A Guide on Building the Infrastructure to Support Telemedicine Delivery

FITZEMEYER & TOCCI ASSOCIATES, INC.

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Building the Infrastructure to Support Telemedicine Delivery Guide

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About this Guide

Remote patient care and treatment through telemedicine provides healthcare organizations with the ability to increase patient-provider interaction at a lower overall cost of service at a rapid internet speed. In addition to improved patient care and convenience, telemedicine provides the societal benefit of extending quality healthcare to rural and other underserved areas and may reduce the overall carbon footprint of healthcare delivery. This guide explores and summarizes the unique physical infrastructure requirements and best practices for creating and maintaining a telemedicine center, whether in an existing healthcare setting or as a stand-alone facility.

This guide will enable readers to:

- Explain what telemedicine is and how it is used in clinical settings
- Identify the requirements to achieve optimal acoustic and visual conditions in a telemedicine setting
- Develop reliable electrical and cooling system infrastructure for telemedicine facilities
- Give examples of the environmental and societal benefits of telemedicine

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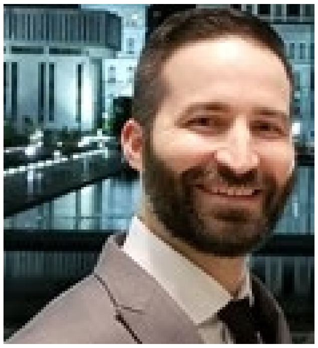

Ted Carlman

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1 Background

Background

Telemedicine is the remote diagnosis and treatment of patients by means of telecommunications technology or two-way, real time interactive communication between a patient and a healthcare professional at a controlled, distant site. This healthcare delivery method provides the means to deliver a wide range of clinical services to patients quickly, effectively and cost efficiently by means of electronic communication. This communication method uses a variety of digital communication modes such as digital video cameras, audio devices, internet telecommunications, robotic telepresence, mobile devices and other technologies. It also requires securely transmitting medical images, charts, and other patient data. Telemedicine differs from **telehealth** in that it refers solely to clinical healthcare services.

Telemedicine can be especially beneficial to patients in isolated communities or remote regions, who can receive care from doctors or specialists far away without the patient having to travel far to visit them. This will greatly improve patient access to medical care and emergency services that may not be otherwise available. Emergency telemedicine can connect patients and first responders from two or more locations during an actual event. Doctors can remotely evaluate these patients, make diagnoses, and provide support and treatment to first responders at an emergency site or a local hospital.

Recent developments in **mobile collaboration** technology can allow healthcare professionals in multiple locations to share information and discuss patient issues as if they were in the same place. Remote patient monitoring through **mobile technology** can reduce the need for outpatient visits and enable remote prescription verification and drug administration oversight, potentially significantly reducing the overall cost of medical care. Telemedicine is also beneficial for injured patients and those with limited mobility.

Early Development

A misconception is that telemedicine is a new technology or healthcare delivery method, when it has been around since with the invention of the telephone in 1879. This was the first doctors used a non “face-to-face” means of communication with patients in an effort to reduce office visits. It was predicted that in 1925 doctors would be using both radio and television to communicate with patients.

The first radiologic images were sent via telephone was in 1948. Video was added to telemedicine in the 1960’s for use with psychiatric consultants and patients with the use of closed-circuit television (CCTV) and considered a major milestone. In 1961, the U.S. Space Program used medical monitoring systems from space to earth via telemetric link to monitor vital life systems of the Apollo astronauts. NASA had a great impact on patient monitoring in this decade.

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With the development and implementation of the internet in the 1990's, this was another breakthrough in the IT infrastructure for telemedicine, along with the subsequent development of the smart phone and tablet technology.

