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Cisco TelePresence Fundamentals

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Foreword

Back in 2004, Cisco decided to look into creating a new type of visual collaboration experience that would surpass the more traditional videoconferencing. After investigating different technologies, the decision was made to build this experience internally at Cisco. Thus, the TelePresence Systems Business Unit was formed and the ultimate outcome was the Cisco TelePresence System that has changed the way that enterprises communicate forever.

Cisco believes in internally trying their own products and, through its Cisco on Cisco organization and in the 3 years since shipping, has deployed more than 350 systems in 42 countries globally and enabled functions such as interoperability with traditional videoconferencing, multipoint, intercompany, and integrated scheduling. At this time, there have been more than 280,000 meetings scheduled and more than 51,000 meetings that have avoided travel, saving the company an estimate of $174 million dollars. TelePresence has become a way of life here at Cisco.

The TelePresence Systems Business Unit was founded on the principle of "It's all about the experience." And that experience shows up in the complete solution that was created. Cisco TelePresence is a solution that encompasses everything from the end user in the room to the administrator. It looks at the room environment and the network to create the best experience for the end users, and it looks at the management interfaces to make the administrator's job as easy as possible. Integration with the Cisco Unified Communications platform enables a seamless integration with your existing telephony network, both for internal and external (B2B) communications.

Tim, Kevin, Roland, and Alan have been part of TelePresence from the beginning. They were instrumental in the creation of the experience and the success that TelePresence has. They have created our deployment guides and successfully worked with our customers, including many of the Fortune 500, to deploy within their own global networks. It is through their dedication and knowledge that TelePresence has become a dominant player in the industry.

I have had the privilege of working with the authors for several years. Their understanding of the Cisco TelePresence Systems and the fundamentals around the solution is unsurpassed. Their book provides the reader with all the information necessary to create a successful deployment. Anyone involved in deploying, managing, or monitoring of TelePresence will greatly benefit from reading this book.

Chris Dunn

Director, Engineering

TelePresence Systems Business Unit

Introduction

I well remember my first Cisco TelePresence experience.

It was in the fall of 2006, and my manager had been urging me for several weeks to check out the first pair of production TelePresence rooms at the Executive Briefing Center at the Cisco headquarters in San Jose. However, I had kept putting it off because I was "too busy." Being familiar with many forms and flavors of video conferencing systems, I was a bit skeptical that there was really anything new or cool enough to merit my walking seven buildings over and seeing for myself. But eventually I relented and made the arduous ten-minute trek, and my life hasn't been the same since.

It's difficult to encapsulate in words how authentic TelePresence is; it just has to be experienced firsthand to really "get it." But I distinctly remember looking at a life-size image of a colleague on the high-definition screen and seeing the second hand on his watch tick in real time and thinking, "This can change everything." And indeed it has and is continuing to do so.

The Cisco company vision has been and continues to be, "changing the way we work, live, play, and learn," and never has a single technology (since perhaps IP itself) had such a cross-functional impact and potential as Cisco TelePresence.

TelePresence quite literally changes the way we work. I can personally attest to this because for the past decade, I had been traveling on average two to three times per month: wasting hundreds of hours in airport lines and lounges, spending tens of thousands of company dollars per year, and burning who knows how many tons of fossil fuels. Now, I walk to the nearest TelePresence room and conduct meetings with colleagues and customers alike and then walk home, simultaneously saving time, money, and the environment.

TelePresence is also changing the way we live. For instance, many Cisco employees usually have at least some members of their families living far away from them. In recent years, during holiday seasons, Cisco has invited employees and their families to book their respectively nearest TelePresence rooms (of which several hundred have been deployed globally) and "visit" with each other. Ongoing research and development is aimed at bringing TelePresence into the home, which would bring all of us closer to our distant friends and families, without having to even leave the couch.

Similarly, TelePresence is changing the way we play. Recent initiatives in the sports and entertainment fields have seen the introduction of TelePresence in various sports venues, allowing for distant friends to "trash talk" while watching a game or for fans to "visit" with their heroes, even though distances of thousands of miles might physically separate the parties.

And finally, TelePresence is changing the way we learn. Geographically disparate teachers and students are meeting and interacting with a degree of ease and effectiveness as never before. Classrooms on opposite ends of the planet are linked together through TelePresence, giving students a broader cultural exposure and a better global perspective.

And the list of ways TelePresence technologies can be applied goes on and on….

And so, in short, I was hooked. Soon after, I was honored and excited to join a cross-functional team of experts, including Kevin, Roland, Alan, and many others, who were tasked with researching and developing Cisco TelePresence solutions.

Shortly thereafter, a social incident further underscored to me the universal appeal of TelePresence. For years, my wife and I had an understanding that at dinner parties, if people asked me what I do, I was permitted to reply with "I'm in computers" and leave it at that. If I was pressed, I could expand with "I design networks for computers," but no further. Otherwise, according to her, if I launched into the technical details of my day-to-day work (which I always thought was interesting), people's eyes would glaze over with sheer boredom, and they would politely nod with feigned interest, and secretly wish they never asked, and made quick mental notes never to invite us again. However, one evening, after having been assigned to work on TelePresence designs for about a year, I found myself at a dinner party with an elderly gentleman next to me asking me what I did. I replied with the usual permitted one-liner, but as he pressed me for more, I quickly glanced at my wife, saw the shooting look of warning in her eye, gathered up some courage, and defiantly began launching into the detailed work we had been doing on TelePresence. To my amazement, he seemed not only interested, but also excited about some of the possibilities for TelePresence. And it wasn't long before the whole table of eight began joining in the animated conversation, talking about TelePresence solutions and potentials at length, at the end of which, I shot a triumphantly victorious look back at my wife, and the rules have been permanently relaxed since.

Back at work, our team immediately started doing research and testing to publish a series of technical papers on best practices for deploying TelePresence systems, and only then did we really begin to grasp how many layers of technology were actually involved in TelePresence solutions, from audio to video to codecs to networks to firewalls to border controllers and so on and so forth. The papers became longer and longer, and we then recognized that having a single depository of such technical information would require a book. And after nearly two more years of work, you hold the result in your hands.

Objectives and Approach

The objectives of this book are to introduce you to Cisco TelePresence technologies, both at a conceptual level and at a technical design and deployment level.

To realize this objective, this book is divided into three main parts:

- The first introduces and overviews Cisco TelePresence systems.
- The second delves into the concepts of the various technologies that comprise TelePresence systems and networks.
- The third details best practice design recommendations on how these technologies are integrated and optimally deployed as comprehensive Cisco TelePresence solutions.

Upon completion, you should have a solid working knowledge of Cisco TelePresence systems and technologies and thus can confidently design, deploy, operate, and manage Cisco TelePresence solutions.

Who Should Read This Book?

The primary group of readers for this book would be technical staff tasked with deploying Cisco TelePresence systems. These might include network administrators, systems administrators, audio/video specialists, VoIP specialists, and operations staff.

A secondary group of readers would be technical decision makers tasked with evaluating the business value and technical feasibility of deploying Cisco TelePresence systems.

A tertiary group of readers would be system engineers, partners, trainers, and other networking professionals who might need to ramp-up technically on Cisco TelePresence systems, with the objective of selling or educating others on these systems.

How This Book Is Organized

This book is organized in such a manner that it can be read cover-to-cover and be used as a quick reference guide to specific technical information and design recommendations.

The content is broken into three main sections: the first section introduces Cisco TelePresence; the second section expands on the various technologies that play a role in TelePresence systems and networks; and the third section describes the Cisco validated best practice recommendations to optimally deploy TelePresence solutions.

The two chapters comprising **Part 1, "Introducing Cisco TelePresence,"** cover the following topics:

- **Chapter 1, "What Is TelePresence":** This chapter introduces Cisco TelePresence, by tracing the evolution of video communications from the 1964 World's Fair to 2006, when Cisco released their first TelePresence system, which featured state-of-the-art technologies designed to transport high-definition audio and video, in realtime, over a converged IP network infrastructure.
- **Chapter 2, "Cisco TelePresence Solution Overview":** This chapter overviews the various components that comprise Cisco TelePresence systems and solutions, including the Cisco TelePresence codec (which is the heart of Cisco TelePresence systems), the Cisco 7975 Series IP Phone, the Cisco Unified Communications Manager, the Cisco TelePresence Manager, the Cisco TelePresence Multipoint Switch, and the Cisco TelePresence Intercompany Solution.

The five chapters comprising **Part II, "TelePresence Technologies,"** discuss the following topics:

- **Chapter 3, "TelePresence Audio and Video Technologies":** This chapter delves into more detail on how the Cisco TelePresence codec interacts with the high-definition displays and cameras, microphones and speakers, the IP Phones, auxiliary components, and, most importantly, the network. Audio/video encoding and packetization are extensively discussed, as are the effects of latency, jitter, and loss on TelePresence flows.

- **Chapter 4, "Connecting TelePresence Systems":** This chapter details how individual components interconnect and interrelate within Cisco TelePresence systems. Additionally, the three main TelePresence deployment models, intracampus, intra-enterprise and Intercompany, are described.
- **Chapter 5, "Network Availability Technologies":** This chapter presents a foundational context for the best practice designs detailed in Chapter 9, "TelePresence Network Design Part 1: Availability Design," by introducing concepts and metrics relating to network availability for TelePresence deployments. A broad spectrum of availability technologies are overviewed, including device, network, and operational availability technologies.
- **Chapter 6, "Network Quality of Service Technologies":** This chapter lays a base for the validated designs detailed in Chapter 10, "TelePresence Network Design Part 2: QoS Design," by introducing concepts and metrics relating to network quality of service for TelePresence deployments. Various quality of service tools are overviewed, including classification, marking, policing, shaping, queuing, and dropping tools.
- **Chapter 7, "TelePresence Control and Security Protocols":** This chapter provides background for the the designs detailed in Chapter 11, "TelePresence Firewall Design," and Chapter 12, "TelePresence Call-Signaling Design," by introducing concepts and technologies relating to signaling, control, and security design for TelePresence deployments.

The technical substance of this book is in the second half, specifically in the seven chapters comprising **Part III "TelePresence Solution Design,"** which detail the following topics:

- **Chapter 8, "TelePresence Room Design":** This chapter describes topics that are rarely covered in Cisco Press books and that many networking professionals might be unfamiliar with but nonetheless are critical to properly designing rooms to support Cisco TelePresence, including wall, floor, and ceiling surfaces; lighting and illumination; acoustics; and heating, ventilation, air-conditioning. and power.
- **Chapter 9, "TelePresence Network Design Part 1: Availability Design":** This chapter details network considerations, targets, and design recommendations for highly available TelePresence networks. Campus designs include virtual switch designs and both EIGRP- and OSPF-routed access designs; branch designs include both dual-tier and multitier branch profiles.
- **Chapter 10, "TelePresence Network Design Part 2: QoS Design":** This chapter details network considerations, targets, and design recommendations for QoS-enabled TelePresence networks. The service level requirements of TelePresence are specified in terms of bandwidth, burst, latency, jitter, and loss. QoS designs for campus networks are detailed, as are WAN/branch and MPLS VPN networks.

- **Chapter 11, "TelePresence Firewall Design":** This chapter outlines firewall design options for TelePresence deployments. Protocol requirements are examined for TelePresence scheduling, signaling, media, and management flows.
- **Chapter 12, "TelePresence Call-Signaling Design":** This chapter examines TelePresence call-signaling components, including the Cisco Unified Communications Manager, Cisco Unified Border Element and Cisco Session Border Controller, and TelePresence signaling operation and design.
- **Chapter 13, "Multipoint TelePresence Design":** This chapter expands the complexity of TelePresence deployments by introducing the Cisco TelePresence Multipoint Switch, which enables up to 48 TelePresence segments to be joined together in a single conference. Additionally, this chapter examines the network design implications of TelePresence multipoint deployments.
- **Chapter 14, "Inter-Company TelePresence Design":** This chapter applies Metcalfe's Law to TelePresence deployments by introducing a solution that enables one business to place TelePresence calls to another, namely the Cisco TelePresence Inter-Company Solution. The end-to-end requirements of this solution are specified, including quality, security, scalability, and reliability. The components of the Inter-Company solution are analyzed, with emphasis on the Cisco Session Border Controller and Cisco Unified Border Element. Additionally, the network architecture and security of the Inter-Company solution are examined in depth.

Finally, this book concludes with the **Appendix, "Protocols Used in Cisco TelePresence Solutions."** This appendix summarizes and details the many network protocols used by Cisco TelePresence Systems.

Tim Szigeti

March 2009

CHAPTER 8

TelePresence Room Design

new systems, you need to focus on the principles discussed in this chapter and how you can apply them to each type of system.

This chapter covers the following topics:

- **Room Dimensions, Shape, and Orientation:** Discusses the physical size, shape, and orientation of the room and the location of doors, windows, columns, and furniture within the room.
- **Wall, Floor and Ceiling Surfaces:** Discusses the recommended colors, patterns, and materials of wall, floor, and ceiling surfaces within the room.
- **Lighting and Illumination:** Discusses overall illumination considerations and specific lighting requirements and recommendations.
- **Acoustics:** Discusses the concepts of sound reproduction and the effects of ambient noise and reverberation within the environment and how they are measured.
- **HVAC:** Discusses the heating, ventilation, and air conditioning (HVAC) requirements and the recommended types and locations of air-conditioning registers within the room.
- **Power Requirements:** Discusses power consumption requirements for the equipment and participants and the recommended types and locations of electrical receptacles within the room.
- **Network Connectivity:** Discusses the network connectivity required within the room for the equipment and the participants and the recommended ways to provide network access to the participants.

Room Dimensions, Shape, and Orientation

The primary criteria for selecting a room is to find one that meets the recommended width, depth, and height requirements and is free from obstructions such as pillars and columns. The dimensions also play a critical role in how much lighting is required, how the room appears visually on the screen, and the acoustic properties of the room.

The following sections provide details on each aspect of room dimensions, including width, depth, height, angles, and shapes, such as curved or concaved walls and asymmetric geometries, protruding entrances and vestibules, and the orientation of the TelePresence within the room.

Tip Each dimensional measurement has minimum, recommended, and maximum values. You should strive to find a room that meets the recommended dimensions for maximum flexibility and performance. Choosing a room that is either too small or too big can have negative side effects as explained within each section.

Width Requirements

The room needs to be wide enough to comfortably fit the TelePresence system and any peripherals that might be located on its left or right sides, with enough extra space on each side for service personnel to access the back of the system to service it. You might also want extra space for furniture, such as cabinets, coffee tables, couches, sofas, or storage space for extra chairs.

Determining Room Width

To begin, find the width of the TelePresence system itself and add at least 1 foot (30.48 centimeters) on each side to enable service personnel to access the sides and back of the system. The Cisco TelePresence CTS-3000, for example, measures precisely 18-feet (5.486-meters) wide. Adding 1 foot (30.48 centimeters) of access space on each side brings the minimum width to 20 feet (6.096 meters). Figure 8-1 illustrates the minimum room width of a CTS-3000.

