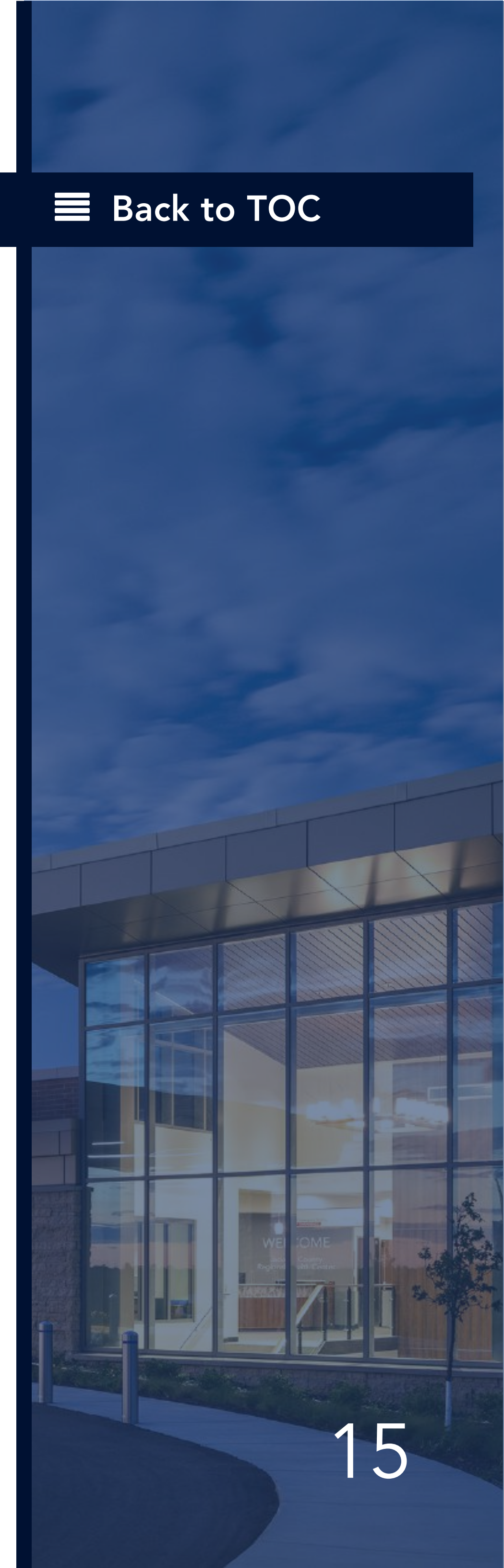
- The issue with general hospital equipment is three-fold:
    - It's often metallic, which can disrupt or block radio signals
    - It's often mobile, continuously and unpredictably moving throughout the hospital facility
- The hospital environment itself is very vast, creating a challenge in terms of wireless coverage across the facility
- Hospital personnel often report that the use of industrial 900 MHz microwave ovens (often in use in hospital cafeterias and breakrooms) cause interference with their electronic hospital equipment.
- People, an obvious and abundant component of hospital settings, can also affect RF signals. Because the human body is made up of mostly water, getting radio waves through it is difficult. With so much inherent water, human body can both reflect and absorb RF energy which means that, the busier the hospital, the more likely the disruption of radio signals due to the vast number of patients, patients' families, and hospital personnel. This is especially applicable to the 2.4 GHz band.

Unpredictable Capacity

Hospitals generally operate all the time… 24/7. Sometimes these hospitals are busy and hectic while at other times they experience lulls in the chaos. The fact that they operate around the clock makes it difficult to predict capacity and plan for wireless connectivity needs. When the hospital faces an influx of patients, this means not only



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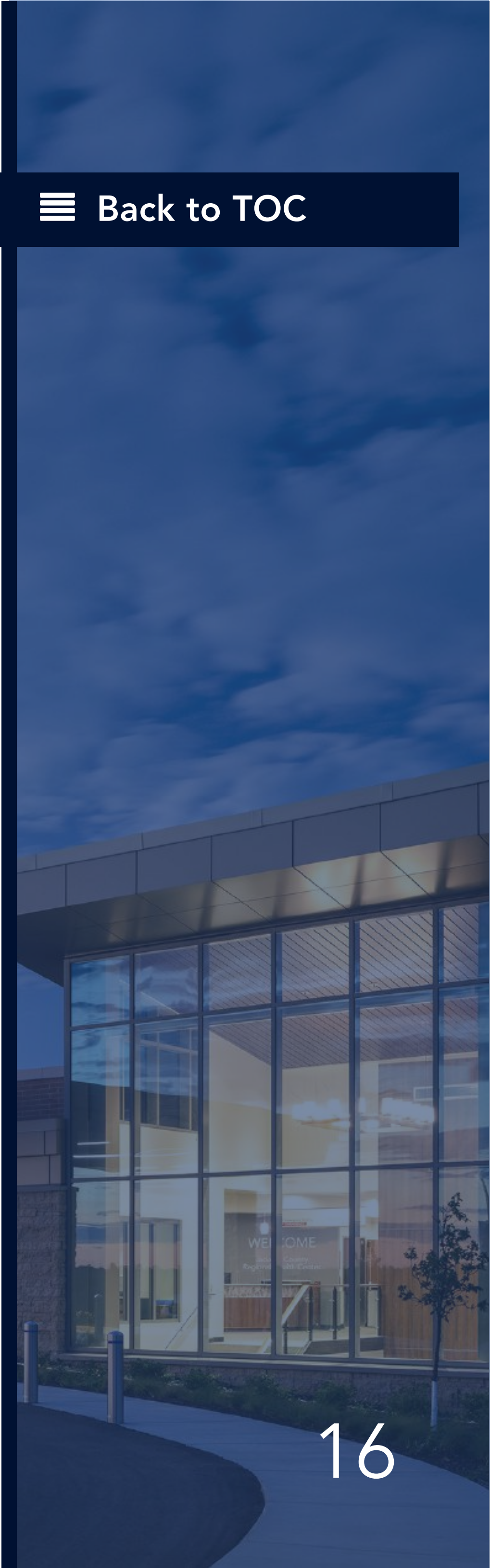
an increased use of wireless medical devices used to treat the patients, but a significant increase of associated non-medical devices as well. The patients and their accompanying family members or friends bring their own devices and their own bandwidth usage – streaming videos, movies, music as well as the plethora of other internet outlets (can anyone truly survive and thrive without constant connection to the internet?).

People, an obvious and abundant component of hospital settings, can also affect RF signals. Because the human body is made up of mostly water, getting radio waves through it is difficult.

With the ever-growing reliance on wireless communication and the sheer number of wireless devices, it's important that hospitals can handle the varying bandwidth needs without sacrificing critical connectivity.

Unique Sites or Situations

Although hospitals in general serve a common purpose, there is no one-size-fits-all connectivity solution for healthcare facilities. Each situation or site is unique and requires a custom solution. Understanding the physicality of the site as well as predicted network needs.



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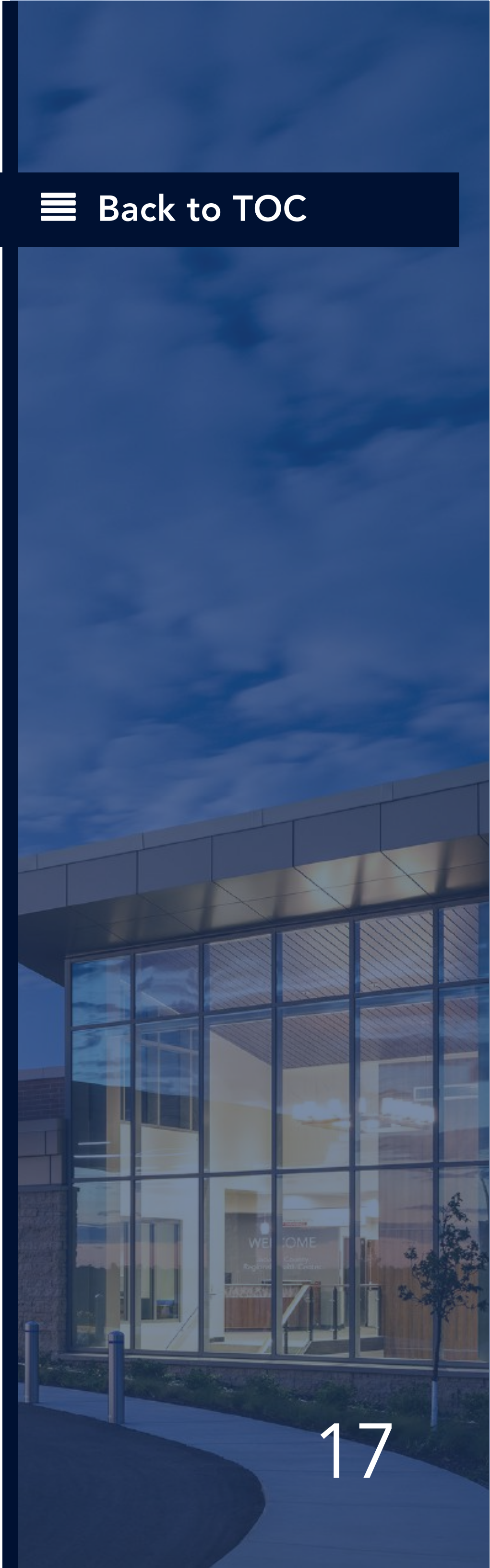

Understanding Bluetooth Technologies

As we've already stated, Bluetooth technology brings with it many advantages to hospitals and other healthcare environments. By understanding various Bluetooth capabilities and how they work can enhance its use in medical facilities. This section delves into coexistence issues that may arise with the use of Bluetooth (and ways to mitigate them) as well as Bluetooth mesh technology which can greatly boost its connectivity performance.

Coexistence Between Bluetooth and Wi-Fi Technologies

Although the risk of interference is present, Bluetooth and Wi-Fi connectivity solutions can be deployed and successfully coexist in a single hospital environment. To better mitigate potential RF clashes between these two technologies, let's take a look at what types of interference could occur in a healthcare environment. The better we understand what causes what types of interference, the better able we are to reduce or avoid it altogether.

Within a hospital setting, there is a wide variety of both medical and nonmedical equipment that can create RF interference. For example, there are likely different devices within the hospital that use Wi-Fi, Bluetooth, Zigbee, LTE, or ANT technologies, all of which operate in the 2.4 GHz band. This fact alone presents RF challenges when they are collocated and operate simultaneously. Add to this all of the personal devices being used by patients, patients' family and friends, as well as hospital personnel – streaming services, voice and video chats, general internet use – and you're likely dealing with some RF chaos.

While Bluetooth and Wi-Fi often use the same frequency band, they are practically

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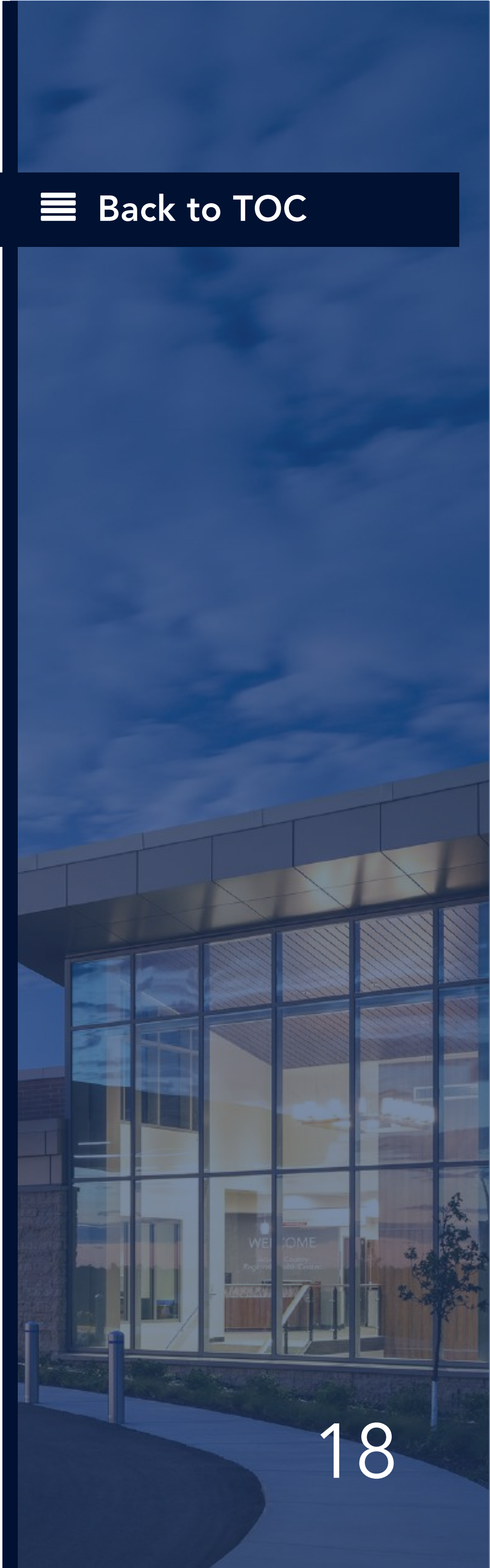
non-competing technologies. Each has its own specific applications and, oftentimes, these applications even require that both technologies co-exist in the same network and sometimes even in the same system. If this coexistence isn't handled effectively, performance of both can be greatly affected. To ensure that Bluetooth and Wi-Fi technologies are not hindered by one another's presence, engineers must not overlook coexistence or collocation when designing RF systems that include both Bluetooth and Wi-Fi.

While Bluetooth and Wi-Fi often use the same frequency band, they are practically non-competing technologies. Each has its own specific applications and, oftentimes, these applications even require that both technologies co-exist in the same network and sometimes even in the same system.

Bluetooth Low Energy

Bluetooth Low Energy, also referred to as Bluetooth LE, is a low power yet extremely robust technology that is intended for situations where battery life is more important than high data rates. It's similar to Classic Bluetooth in the fact that both operate in the 2.4 GHz frequency band and are part of the Bluetooth Core Specification. But they operate in very different ways.

The most significant difference between the two and the reason why Bluetooth LE is an excellent connectivity solution for hospital settings is the fact that Bluetooth LE uses far less power than Classic Bluetooth. Bluetooth LE is ideal for applications that intermittently send small amounts of data – applications we see, for example, in a wide variety of medical devices such as blood glucose monitors and pumps, pulse oximeters, asthma inhalers, fitness trackers, blood pressure monitors, and more.



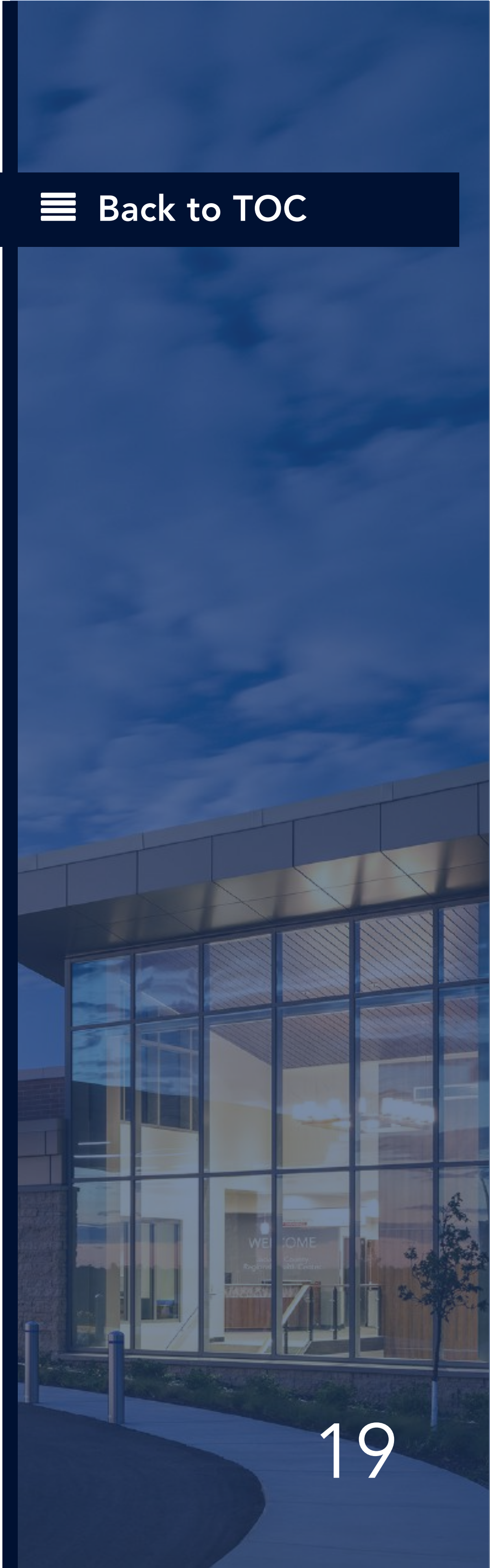
For reliable operation in the crowded 2.4 GHz frequency band, Bluetooth LE utilizes frequency-hopping spread spectrum methods that involve what's called a channel map update procedure. This procedure can be utilized with both non-adaptive channel blocking and Adaptive Frequency Hopping (AFH). We'll dive into both of these methods later in this paper. But first, we'll look at other spread spectrum technologies used by Wi-Fi and Classic Bluetooth.