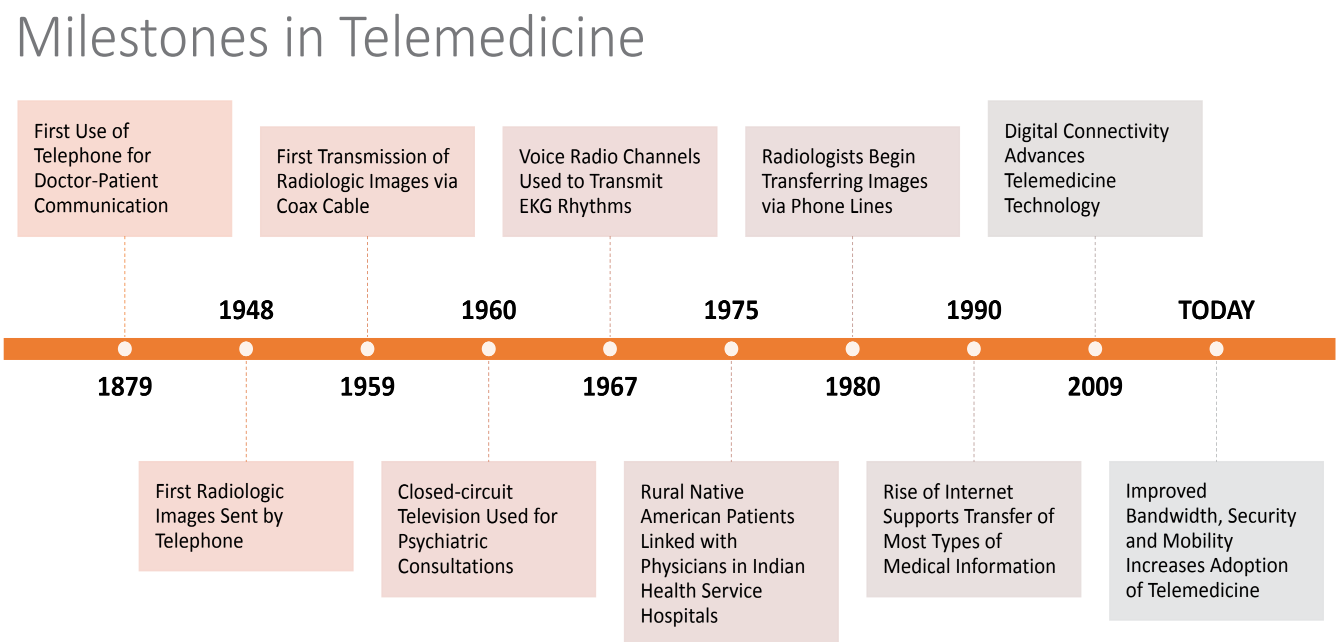

Figure 1: Milestones in Telemedicine (source: CDW Healthcare)

More recently, in 2014 the National Defense Authorization Act expanded the use of telemedicine for military members. In 2016, $16 million was award to the Health Resources and Services Administration (HRSA), an agency of the U.S. Department of Health and Human Services to improve healthcare to people who are geographically isolated, economically or medically vulnerable.

Figure 2: The handling, storage, and security of data is a crucial part of telemedicine delivery infrastructure.

The Current Trend

With the current trend in healthcare focusing on cost-efficiency and convenience, coupled with the establishment of telemedicine services in large, urban-based and community hospitals and emergence of retail outpatient facilities and micro-hospitals (small-scale, inpatient facilities with eight to 15 short-stay beds), telemedicine has created a new tool for how we plan and design these facilities.

Remote patient care and treatment through telemedicine provides healthcare organizations with the ability to increase patient-provider interaction at a lower overall cost of service at a rapid internet speed. In addition to improved patient care and convenience, telemedicine provides the societal benefit of extending quality healthcare to rural and other underserved areas. Over time, it will also likely provide an environmental benefit by reducing the overall carbon footprint of healthcare delivery.

Figure 3: Telemedicine is included as part of the common elements for both hospitals and outpatient facilities in the 2018 FGI Guidelines. Photo: Arizona telemedicine program

This guide explores and summarizes the unique physical infrastructure requirements and best practices for creating and maintaining telemedicine facilities, whether in an existing healthcare setting or as a stand-alone facility. The intent of this guide is to provide healthcare capital planning and facilities personnel with information and recommendations for planning and implementing telemedicine facilities.

2 Telemedicine Facilities - The New Clinical Realm

The delivery of effective clinical telemedicine services requires providing suitable settings for both the provider and patient that foster genuine human interaction. Ease and quality of communication, comfort (both physical and psychological), and physical adaptability are key factors in the design of systems and infrastructure supporting telemedicine facilities. In order to meet the standards of care for telemedicine, the following three requirements in telemedicine settings must be addressed:

- **Providing effective acoustics** for clear, uninhibited communications between patient and provider, isolated from surrounding noises and other audible distractions;
- **Assuring clear and direct visual communication** between the two parties, uninhibited from peripheral distractions, as well as effective lighting suitable for both clinical examination and facial expression recognition; and
- **Establishing resilient telecommunication infrastructure** to provide effective and continuous audio-visual communications, unencumbered by occasional disruptions in line power and voice and data service.

Ultimately, spaces designated for telemedicine operations should strive to maintain the same level of privacy, safety, quality of care and patient experience that would be expected during an in-person clinical exchange between patient and provider.

Spaces designated for telemedicine operations should strive to maintain the same level of privacy, safety, quality of care and patient experience that would be expected during an in-person clinical exchange

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The Provider Perspective

Telemedicine provider settings are envisioned to include individual workstations providing visual and audial privacy. Each workstation may include multiple display screens and cameras allowing natural eye-to-eye contact with the patient. They also typically feature movable screening devices and sound-absorptive material, especially when provider workstations are situated in an open area.   Light sources for workstations are designed to produce diffused light to reduce shadows, while background screening is often pattern free and of a neutral color.

Workstations can be clustered into small groupings of workstations allowing for practitioner collaboration.   Workspaces may also include larger conference and smaller meeting rooms. Ultimately, flexibility is key for telemedicine workspaces that can accommodate changes in clinical services and technology over time.