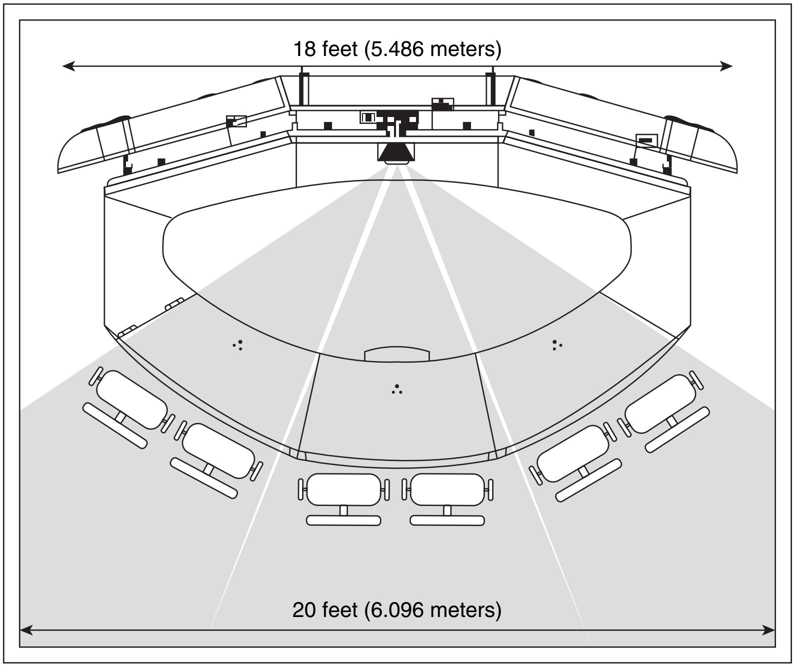

Figure 8-1 *CTS-3000 minimum room width*

The CTS-1000 measures precisely 5.11-feet (1.557-meters) wide. Adding one foot (30.48 centimeters) of access space on each side brings the minimum width to 7.11 feet (2.167 meters). Figure 8-2 illustrates the minimum room width of a CTS-1000.

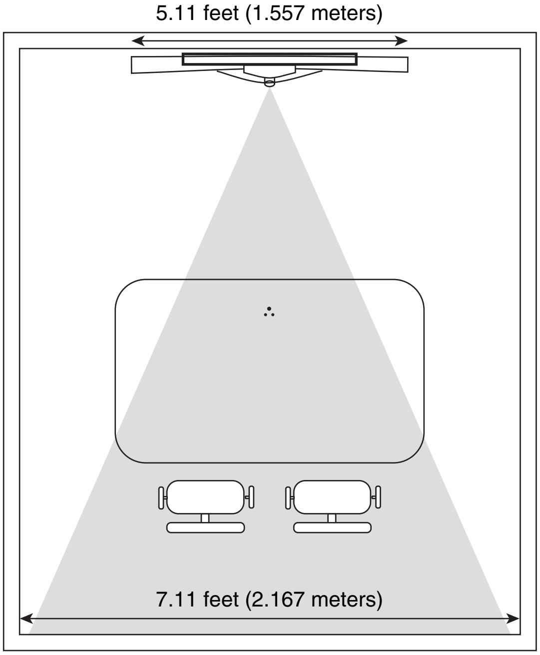

Figure 8-2 *CTS-1000 minimum room width*

Tip The illustrations in this chapter are not necessarily to scale. The measurements clarify the scale of the objects within the illustrations.

Factoring in Peripherals

The second step is to factor in any additional peripherals such as auxiliary data displays or document cameras that might be located on the left or right sides of the system. Both the CTS-3000 and CTS-1000 systems support the use of auxiliary LCD displays and document cameras for use with the Auto Collaborate feature. You can often find these optional peripherals on the left or right sides of the system to obtain the total width of the system. Following are some specific examples to illustrate how to approach these considerations.

LCD displays come in different sizes and can be mounted to the ceiling above the TelePresence system; mounted to the wall on the left or right sides of the system; mounted to a vertical stand with a base located to the right or left sides of the system; or placed on a piece of furniture such as a cabinet or cart to the right or left sides of the system. The section "Height Requirements," covers ceiling-mounted scenarios in greater detail. This current section focuses on left- and right-side mounting options. Consider the example of a customer who wants to install a 52-inch (132.08 centimeter) Sharp 525U LCD on the left side of the CTS-3000. The 52 inches is the diagonal measurement of the display. The actual width of this particular display is 49.4 inches (125.476 centimeters). The bezel of the display might be a few inches away from the edge of the TelePresence system and might be mounted on a stand that has a slightly wider base than the actual width of the display. The recommendation in this example would be to round up 6 inches to 12 inches (15.24 centimeters to 30.48 centimeters) to allow for flexibility in the exact placement of the display. Figure 8-3 illustrates this arrangement.

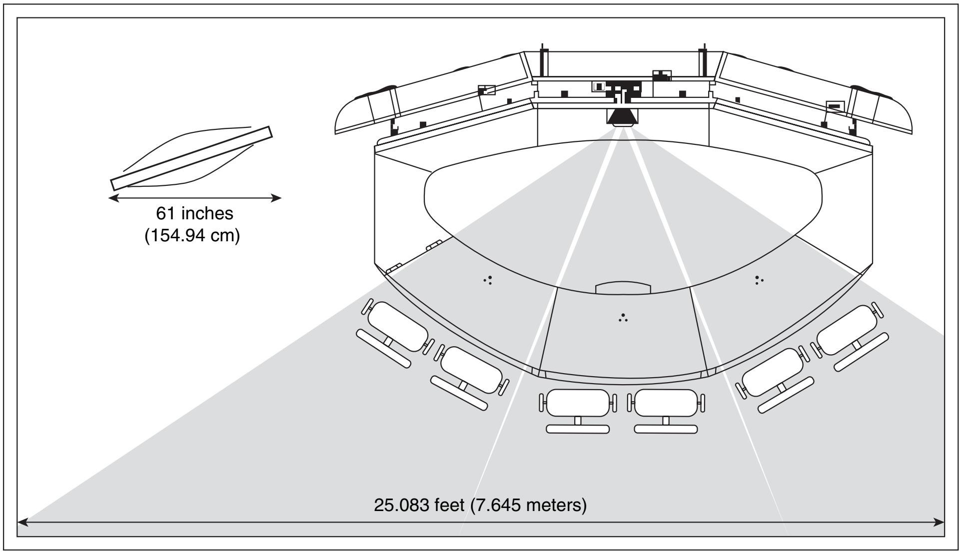

Figure 8-3 *CTS-3000 with optional auxiliary LCD display on left side*

Document cameras can be mounted within the ceiling or located on a flat surface such as a cabinet or table on the left or right sides of the TelePresence system. For the CTS-3000, the optimal solution is to ceiling-mount the document camera above the table where the participants sit. However, on a CTS-1000 it is popular to use a desktop document camera located off to one side or the other. The Wolfvision VZ-9plus Desktop Visualizer, for example, measures 12.6-inches (32.004-centimeters) wide and would likely be located on a cabinet or table surface at least a few inches larger than the actual base of the visualizer. Figure 8-4 illustrates this arrangement, where the cabinet that the WolfVision camera is sitting on measures 2–feet (60.96-centimeters) in width.

Factoring in Additional Participants

The third step is to add enough space for participants sitting on the left or right sides of the TelePresence system. This does not apply to the CTS-3000 model system, but on the CTS-1000 it might come into play depending on the orientation of the system within the room. Figure 8-5 illustrates a CTS-1000 with additional seating on the left and right sides of the table.

The chairs depicted as silhouetted would not be used during an active TelePresence meeting but could be located within the room like this to maximize seating capacity when us-

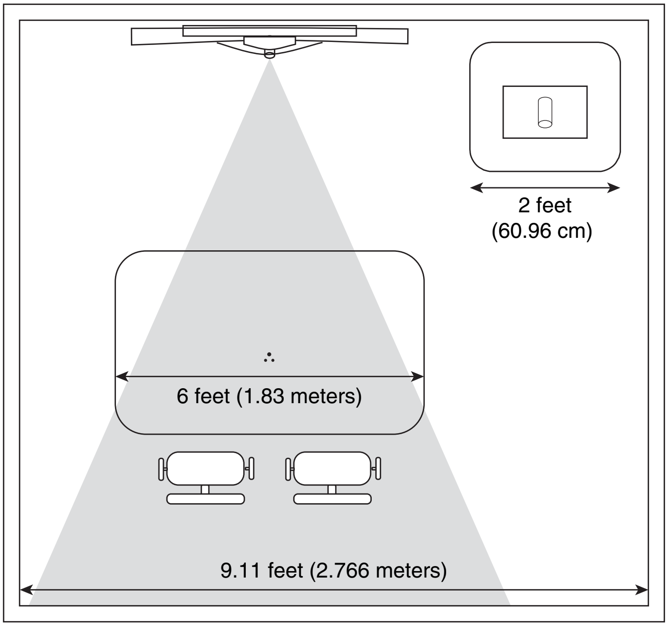

Figure 8-4 *CTS-1000 with optional desktop document camera on right side*

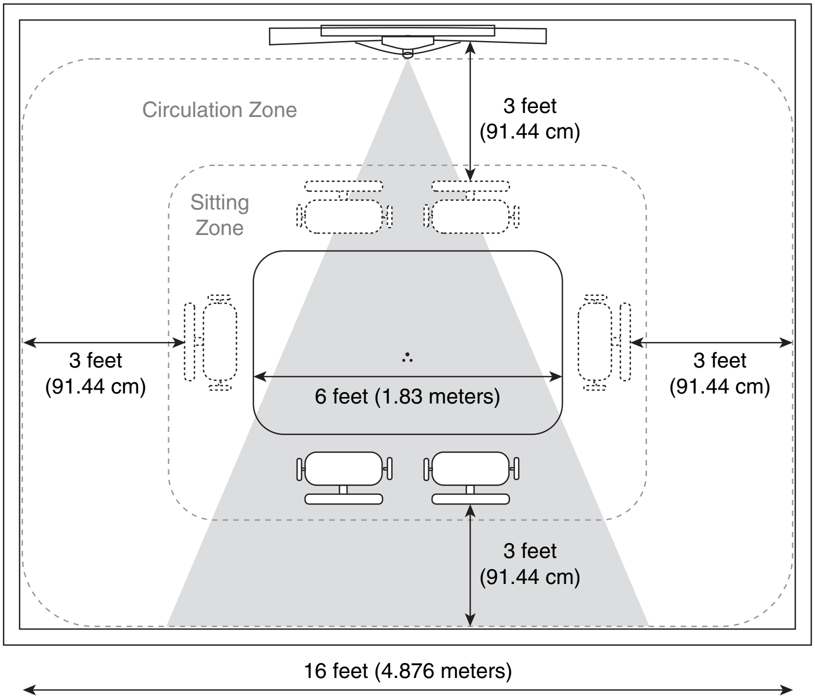

Figure 8-5 *Example of CTS-1000 seating arrangement*

ing the room for non-TelePresence meetings. Interior Design standards specify recommended measurements for the distance from the edge of the table to the back of the participant's chair and from the back of the participant's chair to the wall behind them. These are referred to as the *sitting zone* and *circulation zone*, respectively. The recommended sitting zone is 2 feet (60.96 centimeters), and the recommended circulation zone is 3 feet (91.44 centimeters). The circulation zone provides enough distance for people to get in and out of their chairs and for others to circulate behind a seated participant and accounts for wheelchair accessibility. The third measurement to take into consideration is *elbow room*. Each chair position needs a minimum of 3 feet (91.44 centimeters) of width. For this reason, the recommended table width for a CTS-1000 room is 6 feet (1.828 meters) to comfortably accommodate two participants seated at the table. To accommodate the extra chairs on each side of the table, you need an additional 5 feet (1.524 meters) on both sides of the table, for a total width of 16 feet (4.876 meters).

Factoring in Additional Furniture

The fourth step is to add enough space for any additional furniture, such as cabinetry that might be located along the walls on the left or right sides of the room, extra chairs that might be placed on the side of the room, and so on. Figure 8-6 illustrates a CTS-3000 with cabinets located on the left side of the room and extra chairs stored on the right side of the room.

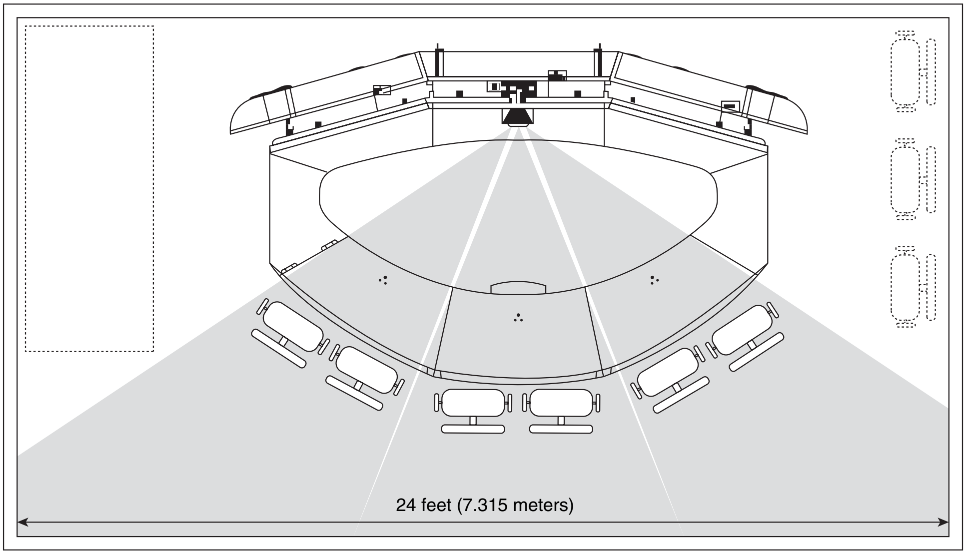

Figure 8-6 *Example of CTS-3000 with cabinets and extra chairs*

Understanding Maximum Width Constraints

Now that you are aware of the minimum and recommended width requirements, you need to understand why Cisco specifies a maximum width. In the case of width, the maximum recommendation comes primarily from the acoustic effects of reverberation within the room. When the width of the room is significantly wider than the recommended value, sound traveling through the air might take longer to reflect off of the walls, resulting in high levels of reverberation. Mitigating reverberation caused by excessively wide rooms can occur a number of different ways. Of course, you can always build false walls on the left or right sides to reduce the width of the room, but this is not always necessary. You can usually achieve the desired results simply by placing furniture within the room such as overstuffed chairs or couches, or covering portions of the walls in acoustically dampening materials such as fabrics or oil paintings. The section "Acoustics," later in the chapter, covers reverberation in more detail.

The other negative effect of excessively wide rooms is the amount of light needed to sufficiently cover the entire room in even, well-distributed light. Avoid dark areas and shadows, even if they are not within the view of the cameras. The wider the room, the more light fixtures you need to blanket the room in light. The section "Lighting and Illumination," later in the chapter, covers lighting in greater detail.

Width Requirements Summary

Based on all of the information covered in this section, Table 8-1 summarizes the minimum, recommended, and maximum width requirements for the CTS-3000 and CTS-1000 model systems.

Table 8-1 *Minimum, Recommended, and Maximum Room Width for CTS-1000 and CTS-3000*

Model	Minimum Width	Recommended Width	Maximum Width
CTS-3000	20 feet (6.096 meters)	22 feet (6.7056 meters)	31 feet (9.448 meters)
CTS-1000	7.11 feet (2.167 meters)	12 feet (3.657 meters)	20 feet (6.096 meters)

Depth Requirements

The room should be deep enough to comfortably fit the TelePresence system, with enough extra space behind the participants for people to walk to and from their seats. You might also want extra space for furniture, such as cabinets and sofas, or for extra chairs behind the primary participants.

Determining Room Depth

To begin, find the depth of the TelePresence system and add at least 5 feet (1.524 meters) past the edge of the table to allow for minimum seating and circulation zones. The CTS-3000, for example, measures precisely 10.07 feet (3.069 meters) from the back of the light façade structure to the edge of the table, and recommended specifications dictate that it be installed at least 12 inches (30.48 centimeters) away from the wall to allow service personnel to access the back of the system. Adding 5 feet (1.524 meters) beyond the table edge for the participant's chairs and a circulation zone behind them brings the minimum depth to 16 feet (4.876 meters). Figure 8-7 illustrates the minimum room depth of a CTS-3000.