Spread Spectrum

Both Wi-Fi and Bluetooth are based on spread spectrum signal structuring where, to put it simply, a narrow band signal is spread over a wider frequency band. In other words, with this radio transmission technique, a narrowband signal such as a stream of zeros and ones is expanded (or spread across a given portion of the radio frequency spectrum) to result in a broader or wideband signal.

Spread spectrum signaling was originally developed for military applications and offers two main benefits. First, a wideband signal is far less susceptible to intentional blocking (jamming) and unintentional blocking (noise or interference) than a narrowband signal. Second, a wideband signal sometimes can be perceived as a part of the noise floor (static interference) and thereby remain undetected.

The two most popular spread spectrum signal structuring techniques are Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS). Bluetooth uses FHSS whereas Wi-Fi uses DSSS. Given that both technologies operate in the same frequency band, this use of differing techniques is the heart of potential Wi-Fi/Bluetooth coexistence issues. FHSS devices and DSSS devices perceive each other as noise—Wi-Fi and Bluetooth are mutual interferers.



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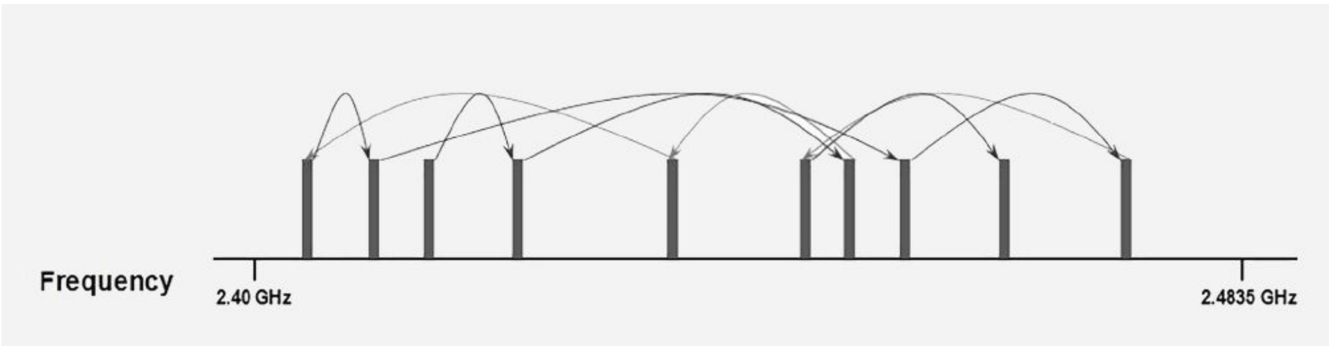
FHSS vs DSSS

FHSS spreads a narrowband signal by "hop-ping" across channels at set intervals in the 2.4 GHz frequency band. The transmitter and the re-ceiver adhere to a common hopping pattern or se-quence of channels during a given session so that the receiver is able to anticipate the frequency of the next transmission. Because of this, Bluetooth makes full use of the 2.4 GHz band.

Figure 1: With Frequency Hopping Spread Spectrum, the signal is transmitted on different frequencies at intervals to spread the signal across a relatively wide operating band



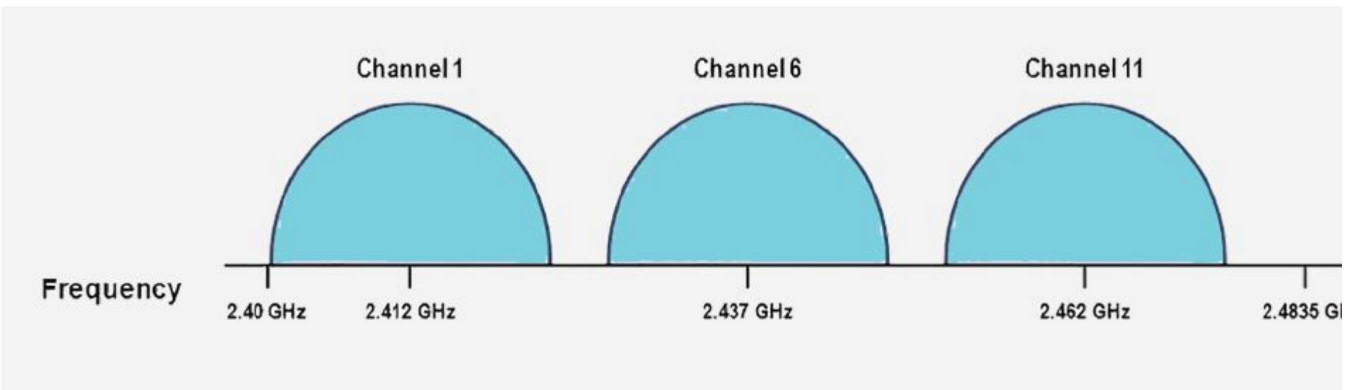


Figure 2: With Direct Sequence Spread Spectrum, the signal is transmitted on a continual basis across a range of frequencies referred to as a channel

DSSS starts with the same sort of narrowband signal as does FHSS but spreads that signal across a spectrum in a very different way. With DSSS, the narrowband signal is

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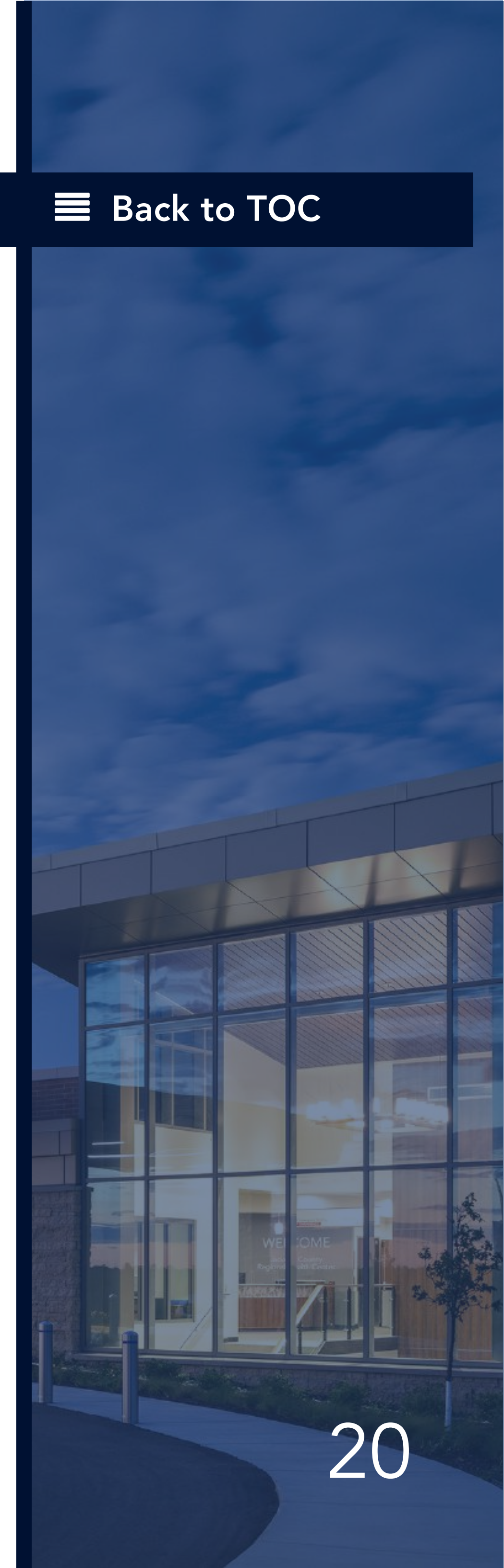

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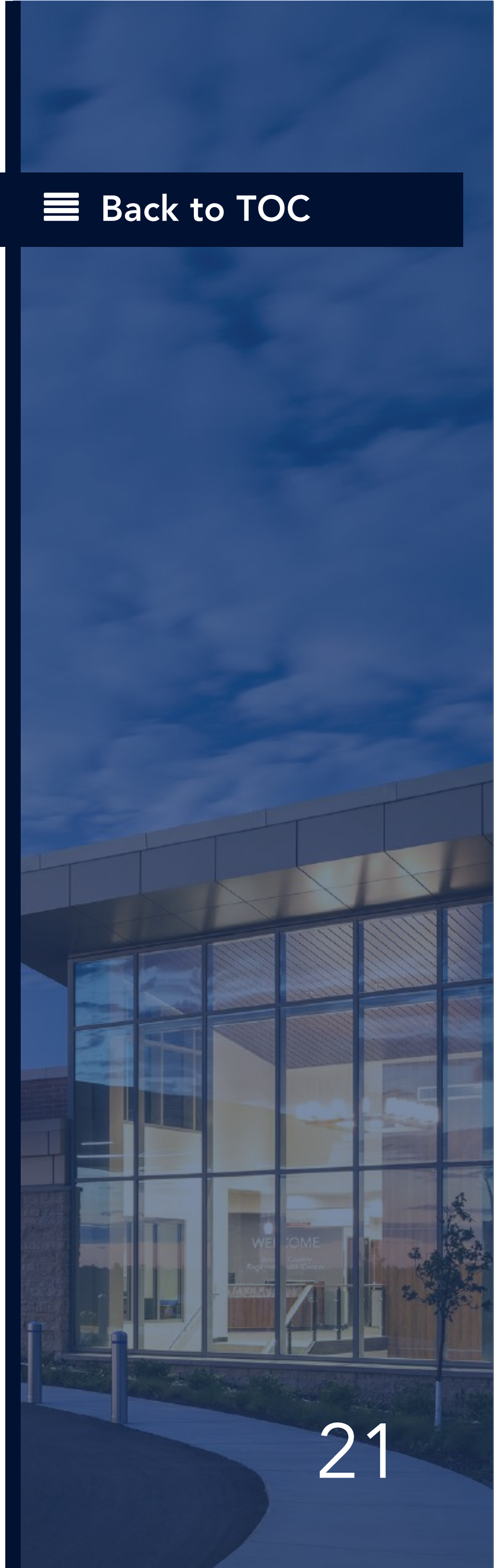
divided and then combined with a sequence called a chipping code. The chipping code spreads multiple copies of the original signal across a wider portion of the operating band to form a channel. Wi-Fi's 2.4 GHz band overlaps with the Bluetooth range, and the Wi-Fi channels are 22 MHz wide. Because the 2.4 GHz band is 83 MHz wide, three non-overlapping Wi-Fi channels are available in Wi-Fi's 2.4 GHz band. Upon receiving a wideband signal, the receiving station decodes the original narrowband signal by using the same chipping code as the transmitting station.

Channel Map Update

As you know, Bluetooth operates on the unlicensed 2.4 GHz ISM frequency band. Although the 5 GHz frequency band has absorbed some of the RF congestion, Bluetooth coexists on this 2.4 GHz band with Wi-Fi, ZigBee, and other commercial applications. It is important that Bluetooth devices can mitigate the interference and communicate effectively on this crowded frequency band.

The channel map update procedure (which was originally part of the Bluetooth 4.0 specification) allows peer devices to determine (or agree on) which channels are best to use – which ones are not hindered by interference. With this information, the master device can then initiate an update to the channel map, disabling any channel that is experiencing a level of interference that adversely affects communication performance. This update is driven solely on the master side.

There are multiple ways that Bluetooth technology companies can implement channel map updates. At the most basic, 'no frills' level, channel map updates simply involve any of the associated Bluetooth devices detecting a channel with high interference and 'suggesting' that it not be used. The master device then disables this 'bad' channel



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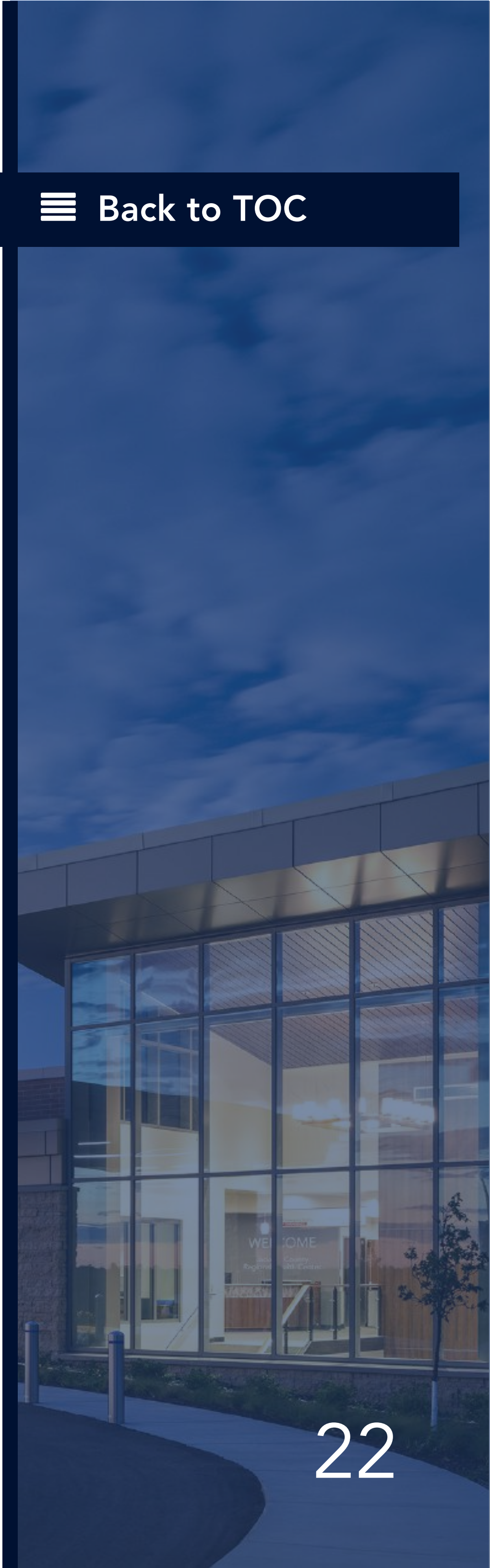
and it remains disabled for the remainder of the current connection. If the interference dissipates, the channel still remains disabled until the devices are disconnected and a new connection is made.

There are two general methods to improve upon this most basic version of channel map updates. In some cases, Bluetooth technology companies develop and initiate their own (often proprietary) algorithm to manage this process. With an effective algorithm in place, the current Bluetooth connection can be monitored for interference across the channels. Periodic updates can then be made (whether to disable a 'bad' channel or re-enable a 'good' channel) based on channel performance and RSSI.

Other Bluetooth manufacturers use Adaptive Frequency Hopping (AFH) to tackle the issue of channel map updates. AFH means different things to different people, but in Bluetooth it involves scanning for busy channels and, when found, altering the channel map to avoid them. The key difference is that, with AFH, it is a dynamic process – the communication devices constantly monitor and can continuously change the channel map to mitigate the interference. Bad channels are excluded only until they are no longer congested. In addition, AFH involves the ability for the selected channel to frequently change to allow the transmission of data over a wider collection of channels to avoid interference and perform better in busy radio environments. Bluetooth Low Energy allows use of a channel map to mark bad channels, under control of the application.