Figure 5: An example of modular telemedicine workstations in an open setting. Photo: Mercy Virtual Care Center

Figure 4: A telemedicine workstation featuring a movable screening device and sound absorptive materials. Photo: Herman Miller, Inc.

Communication and Privacy

Ensuring effective—and confidential—communication between the provider and patient is paramount in telemedicine delivery. The providers must use headsets rather than speakerphones or loudspeakers to have conversations with patients. As with any open plan environment, sound isolation between workstations is not as good as between closed offices, so it is possible that one provider's voice as picked up by another provider's microphone could be audible and intelligible to the patient. To reduce this audibility, use highly sound absorptive ceilings and absorptive wall panels through the open plan spaces and barrier screens between providers. Also, use highly directional noise-cancelling headset microphones positioned close to the talkers' mouths and use sound masking in the space loud enough to cover up the remaining adjacent conversation sounds but quiet enough not to cover up the voice of the provider wearing the microphone. The headsets should cover both ears and should have high passive noise reduction to reduce distractions to providers from nearby providers having other conversations.

The Patient Perspective

Providing compassionate clinical care to patients through telemedicine requires careful selection of settings, equipment and background. In clinical settings, telemedicine services are offered from either dedicated telemedicine rooms or with portable equipment in conventional exam rooms. In either case, attention must be given to providing privacy for the patient from casual observers outside the procedure or consultation space. Walls that extend to the deck and doors that are gasketed are required. Furthermore, the background of the patient space must include colors and finishes to maintain a natural rendition of color and pattern, while the lighting systems should be selected to avoid shadows and glare. The staff must be able to use the audio and visual technology to facilitate a productive conversation between clinician and patient.

Figure 6: A mobile telemedicine clinical workstation. Photo: Facility Guidelines Institute

Figure 7: A telemedicine exam room. Notice the use of neutral colors to avoid the subject appearing either too dark or washed out. Photo: Facility Guidelines Institute

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Ensuring Effective Audio Communications

A video conferencing system attempts to replicate an in-person conversation as closely as possible. Our biological systems can adapt to challenging environments that help us to listen and focus in on information that is important to us. A listener in the same room as the talker can understand the talker despite this acoustical interference because the interfering sounds arrive at the listener's ears at different times and from different directions than the direct sound from the talker.

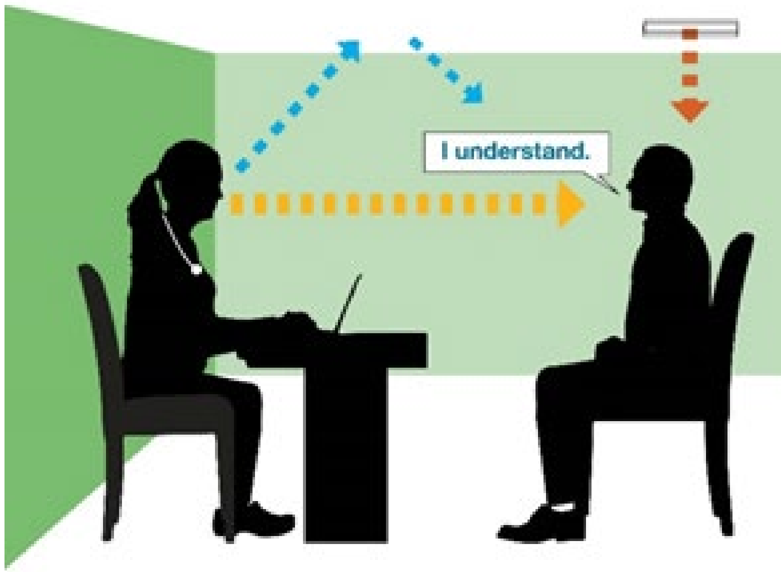

FIgure 8: Communication with speaker and listener in same room. The yellow arrow represents the direct sound, the blue arrow the sound reflections, and the orange arrow mechanical noise.

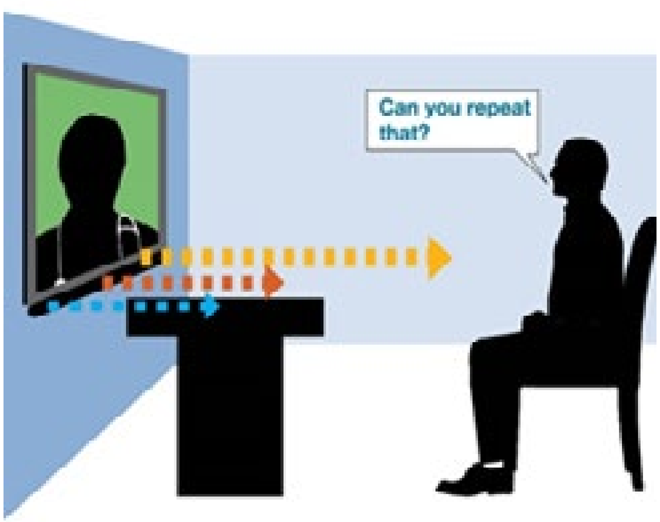

FIgure 9: Communication with speaker in remote room, untreated.