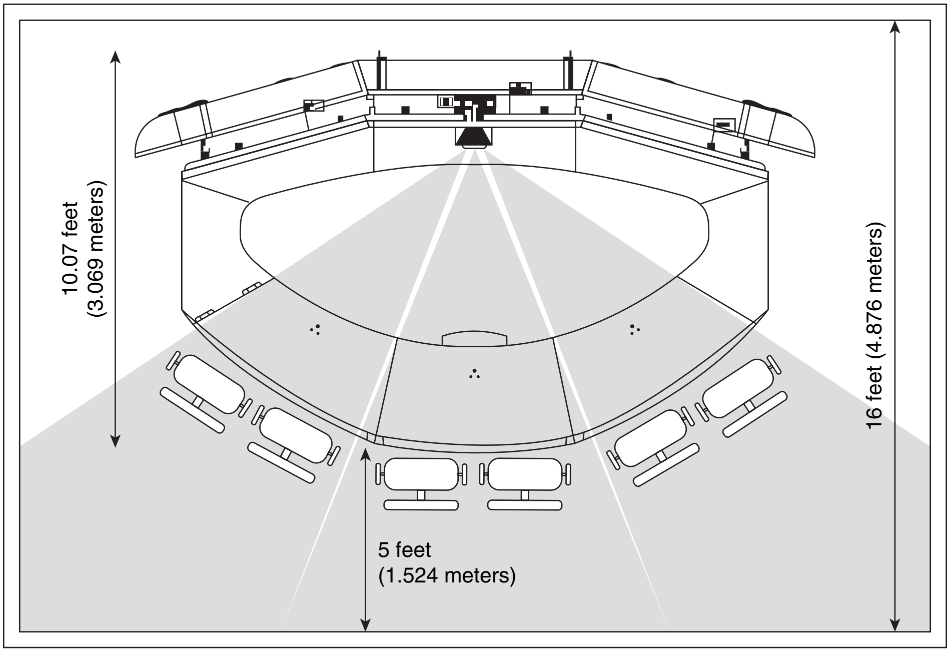

Figure 8-7 *CTS-3000 minimum room depth*

The CTS-1000 is a little different because it does not include an integrated table, so the customer must supply a table and must understand how far away the table should be placed from the system. The system itself measures precisely 9 inches (22.86-centimeters) deep and is bolted flush to the wall. But the distance from the camera to the edge of the table is a critical measurement because the camera on the CTS-1000 has a fixed focal length and depth of field. If the participants sit too close to the system, they will appear out of focus, and the vertical angle of the camera to their faces will be skewed, resulting in a distorted view. Likewise, if they sit too far away from the system, they will also be out of focus and will appear smaller than life size. The distance from the camera to the edge of the table should be precisely 8.5 feet (2.59 meters). Adding 5 feet (1.524 meters) beyond the table edge for the participants' chairs and a circulation zone behind them brings the minimum depth to 14.25 feet (4.343 meters). Figure 8-8 illustrates the minimum room depth of a CTS-1000.

Caution The minimum depth is a critical measurement that should not be compromised.

It is common for customers to want to sacrifice the service access zone behind the system or the circulation zone behind the participants' chairs to fit the system into a room that is slightly smaller than the minimum measurements previously specified. For example, many customers have asked if the CTS-3000 can be made to fit within a room that is only 14-feet (4.267 meters) deep, or a CTS-1000 into a room that is only 10-feet (3.048 meters) deep. However, you need to understand several critical aspects that should dissuade you from doing this.

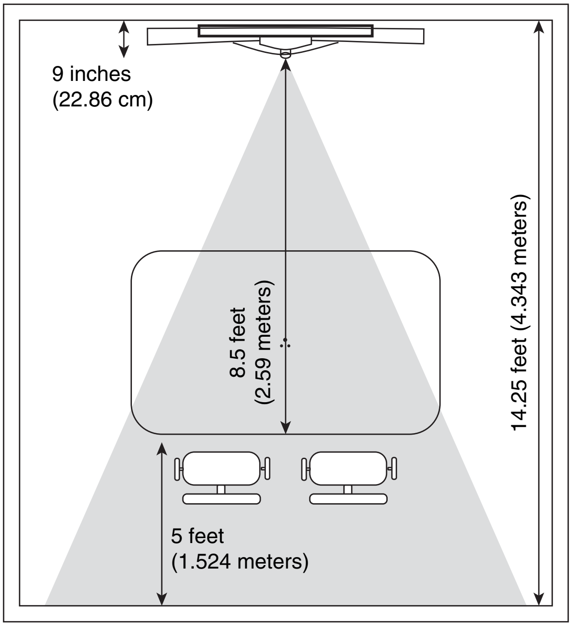

Figure 8-8 *CTS-1000 minimum room depth*

Camera Focal Length and Depth of Field Considerations

First, the focal length and depth of field of the cameras on the CTS-3000 and CTS-1000 model systems are precisely designed to capture a subject that is 8.5 feet to 14.5 feet (2.59 to 4.419 meters) away from the camera. When the wall is too close behind the seated participants, it has two negative side effects:

- The participants appear "painted" onto the wall behind them because you have no depth between them and the wall.
- The wall appears to be "crawling" because it's so close to the camera that it is within the depth of field, and the pattern of the wall surface is visible on camera. Even relatively smooth wall surfaces such as painted gypsum drywall exhibit this behavior.

In addition to these two visual side effects, the walls become marred and scratched over time from participants bumping the backs of their chairs up against them.

Camera Vertical Viewing Angle Considerations

Second, the vertical angle of the camera's field of view is designed to be precisely 7 degrees above the participants' eyes (give or take a degree or two to accommodate different people's heights when seated). This provides optimal vertical eye gaze alignment. On the CTS-3000, it is not possible to sit too close to the camera because it comes with an integrated table, but on the CTS-1000, if the participants sit too close to the system, they appear out of focus and too low on the screen. The natural inclination is for the installer to adjust the vertical angle of the camera slightly downward and pull the focus as far in as it will go to get the participants within the camera's field of view. By angling the camera down, however, you distort the angle of the camera to the subject resulting in a "downward" appearance of the participant on screen and a misalignment of the vertical eye gaze. Figure 8-9 illustrates this concept.

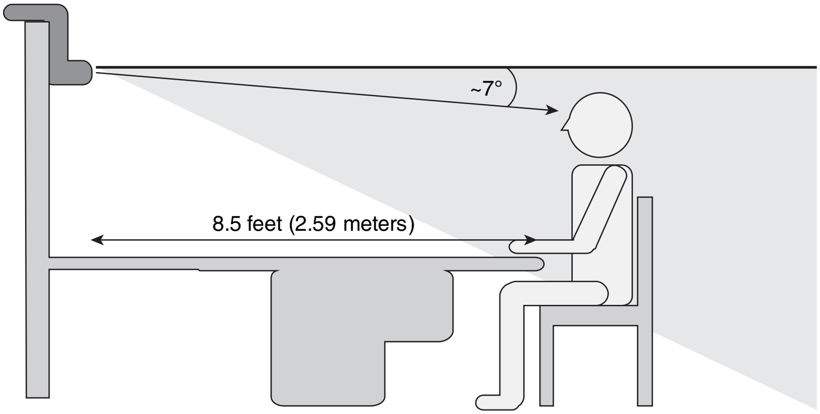

Figure 8-9 *CTS-1000 minimum distance from camera*

Factoring in Additional Furniture, Seating Capacity, and Wall Adornments Behind the Participants

Now that you understand the absolute minimum depth requirements, consider the space required for optional furniture, extra seating, and wall adornments in the back of the room behind the primary participants. It is highly desirable that customers consider doing this because placing adornments and furniture behind the participants creates a sensation of "depth" on the screen and makes the participants and their environment look as lifelike as possible. You might want to place cabinetry or artwork on the back wall, some couches or overstuffed chairs for decorative purposes, or a combination of both. Figure 8-10 illustrates these concepts.

> **Tip** If you add furniture and adornments to provide the sensation of depth within the view of the camera, take caution to choose patterns and colors that look good on camera and complement people's skin tones. Avoid highly reflective surfaces such as glass picture frames and certain colors such as deep reds and mahoganies or extremely bright colors such as fluorescent signs. The section "Wall Surfaces," later in the chapter, covers this in more detail.

Understanding Maximum Depth Constraints

The last thing to consider is the maximum room depth. As with the maximum width discussed previously, the maximum depth requirement is due primarily to lighting and acoustic considerations, although the lighting consideration is even more severe in this case because the back wall is within the view of the cameras, making shadows and dark areas even more pronounced and undesirable. In addition, objects further than 15 feet

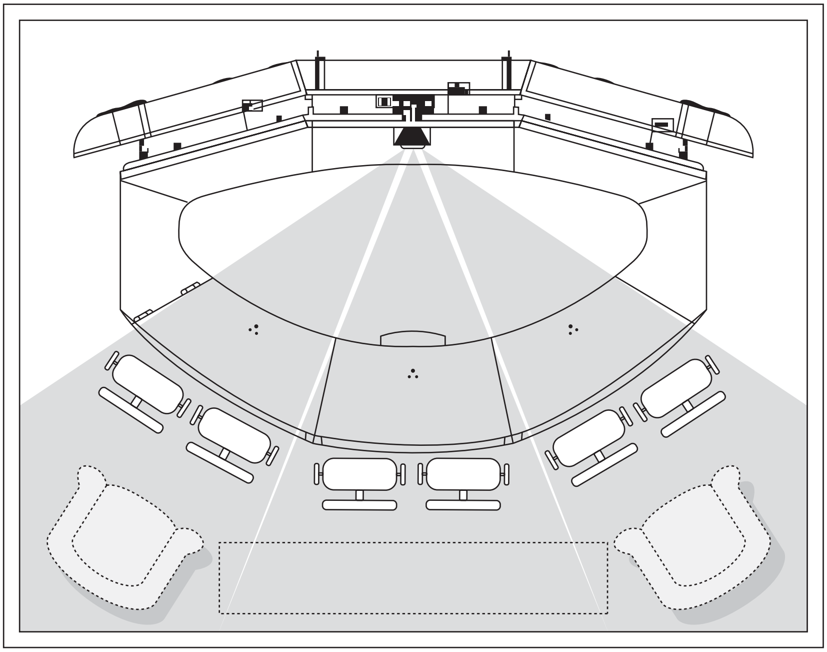

Figure 8-10 *CTS-3000 with cabinet and chairs along back wall*

(4.572 meters) or so away from the cameras will become increasingly out of focus. Therefore, although it is desirable to have slightly more than the minimum depth to allow for the placement of furniture and artwork to create the sensation of depth in the image, if the room is too deep, this will backfire on you because the objects on the back wall will be completely out of focus.

Depth Requirements Summary

Based on all the preceding information, Table 8-2 summarizes the minimum, recommended, and maximum depth requirements for the CTS-3000 and CTS-1000 model systems.

Table 8-2 *Minimum, Recommended, and Maximum Room Depth*

Model	Minimum Depth	Recommended Depth	Maximum Depth
CTS-3000	16 feet (4.876 meters)	20 feet (6.096 meters)	23 feet (7.01 meters)
CTS-1000	14.5 feet (4.419 meters)	16 feet (4.876 meters)	20 feet (6.096 meters)

Height Requirements

The ceiling height of the room should be high enough to comfortably fit the TelePresence system and any peripherals that might be located above the system and be within local construction codes for fire suppression systems, suspended light fixtures, and so on.

These codes vary by location and the age of the building, but in general, a minimum ceiling height of 8 feet (2.438 meters) is necessary for a TelePresence system.

Determining Room Height

To begin, find the height of the TelePresence system. The CTS-3000, for example, measures precisely 6.76-feet (2.060-meters) high. The CTS-1000 measures precisely 6.48-feet (1.975-meters) high.

Vertical Clearance Considerations for Light Fixtures and Fire Suppression Systems

However, the height of the system is not the critical factor that determines the minimum ceiling height. What's more important are the light fixtures and fire suppression systems. Suspended light fixtures require a minimum vertical clearance from the top of the fixture to the ceiling from which it hangs to achieve optimal reflectivity of the light bouncing off the ceiling, and a minimum vertical clearance from the bottom of the fixture to the tops of people's heads. Even recessed light fixtures have a minimum vertical clearance to throw the light out at the correct angle to provide the optimal coverage pattern. If the ceiling is too low, even the most-expensive recessed light fixture cannot distribute the light properly. The section "Lighting and Illumination," later in the chapter, covers more about light fixtures. Likewise, fire suppression systems have regulations that determine the minimum vertical clearance from the sprinkler head to the equipment and people below it. Consult your local city or state ordinances to understand this better.

Factoring in Vertical Clearance for Peripherals

Second, additional peripherals such as auxiliary data displays or document cameras might be located in the ceiling or suspended from the ceiling. Both the CTS-3000 and CTS-1000 systems support the use of optional LCD displays that you can mount to the ceiling above the system or locate on the right or left sides of the system. If the LCD display is above the system, you need to allow sufficient space between the light façade structure of the system and the ceiling to accommodate the additional overhead display.

Consider the example of a customer who wants to install a 40-inch (101.6-centimeter) NEC 4010-BK LCD display mounted to the ceiling above the CTS-3000. The 40 inches is the diagonal measurement of the display. The actual height of this particular display is 24 inches (60.96 centimeters), and you might want to leave a couple of inches between the bottom bezel of the LCD display and the top edge of the TelePresence system to allow for flexibility in the exact vertical placement of the display. Figure 8-11 illustrates this arrangement.

However, note that in Figure 8-11, if you suspend light fixtures that hang down 24 inches (60.96 centimeters) below the ceiling, they might obstruct the participants' view of the overhead LCD display. Therefore, the ceiling must be high enough so that the angle of the participants' view of the LCD display clears the bottom of the light fixture by a comfortable number of inches (centimeters).

Document cameras, such as LCD displays, can also be mounted from, or within, the ceiling. You can install the Wolfvision VZ-32 Ceiling Visualizer, for example, within a plenum housing recessed within a dropped ceiling, or from a pole in situations where recessing it

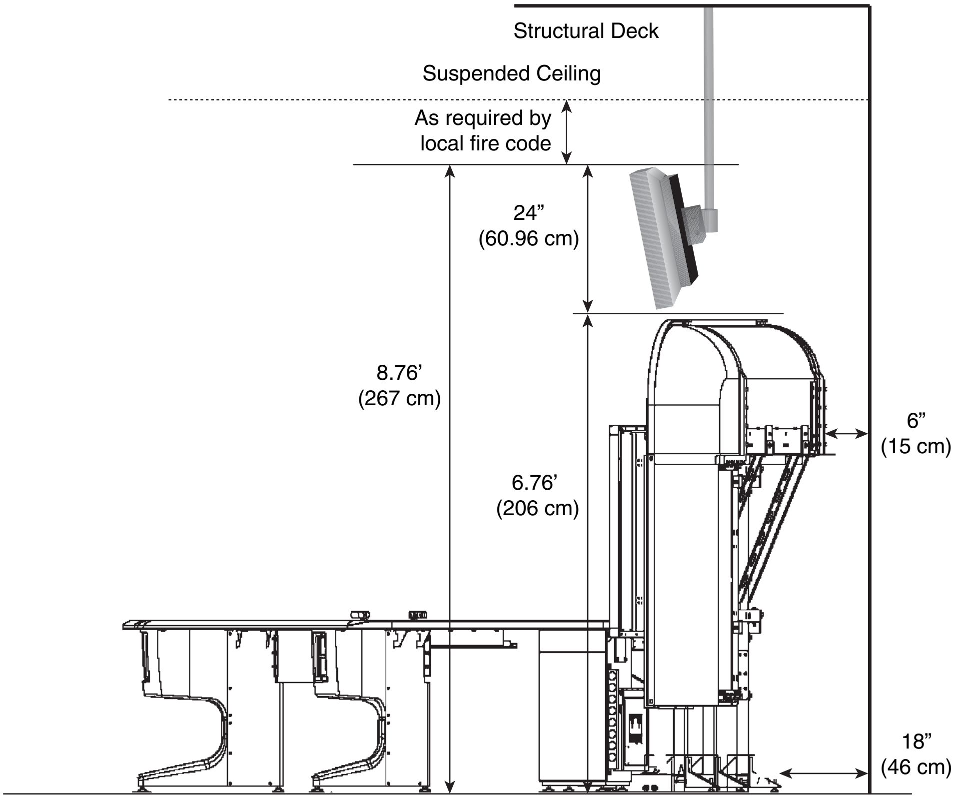

Figure 8-11 *CTS-3000 with optional auxiliary LCD display on top*

is not an option. In either case, the Wolfvision VZ-32 Ceiling Visualizer has a minimum height requirement to properly capture a document or other object located on the table surface of the TelePresence system. This is because you must install this particular camera at an 18-degree angle from the area of table it will be capturing. Figure 8-12 illustrates this arrangement.