So, to summarize… channel map updating technologies universally monitor channel health to determine whether or not effective and reliable Bluetooth communication can occur. In addition, for all methods, the master device can disable any channel deemed 'bad' to ensure it's not used. The difference in specific technologies, to put



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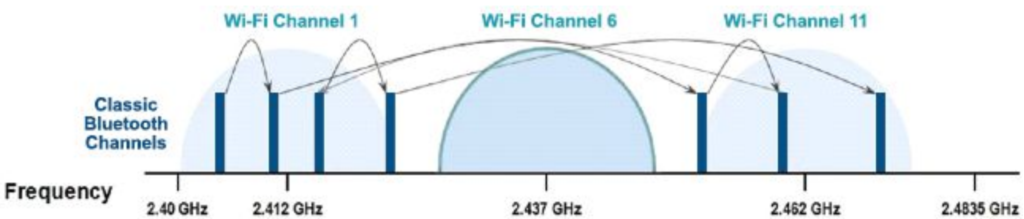
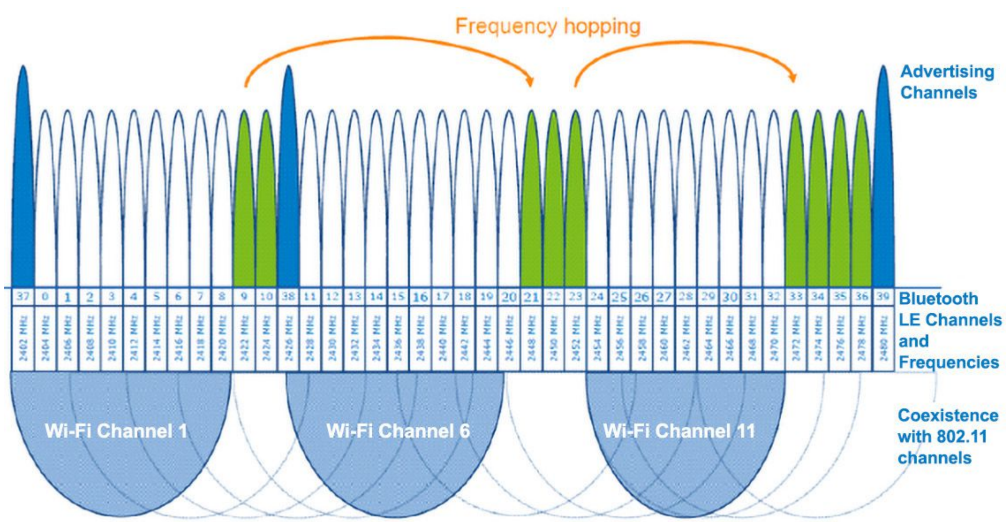
it very basically, is how often this monitoring (and response to monitoring) occurs. Non-adaptive channel blocking might be implemented by keeping channels disabled until a new connection is made, or by periodically making updates to the channel map during the current connection. Adaptive Frequency Hopping, on the other hand, continuously monitors and dynamically adjusts selected channels accordingly. The selected channel can change (hop) frequently which allows Bluetooth communication over a wider group of channels.

Adaptive Frequency Hopping functions a bit differently between Classic Bluetooth and Bluetooth LE...



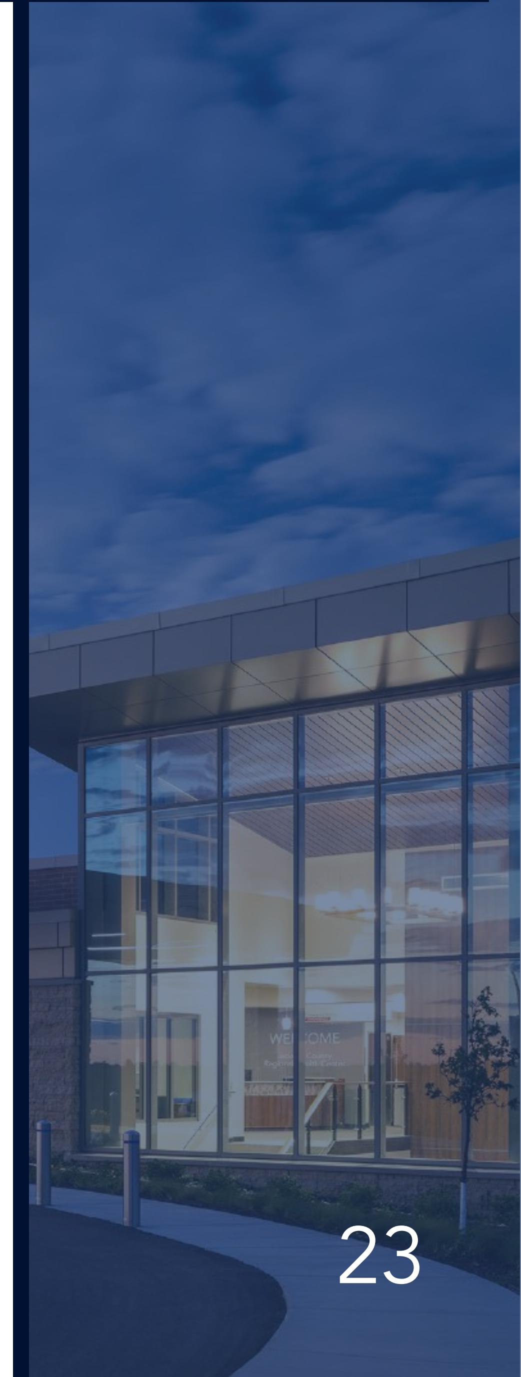
Classic Bluetooth: Radios scan on 79 individual one-Mhz wide operating channels.

Hopping occurs at a fixed rate: Every 1.25 msec



Bluetooth LE radios scan on 40 channels that are two megahertz wide with more tolerant modulation to get better penetration.

Hopping ranges from 7.5 msec to ~4 seconds (negotiated at the time of connection and can be renegotiated during the connection).



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Throughput and Range Tradeoffs in Bluetooth LE

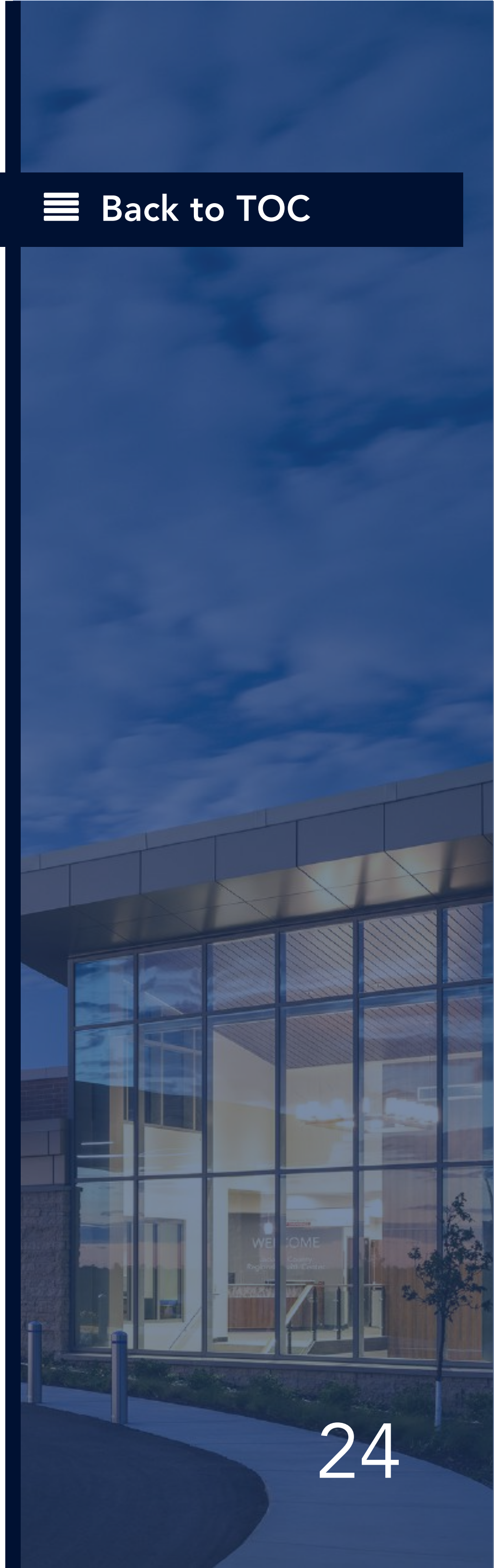
To adjust to difficult environments where Bluetooth connectivity might be challenged, Bluetooth 5 offers two new physical layer schemes that each have their own advantages. Your choice depends on whether you need greater throughput or greater reliability in range.

Bluetooth 5 offers two new physical layer schemes that each have their own advantages. Your choice depends on whether you need greater throughput or greater reliability in range.

Better Range with LE Coded PHY

Bluetooth 5 has an excellent feature for expanding the range of wireless devices, called LE Long Range/Coded PHY, which provides increased range not by increasing the output power but by using bit expansion using Forward Error Correction (FEC) coding. It sends each bit in the data packet as coded 2- or 8-bits in order to give more devices at farther distances the opportunity to successfully receive transmissions.

Initially, it may not seem plausible that simple expansion can truly improve the range



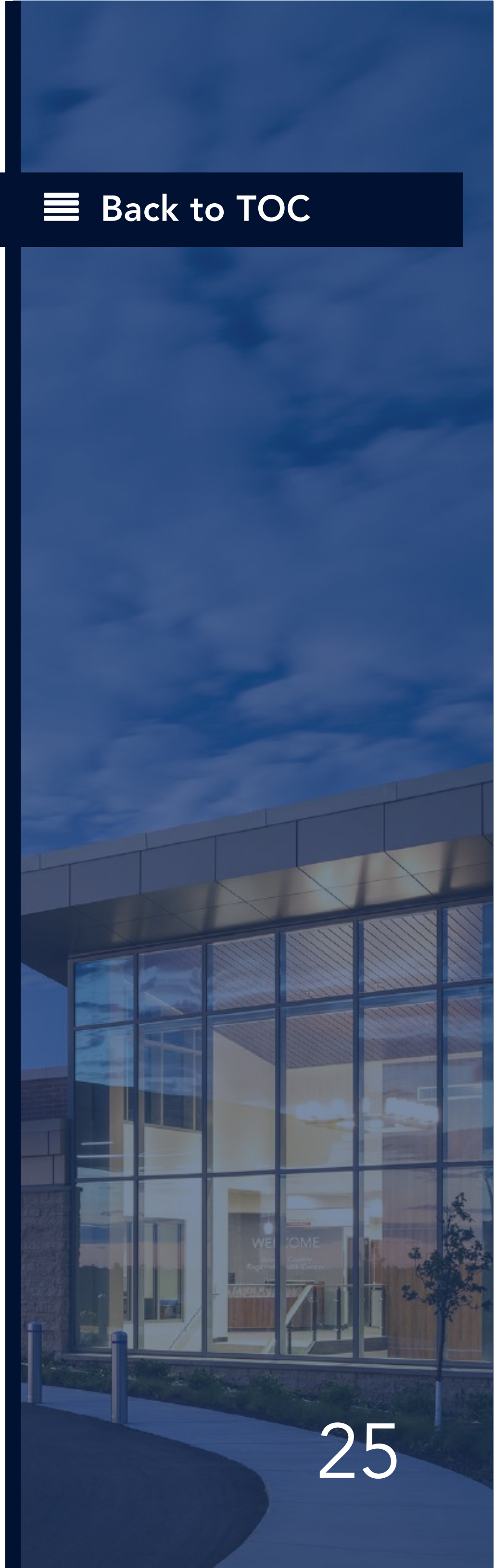
of listening devices that can successfully receive transmissions – especially since range issues have traditionally been solved by pushing more power into antennas. But there's a simple analogy that illustrates it in everyday terms: if there is a large room of people at various distances from you, only the closest people will be able to closely follow a story you are telling at a normal speaking voice. Let's say everyone within eight feet of you. To help more people follow along, you could yell your story (i.e. increase power to the antenna to amplify output), or you could continue speaking at a normal volume but repeat each word two or eight times. Each person in the room would simply need to hear one of those repetitions to follow your story, which gives the people in the back of the room a far better chance to understand what you're saying.

Repetition is remarkably effective at increasing range without the need to "yell across the room," and testing by the Laird Connectivity team and other organizations show that LE Long Range/Coded PHY can successfully increase range up to 4 times while also improving sensitivity of receiving devices by 4 or 12 dB.

Higher Throughput with LE 2M PHY

Prior to Bluetooth 5, BLE operated on 1 Mbps modulation only. Bluetooth 5 adds support for an 2 Mbps PHY, known as LE 2M PHY. It allows data to be transmitted at the higher two Mbps symbol rate, which achieves around 1.5x the final throughput of the original 1 Mbps modulation.

Both 2M PLY and LE Coded PHY achieve their results without an increase in power, and both have their advantages and disadvantages. In general, if higher throughput isn't a requirement for your application, LE Coded PHY provides an obvious advantage. Connectivity in medical applications is critical, and LE Coded PHY provides a reliability



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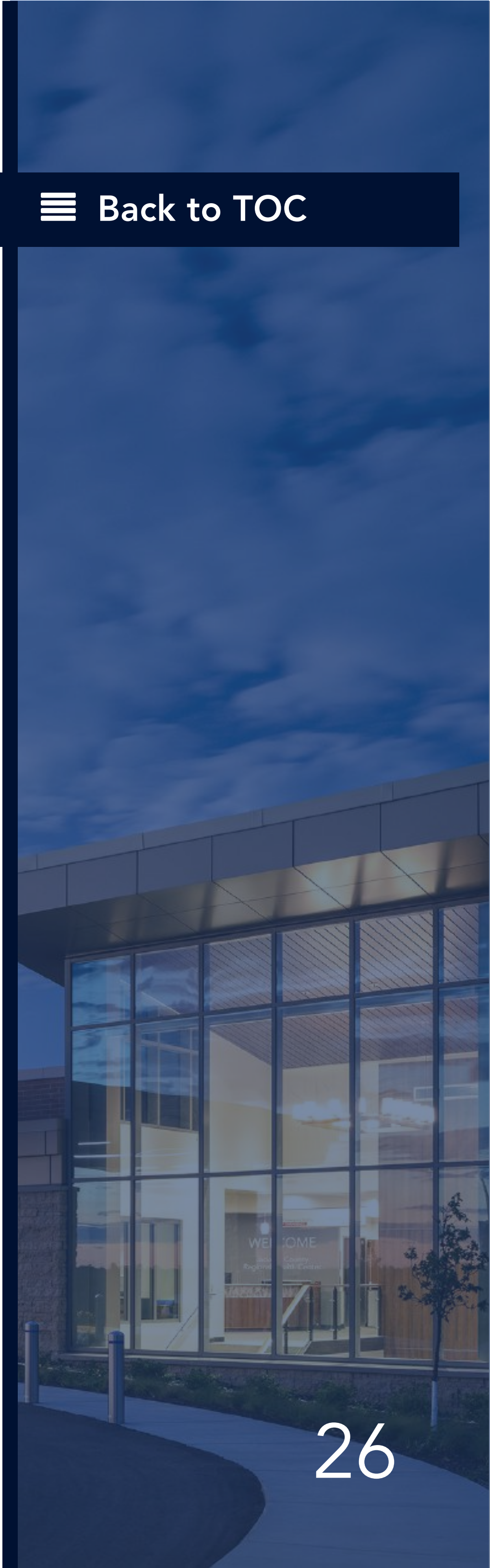

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boost, especially considering the densely populated environment of a hospital.

Ultimately it's about choice and flexibility, and your application and environment can make the decision about which modulation scheme is right for your devices.

Bluetooth Security

Earlier Bluetooth devices were shunned in healthcare due to the importance of secure patient and medical data. Early pairing implmentetaions by OEMs tended to have simple 4 digit preset passcodes (0000, 1234) for user simplicity, which were therefore fundamentally easy to guess. But as Bluetooth security has been enhanced using asymmetric cryptography, major security concerns have been addressed (especially beginning with BT 4.2) and adoptions of Bluetooth in medical have increased.

Bluetooth 2.1 and Simple Secure Pairing introduced new 6 digit random passcodes with confirmation. During pairing with SSP, security features (such as I/O capabilities and requirements for MITM attack protection) were exchanged via the pairing request and pairing response packets. For example, if one device had a display and the other had a keyboard input, the first device can show a 6 digit random key and the second device can confirm it, ensuring they are each paired to the correct device.

Pairing modes prior to Bluetooth 4.2 are now known as legacy pairing. Since Bluetooth 4.2, pairing now involves LE Secure Connections based on Eliptic Curve Diffie-Hellman cryptography. By incorporating ECDH into Simple Secure Pairing, Bluetooth now uses private and public key pairs that are extraordinarily difficult to break.

Once paired, Bluetooth LE modules within devices are extremely secure. The most vulnerable time for attacks is during the pairing process itself. These include Man in the Middle (MITM) attacks (or active eavesdropping), and identity tracking. (See Figure A) Once paired, the encryption information is stored, and these two devices no longer need to pair to connect. They are bonded, and no longer require sharing vulnerable secrets openly to reconnect.

Some of the other enhancements since Bluetooth 4.2 include: connection orientated isochronous communication and mode 3 security for LE audio; enhanced attribute protocol to require encrypted connection to transmit data; configurable minimum key size to ensure connections have a baseline level of security; 2M PHY for faster and easier OTA updates. Bluetooth continues to innovate in this area to meet requirements for existing and emerging use cases.

For a deep look at security features in Bluetooth LE and some comprehensive design recommendations, we recommend

Passive eavesdropping

When a third malicious device listens in to the information exchanged between the other two paired devices and is able to understand the data (either with access to the encryption key or because the data is not encrypted).

Man in the Middle (MITM) attack

When a third malicious device mimics the two paired devices and intercepts the communication being shared between them. Each of the devices (central and peripheral) connect to this third device thinking it's the original paired device. The third device then reroutes the data so the paired devices are unaware of the attack and may even insert false data into or remove actual data from the communication packet. This type of attack is also referred to as active eavesdropping.