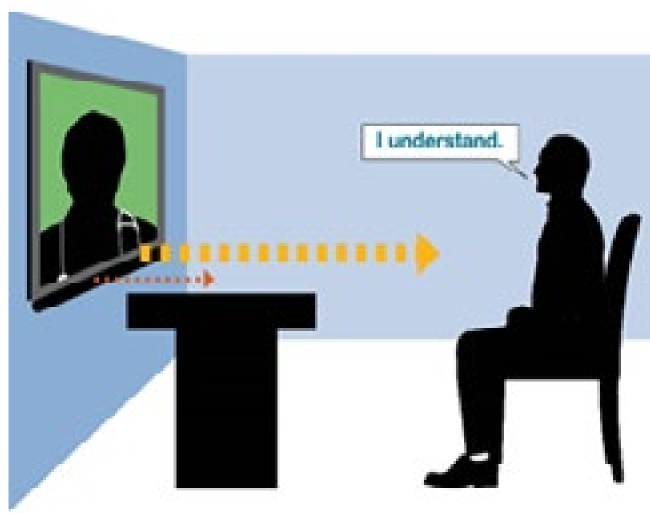

Figure 10: Communication with speaker in remote room, acoustically treated.

Audio Communications content and graphics provided by ***Acentech, Inc.***

An electronic system does not know what is important information (signal) or what is not (noise). When a microphone is placed at a distance from the talker, the interfering sounds are picked up by the microphone and played through the same loudspeakers as the direct sound on the remote end. All the sound from the talker's room is being sent from the same direction. This combination of sounds at the same loudspeakers makes it difficult for the listener to separate the talker's direct sound from the interference, making the talker harder to understand (Figure 9).

If the source room is treated by using a sound absorptive ceiling, absorptive panels on some of the walls, and a quieted mechanical system, the signal sent to the listener consists mostly of the direct sound and is easier to understand (Figure 10). The microphone should be as close as possible to the people talking in order to maximize the ratio of signal to noise reaching the microphone. The sound levels from building mechanical systems should be as low as possible; these levels would preferably be as low as NC-25 but no higher than NC-30.

Resiliency

Spaces designed for telemedicine must have suitable electrical power, including emergency backup power for services involving videoconferencing. Telemedicine facilities in inpatient settings providing continuous patient monitoring such as in Intensive Care Units require automatic power transfer switching for continuous monitoring operations.

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3 Telemedicine Infrastructure Solutions

Electrical Requirements

Rooms and facilities designated for telemedicine require sufficient and reliable power. It is important during design to understand the technologies and equipment to be utilized in the telemedicine rooms or areas and plan appropriately for the power and data requirements. The increased data requirements for telemedicine lead to increased telecommunication infrastructure. The telecommunication infrastructure then leads to increased power requirements for the facility.

The power requirements for telemedicine vary depending on the application. Telemedicine facilities and infrastructure includes telemedicine service centers, exam rooms, kiosks and the data centers required for the support of the facilities.

Telemedicine service centers consist of individual cubicles in various configurations as described in Section 2. The cubicles are provided with video communication equipment. The power requirements for these centers will be higher than a general office building due to the quantity of video communication equipment required. Additionally, the telecommunications infrastructure required to support the facility will be greater than a typical office building. Increased telecommunications infrastructure include larger or more telecommunications rooms with additional servers, video management and storage, associated uninterruptible power sources (UPS's) and increased cooling requirements. During the design of a telemedicine facility, it is important to take in to account the effects of the increased telecommunications infrastructure on power requirements.

FIgure 11: Telemedicine service center workstations.
Photo: The Commonwealth Fund

Exam rooms utilizing telemedicine services will have increased power requirements for the video communication systems. A typical exam room will have outlets for convenience and computers. In a telemedicine exam room, there are additional requirements for the camera(s), microphone(s) and speakers. A typical exam room's power density is roughly 2 Watts per square foot (W/SQFT), not including lighting or HVAC power requirements. With the addition of telemedicine equipment, the overall exam room power density would increase to roughly 4 W/SQFT. This additional load effectively doubles the power requirements of a typical exam room. Depending on the quantity of telemedicine exam rooms in a facility, the additional power density required for telemedicine equipment could result in a significant increase to a facility's overall electrical load.

Data centers associated with the facilities utilizing telemedicine will have higher power requirements. Telemedicine facilities have increased telecommunication requirements as well, which translates to more equipment required to support and store the data. Additionally, the more equipment required the higher the cooling requirements for the data center.

Reliable power is required not only for the specific telemedicine exam rooms, but also for any of the required healthcare provider's telecommunications infrastructure, including associated telecommunications rooms and data centers.