Tip Mount the Visualizer to the structural deck in such a way as to eliminate vibrations. Vibrations caused by Heating, Ventilation, and Air Conditioning (HVAC) systems can cause the image on the Visualizer to "shake." Refer to the manufacturer's documentation for recommended ceiling installation procedures.

Based on all the preceding information, the recommended ceiling height of a Cisco TeleP-resence CTS-3000 and CTS-1000 room is 10 to 12 feet (3.048 to 3.657 meters).

Understanding Maximum Height Constraints

The last thing to consider is the maximum ceiling height. Like the maximum width and depth discussed previously, the maximum height is primarily a function of lighting and

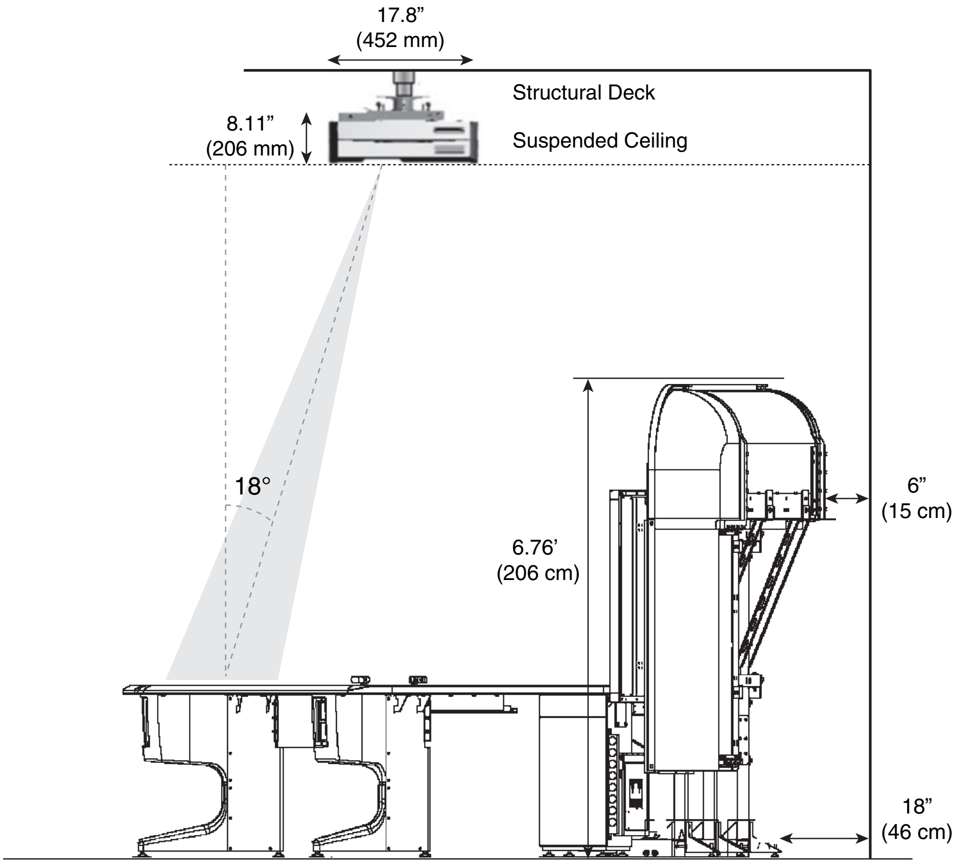

Figure 8-12 *CTS-3000 with optional wolfVision ceiling visualizer*

acoustic considerations. Excessively high ceilings might make it extremely difficult to provide the correct amount of light throughout the room and might cause severe shadowing and dark areas, which must be avoided. Light fixtures take advantage of the reflective properties of the ceiling material (for example, the ceiling tiles of a dropped ceiling reflect light off their surface) to allow light emitted from the fixture to be spread evenly throughout the room. Likewise, the ceiling materials also reflect some percentage of sound. If the sound takes a long time to travel to and from the ceiling, it can result in high levels of reverberation within the room.

The most effective method of mitigating a ceiling that is too high is to install a dropped ceiling to reduce its height. However, if the ceiling is only a few feet too high, to mitigate lighting and acoustic issues, it might be adequate to simply use higher wattage bulbs in your light fixtures and use ceiling tiles that have a high Noise Reduction Coefficient (NRC) Rating to reduce reverberation. The sections “Lighting and Illumination” and “Acoustics” cover more about light fixtures and reverberation. You might need to consult a lighting expert to determine the most optimal type and quantity of light fixtures and bulb wattage required based on the height of your ceiling.

Height Requirements Summary

Based on all of the preceding information, Table 8-3 summarizes the minimum, recommended, and maximum height requirements for the CTS-3000 and CTS-1000 model systems.

Table 8-3 *Minimum, Recommended, and Maximum Room Height*

Minimum Height	Recommended Height	Maximum Height
8 feet (2.438 meters)	10 feet (3.048 meters)	12 to 14 feet (3.657 to 4.267 meters)

Angles, Shape, and Orientation

Rooms are not always square or rectangular in shape, often have protruding entrances, vestibules, or columns, and the walls can be curved or concaved. Walls and ceilings can also be vertically or horizontally asymmetrical.

These types of geometric patterns can be good or bad, depending on the orientation of the TelePresence system within the room. Consider the three primary factors:

- How angles and shapes within the field of view of the camera appear on screen
- Whether obstructions, such as protruding entrances and columns, interfere with the location of the TelePresence system within the room
- How the acoustics might be affected by curved, concaved, or asymmetric wall and ceiling angles

Considering the Effects of Protruding Walls

First, consider how objects appear within the camera's field of view. Figures 8-13 and 8-14 illustrate the horizontal and vertical fields of view on the CTS-3000.

From a top-down perspective (horizontal field of view), the cameras capture a portion of the side walls and the entire back of the room. From the side perspective (vertical field of view), the cameras capture everything from just above the participants' heads all the way down to the baseboards and even the floor, depending on how far away the back wall is from the cameras. Refer back to the "Depth Requirements" section in this chapter for guidance on how deep the room should be.

The point of these illustrations is to highlight that everything within the camera's field of view will show up on screen. Vertical and horizontal lines and shapes on the walls and floor can appear on camera and be distracting; inverted corners can cause undesirable shadowing because light from the ceiling fixtures might not reach it; and protruding walls can interfere with the placement of the system.

For example, consider what would happen if a protruding wall or column were placed within the room. Figure 8-15 illustrates this arrangement.

Not only would this protruding wall become an obstacle for the two participants seated on the right side of the system and interfere with the circulation zone behind them, but

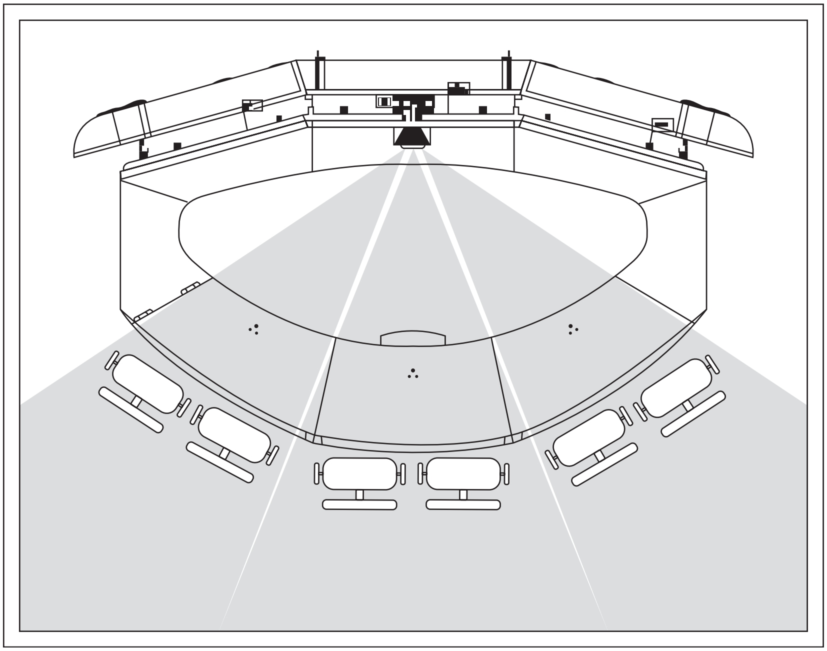

Figure 8-13 *CTS-3000 horizontal field of view*

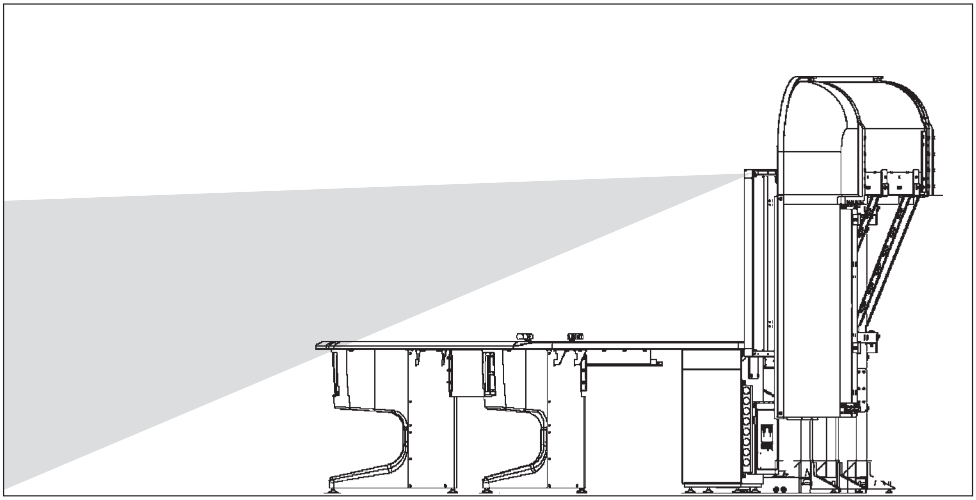

Figure 8-14 *CTS-3000 vertical field of view*

also the vertical edges of the wall would appear on camera and could be distracting. Most important, in this particular example, the corners where the back and side walls meet the protruding wall will likely be darker than the other wall surfaces because light from the ceiling fixtures will not illuminate them as well. Depending on the dimensions of the room, it might be possible to reorient the system to avoid this situation. Figure 8-16

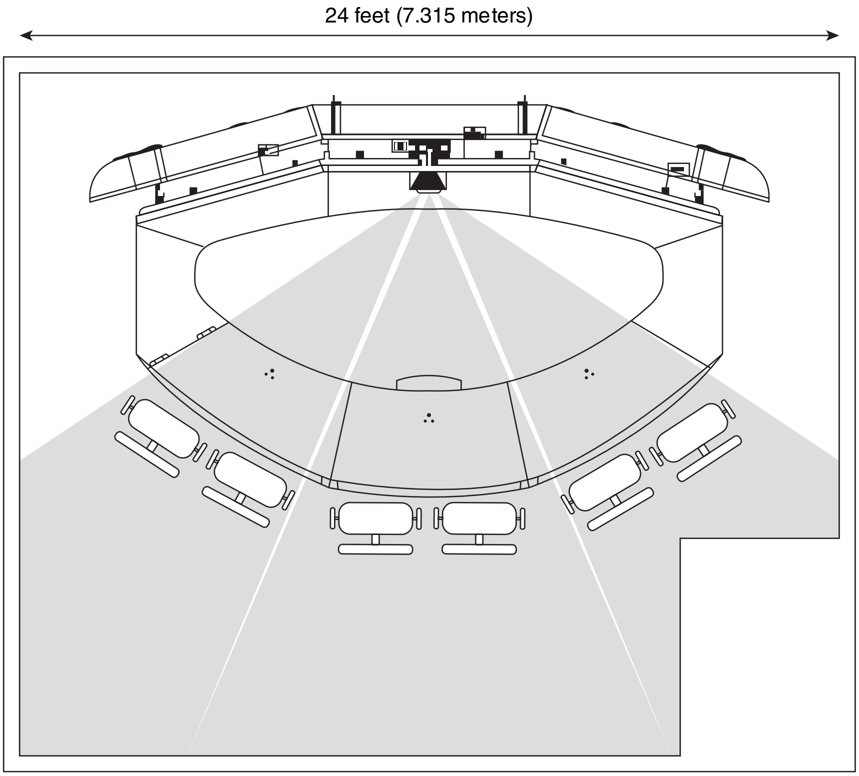

Figure 8-15 *CTS-3000 with protruding wall within the horizontal field of view*

illustrates one example of how this can be achieved, provided that the walls are wide enough the fit the system and depending on the location of the door.

This example arrangement sacrifices access to the back of the system from the left side of the system to place the system as close to the middle of the room as possible, but access is still available from the right side, so it might be the best compromise in this example. This arrangement also leaves no room on the left or right sides of the system for optional peripherals such as auxiliary LCD displays; however, if the ceiling is high enough, the customer might opt to mount the auxiliary LCD display from the ceiling above the system. Also, depending on the location of the door, this arrangement might not be possible at all, or the door would need to be moved to an alternative location. The customer must weigh the pros and cons of these trade-offs. The best solution might be to simply find a different room or investigate how much it would cost to have the protruding wall removed.

Considering the Effects of Curved and Concave Walls

Next, consider the effect of curved and concaved wall surfaces. Depending on their shape and the orientation of the system within the room, curved and concaved wall surfaces can produce unfavorable acoustic side effects because sound reverberating off their surfaces could converge at a certain place within the room. Figure 8-17 illustrates an example of this effect.