Identity tracking

When a malicious third party tracks the devices and users by their Bluetooth address. Bluetooth LE allows radios to use random addressing that can change on a regular basis, so identity tracking is mitigated

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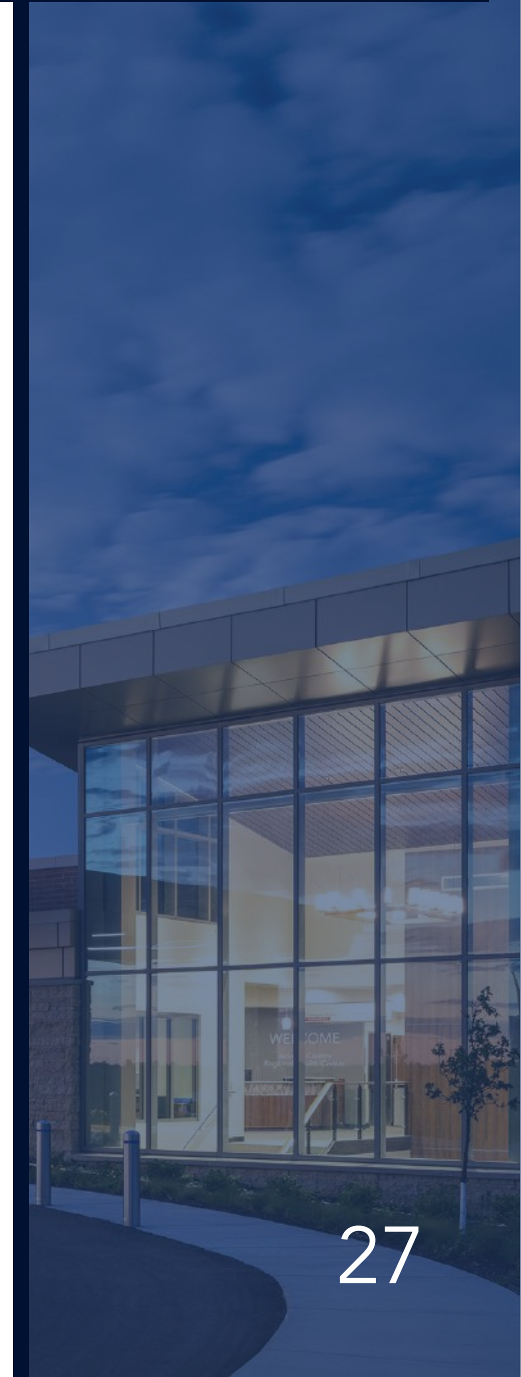

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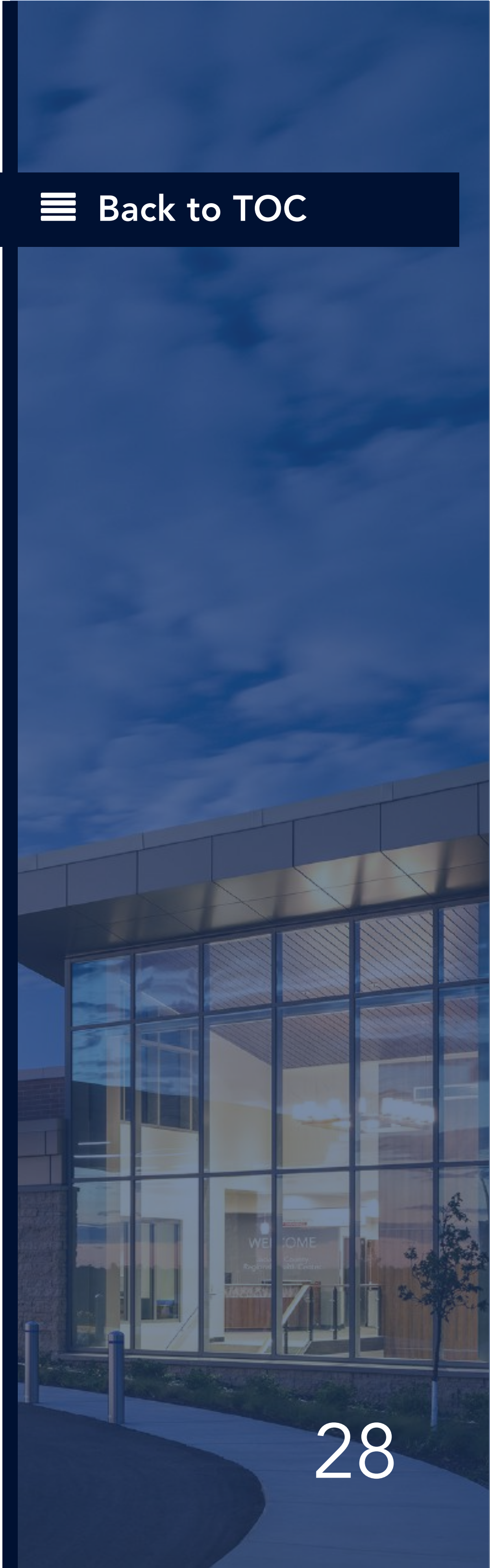
reading the Bluetooth **SIG's Bluetooth LE Security Study Guide**, and in particular the recommendations it makes to developers in chapter 2.

Pairing is a three-step process for both LE Legacy Pairing and LE Secure Connections. Phases one and three are identical for both but the second phase is where the main differences lay. The following defines each of these phases and explains how they are different.

	LE Legacy Pairing (Bluetooth 4.0 and 4.1 devices)	LE Secure Connections (Bluetooth 4.2 and later devices)
Phase 1	**Pairing Feature Exchange** The two Bluetooth devices exchange the following information: • I/O capabilities • Authentication requirements • Maximum link key size • Bonding requirements	
Phase 2	**Key Generation Method Selection** **Short Term Key (STK) generation** The two devices exchange a TK in order to generate the STK using one of the following pairing models: • Just Works • Passkey • Out-of-Band (OOB)	**Long Term Key (LTK) generation** The two devices generate an LTK to encrypt the connection using one of the following pairing models: • Just Works • Passkey • Out-of-Band (OOB) • Numeric Comparison
Phase 3	Transport Specific Key exchange (optional)	

NOTE: LE Secure Connections uses a FIPS-compliant algorithm called Elliptic Curve Diffie Hellman (ECDH) public key cryptography. This method provides enhanced security against threats such as passive eavesdropping and MITM attacks because no information is transmitted over an unencrypted link that can be used to establish or spoof the encryption keys.



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The following are detailed descriptions of the pairing methods mentioned in the previous table:

Just Works

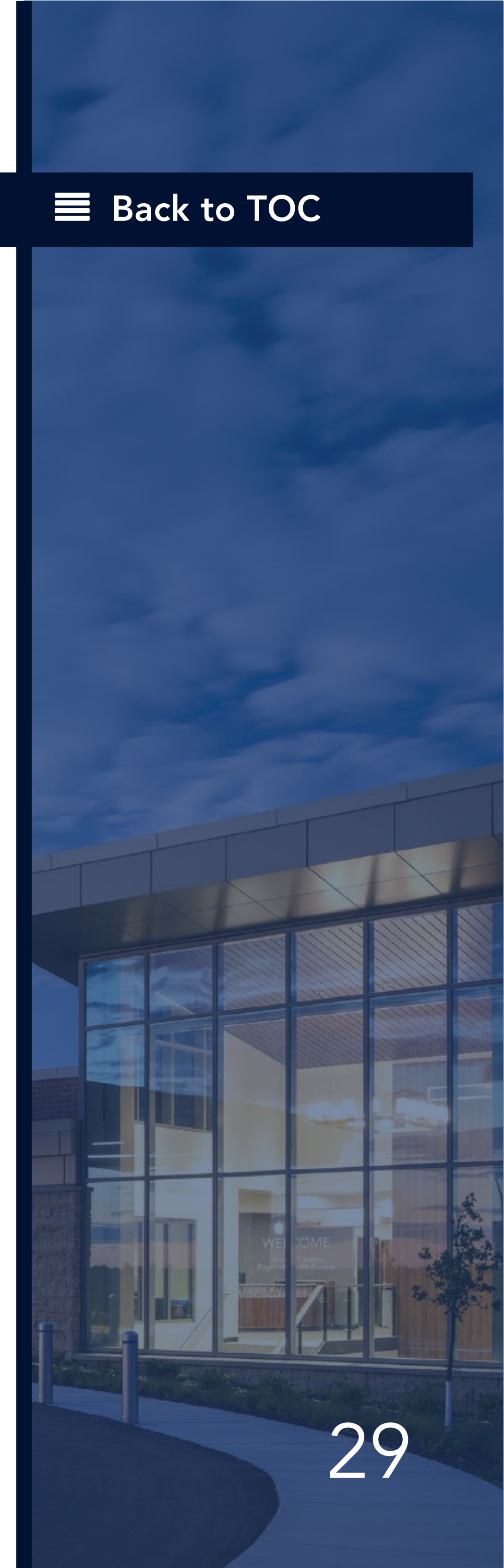
In this model, the six-digit TK is set to all zeros. This method is common especially for devices with no display (such as a speaker or headphones). Because the TK is set to 0, it's fairly easy for an attacker to eavesdrop on the connection. Also, this method provides no MITM protection because it offers no way to verify the devices involved in the connection.

Passkey

With this method, the user passes the TK between the devices as a six-digit number. This can be done in a variety of ways. For example, one of the devices may generate a random six-digit number that is then displayed on an LCD for the user to manually enter into the other device (Bluetooth pairing in automobiles, for example). Unless an attacker is listening during this pairing process, this method is relatively secure from passive eavesdropping. It is also considered secure from most MITM attacks as long as the attacker cannot acquire the passkey in another way (other than the Bluetooth LE connection).

OOB

With Out of Band pairing, a different wireless technology (such as NFC) is used to exchange the TK. One significant benefit of this type of exchange is the fact that a very large TK (up to 128 bits) can be used. With the larger TK, security is enhanced. The Bluetooth LE connection is protected from MITM attacks and passive eavesdropping as long as the OOB channel is also protected from these two attacks. Of these three legacy pairing methods (Just Works, Passkey, and OOB), OOB is the most secure.



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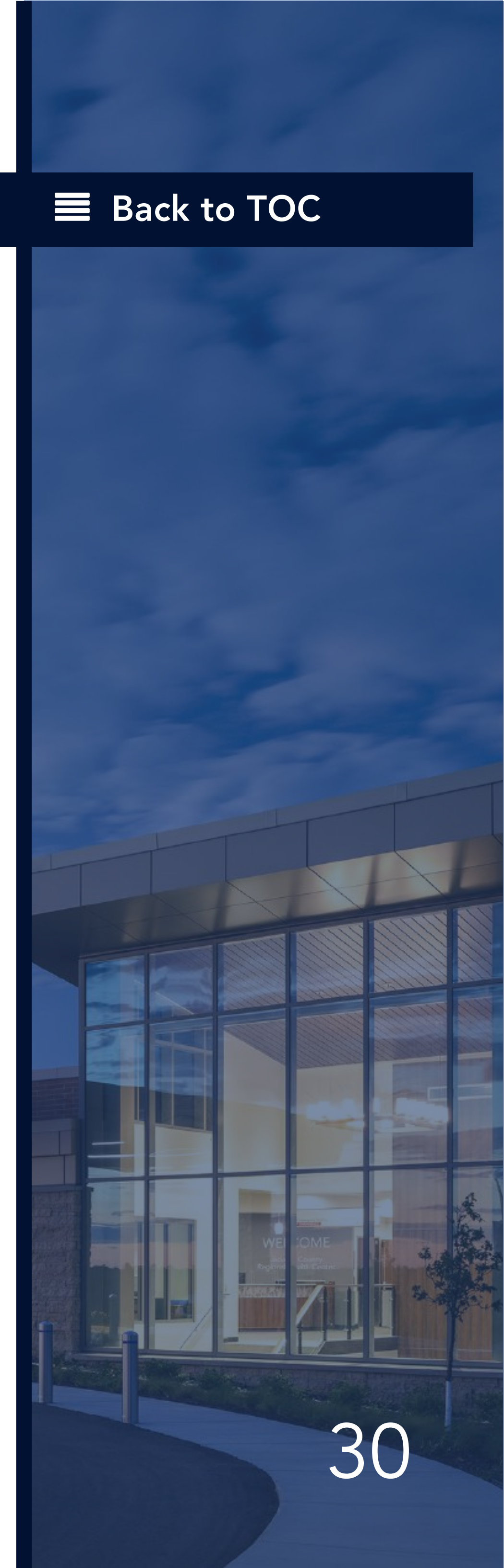
Numeric Comparison

This method functions identical to Just Works except that it adds an extra step at the end. After the initial confirmation, both devices then independently generate and display a final six-digit number. The user must then manually confirm that both values match before the connection is approved. This extra step is what protects this method from MITM attacks.

Because of its advanced protection against threats such as passive eavesdropping, MITM (active eavesdropping), and identity tracking, the advanced LE Secure Connections (LESC) and LE Privacy v1.2 offered with Bluetooth 4.2 (and later) devices provide the enhanced security required for critical environments such as hospitals and other healthcare facilities.

Note: For more information on this pairing process, refer to the Bluetooth SIG website for a series of pairing 'tutorials': ***https://www.bluetooth.com/blog/bluetooth-pairing-part-1-pairing-feature-exchange/***



Conclusion: Ready for Prime Time

Hospitals are full of people, equipment, obstacles. People spend a lot of time in hospitals with their cell phones, video games, and other potential sources of RF interference.

Hospitals and other healthcare facilities are critical environments where reliable and secure wireless connectivity is vital. Because these environments are already flooded with wireless signals and early Bluetooth pairing could be easily cracked, it was easy to say no to Bluetooth. It seemed counter-productive to add another RF technology to an already-congested 2.4 GHz frequency band and risk experiencing interference and disruption of wireless communication. Maintaining consistent and reliable connections between RF devices was far too critical in a healthcare setting to take the risk.

But, as Bluetooth technology has evolved to be more secure, more and more applications that leverage this technology have come into play, even in medical spaces. Personal monitoring devices such as fitness trackers and glucose monitors leverage Bluetooth and because of the increasing use of these devices, critical care environments have recognized the usefulness of this technology. In addition to these monitoring devices, it's also being effectively used as a wire replacement in hospital operating rooms and other medical locations where a high number of devices are in use. Simply put, with its low-power consumption ability, its prolific global use, and its scalability, Bluetooth is a great add-on to wireless infrastructures that support critical healthcare settings.

Laird Connectivity's Bluetooth Modules:

Implementing a Bluetooth solution for your product has never been this easy. Our Bluetooth module portfolio is designed to provide robust performance, easy global certification and simple implementation to accelerate your entire new product devel-

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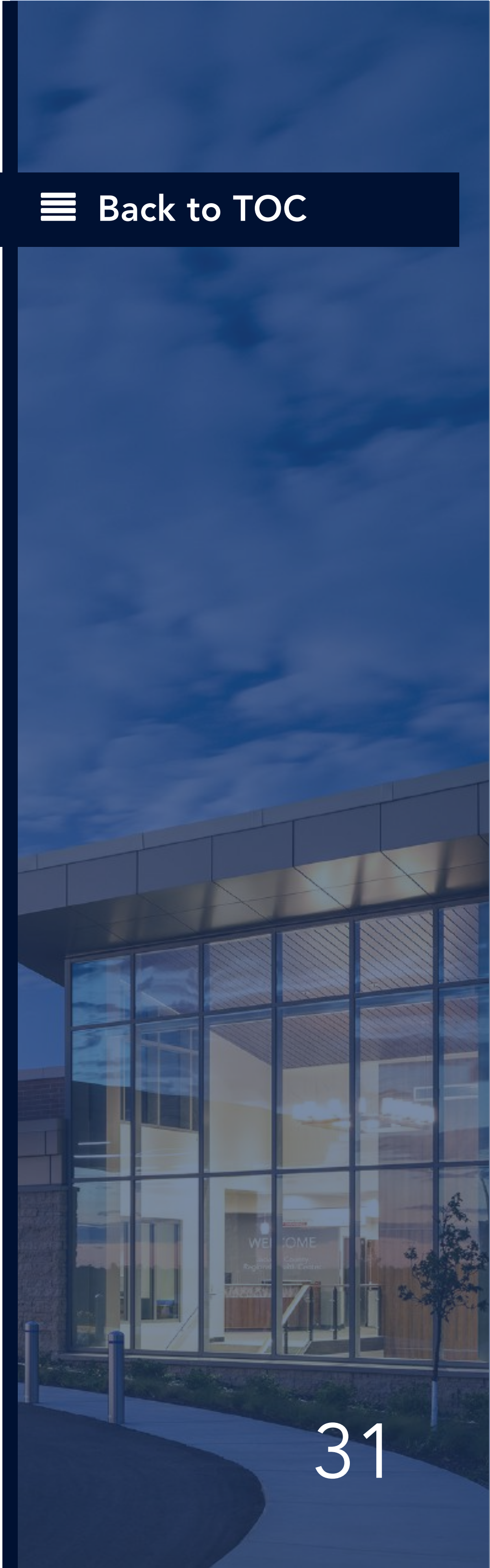

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opment cycle. We are the ideal Bluetooth/Bluetooth Low Energy (BLE) partner to help you simplify your next Bluetooth design. For more than 15 years, we have developed and produced Bluetooth modules, products and associated development kits.