Telemedicine centers require no downtime in power or communications. A typical solution to providing uninterruptable power would be to provide UPS's in the patient care/exam rooms as well as for the telecommunications infrastructure. UPS's are a temporary solution and ensure power is provided until another source of power can be provided. Depending on the size and requirements of the facility, alternate power sources may be either an on-site standby generator or a second utility source or even both.

An on-site standby generator would be sized to support any loads required to maintain the functionality of the facility and telemedicine. With a single utility source and a generator, in the event the utility source goes down, the generator will run until the utility source is back on. As with any generator installation, the placement of emergency generators in close proximity to telemedicine spaces must be carefully considered to minimize noise and vibration transmission. Emergency generator systems require maintenance and regular testing to ensure a reliable and functioning system.

In order to provide a secondary utility source coordination is required with the utility to determine what is required. With two utility sources there are multiple options for the distribution, including, a main-tie-main distribution system with automatic transfer controls or separate switchboard/ switchgear that are redundant, and automatic transfer controls. In order to be more reliable, the additional utility service should be obtained from a different utility substation than the first service. This ensures that if there is an issue at one substation or after this would not affect the second service.

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For data centers, the general solution is to provide separate utility sources and standby generators. The utility sources feed either the main-tie-main switchboard or separate switchboards/switchgear with fully redundant distribution equipment down to the distribution panelboards utilizing automatic transfer switches to switch between services. Generators are typically provided to be redundant in the same manor that the utility services are. This provides greater redundancy and ensures the likelihood of downtime is low.

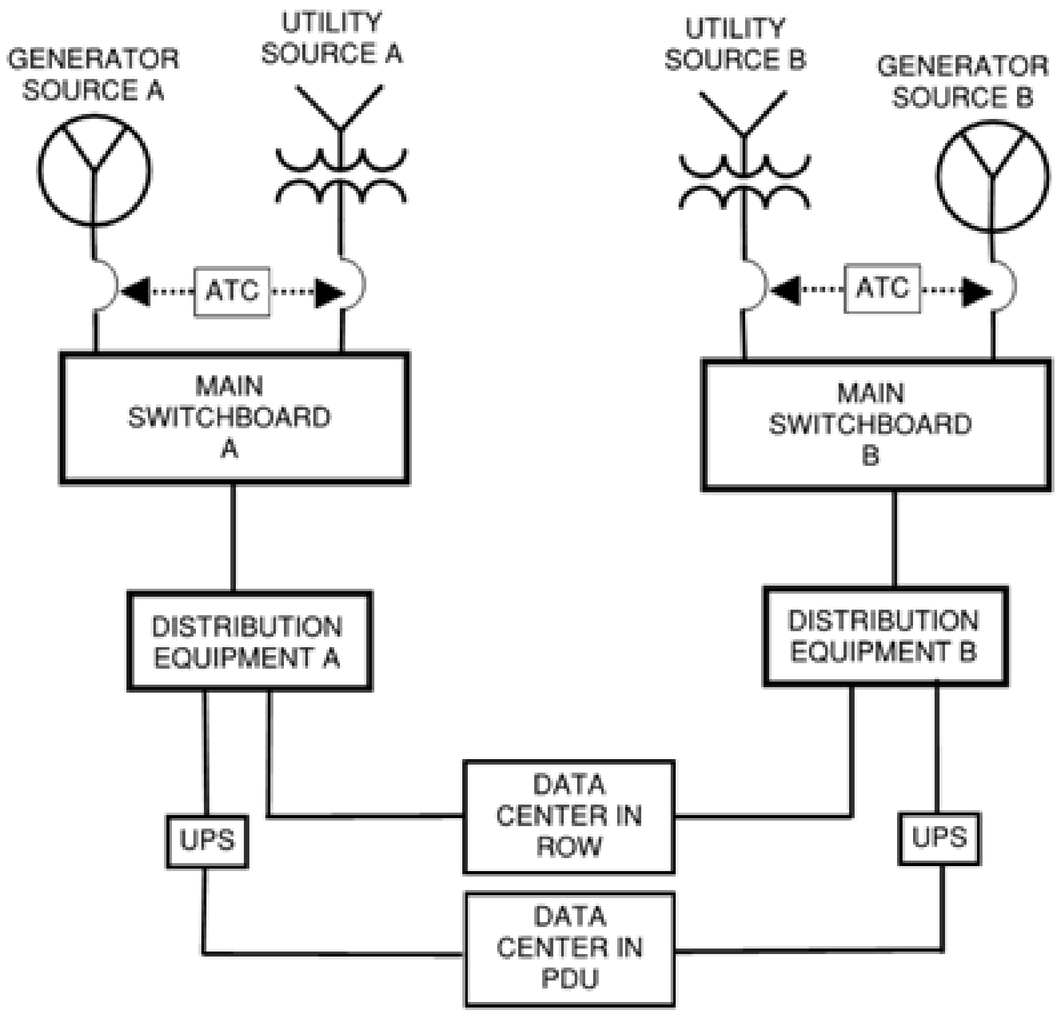

Figure 12: Typical Data Center Electrical Distribution

Aside from the resiliency of the power source for the facility, the telecommunications service should also be provided with resiliency. Multiple services in to the building for telecommunications may be provided in order to ensure redundancy, in addition to the redundancy provided for the power to the telecommunications infrastructure.