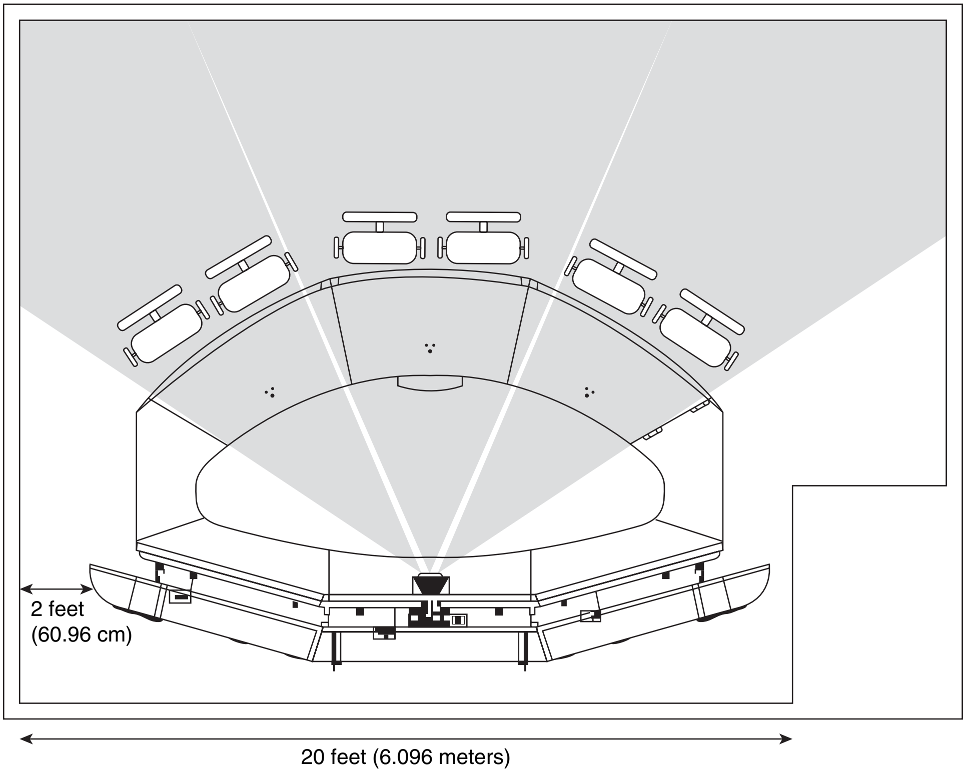

Figure 8-16 *CTS-3000 reoriented to eliminate protruding wall*

The arrows within the diagram illustrate how sound emanating from the system reflects off the walls in such a way that it converges in the center of the room. Reverberation levels in the center are higher than on the outsides, which can throw off the echo-cancellation algorithms of the system and cause a negative acoustic experience for the participants. Simple tactics for reducing this effect include placing furniture or hanging acoustic-dampening material, such as fabrics or oil paintings, on or near the back wall to either absorb the sound or cause it to reflect in a different direction. The section "Acoustics" later in the chapter, covers reverberation in greater detail.

Considering the Effects of Asymmetric Wall and Ceiling Angles

Finally, consider the effect of asymmetric wall and ceiling angles. Walls can be asymmetrical both vertically (the angle of the wall from floor to ceiling is not straight up and down) or horizontally (the length of the wall goes in toward the room or out away from the room at an angle). Ceilings can also be at asymmetrical angles. Figures 8-18 and 8-19 illustrate asymmetric wall surfaces from a top-down and side perspective.

These types of geometries can actually have a positive effect on the acoustic properties of the room because sound emanating from the system reflects in different directions. However, the wall surfaces that appear within the camera's field of view might be at odd

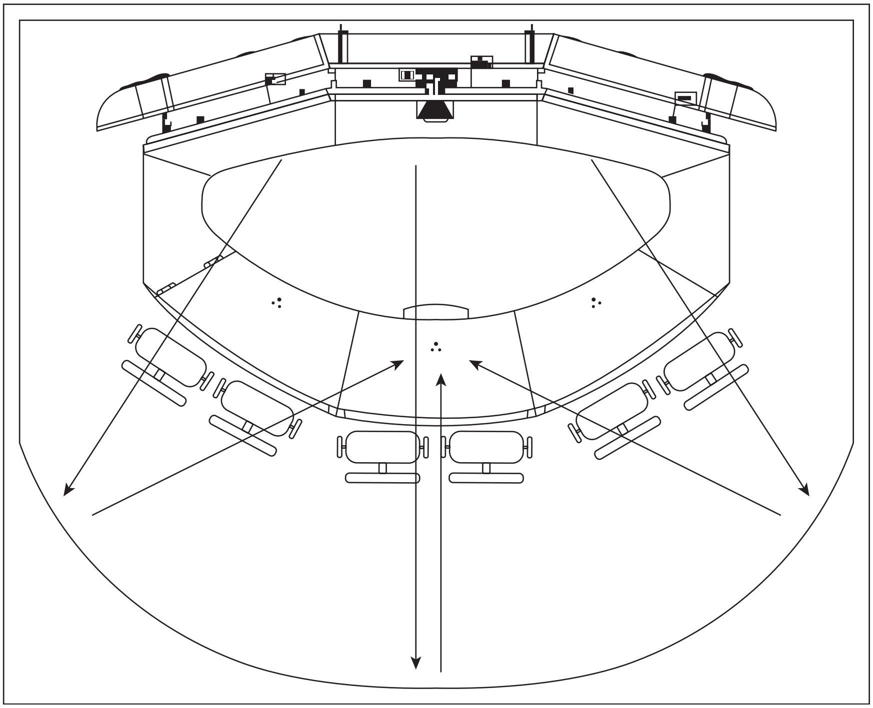

Figure 8-17 *CTS-3000 with concaved wall surfaces*

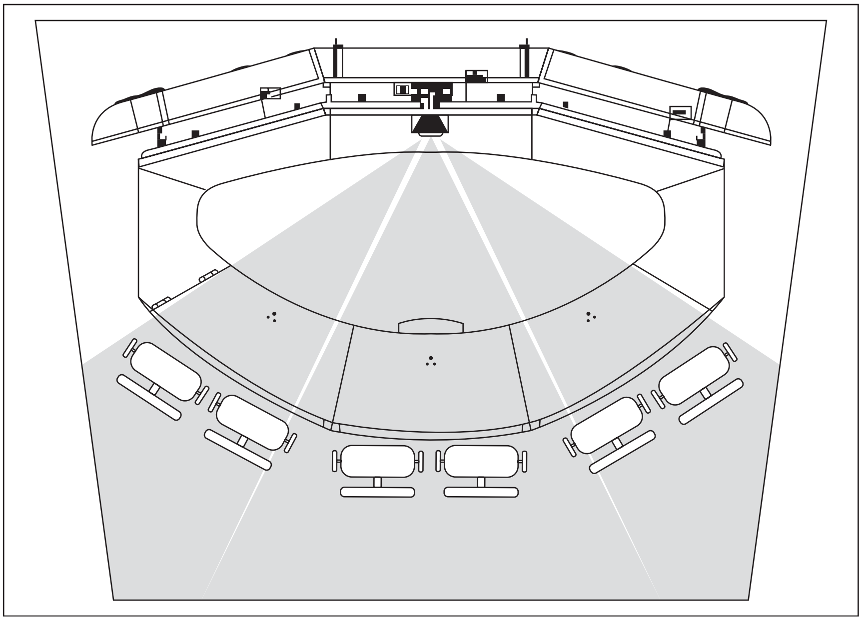

Figure 8-18 *CTS-3000 with horizontally asymmetric wall surfaces*

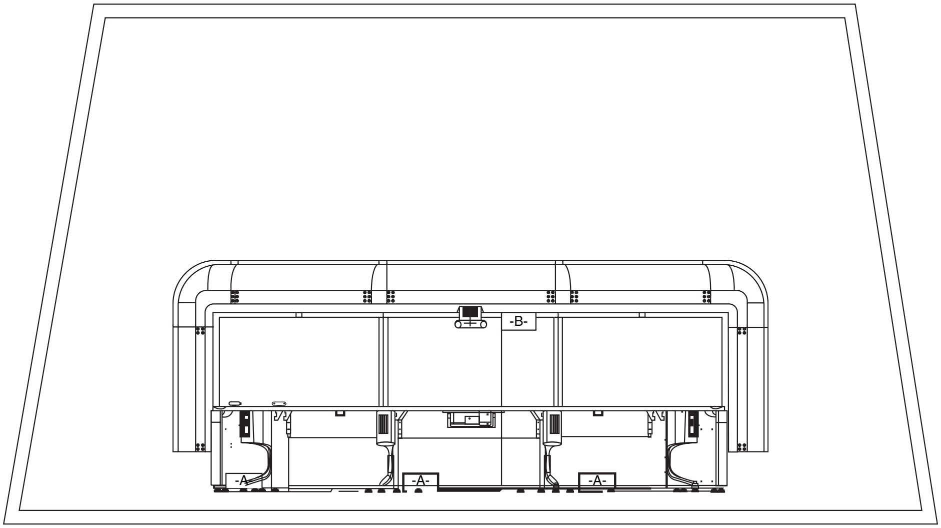

Figure 8-19 *CTS-3000 with vertically asymmetric wall surfaces*

angles and end up being a distraction. You might also find it more difficult to achieve a consistent level of illumination along the wall surfaces because of the odd-shaped corners.

Doors and Windows

The primary goal is to keep all doors and windows outside of the view of the cameras. However, this is not always possible and should not be considered a strict requirement. Doors should ideally be located so as to maximize the circulation zone around participants' chairs and should not be located behind or on the sides of the system. Figure 8-20 illustrates the recommended door locations on a CTS-3000.

The ideal arrangement is to have a vestibule, although this is seldom feasible given standard conference room dimensions. Figure 8-21 illustrates an example vestibule arrangement.

Remember that any surface within the view of the cameras should be made of a material that looks good on camera and complements the décor of the room. Therefore, steel and wood grain doors should be avoided, particularly if they are within the view of the cameras. Painted surfaces free of any distracting textures are the best choice.

Door jambs should be sealed to block ambient sound from outside the room from leaking through the cracks in the door jamb or the space underneath the door. The section "Acoustics," later in the chapter, covers ambient noise in greater detail.

Cover windows, regardless of their location, to block out all sunlight and reduce acoustic reverberation. Windows that face the interior of the building and do not allow any sunlight into the room do not necessarily need to be covered, although you might still want to do so for purposes of acoustics and aesthetics. When windows are within the view of the cameras, special care needs to be taken to choose a window covering that looks good on camera. Horizontal and vertical blinds are not recommended. Loose, billowy drapes

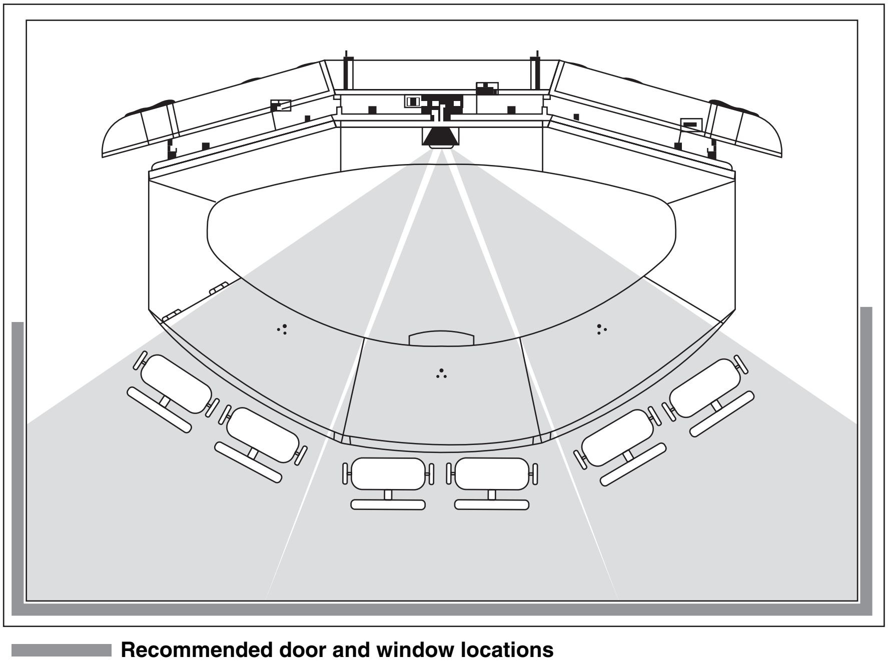

Figure 8-20 *CTS-3000 recommended door locations*

and curtains are also not the best choice. Drapes made from a straight or taut material are the most suitable and should ideally be a solid color, free of any distracting patterns or textures, look good on camera, and complement the décor of the room.

Wall, Floor, and Ceiling Surfaces

Now that you have an idea of the necessary size, shape, and orientation of a TelePresence room, the following sections discuss the importance of colors, textures, patterns, and the acoustical behavior of the wall, floor, and ceiling surfaces within the environment.

Wall Surfaces

The color, Light Reflectivity Value (LRV), texture, and patterns of visible wall surfaces greatly influence the quality of the video experience and the capability of the TelePresence system to accurately reproduce human skin tones. In addition, certain wall surface materials provide better acoustic behavior than others. Some materials reflect sound, whereas others absorb it. The most common types of wall surface construction materials are gypsum drywall, wood paneling, brick or cinder block, and glass.

Considering Surface Pattern and Texture

The first element to consider is the pattern and texture of the material. The patterns and textures of wood grain surfaces and brick and cinder block materials can create odd visual disturbances in the video and therefore should be avoided on all wall surfaces that are

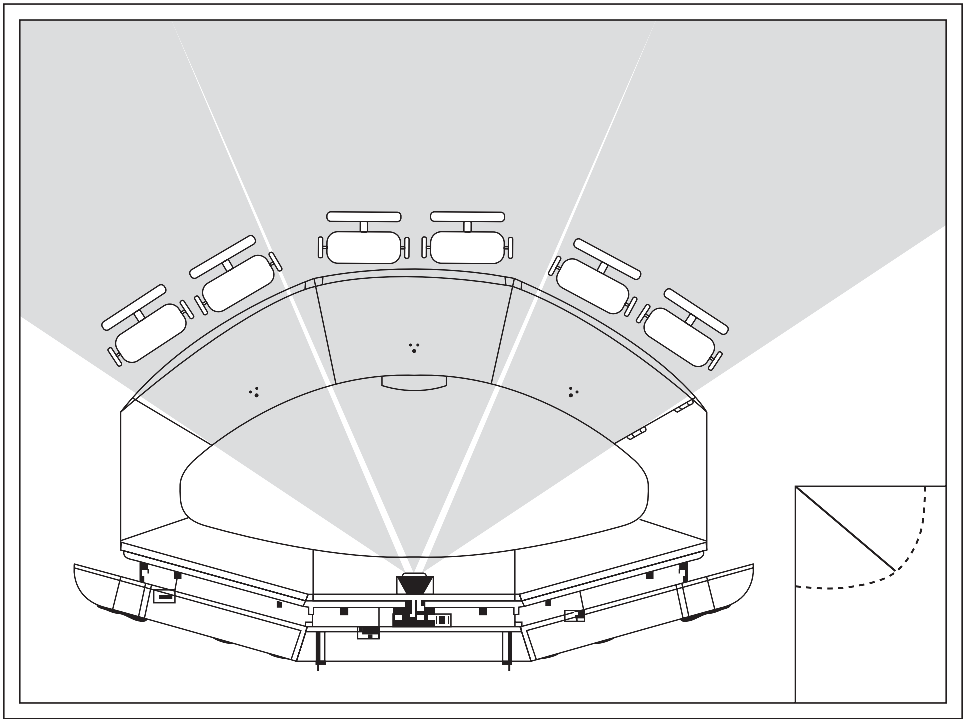

Figure 8-21 *CTS-3000 with vestibule entry way*

within the camera's field of view. Likewise, surfaces with horizontal or vertical lines, such as wood paneling, should ideally be avoided. Finally, surfaces with busy patterns such as wallpaper are discouraged. The optimal choice is painted gypsum drywall.

Considering Surface Acoustic Properties

The second aspect is the acoustic behavior of the material. The wall surfaces should absorb sound from within the room and from outside the room. Sound emanating from within the room should be absorbed by the wall material rather than reverberate off of it. The amount of sound reflected by a material is the Noise Reduction Coefficient (NRC). The higher the NRC rating, the more sound is absorbed by the material. In addition, sound emanating from within the room should not transfer through the wall material, nor should sound emanating from outside the room transfer through the wall material into the room. The amount of sound absorbed as it penetrates through a material is the Sound Transmission Class (STC). The higher the STC rating, the more sound is absorbed as it passes through the walls. This also applies to doors and windows. Doors should be solid, not hollow, and the door jambs should be sealed to reduce the amount of noise allowed to transfer through the cracks around the sides, top, and under the door. The section "Acoustics," later in the chapter, covers NRC and STC ratings in greater detail.

Although wood and gypsum drywall tend to absorb sound, materials such as brick or cinder block and glass surfaces tend to reflect sound. Finished wood surfaces such as paneling can also be highly reflective. Therefore, even if the wall surface in question is outside the view of the cameras, it might still be undesirable from an acoustical perspective. However, an acoustically reflective surface on one side of the room can be offset by an acoustically absorptive surface on another, so just because the material is acoustically reflective does not mean you shouldn't use it in certain portions of the room for its aesthetic appeal.