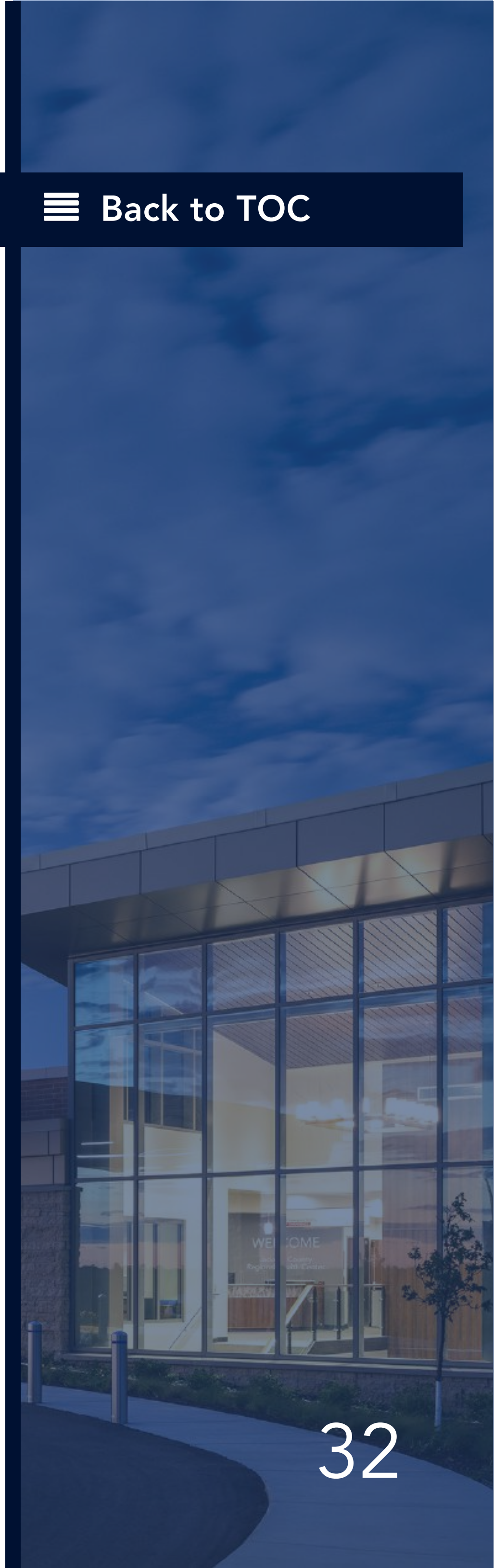
Our portfolio spans the full Bluetooth connectivity range from the latest Bluetooth LE 5.4 modules to Classic Bluetooth BR / EDR. They support some of the latest software features such as Bluetooth LE audio — all available in software stack onboard or host-based modules.

For more information, visit **lairdconnect.com/bluetooth**

About Laird Connectivity:

Laird Connectivity simplifies wireless connectivity with market-leading RF modules, system-on-modules, internal antennas, IoT devices, and custom wireless solutions. Our products are trusted by companies around the world for their wireless performance and reliability. With best-in-class support and comprehensive product development services, we reduce your risk and improve your time-to-market. When you need unmatched wireless performance to connect your applications with security and confidence, Laird Connectivity Delivers – No Matter What.

Learn more at **lairdconnect.com**



Case study: Hospital achieves resilient design

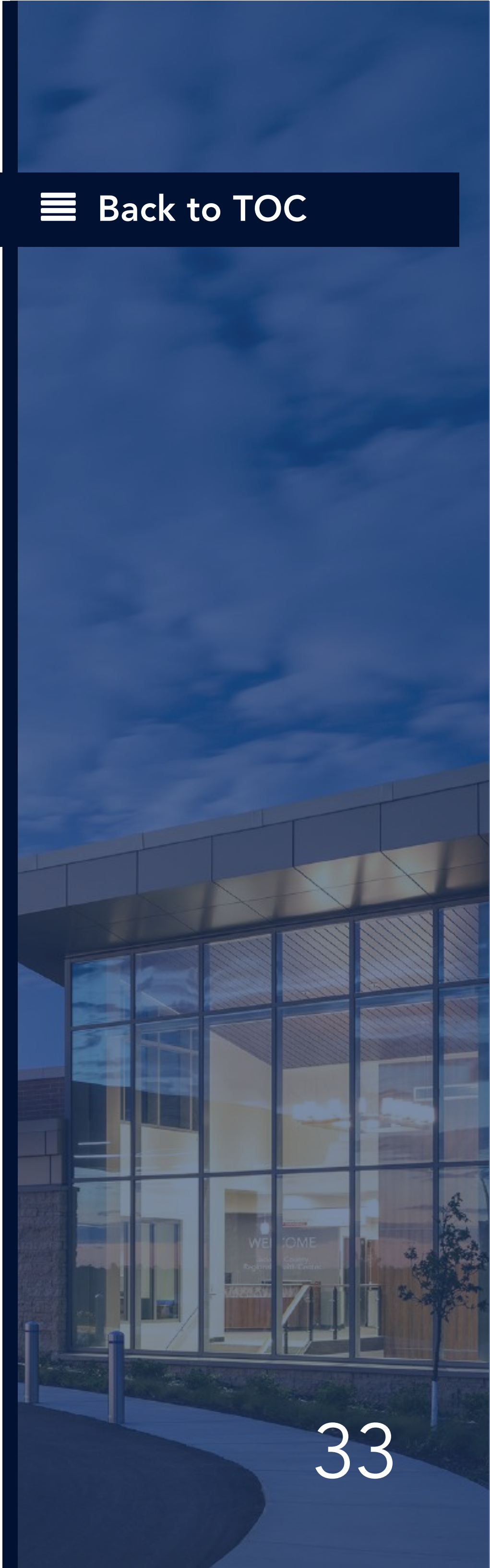
Well in advance of COVID-19, Silver Cross Hospital designed for resiliency measures no one could have predicted

In 2008, Silver Cross Hospital embarked on the initial planning for a 760,000-square-foot replacement hospital in the Chicago suburb of New Lenox, Ill. The new facility's planning included an all-private and family friendly 289-bed facility program with med/surge, pediatric, obstetrics, intensive care unit, behavioral health and rehabilitation beds. To best support the hospital's mission of providing quality services and dependable health care for a growing community, resiliency was a priority in the planning process.

Leadership at SCH, architects from CallisonRTKL, engineers from IMEG Corp. and construction management from Mortenson collaborated to ensure the topic of resilient design was discussed throughout the entire planning and design process. Throughout the project, the design and construction team held dedicated user group meetings with SCH clinical and facility operations staff to discuss emergency preparedness in the event of natural disasters, infrastructure failure, epidemics and man-made hazards. Vulnerability assessment tools were used to assess each potential hazard and provide a systematic approach to evaluate the risks and prioritize the planning.

Several resiliency measures discussed in these meetings were implemented in the final project, including:

- Building hardening.
- Infrastructure redundancy.



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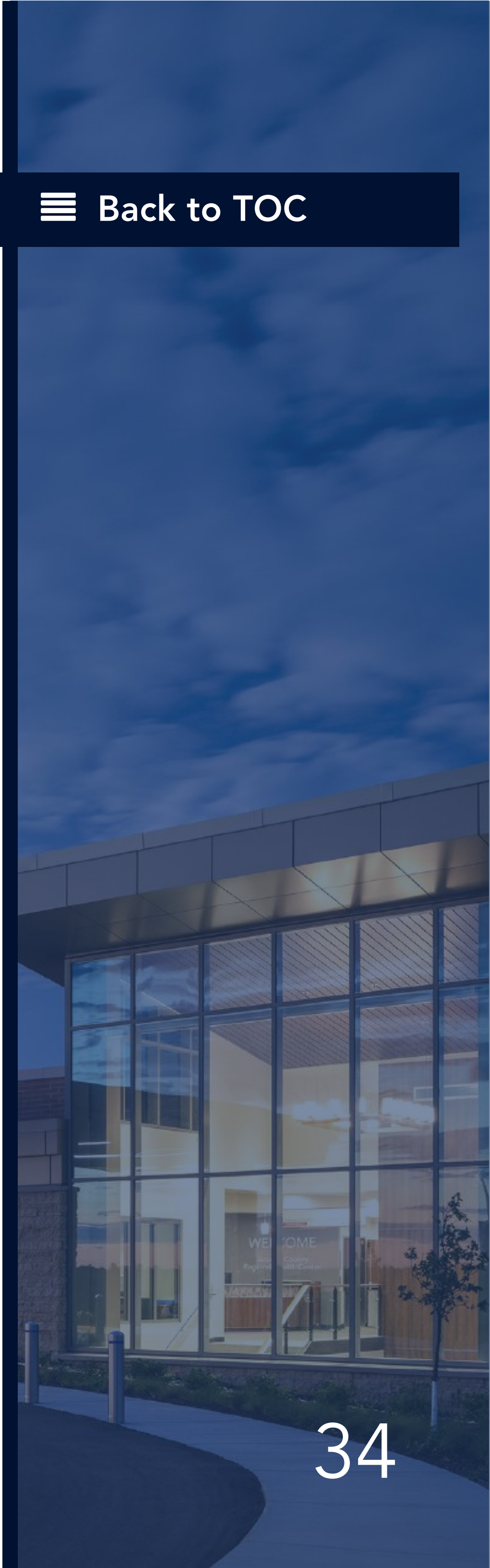
- Emergency department expandability.

Providing SCH with the flexibility to address an infectious disease outbreak was among the major topics discussed during the resiliency and emergency preparedness user group meetings. SCH infection control team members were interested finding a solution that would provide a quarantine space capable of isolating a large number of infected patients from the rest of the hospital. At the time of planning in 2008, most hospitals did not support a permanent quarantine space because it can be a substantial investment to create an area that is used rarely, if ever.

SCH requested a space for the quarantine area that would not recirculate air from the infectious disease zone and that would have a negative pressure relationship to surrounding areas. The team discussed options such as 100% outside air ventilation systems and dedicated air handling systems, but SCH challenged the design team to provide an heating, ventilation and air conditioning system that balanced first cost, operating cost and ease to implement.

The team ultimately created a design using emergency exhaust fans placed strategically to allow two wings of the inpatient bed area on the sixth floor and half of the emergency department exam rooms to switch over to 100% outside air and negative pressure wards with the push of a button.

The emergency exhaust fans were tied into the return duct distribution system for these spaces. Under normal operation, the air in these spaces is recirculated to the HVAC system through the return ductwork. But in an emergency situation, the building automation system signals a motor-operated damper on the return ductwork serving the spaces to close and an emergency exhaust system damper to open the emergency



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fans. The spaces become negative and remove the risk of recirculating air from these infectious disease zones back to the HVAC system.

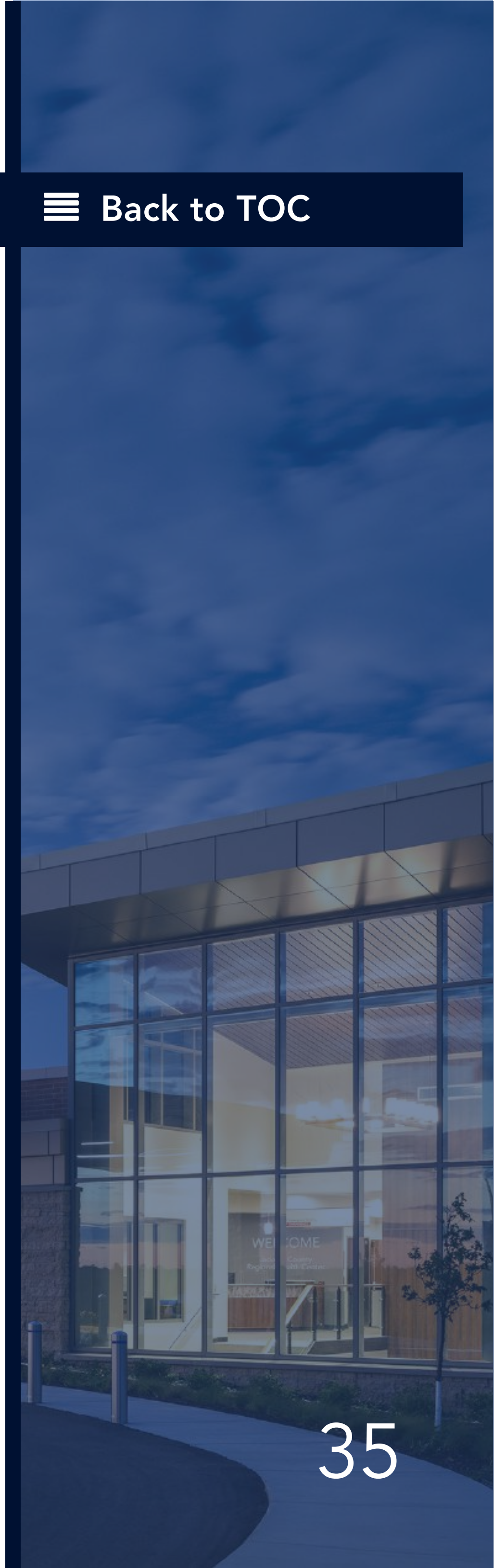
When SCH moved into its replacement hospital in 2012, both clinical and facility staff were aware of the resilient design measures put in place during design to address a potential infectious disease outbreak. As part of the ongoing disaster preparedness training, the emergency system is tested annually to ensure its operation and staff's understanding on how to implement it should the need arise.

In early 2020, the SCH clinical and facility team was prepared to quickly and easily adapt the facility and quarantine space to address the anticipated patient surge due to the COVID-19 pandemic. This seamless transition would not have been possible without the extensive resiliency measures taken more than 10 years before the outbreak.

No one on the design team or SCH's staff could have guessed when a pandemic might arise or what it would be, but significant planning and creativity equipped the hospital with the means necessary for treating COVID-19 patients while keeping staff and other patients safe from infection.

Mike Zorich

Mike Zorich *is a principal and serves as IMEG's national director of health care. He is a licensed mechanical engineer with more than 15 years of experience. Zorich previously served as the health care client executive for IMEG's Quad Cities office and has extensive experience in the design of all types of health care facilities and specialized departments.*



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Episode 32: Introducing the Summit Suite

The Summit Suite is the result of decades of software development in high-security environments, such as embedded medical devices. It includes our capabilities in secure and encrypted boot, key management, signed software images, secure storage, and more. In this video, senior product manager Dan Kephart explains how the Summit Suite performs as a secure enclave on module, support for FIPS now and in the future, and how it solves the emerging demands of industries beyond medical.


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FIPS 140-2 VALIDATED
FIPS 140-3 VALIDATED
Learn More

What healthcare IoT could mean for hospital design

IoT is going to become a major player within the healthcare industry by catering to patients and increasing efficiency.