HVAC Requirements

Data Centers

Resilient telecommunication can be obtained by incorporating redundant systems into the telemedicine support infrastructure. A key component in providing effective and continuous audio-visual communication is ensuring the data center providing that functionality also functions efficiently and continuously. Data centers have equipment with specific temperature and humidity requirements that also give off substantial heat. The mechanical cooling systems are designed to be entirely redundant, with separate "A" and "B" systems, including chiller equipment, pumping systems, piping systems, in-row coolers and fan-coil connections. The separate systems typically share a common pipe distribution system with valving that allows for quick system change over in the case of a failure.

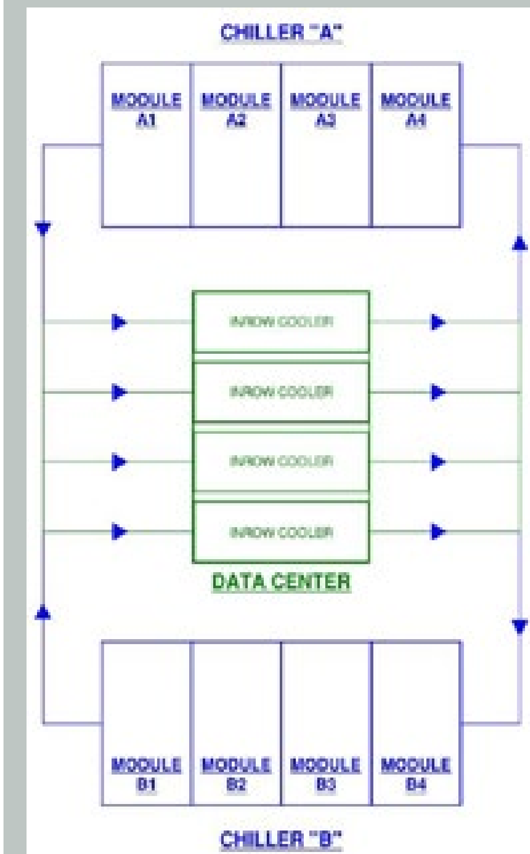

Figure 13: Fully Redundant Data Center Chiller System

Each A/B primary cooling system includes a modular air-cooled chiller with integral air-side free cooling. The modular design provides additional redundancy within each chiller system. Some of the features of the modular chiller system include:

- Premium efficiency compressor motors to reduce energy usage.
- Multiple, independent refrigeration circuits for added redundancy for each chiller module.
- Compressor sound attenuation to reduce noise produced by the chillers.
- Variable speed drive condenser and free-cooling fans for efficient energy usage.
- Single point power with individual disconnects by module to allow maintenance of a chiller module while the remaining chiller modules remain active.

Telemedicine Service Centers

There are many configurations of mechanical systems that are used in today's buildings to meet the needs of facilities while operating as efficiently as possible. For a telemedicine service center, the main factors that should be considered in designing an HVAC system include:

- Simultaneous heating and cooling, available year round
- Individual zone space control
- Low noise levels
- Adequate ventilation
- Energy efficiency

An effective system configuration for a telemedicine service center includes the use of fan-coil units. Fan-coil systems provide for simultaneous heating and cooling within a building. Each space or zone has its own fan-coil unit and the call for heating or cooling in a given zone is independent from other spaces.

Fan-coils come with many different options, depending on the type of base system, for example, whether utilizing hot water and chilled water or a variable refrigerant flow (VRF) system. Each fan-coil unit is connected to a thermostat located in the space or zone to provide for individual (and possibly occupant adjustable) climate control. Variable refrigerant flow systems also provide superior energy efficiency, which can transfer heat from one space to another rather than from a central energy source (i.e. boiler or chiller) under certain conditions.