Considering Surface Color and Light Reflectivity Value

The third aspect is the color and Light Reflectivity Value (LRV) of the surface. LRV is a measure of how much light is reflected off a painted surface and, conversely, how much is absorbed. Figure 8-22 illustrates a simple LRV scale.

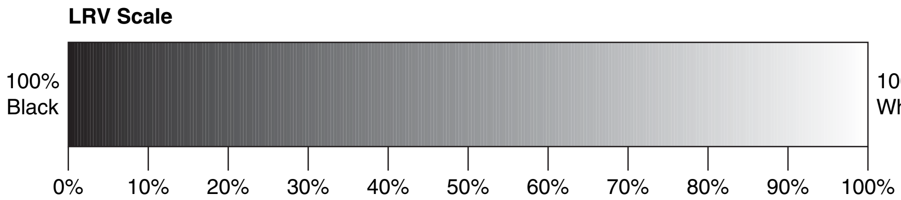

Figure 8-22 *Light Reflectivity Value (LRV) scale*

Depending on the amount of pigment within the paint, deep, dark colors tend to absorb certain light spectrums while reflecting others. For example, a cherry or mahogany wood desk or cabinet can create a reddish hue on objects within the camera's field of view and cause certain people's skin tones to look too red. Other colors can give people a greenish or yellowish hue making them look ill. People who work with cameras and video equipment, such as studio camera crews, newscasters, and the like know full well the effects that different paint colors have on people's skin tones. The behavior of the paint color also depends on the color temperature and intensity of the light within the room. The section "Lighting and Illumination," later in this chapter, provides more detail about light color temperature and luminosity.

For the uninitiated, rather than delving into the theory behind these concepts and expecting TelePresence customers to become overnight experts in paint colors, Cisco has attempted to simplify this entire issue by defining a palette of recommended colors to choose from that provide optimal flesh tone depiction within the Cisco-specific camera, codec, and plasma technology. For the specific color temperature and luminosity of a CTS-3000 or CTS-1000 environment, Cisco has found that the best choice of paint colors are those that are of a neutral tone, are chromatically tame, and fall within an LRV range of 18 to 20 percent. Other TelePresence vendors and even future models of Cisco TelePresence solutions might provide slightly different color recommendations based on the design of their systems and the type of virtual experience they want to create. For example, a TelePresence solution designed for a doctor's office or a hospital's surgery room, or a solution designed for a presenter on stage in front of a virtual audience might have radically different paint color and lighting recommendations.

However, because of the vast number of different color systems and paint manufacturers throughout the world, it has not been possible for Cisco to specify exact color reference indexes on a global level. Therefore, Cisco took the approach of selecting several paint colors from Benjamin Moore and providing those as "example" recommended colors. The list that follows provides the currently recommended Benjamin Moore colors:

- Wilmington Tan: HC-34
- Huntington Beige: HC-21
- Woodstock Tan: HC-20
- Cork: 2153-40
- Classic Caramel: 1118
- Fairmont Gold: 1071
- Peach Brandy: 112

Tip Do not rely on electronic or printed color samples. Computer monitors and printers are not calibrated to accurately reproduce these colors; therefore, these should be considered as examples only. Customers are encouraged to order physical color samples (also known as color swatches) from Benjamin Moore and take those to their local paint supplier to have them matched.

Considering Surfaces in Camera Field of View

The last item to discuss is any other wall surface treatments or adornments that might be within the camera's field of view. This includes door and window frames, cabinetry, recessions and other aesthetic wall construction, paintings, signs and company logos, or any other object that has a surface that is within the camera's field of view. The same principles of color, texture, and pattern described previously apply to these objects as well. In addition, avoid bright contrasts, such as neon lights within a sign or company logo, and reflective surfaces, such as glass picture frames and dry-erase boards; however, some amount of contrast is encouraged. For example, window treatments, a company logo, or an oil painting that complements the look and feel of the room can provide just the right amount of contrast to complement a large surface of painted gypsum drywall.

Flooring Surfaces

The type of flooring material used within the TelePresence room can greatly affect the acoustical experience of the system. The most common types of flooring surface material are carpet, wood, tile and marble, and raised plenum floors. To be blunt, all materials other than carpet are terrible from an acoustic perspective and should be covered with carpeting. This can be an unfortunate yet necessary step for customers who have invested a lot of money installing beautiful marble floors or those wanting to install a TelePresence system in a room that has a raised plenum floor. There are two aspects to the acoustic behavior of flooring materials that you need to consider:

- The amount of ambient sound that bounces off the surface versus being absorbed by the surface is the Noise Reduction Coefficient (NRC). All flooring surfaces have an

NRC rating assigned to them. The higher the NRC rating, the more sound is absorbed by the surface. Carpet provides the highest NRC rating of all flooring surfaces.

- The amount of noise created by walking on the surface. This is the Impact Insulation Class (IIC) and is also commonly referred to as *foot fall*. All flooring surfaces have an IIC rating assigned to them. The clicking and thumping sounds produced when people walk across a floor surface can reverberate throughout the room. This is especially important for raised plenum floors because the sounds reverberate within the hollow space underneath the floor.

Note The section "Acoustics," later in this chapter, covers NRC and IIC ratings in more detail.

Consider the type of carpet you should use, given that carpet is the inevitable choice:

- Portions of the carpet might be visible within the camera's field of view, depending on the depth of the room. (Refer back to Figure 8-14 in the Depth Requirements section earlier in this chapter.) Therefore, the same principles discussed in the previous section for paint colors, textures, and patterns apply to this portion of floor surface as well. You need to choose a color for your carpet that looks good on camera, is complementary to the rest of the room, and is free of loud or busy patterns. If the carpet is not within the field of view of the camera, you are free to choose whatever colors and patterns suit your artistic desires, although most corporate environments tend to use warm or neutral tones.
- The carpet should not be excessively thick or else the participants will have difficulty rolling their chairs in and out from the table. Standard industrial-strength, short carpeting, typical of what is found in the average corporate conference room is recommended.
- The carpet does not have to be laid in one solid piece. You can use tiled carpet that is applied in sections. This is especially useful on raised plenum floors so that you can still access the floor tiles to run conduit or cabling. However, tiled carpeting can tend to wear around the edges because of foot traffic, so you need to consider how and where it is applied and solicit the advice of a carpeting expert for assistance.

Ceiling Surfaces

The type of ceiling material used within the TelePresence room can greatly affect the acoustical experience of the system and the illumination. The most common type of ceiling material in corporate environments is dropped ceiling tiles (also known as suspended ceilings). However, metal, wood, gypsum drywall, and cement ceiling surfaces are also found in some locations.

Before analyzing different ceiling materials, it is worth stating that every TelePresence room, regardless of size, needs a ceiling over it. This might seem like an odd thing to say, but some customers have tried to install TelePresence systems in rooms that have an open ceiling. For example, this has been an issue when attempting to demonstrate a TelePresence system in a trade show environment such as a convention center where they build a booth to contain the system.

A ceiling is necessary for two reasons:

- To isolate the room from outside noise, such as foot traffic and conversations in adjacent rooms and hallways.
- Overhead, ceiling-mounted light fixtures are mandatory to provide the proper levels of ambient light throughout the room.

Trade show environments have special ceiling considerations because anytime you put a ceiling over something, all sorts of fire and electrical codes come into play. These subjects are outside the scope of this book. You should consult a company that specializes in constructing trade show booths for details.

Dropped ceilings with removable tiles provide the best acoustical and illumination performance. They also provide the most flexibility for rearranging objects within the ceiling such as light fixtures, air conditioning registers, ceiling-mounted document cameras, and the like. However, dropped ceilings might not be possible if the height of the ceiling is too low. Customers should be aware of the negative consequences and what features they might lose by installing a system in a room that does not have a dropped ceiling. After reviewing this section and referring back to the "Room Height Requirements" section previously in this chapter, when you take all factors into perspective, the best choice might be to find an alternative room.

Two primary considerations when choosing a ceiling material follow:

- **Acoustic properties:** How much sound is absorbed by the ceiling material?
- **Reflectivity:** How much light is reflected off the ceiling surface?

Considering the Acoustic Properties of the Ceiling

First, the ceiling material should absorb sound from within the room and from outside the room. Sound emanating from within the room should be absorbed by the ceiling material rather than reflecting off of it. The amount of sound absorbed by a material is the Noise Reduction Coefficient (NRC). The higher the NRC rating, the more sound is absorbed by the material, which, in turn, reduces the amount of acoustic reverberation within the room. In addition, sound emanating from within the room should not transfer through the ceiling material, nor should sound emanating from outside the room transfer through the ceiling material into the room. The amount of sound absorbed as it penetrates through a material is the Sound Transmission Class (STC). The higher the STC rating, the more sound is absorbed as it permeates through the ceiling. These concepts are further explained in the "Acoustics" section later in this chapter. Ceiling tiles with an NRC rating of .80 or greater and an STC rating of 60 or greater are recommended, as described in Table 8-4 and illustrated in Figures 8-40 and 8-41.

Considering the Light Reflectivity of the Ceiling

Second, as discussed in the "Lighting and Illumination" section, the goal of the light fixtures in the ceiling is to fill the room with just the right amount of ambient light. The ceiling material chosen can either complement or detract from this goal. Ceiling materials that are bright in color tend to reflect light off their surface, allowing the light fixtures in the ceiling to reach their full potential. Conversely, ceiling materials that are dark in color tend to absorb light, reducing the effectiveness of the light fixtures in the ceiling and making it more difficult to achieve the proper amount of illumination within the room. Ceiling tiles illustrated that are white or beige in color are reflective in nature. A surface that is too reflective can cause the amount of light bouncing off the ceiling to be uncomfortably bright. The reflectivity of the ceiling surface should not be as reflective as a mirror, for example. It should diffuse the light, while reflecting it to produce a soft glow unnoticeable to the human eye.

Lighting and Illumination

Lighting is the single most critical element that can influence the quality of the perceived video. It is affected by the dimensions (width, depth, and height) and angles of wall surfaces of the room; the diameter of the camera lens (known as the aperture); and the color and reflectivity of wall, floor, and ceiling surfaces. Too much light, and the room will feel like a recording studio and will be uncomfortable for the participants to sit in for long durations of time. Conversely, a room that is not lit well enough will appear dark on camera, shadows will appear around the face and neck of participants and in the corners of the room, and the perceived quality of the video will suffer.

Have you ever wondered how television and movie directors record such vibrant looking scenes, or how camera crews can take a picture of a room that looks so stunning and realistic? The secret is in how they illuminate the environment. Film and camera crews use special studio-quality lighting to illuminate their subjects in just the right way to produce the richest, most vibrant images possible. If you've ever been on stage, in a recording studio, or in a photo shoot, you'll probably recall how warm, bright, and uncomfortable it was under those lights. The primary goal of these environments is to illuminate the face of the subjects, along with their background environment, so that they look good on camera.

Conversely, the average conference room or meeting room and cubicle and hallway environments in office buildings are generally designed to provide a warm, soft lighting environment that is comfortable to work in for long durations. The primary goal of these environments is to illuminate table and work surfaces where people write or type on computer keyboards.

The goal of a TelePresence room is to strike just the right balance between studio-quality lighting and comfort for the participants. The participants and the environment around them must be illuminated properly to produce the most realistic, lifelike video quality. However, the environment should be comfortable enough for the participants to sit in it for hours without developing a headache or eye strain.

The three aspects to the design of lighting within a TelePresence room follow:

- The angles and direction of the light and which surfaces it illuminates
- The temperature or color of the light
- The strength or intensity of the light

The following section begins by investigating the angles and direction of light required.

Considering Light Angles and Direction

In a *three-point lighting* system, three points, or directions, of light influence what the camera sees:

- First, the light that fills the entire environment is ambient light, or fill light. This light generally comes from fixtures in the ceiling to blanket the room in even, well-distributed light.
- Second, the light that falls on a participant's face is participant light, or point light. This light illuminates the face to reduce shadows around the eyes, neck, and other such surfaces that directly face the camera. Point lighting generally does not exist in the average conference room and, therefore, must be supplied as part of the TelePresence system.
- Third, the perceived depth in an image as viewed by a camera is best when the subjects' shoulders and the tops of their heads are gently illuminated, causing them to "pop out" from the background behind them. This is shoulder lighting, or "rim lighting and is optional for a high-quality TelePresence image. You can also use rim lighting to illuminate the wall behind the participants to achieve a similar effect (depth in the perceived image).

Figures 8-23 through 8-26 illustrate the effects of fill, point, and rim lighting on a subject.

The critical types of light for a TelePresence solution are ambient (fill) and participant (point) lighting. Shoulder (rim) lighting is optional and left to the discretion of the customer whether to implement it. The remainder of this section focuses on ambient and participant lighting.

Before getting into the details of how to design the proper amount of ambient and participant light into the room, let's quickly touch on the concepts of light color temperature and intensity.

Considering Light Color Temperature

The color temperature of a light source is effectively a measure of how yellow, white, or blue it appears. The system of measurement used for rating the color temperature of light bulbs is the Kelvin (K). Incandescent light bulbs produce a yellowish light, with a Kelvin rating of approximately 2800K. The average fluorescent light bulb used in commercial construction is 3500K. Studio environments typically use 5000K fluorescent bulbs that produce a white light. Lower color temperatures are easier on the eyes and, hence, their popularity in homes and office buildings; however, they do a poor job of illuminating things sufficiently to make a subject look good on camera. By contrast, a room lit with

Figure 8-23 *A subject on camera with fill lighting only*

Figure 8-24 *A subject on camera with point lighting only*

5000K fluorescent bulbs will make you look fantastic on camera but will be uncomfortable to sit in for long durations. After much trial and error during the early phases of design on the CTS-3000, Cisco found that the best color temperature to use in TelePresence rooms is 4000K to 4100K. Incandescent light bulbs do not produce this temperature of

Figure 8-25 *A subject on camera with rim lighting only*

Figure 8-26 *A subject on camera with 3-point lighting*

light, and, therefore, fluorescent bulbs and fixtures are recommended. Fluorescent light bulb manufacturers use different "friendly" terms to describe the temperature of their bulbs, such as "cool white," but in most cases they also print the Kelvin rating on the bulb.

For those that do not print the Kelvin on the bulb, you can usually look it up on the manufacturer's website based on the part number printed on the bulb.

Measuring Light Intensity

The intensity or strength of a light source such as a fluorescent bulb is effectively a function of its wattage. There are various systems of measurement for this, including lumens, lux, foot candles, and candela. Cisco has chosen to standardize on the lux measurement in all TelePresence-related documentation. Lux is a measure of the intensity of light within a volume of space. It is also a measure of the intensity of light that hits a surface, such as a wall, a subject's face, or a table surface. The lumen, by contrast, is a measure of how much light is emitted by a source. So although a bulb produces light in terms of lumens, what you're actually concerned with in a TelePresence room is how much lux it provides at various points within the room. The average conference room or meeting room found in corporate environments is approximately 150 lux to 300 lux. This is much too dark for the aperture of a camera to sufficiently capture a human subject in good detail. By contrast, the average studio environment is approximately 700 lux, which is much too bright for humans to be comfortable for long durations. After much trial and error during the early phases of design on the CTS-3000, Cisco found that the ideal light intensity for a TelePresence room is 400 lux.

To summarize, the goal is to fill the room with 400 lux of well-distributed ambient light, using fluorescent bulbs with a color temperature of 4100K. However, when measuring the light within the room, it is critical to understand the angles from which lux is measured within a TelePresence room.