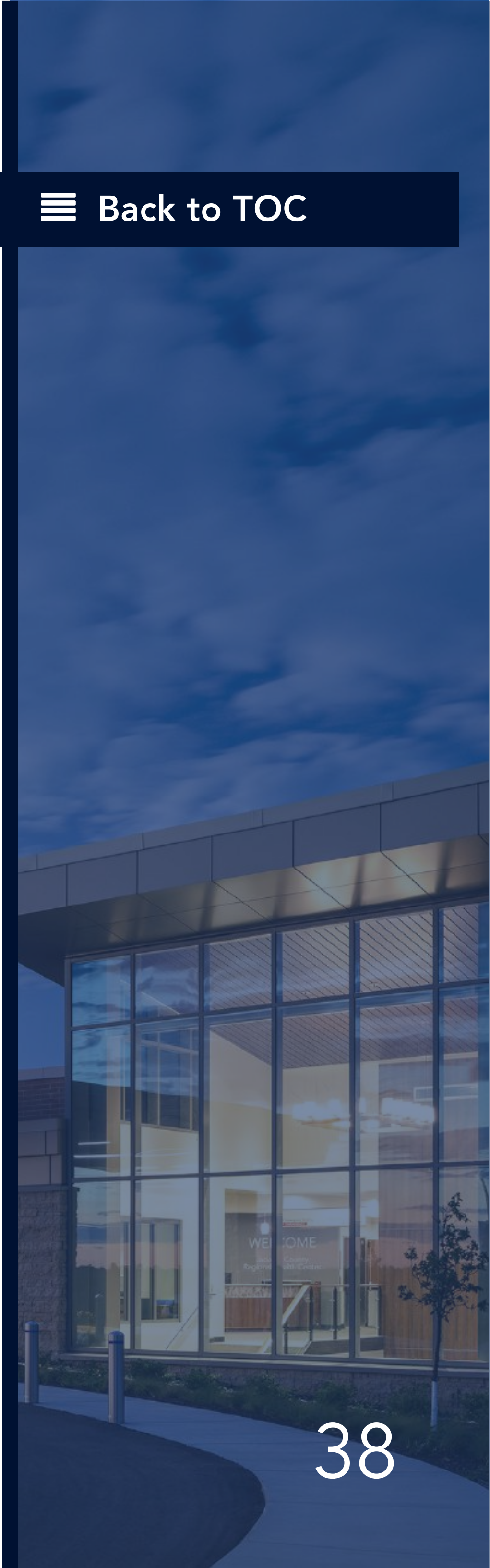
The number of internet-enabled devices in everyday use has skyrocketed in the last several years. In 2018, there were about 2.4 networked devices per capita. By 2023, that number is expected to be 3.6, which is around 29.3 billion internet-enabled devices around the world. While many will be smartphones, tablets and other personal devices, an increasing number will belong to the Internet of Things (IoT). From everyday objects to specialist equipment like CCTV cameras and medical sensors, these devices are already being used in homes, businesses and healthcare settings and are only going to continue to grow, especially in hospital design.

IoT is beginning to impact the way the healthcare industry operates and makes plans. IoT is likely to have major applications in hospitals and the wider healthcare industry because it allows doctors, nurses and hospital managers to improve patient care, patient outcomes and hospital efficiency.

What kind of applications can we expect to see? How will the IoT impact hospital design? Looking into the future of smart hospitals and examining how IoT-enabled devices could be used can provide some insight.

The IoT and healthcare

The idea of a smart hospital isn't new. Healthcare providers have been using IoT technologies to make their business processes faster, more controllable and efficient for



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years. As devices linked to the IoT become smarter, the number used in the healthcare industry will continue upward.

The IoT can provide many important applications in the healthcare industry such as:

- Safety
- Patient monitoring
- Communication
- Financial efficiency

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- Energy efficiency.

Automatic lighting and thermostats can be used to ensure patients are comfortable. Wearable, internet-enabled monitors can be used to inform doctors of a patient's condition. Ultraviolet light sanitation systems can be used to sterilize hospitals, preventing infection.

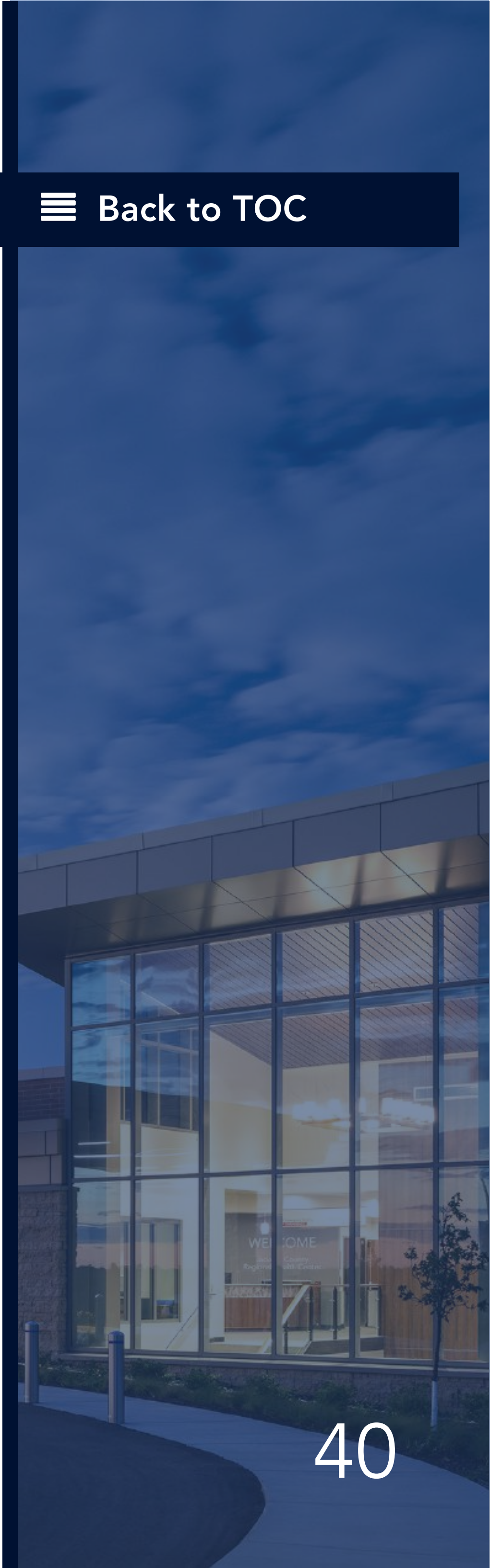
From a safety perspective, internet-enabled sensors could be used to check for smoke and fires, improving safety and decreasing instances of nuisance alarms. Smart monitoring and integrated Bluetooth emergency button systems can boost security and help to keep patients and healthcare professionals safe.

Many IoT devices aid communication between healthcare professionals and hospital departments. This can speed up services and help healthcare settings make patient care more efficient.

How IoT impacts hospital design

IoT also can impact a hospital's physical and digital design. Improved premises monitoring can help ensure a smooth flow of patients, which could minimize the need for waiting rooms and ease congestion in treatment areas.

According to the Occupational Safety and Health Administration (OSHA), cramped waiting areas and long waiting times are two major factors in violence against healthcare workers. Addressing these issues could help to reduce violence and keep hospital workers safe.



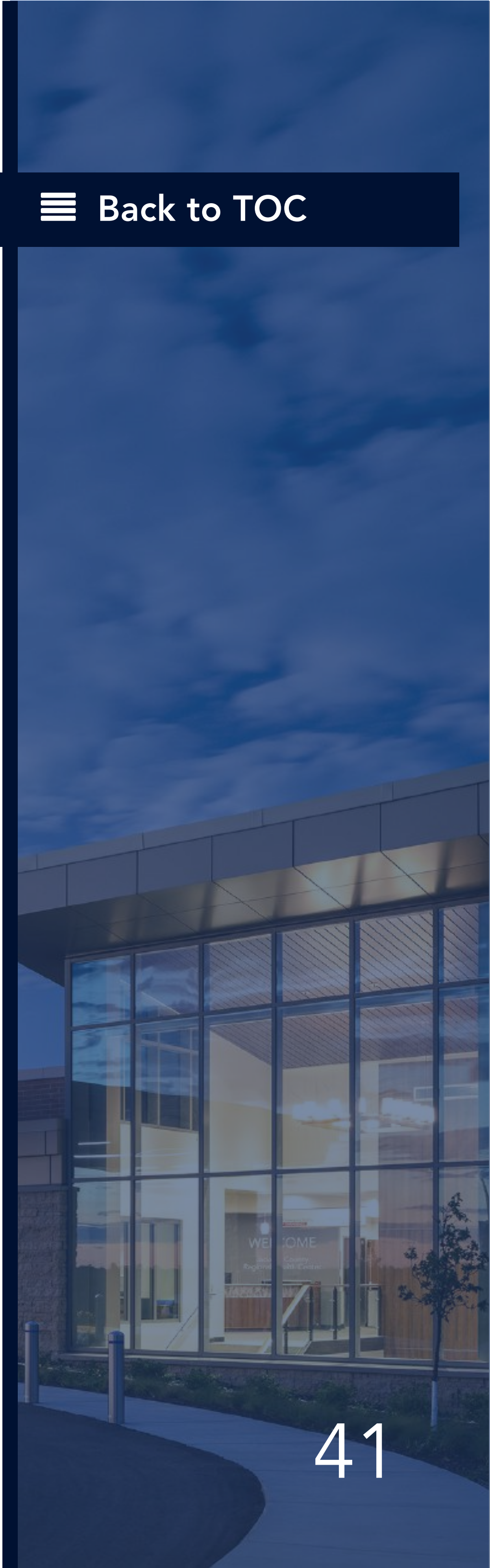
IoT will play a large role in making hospitals more energy efficient. Hospitals could be designed with automatic window shading to keep rooms cool, reducing the need for air conditioning. Motion-activated can help to reduce energy consumption, and monitoring hospital occupancy can ensure that resources are used efficiently.

The data produced by IoT will inform the future of hospital design. The data can be instantly uploaded to the cloud and analyzed to spot trends and issues. This will provide architects and engineers with information on how hospitals are used, allowing them to adjust their designs to better suit the healthcare system.

IoT is growing in scale every year. It's influencing the way hospitals by offering many possibilities for improving safety, efficiency and usability. With more and more devices being a part of IoT and technology becoming smarter and more targeted, IoT looks set to be an integral part of the healthcare industry.

Yasmine Mustafa

***Yasmine Mustafa** is a social entrepreneur and the CEO & Co-Founder of ROAR for Good. Based in Philadelphia, ROAR is a woman-led and mission-driven technology company dedicated to cultivating safer workplaces. Their staff safety platform, The AlwaysOn™, is specifically designed for the hotel industry to summon help with one touch of a button. Fueled by a passion to leverage technology for good, she leads the ROAR team in their mission to create safer workplaces and empowered communities.*



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A five-step health care emergency preparedness plan

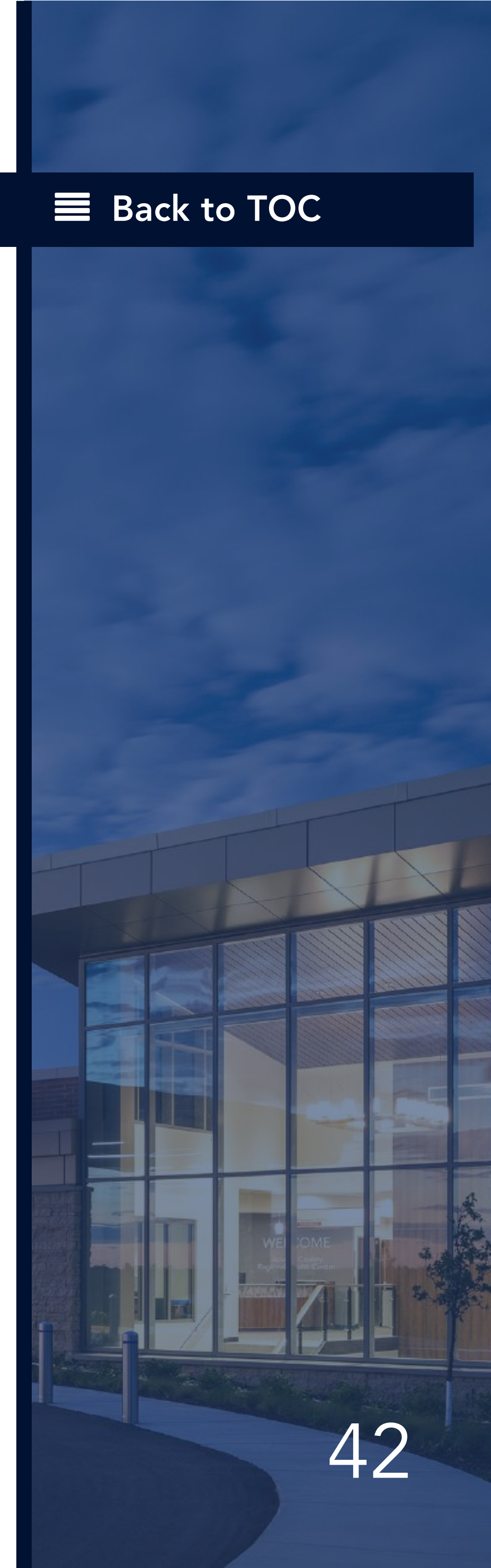
Learn about the basic concepts of emergency preparedness planning — a vital component of a health care facility's overall resiliency — and the role of the consulting engineer

We expect health care institutions and their providers to always be available in our times of need — regardless of inclement weather, natural disaster, a world-wide pandemic, active shooter event, power loss, infrastructure failure or any number of additional emergencies.

Being able to meet this expectation of uninterrupted care, however, is no small feat and requires health care institutions to conduct extensive emergency preparedness planning, training and testing. This is the only means by which they can ensure they are prepared for the wide range of scenarios that could threaten their ability to provide continuous care and service.

The depth and reach of the potential risks to health care facilities can be overwhelming. One only need recall disastrous events from 2021 — the cold weather and resulting brownouts in Texas, the wildfires in Colorado, the EF4 tornado in Kentucky and the 45 million people affected by cybersecurity breaches at health care institutions — for a short list of real-life events that can test nearby health care facilities' resiliency.

To address this concern, the risks to health care facilities are placed into four risk categories:



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- Natural disaster.
- Infrastructure.
- Hazardous materials.
- Human-made events.

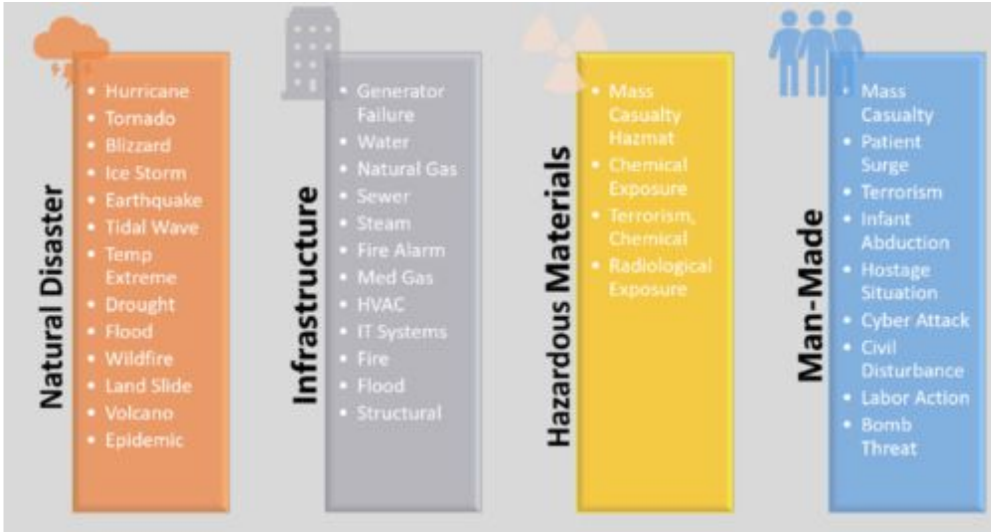


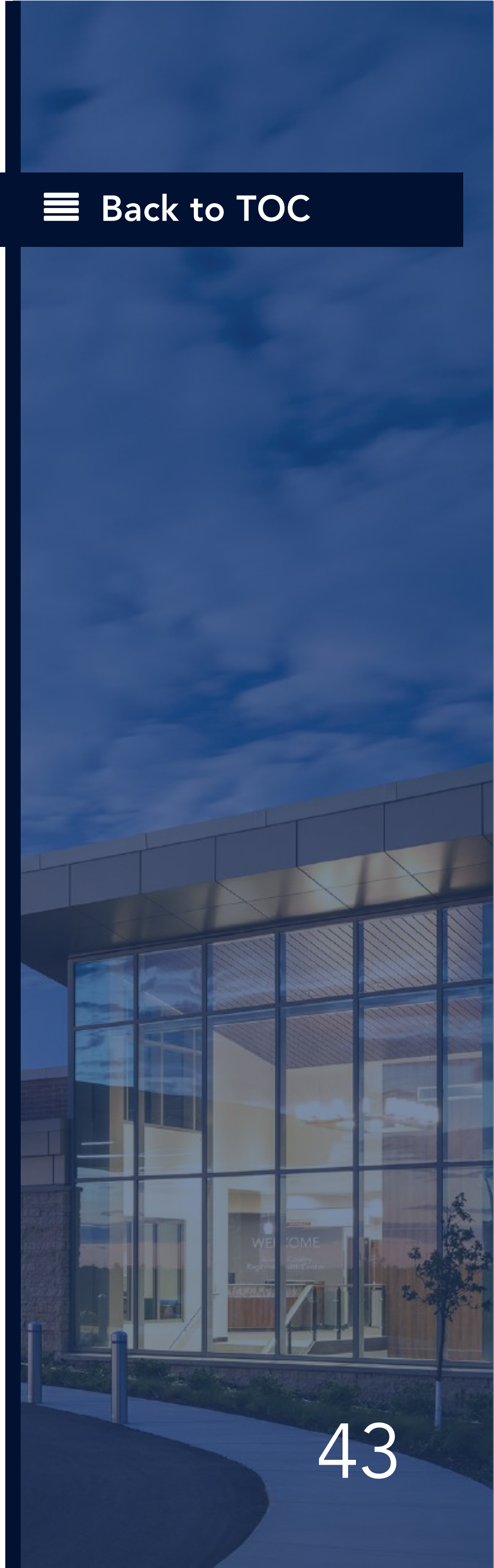
Figure 1: Health care risk categories. Courtesy: IMEG Corp.