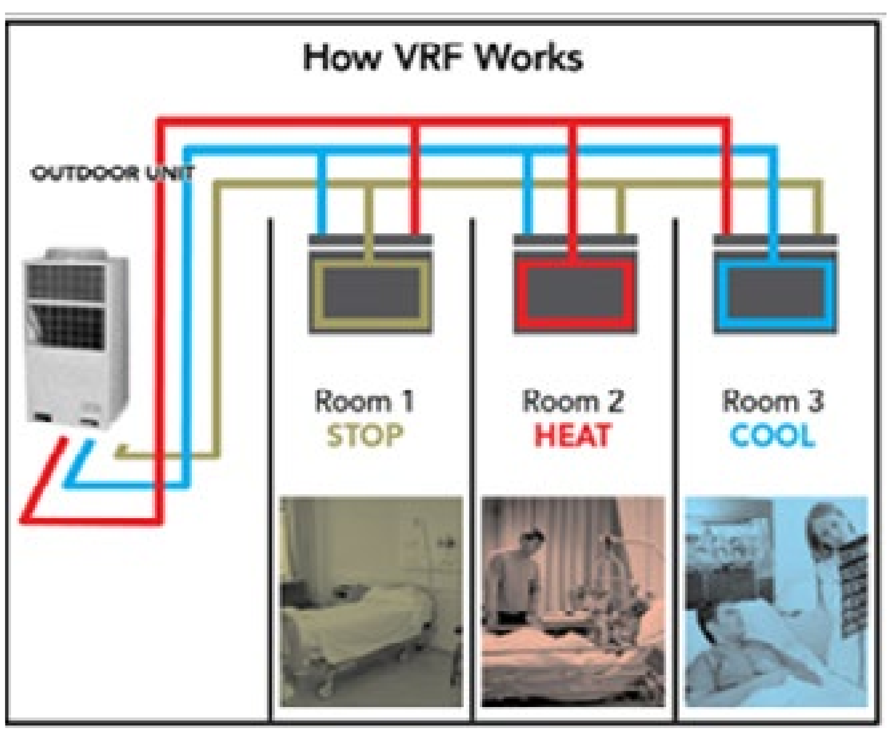

Figure 14: VRF for patient spaces. Photo: Buildings.com - VRF Systems in the US Market

With the use of fan-coil units, occupant ventilation would be provided via an air handling unit dedicated to providing fresh air directly to the space, such as with an energy recovery ventilator (ERV) or dedicated outdoor air system (DOAS).

Patient Space

The basic concept of telemedicine is to connect providers to patients remotely yet seamlessly. Anecdotal data seems to indicate that HVAC requirements, including climate control and air change requirements, for a patient space utilizing telemedicine are no different than a clinical space without the additional equipment. It is advisable, however, to provide the staff working alongside the patient the ability to adjust space temperature in certain clinical settings during an exam or consultation. Furthermore, it would appear useful for the remotely based provider to have real-time knowledge of those conditions. Consider, for example, a doctor questioning a patient about perceived sense of temperature, e.g., "are you feeling hot or cold?" without having perspective of the actual conditions within the space. Having that data may enhance or impact a diagnosis. It is recommended that real-time space condition information be a part of the remote interface or data system in certain telemedicine clinical settings.

Sound Considerations

There are also acoustic issues to consider when determining the type of HVAC system used. The 2018 addition of Guidelines for Design and Construction of Hospitals, Facilities Guidelines Institute (FGI), recognizes the growing telemedicine market and has added sections to help standardize telemedicine spaces—for both the provider and patient setting—that primarily focus on audio and visual considerations. For example, the guideline states, "The acoustic environment should be designed to facilitate speech intelligibility and communication...Cooling fans for equipment should be controlled and limited for telemedicine bays, cubicles, or rooms."

The following design noise criteria for interior spaces is from Table 1.2-5 of the FGI guideline. Table 1.2-5 shows that a teleconferencing room has a lower design noise criteria (NC) or background noise than that recommended for a standard examination or procedure room. The teleconferencing goal of NC-25 is a good aspirational goal but will certainly require terminal box noise control and larger ducts than typically used to reduce airflow noise. NC-30 is a best practice goal for conference rooms and will likely be sufficient for most telemedicine uses.

FGI Guideline Table 1.2-5: Maximum Design Criteria for Noise in Interior Spaces Caused by Building Systems		
Room Type	NC	dBA
Examination/treatment room	40	45
Procedure room	40	45
Teleconferencing room	25	30
Private office	40	45

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Building Management System

A Building Management System (BMS) would play a key role in managing buildings and spaces that are dedicated to telemedicine on both the provider and patient side. It allows for centralized management of critical infrastructure and local space monitoring and control, while ensuring operations are being run effectively, efficiently and securely. A properly designed and implemented BMS will provide the following:

- Local and remote control of space temperature, humidity and lighting as well as monitoring of these conditions.
- Automation of central HVAC, lighting, water and power systems as well as other essential equipment.
- Tracking and trending of space temperatures and humidity levels, as well as energy consumption.
- Centralized alarms and automatic notifications (via email, text, phone message, etc.) alerting of system or equipment faults.
- A resource to support a continuous commissioning program for system optimization.

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5 The Societal Perspective

Addressing the Needs of Patients in Underserved Areas

Melissa Powell writes that the recent uptick in telemedicine can be attributed in large part of the decline of rural healthcare. [2] Studies by the HRSA[3] show people in these communities tend to be older. They have high acuity needs and chronic conditions yet find it more difficult to travel to receive the necessary care. Yet only 10 percent of physicians serve rural populations, and the number of specialists per capita is a third of the number that practice in urban areas. [4] The decline of rural healthcare facilities and shortage of physicians in those areas means fewer resources to treat and care for those in need.