Cisco uses a tool called a lux meter to measure the intensity of light at various points within the room. There are essentially four different angles from which light should be measured:

- From the camera's point of view, looking toward the participants
- From the participant's point of view, looking toward the cameras
- From the participant's point of view, facing upward toward the ceiling
- From the perspective of the side and back walls

Cisco divides the room into sections, or zones, to measure light from all these different perspectives. Figure 8-27 illustrate the zones of a CTS-3000 room.

Zones 1 to 3 provide a measure of how much light is seen from the perspective of the cameras. Zones 4 to 6 provide a measure of how much light is seen from the perspective of the participants, and hence how well lit the participants will look on camera. Zones 4 to 6 also measure how much downward light strikes the shoulders of the participants and the table surface. Zones 7 to 9 provide a measure of how much light reaches the back wall. Within each zone, it is important to note the direction from which the light should be measured. In zones 1 to 3, the measurement is taken with the lux meter facing the participants. In zones 4 to 9, the measurement is taken with the lux meter facing the cameras. In zones 4 to 6, there is an additional measurement taken with the lux meter facing up toward the ceiling at shoulder height. Figure 8-28 illustrates the direction the lux meter should be facing within each of the zones.

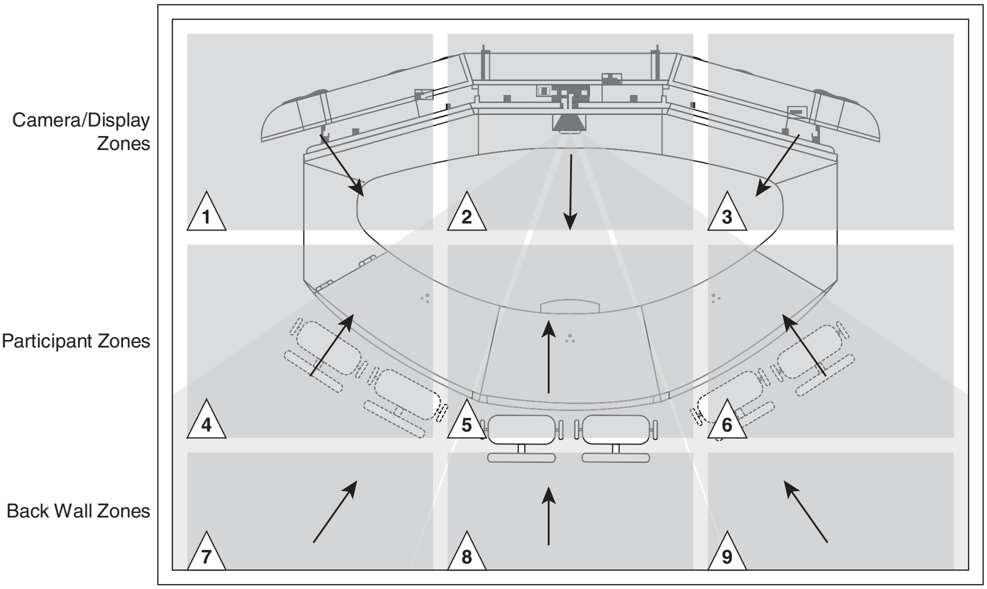

Figure 8-27 *CTS-3000 illumination zones—top down view*

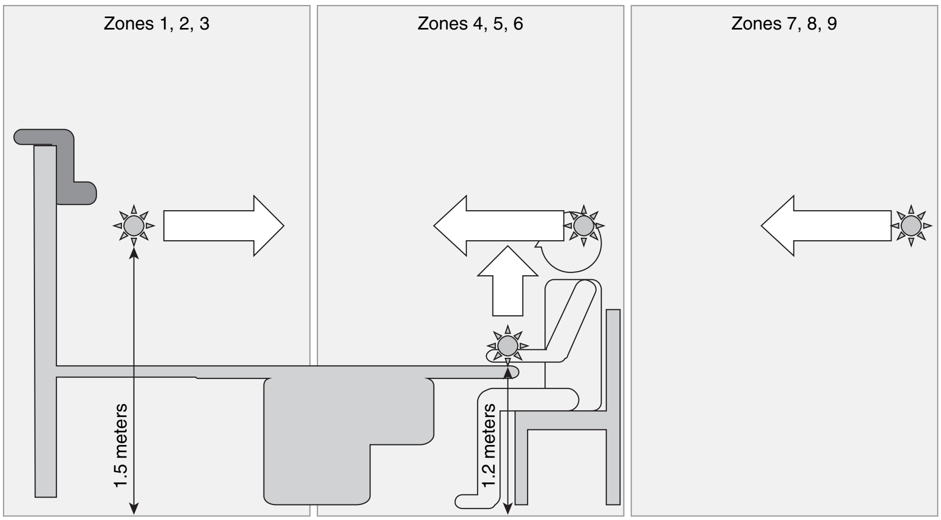

Figure 8-28 *CTS-3000 illumination zones—side view*

In zones 1 to 3, the light is measured with the lux meter facing toward the participants at approximately 5 feet (1.5 meters) from the floor. In zones 4 to 6, two separate measurements are taken:

- One with the lux meter facing toward the cameras at approximately 5 feet (1.5 meters) from the floor.
- The second with the lux meter facing up toward the ceiling at approximately 4 feet (1.2 meters) from the floor.

Finally, in zones 7 to 9, the light is measured with the lux meter facing toward the cameras at approximately 5 feet (1.5 meters) from the floor. Throughout all 9 zones, the light should measure approximately 400 lux, except for the second measurement in zones 4 to 6, in which the light should measure approximately 600 to 700 lux. No point in the room should measure lower than 150 lux or higher than 700 lux. Areas that are lower than 150 lux appear completely black on camera, and areas that are higher than 700 lux appear washed out on camera.

By following this methodology for measuring light within your TelePresence environment, you can achieve the best quality video and consistent, reproducible results. Although the illustrations provided are specific to the CTS-3000, you can use the same methodology in smaller or bigger rooms by simply shrinking or increasing the size and number of zones.

Light Fixture and Bulb Considerations

Fluorescent bulb manufacturers specify bulb intensity in terms of how many lumens they produce, but you are concerned with how much light they provide (in terms of lux) at various places throughout the room. The challenge, therefore, is to identify the number of bulbs per fixture, the number of fixtures, and the wattage per bulb required to achieve the desired amount of lux throughout the room. An expert lighting consultant can assist you to determine the best lighting configuration for any given room, and there are lighting design software applications on the market to help you determine precisely which type of fixture, how many bulbs per fixture, and what wattage of bulb you should use. Cost is obviously an important factor as well, so the ultimate goal is to find the right combination at the best possible price. This can also vary by city and by country because of the variety of fixture manufactures and construction costs in various parts of the world. The following sections provide some recommendations on the types and quantity of light fixtures that have been used successfully in Cisco TelePresence rooms to date.

The two most common types of ceiling light fixtures used within TelePresence rooms are pendant-style fixtures that hang down from the ceiling and recessed fixtures that are recessed within the ceiling. Both types are further broken down into three subtypes based on what direction the light is thrown: 100 percent direct, 100 percent indirect, and direct-indirect. Figure 8-29 and Figure 8-30 illustrate these various types of fixtures.

One hundred-percent direct light fixtures direct the light straight down instead of dispersing it evenly throughout the room. Therefore, the light will be more intense directly under the fixture compared to the perimeter of the area, or zone, in which it's measured. This results in hot spots on camera where the tops of people's heads and table surfaces is extremely bright and washed out, but the background areas such as wall surfaces are darker and shadowed. Therefore, 100-percent direct light fixtures are not recommended.

One hundred-percent indirect light fixtures function by directing light upward toward the ceiling or by refracting the light off a reflective surface within the fixture. This allows the light to be more evenly distributed throughout the room. As illustrated in Figure 8-30, indirect light fixtures can either be hung from the ceiling as a pendant-style fixture or recessed in the ceiling. Both types are recommended, but which one you ultimately decide to use depends on the dimensions (width, depth, and height) of the room.

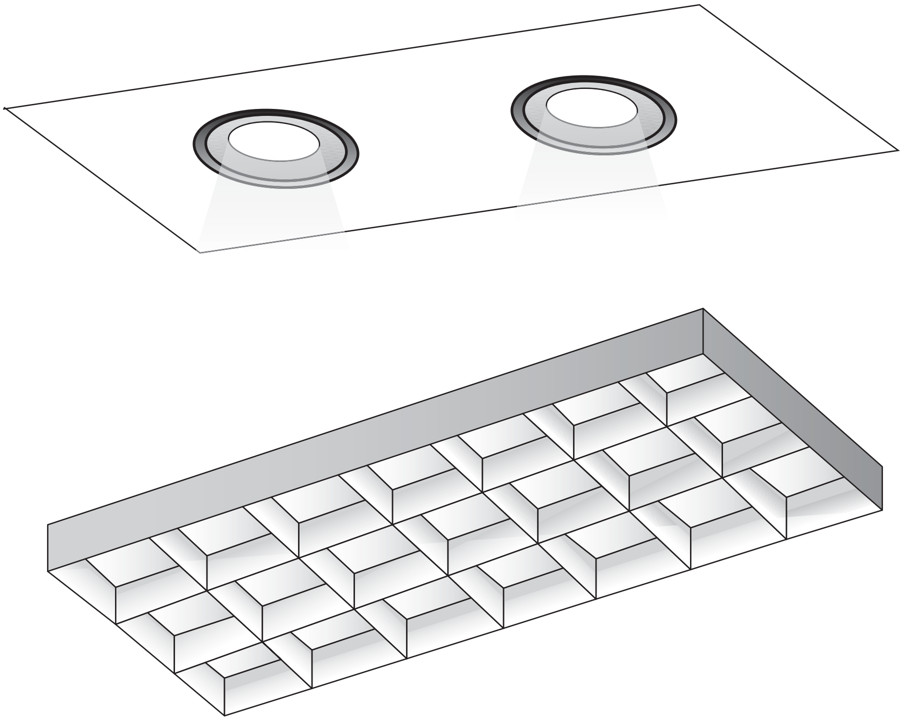

Figure 8-29 *Example of 100 percent direct light fixtures*

Both pendant-style and recessed-style fixtures are also available in direct-indirect configurations, where a portion of the light (for example, 20 percent) is directed downward while the remaining portion (for example, 80 percent) is directed upward toward the ceiling or reflective surface within the fixture. These are not recommended for the same reason that 100-percent direct fixtures are not—the portion of light that is directed downward could create hot spots. Figure 8-31 illustrates the difference between a direct and indirect fixture and a 100-percent indirect fixture.

Another aspect of indirect light fixtures is the degree of dispersion, which is a measure of the angle at which light is thrown from the fixture. The greater the degree of dispersion, the less fixtures are required to provide the same coverage of an area. Figure 8-32 illustrates the difference between a standard fixture that has a degree of dispersion less than 60 degrees and a higher-end fixture that has a degree of dispersion greater than 60 degrees.

Now, consider some example 100-percent indirect ceiling fixture arrangements, based on different room dimensions. These examples assume the use of a CTS-3000 room measuring 20-feet wide x 15 feet to 20-feet deep (6.096 meters wide x 4.572 meters to 6.096 meters deep). Figure 8-33 illustrates the recommended number and placement of fixtures using standard quality 2-feet x 4-feet (.609 meters x 1.219 meters) recessed fixtures.

Figure 8-30 *Example of 100 percent indirect light fixtures*

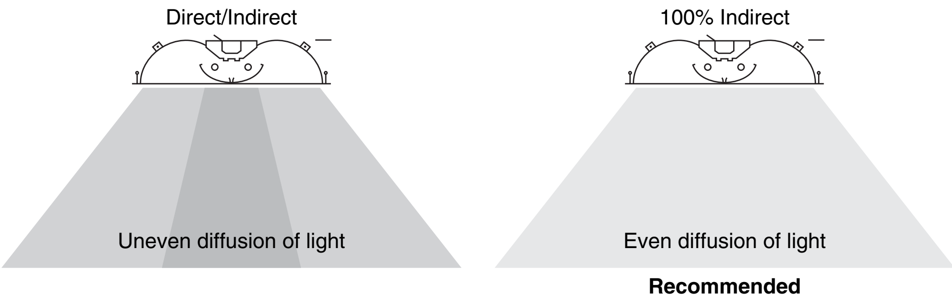

Figure 8-31 *Direct and indirect light fixture versus 100-percent indirect light fixture*

You can also achieve the same results using a higher-end model of fixture that provides either more bulbs per fixture (for example, four bulbs instead of two), run at a higher wattage level per bulb (for example, 80 watts instead of 40 watts) or with a higher degree of dispersion. Figure 8-34 illustrates this arrangement.