Regardless of the type of risk, achieving resilience begins and ends with a comprehensive emergency preparedness plan (see Figure 1).

Why an emergency preparedness plan is needed

Benjamin Franklin said, “If you fail to prepare, prepare to fail.” This certainly rings true for health care institutions and what can likely happen in the absence of a comprehensive emergency preparedness plan. Having a well-thought-out emergency plan is not only a good idea, it is also required by the federal government for most health care facilities.

The Centers for Medicare & Medicaid Services requires health care institutions who receive reimbursements to comply with the Emergency Preparedness (EP) Rule, implemented in November 2017. The EP Rule covers four main components:



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- **Emergency plan and hazard vulnerability assessment (HVA):** Uses an integrated team to develop a comprehensive emergency plan based upon a site-specific risk assessment.

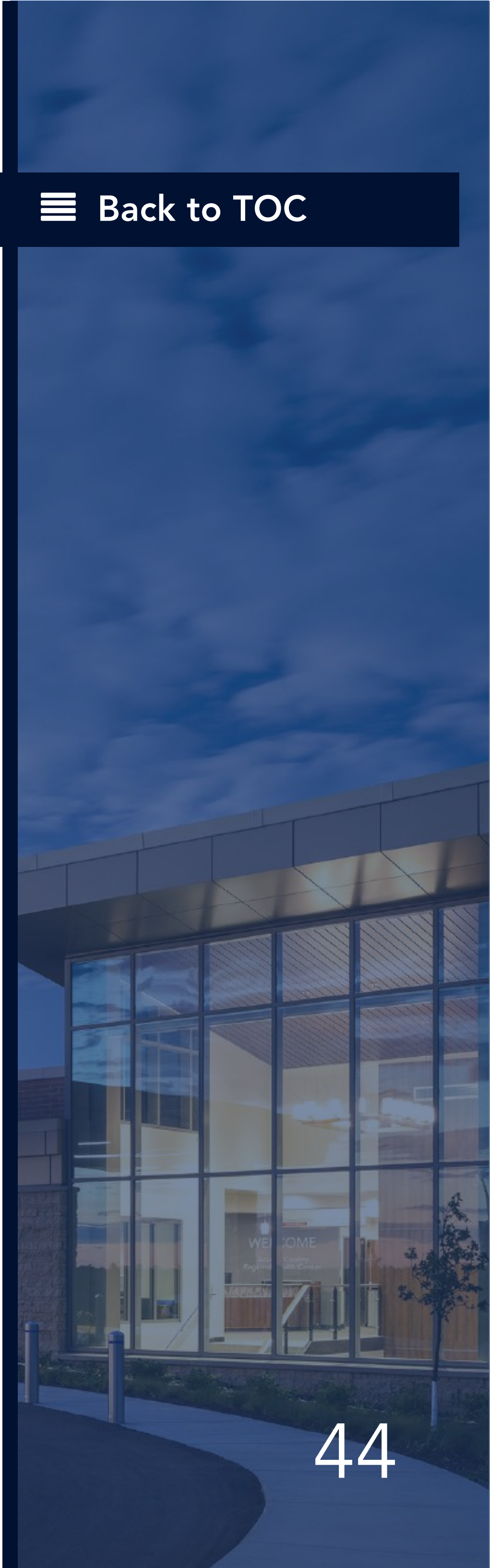
- **Policies and procedures:** Identifies the internal policies and procedures that the facility and all departments intend to deploy during various types of emergencies.

- **Communication plan:** Establishes the internal and external communication plan the health care institution intends to deploy during an emergency. This plan often includes members of the local community including law enforcement, fire departments and governmental entities.

- **Training and testing:** Requires health care facilities to test their emergency plan annually with a combination of a full-scale exercise and tabletop session.

Of the four core components of the EP Rule, consulting engineers will have the largest involvement and greatest impact on the emergency plan and HVA. This component can be completed in parallel with a major health care renovation or expansion, as part of a greenfield design or simply as a yearly validation process.

For most major threats to a health care facility, a component of mitigation before and during an event will include hardening some type of building infrastructure — HVAC pressurization, fuel storage capacity, redundant electrical feed, off-site data center, etc. Therefore, it is important for the consulting engineer to understand how a health care facility's emergency plan is developed and how to contribute to it. To aid in this understanding, following is a step-by-step process that is used by most health care institutions.



Health care emergency plan process

By implementing the following steps, the consulting engineer can effectively address a multitude of risks in a health care building design:

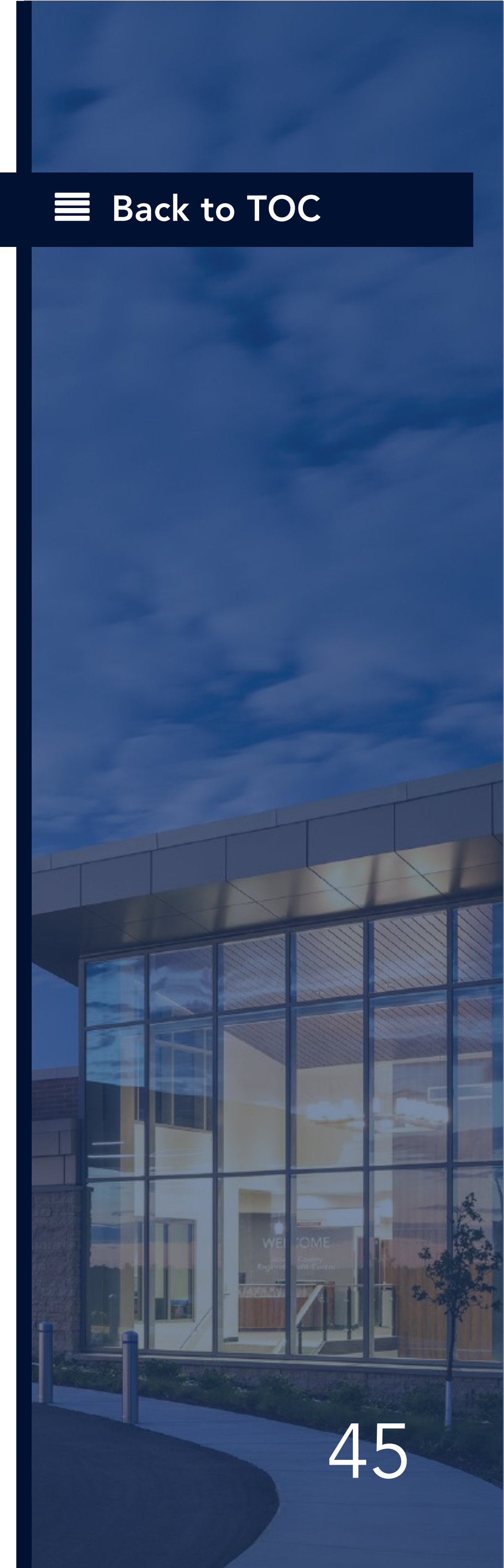
Figure 2: A diverse assessment team is critical for analyzing specific risks. Courtesy: IMEG Corp.

Step 1: Assessment

Oftentimes a health care organization will establish an assessment team to address a very particular risk and then stack the team with subject matter experts on that specific risk. For example, when evaluating a health care organization's risk for a cyberattack, an organization may establish a team consisting of the CIO, information technology leadership, engineering and an outside security software vendor to lead the emergency planning efforts.

Different risks obviously require a different assessment team makeup. In addition, such teams benefit from having a diverse group that includes not only technical experts but also clinicians with an operational perspective. For example, for a recent emergency planning exercise focusing on patient surge, the assessment team consisted of the hospital's chief nursing officer, CIP, facilities staff, architect, mechanical engineer, electrical engineer, security staff and contractor.

In all risk assessments, emergency preparedness planning deals not only with prevention, but should consist of before, during and after emergency planning components (see Figure 2).



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Step 2: Threat analysis

In this step, the assessment team conducts the HVA. The vulnerability analysis defines the severity of the risk, which incorporates the likelihood, the magnitude and the mitigation efforts associated with the risk. Key criteria to evaluate for many events includes the impact to building occupants, the building itself and the ability for the organization to maintain business operations.

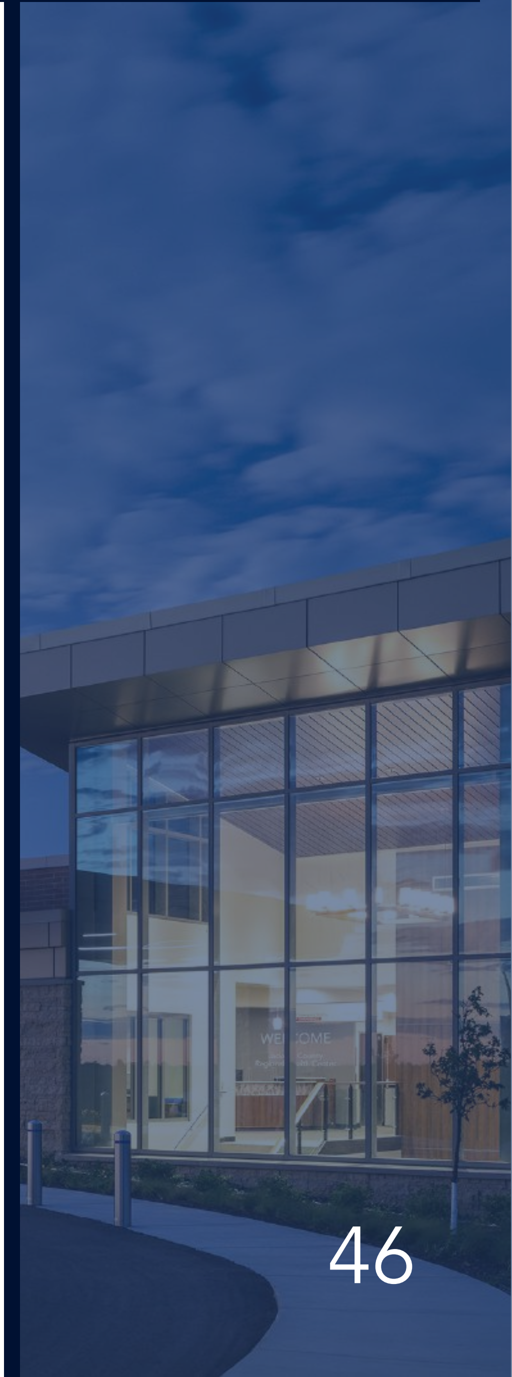
Using a qualitative tool is beneficial to the process. Many such tools are available, but a preferred tool by many organizations is the Kaiser Permanente Hazard Vulnerability Analysis Tool (see Figure 3).

EVENT	PROBABILITY	HUMAN IMPACT	PROPERTY IMPACT	BUSINESS IMPACT	PREPARED-NESS	INTERNAL RESPONSE	EXTERNAL RESPONSE	RISK
	Likelihood this will occur	*Possibility of death or injury*	*Physical losses and damages*	*Interruption of services*	*Preplanning*	*Time, effectiveness, resources*	*Community/ Mutual Aid staff and supplies*	*Relative threat**
SCORE	*0 = N/A 1 = Low 2 = Moderate 3 = High*	*0 = N/A 1 = Low 2 = Moderate 3 = High*	*0 = N/A 1 = Low 2 = Moderate 3 = High*	*0 = N/A 1 = Low 2 = Moderate 3 = High*	*0 = N/A 1 = High 2 = Moderate 3 = Low or none*	*0 = N/A 1 = High 2 = Moderate 3 = Low or none*	*0 = N/A 1 = High 2 = Moderate 3 = Low or none*	*0 - 100%*
Fuel Shortage	2	2	2	3	1	2	1	41%
Generator Failure	2	2	3	3	1	2	2	48%
Natural Gas Failure	2	2	3	3	3	3	2	59%

Figure 3: A vulnerability analysis sheet. Courtesy: IMEG Corp.

Step 3: Gap analysis

During the gap analysis, the assessment team will try to identify holes between their assumed response scenarios and actual response conditions. This is also often referred to as identifying the blind spots in a facility's operation.



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For example, the quantity of on-site fuel storage for emergency power generation is often analyzed during a gap analysis. For most locations, NFPA 99: Health Care Facilities Code dictates the code minimum for on-site fuel storage for health care facilities, but whether this is 48 or 96 hours of fuel capacity, the limitation of this key infrastructure needs to be coordinated with the operational intent of the facility. Solutions to expand fuel capacity include pre-negotiated fuel service contracts or electrical load shedding,

Step 4: Cost analysis

The previous steps will help the identification of risks and development of options on mitigation. Options for mitigation could range from minor changes in internal communication plans to major options that consider compartmentalized air handling units with 100% outside air capability.

Most planning exercises will develop several options, but it is not economically feasible to spend financial resources on each disaster scenario. The cost analysis step looks at the combination of the likelihood of the risk, the additional cost required to mitigate or reduce the risk and the cost should the risk occur with the worst-case impact. Taking these three items into account allows the health care organization to make an informed financial decision.

Step 5: Testing and implementation

The final step in the process is to conduct internal testing to evaluate the effectiveness of the health care organization's emergency preparedness plan.

Inpatient facilities are required by the CMS EP Rule to perform one full-scale exercise

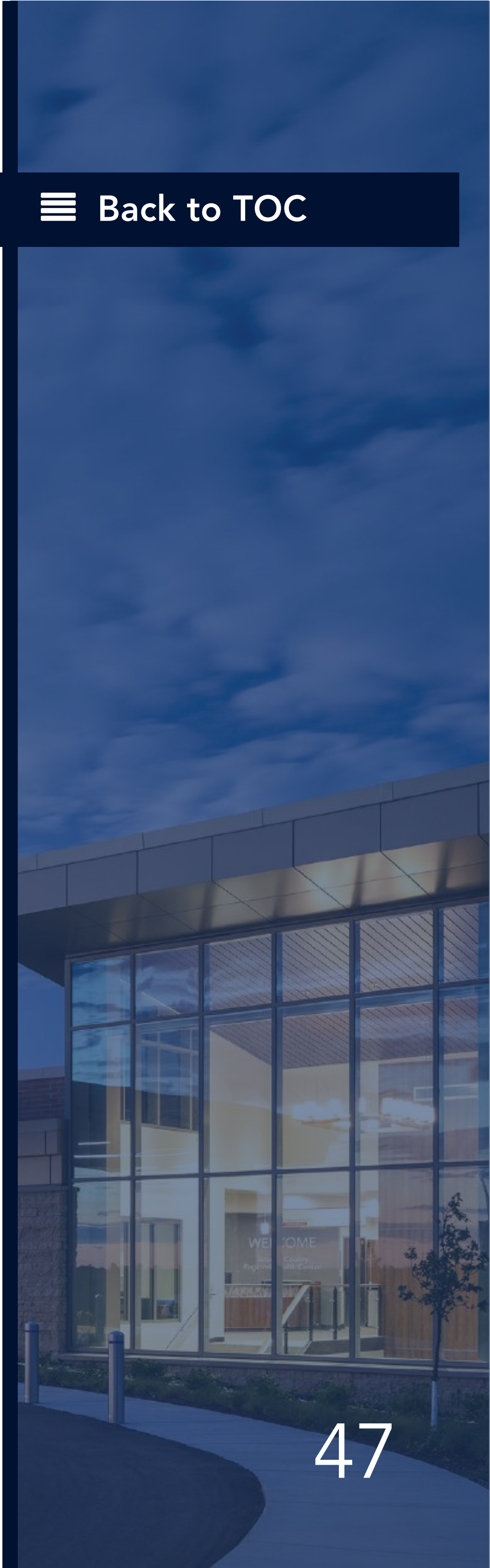

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Figure 4: The risks to health care facilities are placed into four risk categories: natural disaster, infrastructure, hazardous materials and human-made events. Courtesy: AJ Brown Imaging, IMEG Corp.

and at least one other exercise of their emergency preparedness plan each year. The additional exercise is often a table-top session in which several stakeholders work through an emergency event. The team walks through the before, during and after scenarios and makes modifications as need.