The good news is that most rural areas have broadband access, which enables video interface with specialists in other locations.[5] Telemedicine is expected to play an important role in delivering healthcare to the rural population. In an effort to improve access to care, the Centers for Medicare and Medicaid Services (CMS) has created preferential payment schedules including reimbursement for telemedicine services for patients located in geographic health professional shortage areas (HPSAs). [6]

Figure 16: Telemedicine will help healthcare providers treat an underserved rural population, especially the elderly who tend to require frequent and specialized medical care. Photo: Allscripts

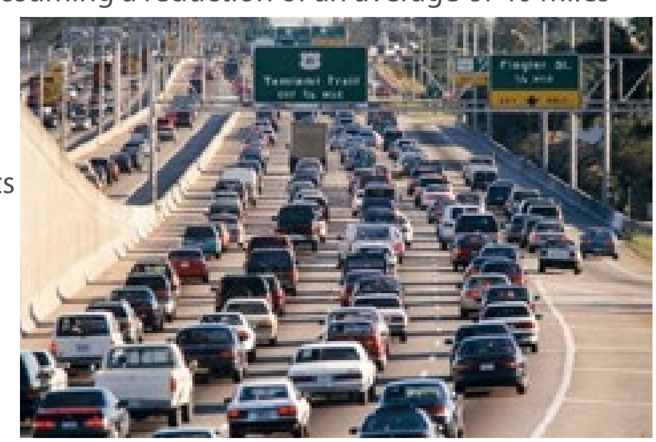
Access to healthcare is also a challenge for patients in urban settings. The issue for urban patients is the ability to secure appointments with healthcare providers. In fact, a 10-state study[7] showed that urban patients face greater challenges in securing appointments than patients in rural settings. A new patient in Boston should expect to wait more than 52 days before seeing a doctor.[8] Telemedicine may help improve access to healthcare for patients in urban settings by improving the efficiency in which primary care providers and specialists are able to see patients faster and more readily by leveraging telemedicine at neighborhood clinics supported by large urban hospitals.

Figure 17: Telemedicine may help reduce wait times for appointments with primary care physicians and specialists alike for patients in urban areas. Photo: Mehealth

The Environmental Benefit

Hospitals are the most energy intensive building types in the U.S., second only to food service.[9] Patient and provider transportation to and from hospitals, clinics and the like compound the net environmental impact of healthcare. In one report on the potential environmental impact of telemedicine in dermatology, telemedicine could reduce travel requirements 60% of the time.[10] Another report indicated that a net carbon reduction benefit occurs when a patient must travel a distance as little as two miles to as much as 20 miles for an appointment, depending on the procedure.[11] The opportunity for carbon reduction via telemedicine is immense and clearly indicates that up-scaling the use of telemedicine could have a large impact on the overall carbon footprint of the health sector and a positive societal benefit.

To illustrate the potential impact of telemedicine on the environment, consider that Massachusetts General Hospital, a 999 bed, leading teaching hospital in Boston, Massachusetts, handles 1.5 million outpatient visitors annually.[12] If the number of outpatient visitors at this single hospital could be reduced by only 10% with the use of telemedicine, assuming a reduction of an average of 40 miles per visit in auto travel, that would result in a savings of 12,000 barrels of oil.



The application of telemedicine clearly provides a compounding societal impact, by benefiting patients in terms of quality of care as well as saving time and expense while simultaneously reducing the net environmental impact of healthcare delivery. Its widespread use will also have a measurable impact on the cost efficiency of healthcare delivery, which should improve the bottom line of the industry as a whole.

6 Conclusions

While the possibilities of telemedicine seem boundless due to the ever-growing cloud, smart technology, telecommunication speed and the resiliency of datacenters, we experience challenges in the physical plant or facility. Retrofitting existing healthcare spaces or providing new spaces while maintaining the same level of privacy, comfort, communication, security and quality of care as traditional "face to face" consults is essential. Lighting, acoustics, space requirements and adjacencies are also heavily considered. These challenges are met by careful design of spaces and infrastructure.

Telemedicine has evolved quickly over the past few years, suggesting that it will continue to develop at a rapid pace. [13] As technology advances and organizations become more familiar with platforms and service options, minimum built-environment standards to support these practices may need to be refined.

> Telemedicine has evolved quickly over the past few years, suggesting that it will continue to develop at a rapid pace.

Resilient telecommunication between a patient and a healthcare giver is a key component to successful telemedicine. Not unlike other market sectors that require non uninterruptable power and telecommunications, telemedicine power and IT infrastructure requirements need to be planned for in the same way and maintained as a critical 24/7 function.

Opportunities exist to design and implement best practices for creating and maintaining a telemedicine center, with its unique physical infrastructure requirements whether in an existing healthcare setting or as a stand-alone facility. Design teams can provide healthcare capital planning and facilities personnel with the information and recommendations needed for planning and implementing cutting edge telemedicine facilities.

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