System specification

Health care engineers are well versed in the code requirements for health care facilities and the high level of attention required on major infrastructure for life safety and continuous operation. This includes requirements for essential electrical systems, N+1

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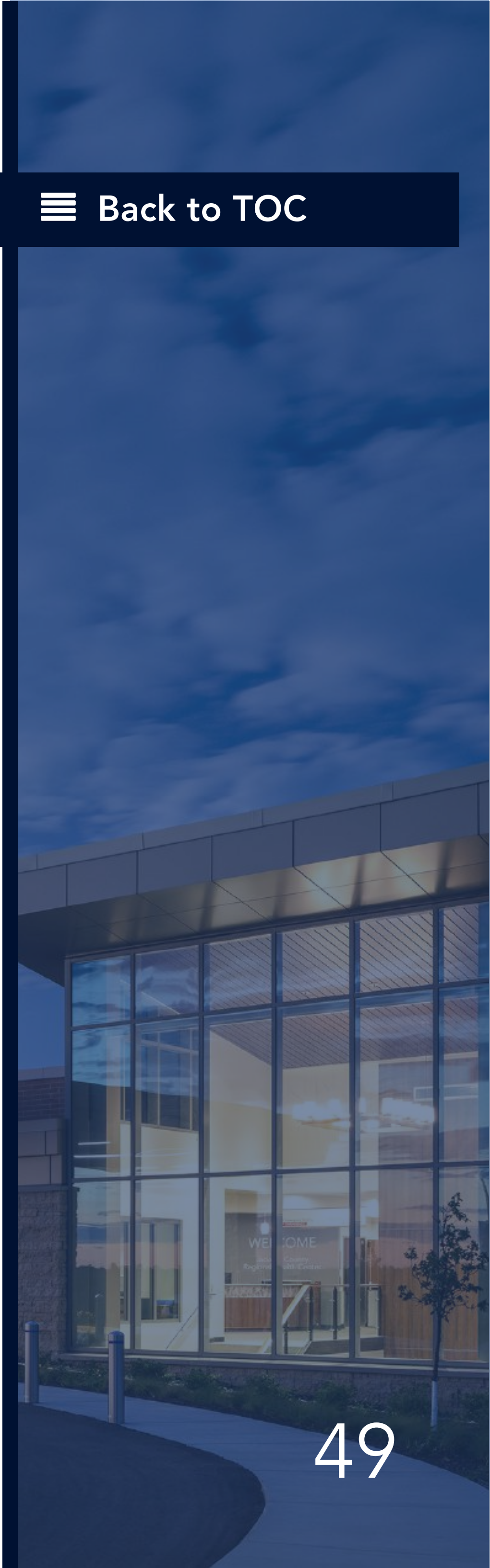
heating, mass notification systems, etc. However, a health care facility's comprehensive emergency preparedness plan is often deemed as scope or responsibility outside of design.

At a minimum, consulting engineers have an obligation to ask their health care clients how their designs will impact the organization's current emergency plan and encourage a review that involves several members across the organization.

Though no facility wants to undergo a worst-case scenario, emergency preparedness can help health care clients mitigate the impact of an incident, allowing them to continue delivering quality care to their patients and protecting employees and the community at large.

Mike Zorich

Mike Zorich *is a principal and serves as IMEG's national director of health care. He is a licensed mechanical engineer with more than 15 years of experience. Zorich previously served as the health care client executive for IMEG's Quad Cities office and has extensive experience in the design of all types of health care facilities and specialized departments.*



Designing for healthcare provider health, wellness, and retention

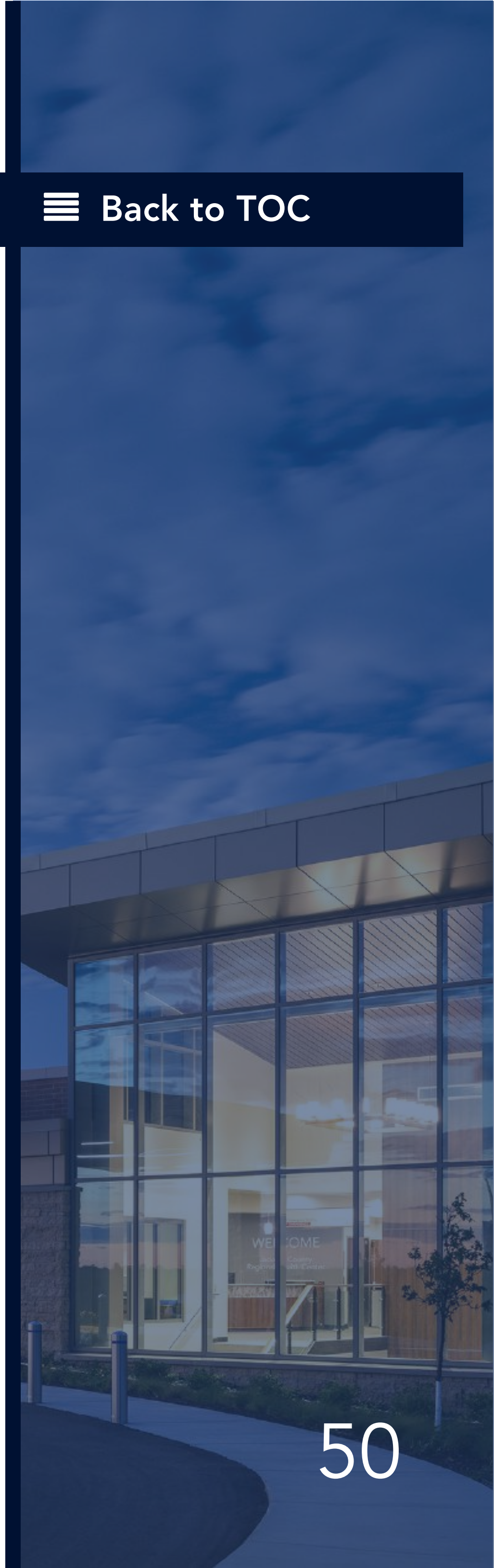
Current trends show a focus on the needs of healthcare workers.

For years, healthcare design has been focused on the needs of patients, and with good cause. But current trends, accentuated in large part by the pandemic, are casting a similar spotlight on healthcare workers. The enduring health, wellness, and retention of the more than 22 million healthcare workers nationwide is essential to the success of our nation's healthcare system, and it takes a carefully thought through plan and actively engaged healthcare administrators to successfully and effectively design to improve the patient and healthcare worker environments.

Impact of High Healthcare Turnover

While many professions deal with turnover problems, healthcare has recently taken it to a new level. According to indeed.com, the average U.S. hospital has turned over 91% of its workforce in the past five years with 60-65% of all turnover happening in the first year of employment. The cost to replace one registered nurse is estimated to be 1.3 times salary. Nurse dissatisfaction has been shown to be the most consistent predictor of turnover, adverse events, and patient dissatisfaction.

Causes for the high turnover rate include high levels of stress, exhaustion, and burnout, which has been exacerbated by the pandemic. 18% of healthcare workers have left the profession altogether since the pandemic began, and another 12% have been laid off. Healthcare staff have often cited empty pandemic promises regarding workplace well being from healthcare administrators as a reason for considering quitting their position. Other primary factors for leaving include family needs and violence in



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the healthcare setting. Data from 268 nursing units at 100 hospitals indicate higher levels of turnover are associated with increased medical errors and patient falls. Additionally, workforce challenges are also compounded with the nurse population rapidly aging.

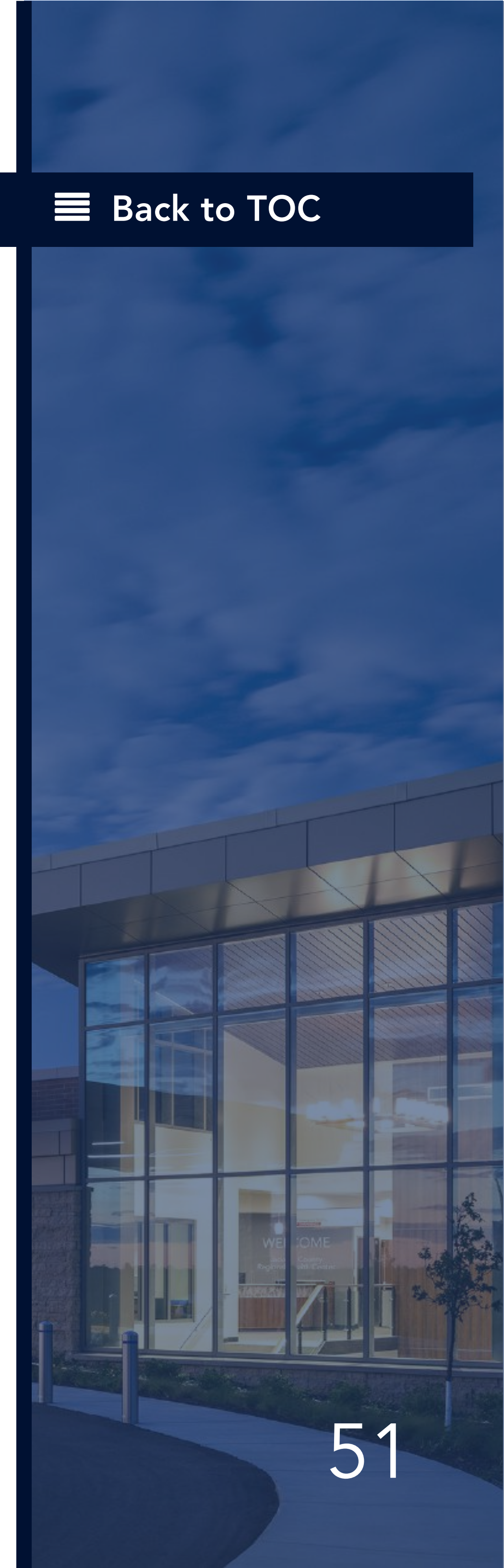
Courtesy: Dewberry

Incorporating Design Elements that Promote Well Being

Design can improve working conditions of healthcare staff in many ways and at an affordable cost. By adhering to WELL Building Standards—air, water, nourishment, light, fitness, comfort, and mind—designers can positively impact the staff experience. Impacts can include reducing staff stress and anxiety which can lower risk for other conditions such as heart disease, high blood pressure, diabetes, obesity, and depression. Changes as simple as new ceilings, new wall paint, and floor finishes can make spaces much more inviting, comfortable, and help relieve stress. Similarly, removing walls and barriers to create more open space and to allow for direct lines of sight can have a positive impact on the mental health and wellbeing of occupants.

Other positive design strategies include:

- Technology/equipment upgrades



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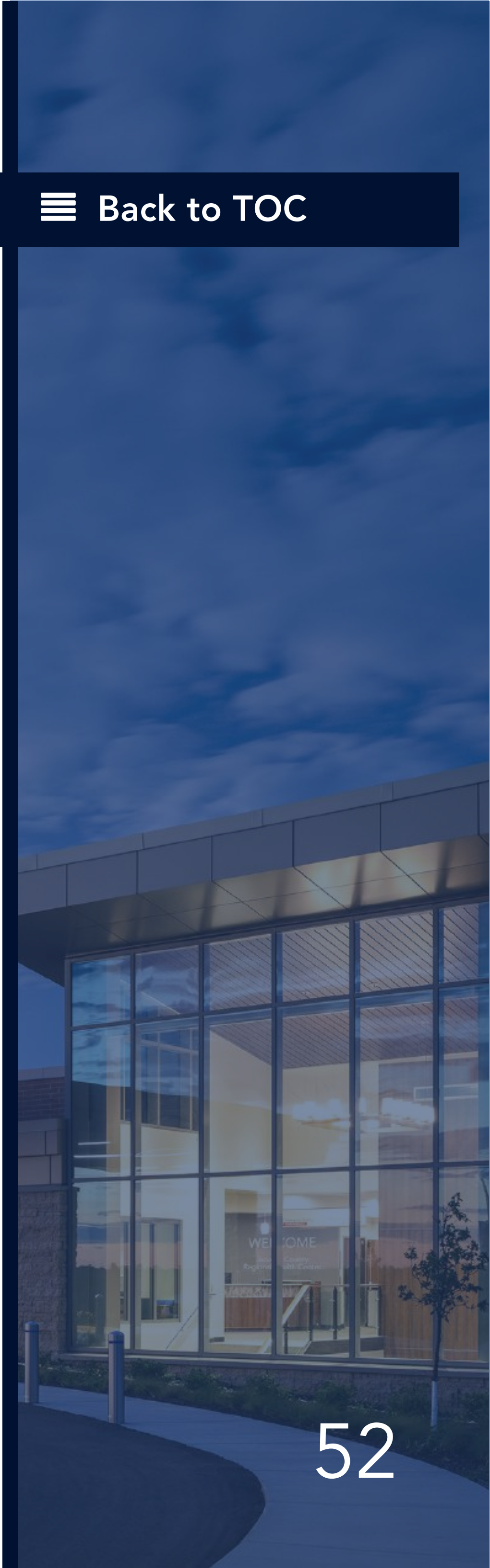
- Touch-down spaces
- Increasing artificial and natural light
- Ergonomic solutions
- Scenic views
- Tranquil colors
- Landscaping/green roofs
- Water features
- Acoustical privacy/respite areas

Designers should be the tip of the spear in recommending to clients the benefits of WELL design. Some best practices architects and consultants can offer to aid health-care administrators include:

- Listen to staff. Promote ownership of solutions.
- Consider more break room and relaxation space on the same or different floor
- Change space use or cross-utilize spaces



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- Consider separating patient-facing from non-patient-facing spaces to improve staff circulation and efficiency

- Consolidate non-patient-facing staff space in proportion to remote work opportunities

- Maximize use of unused departments, floors, units, or wings

- Design flexible new space for future similar needs

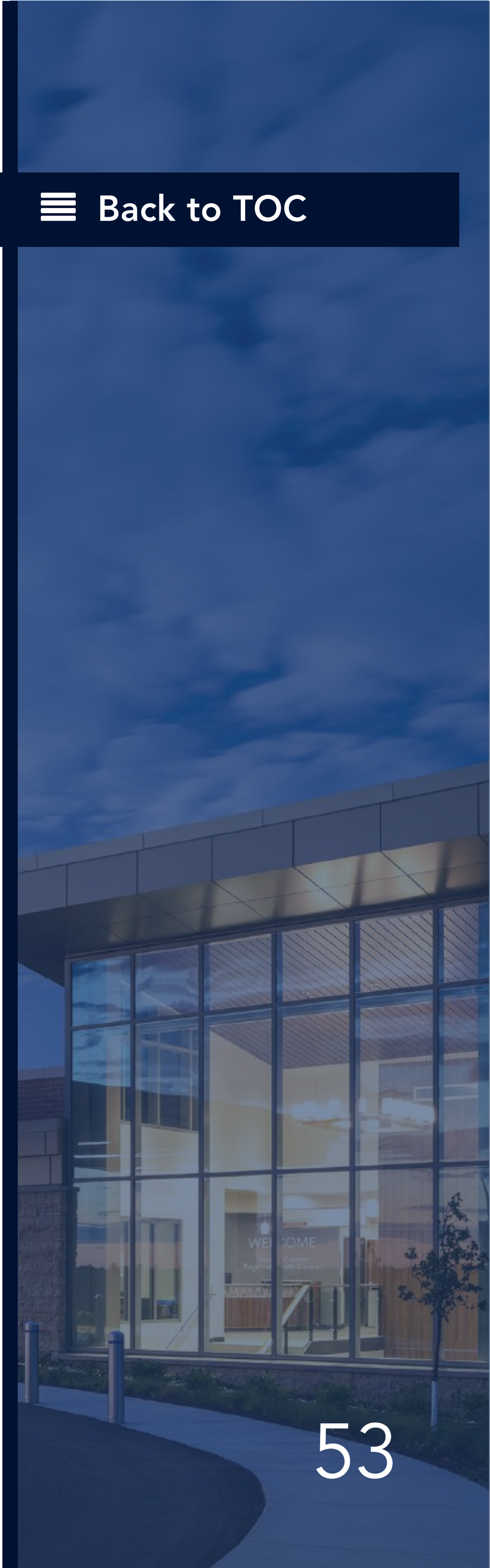
- Verify code compliance

Staff Satisfaction = Patient Satisfaction. It All Begins with Leadership.

There are many design strategies that help improve healthcare staff retention, but it ultimately requires commitment from healthcare leadership to engage in these projects. Strong healthcare leaders find value in a meticulous strategic plan that considers the wellbeing of patients and staff in equal measure. According to research, staff satisfaction scores increase at nearly three times the increase in leadership scores, so there is a strong return on investment. Effective leaders invite deep staff participation, set priorities and goals for project outcomes, and follow through with implementation of agreed upon staff-focused solutions. Healthcare leaders don’t need to tackle all of this on their own, architecture and design consultants can help build an effective plan and can offer the best recommendations when it comes to implementing the benefits of WELL design.

David Huey

***David Huey** is President of Dewberry Architecture.*



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