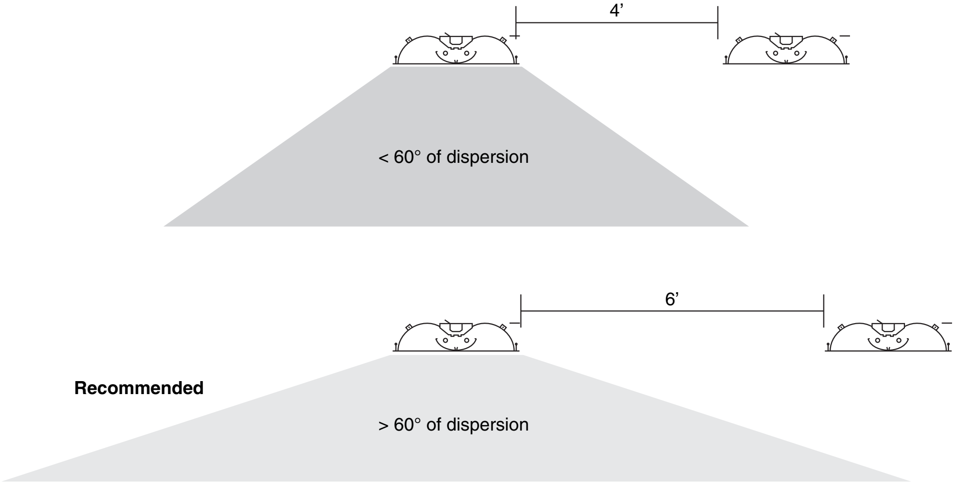

Figure 8-32 *Light fixture degrees of dispersion*

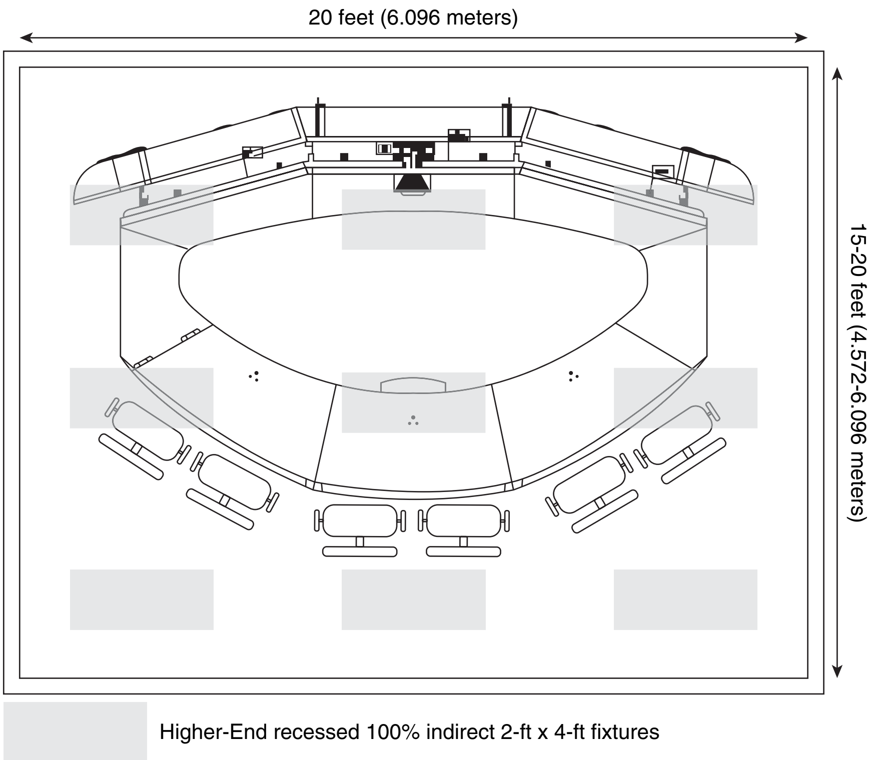

Figure 8-33 *Example CTS-3000 using standard recessed light fixtures*

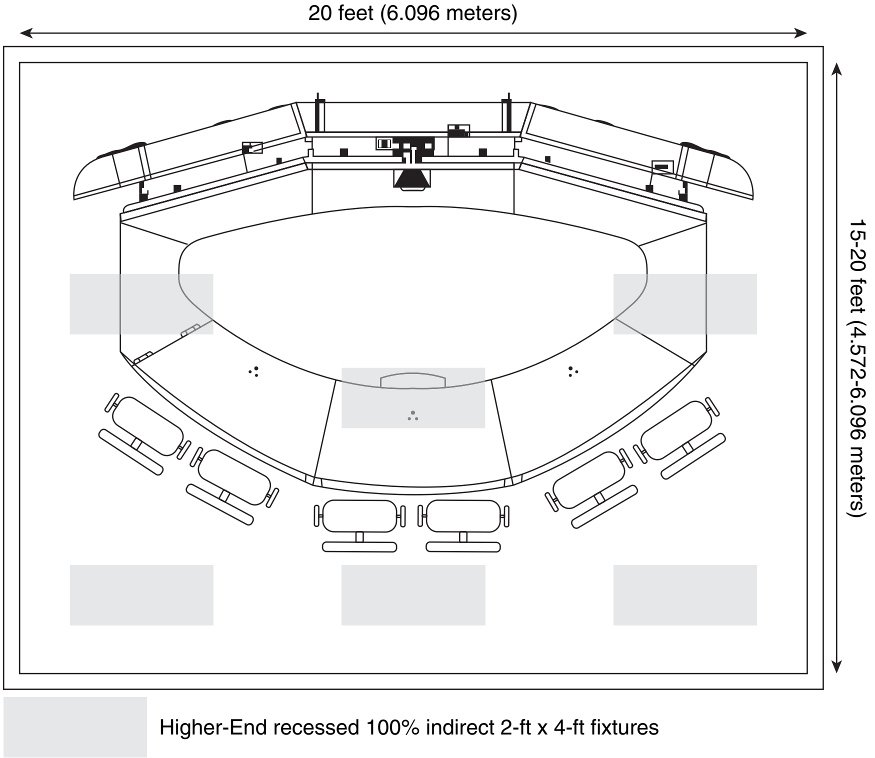

Figure 8-34 *Example CTS-3000 using higher-end recessed light fixtures*

Likewise, you can achieve the same results using 100-percent indirect standard suspended light fixtures. Figure 8-35 illustrates this arrangement for a room that is 15-feet deep (4.572 meters deep), while Figure 8-36 illustrates this arrangement for a slightly deeper room.

Light Fixture Ballast Considerations

The last item to consider when choosing a light fixture is the type of ballast it uses. The ballast is the device within the fixture that regulates the flow of power through the bulb. Fluorescent light fixtures have two types of ballasts: magnetic and electronic. Although magnetic ballasts are frequently preferred for their durability and long life, they produce a flickering effect on the TelePresence video because the cameras operate at a different frequency than the light fixtures. Therefore, electronic ballasts are required for Cisco TelePresence rooms.

Tip It is important that you use light fixtures with electronic ballasts. It is common to overlook this when designing the TelePresence room;, when the system is installed and first used, the customer sees the flickering on the screen, and then the light fixtures have to be swapped out. This can cause the installation to be delayed and the costs of the installation to increase.

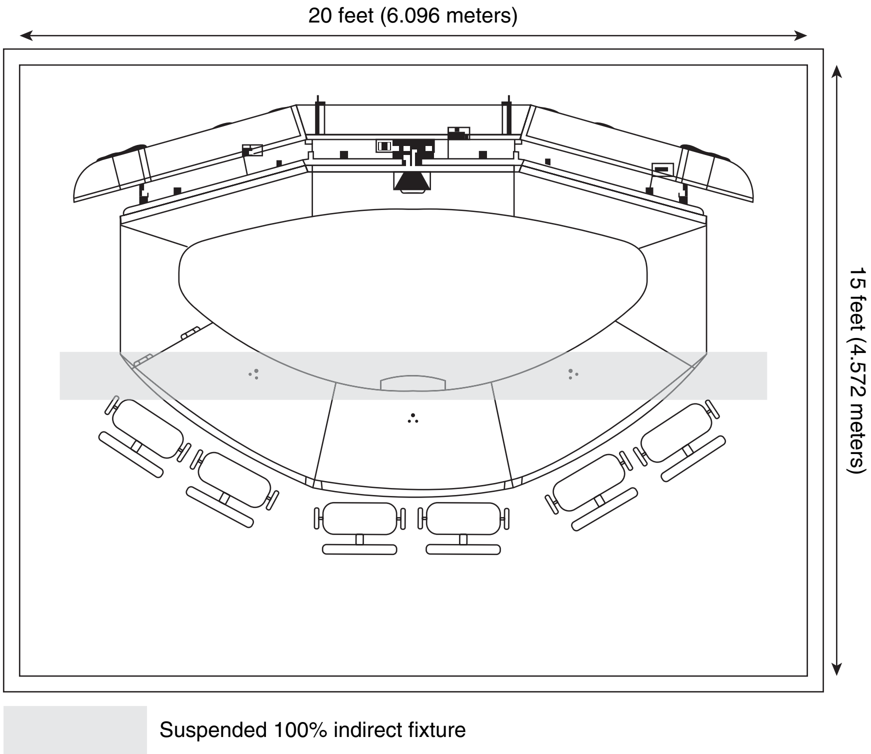

Figure 8-35 *Example CTS-3000 suspended light fixture for a 15-foot deep room*

Acoustics

One of the most impressive aspects of the Cisco TelePresence solution is its audio quality. The sound is spatial (emanates from the direction of the person who is speaking) and is full-duplex. (You can talk over each other with no clipping.) The microphones are directional and have a coverage pattern designed to capture the voice of the participants sitting directly in front of them. The microphones also filter out certain background frequencies. The audio compression board in the system encodes the voice from the participants at 48KHz using the Advanced Audio Coding—Low Delay compression algorithm. On the receiving end, the speakers are specifically designed to reproduce the frequency range and decibel levels of human speech so that it feels life-like, as if the person is sitting 8 feet (2.438 meters) or so away from you on the other side of the virtual table.

Other capabilities within the Cisco TelePresence portfolio exploit the acoustic properties of the Cisco TelePresence system. In multipoint meetings for example, the Cisco TelePresence Multipoint Switch (CTMS) relies on the signal strength of the audio coming from each microphone to determine which segment should be displayed at any given time.

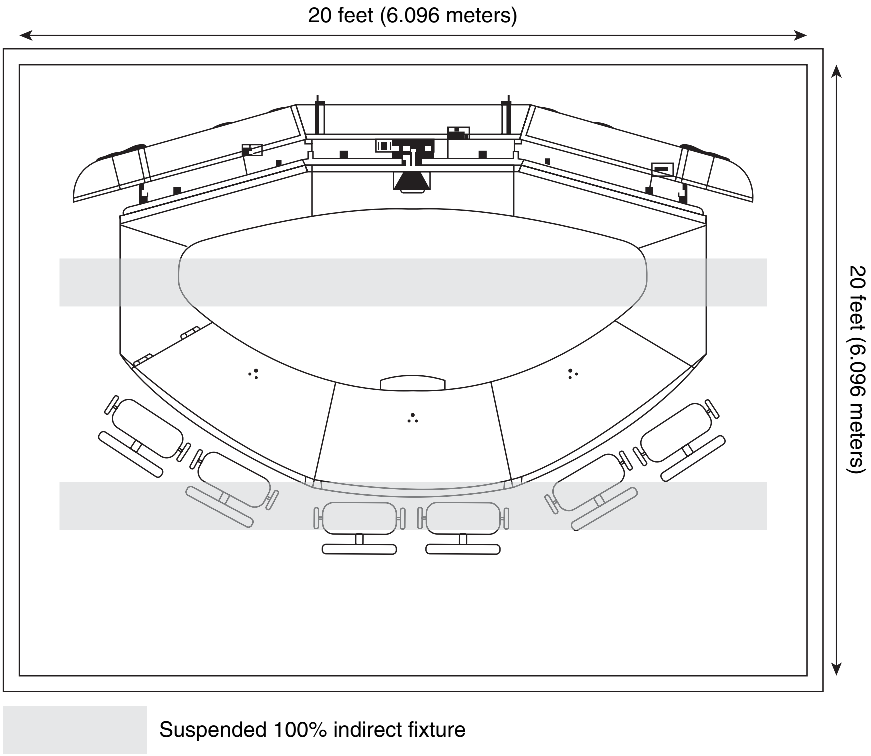

Figure 8-36 *Example CTS-3000 recessed light fixtures for a 20-foot deep rooms*

Background noise and reverberation in the room can degrade these acoustic qualities and even disrupt the switching behavior in multipoint meetings. Therefore, careful engineering of the environment must be done to ensure that ambient noise and reverberation levels within the room are kept in check. However, you don't want the TelePresence room to be so flat and sterile acoustically speaking that it feels like you're in a sound chamber or recording studio. The goal is to re-create the experience of an in-person meeting, so some amount of ambient noise and reverberation is tolerable—even desirable. Cisco has defined precise targets and thresholds for ambient noise and reverberation levels within a TelePresence room, providing a comprehensive test methodology for measuring those levels and recommendations for remediating typical sources of higher than desired ambient noise and reverberation.

Measuring Ambient Noise

Ambient noise is everywhere and is generated by numerous things. Take a moment to pause and listen to the background noises around you. Have you ever noticed the sound of the air whooshing through the air-conditioning ventilation vents in your room, the gentle humming of the air-conditioning machinery in the ceiling, the buzzing of fluorescent light fixtures above you, the sound of cars and buses and ambulances passing by on the street outside your building, the people talking in the room next door, or the sounds of phones ringing in the offices and cubicles around yours? You probably haven't because your brain has become accustom to those sounds and unconsciously tunes them out, but those are exactly the types of sounds we are interested in measuring and, to the degree possible, eliminating inside the TelePresence room.

Ambient noise can emanate through thin, hollow walls or through the cracks in the door jamb around the door. It can travel up and over walls from adjoining rooms and corridors and permeate through the ceiling into your room. This section discusses methods for treating the walls, doors, flooring, and ceiling materials to remediate these sources of noise, but first, consider how these noise sources are measured.

Cisco uses a Sound Pressure Level (SPL) meter to measure the level of ambient sound within the room. SPL is a logarithmic measurement of the root square mean (or average power) pressure of sound relative to silence. It is denoted in decibels (dB), with silence equal to 0dB. Sound travels through the air in waves. Therefore, SPL is simply a measure of the strength, or pressure, of that wave.

The SPL of human speech is generally 60dB to 65dB. Because of the way the human ear and brain work, background sound that is 25dB to 30dB less than human speech generally goes unnoticed. Therefore, the goal is create a room where the average SPL of ambient background noise is no greater than approximately 36dB. Noise levels exceeding 42dB are cause for concern, and levels exceeding 50dB can cause significant problems with the TelePresence experience.

When measuring the SPL level of a room, the average measurement across the entire environment (that is, throughout the room) is used. This establishes a baseline measurement referred to as the *noise floor average*. However, because sound dissipates over distance, when measuring the SPL of a specific source, such as an air conditioning vent or fluorescent light fixture, the SPL is taken from a defined distance from the source (for example, SPL = 30dB at 1 meter away from the vent).

As with the lighting measurement techniques discussed in the previous sections, Cisco divides the room into sections, or zones, to measure the ambient noise floor average at various points within the room. Figure 8-37 illustrates the acoustic zones of a CTS-3000 room.

Within each of the six zones, the ambient noise is measured with the decibel meter approximately 5 feet (1.5 meters) from the floor using a slow sweeping motion to capture the average SPL for that zone. These measurements are done using an A-weighted test. A seventh measurement is taken using a C-weighted test within the middle of the room (front of zone 5) to capture the C-weighted average SPL for the entire room. Note that the C-weighted target is approximately 52dB, compared to the A-weighted target of 36dB mentioned previously. Finally, specific measurements are taken of any particular source of noise, such as each of the air conditioning vents in the room, at a distance of 3 feet (1 meter) from the source, using an A-weighted test. You should be concerned with any A-weighted measurements that exceed 36dB, a C-weighted measurement that exceeds 56dB, or any specific source such as HVAC vents that exceed 36dB at 3 feet (1 meter) distance from the

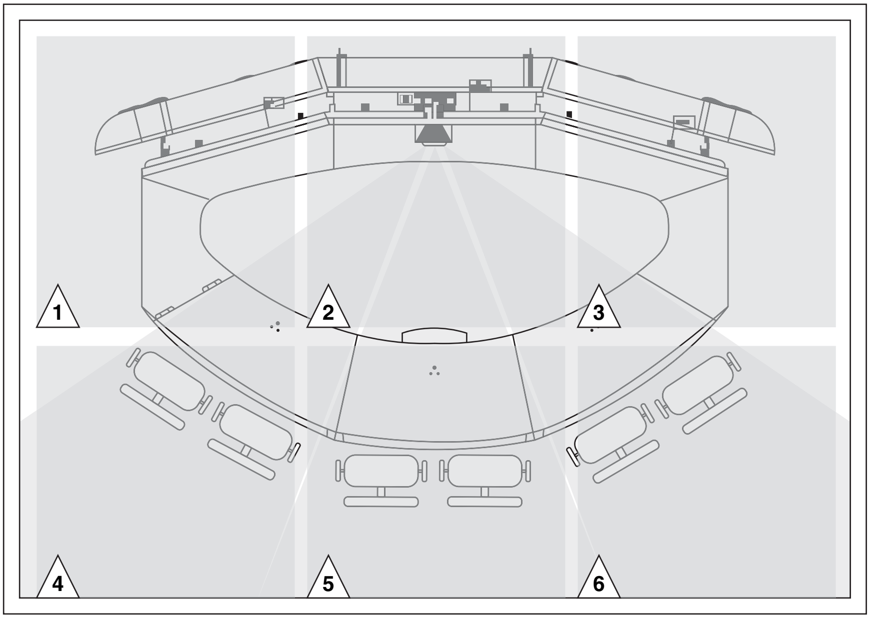

Figure 8-37 *CTS-3000 acoustic zones: top down view*

source. For all these tests, you should choose a time of the day that represents the high average, ideally, when the HVAC is actively producing air flow through the vents.

Measuring Reverberation

Reverberation is essentially a measurement of how long a sound continues to bounce around the room before decaying to the point that it can no longer be heard. The measurement used to denote reverberation is called RT60, which is a measurement of the time required for a sound to decay by 60dB. For example, if you have a source generating sound at 65dB, and it takes 200ms for that sound to dissipate to 5dB, the RT60 measurement for that sound is 200ms. The more the sound can reflect off of walls, ceiling, flooring, and other surfaces, the longer it will take for that sound to decay. Figure 8-38 illustrates this concept.

The ideal reverberation level for a Cisco TelePresence room is 150ms to 300ms. Levels ranging from 300ms to 500ms are cause for concern, and levels exceeding 500ms can cause significant problems with the TelePresence experience. Reverberation is measured for each of the following frequency ranges independently: 125Hz, 250Hz, 500Hz, 1kHz, 2kHz, and 4kHz. Different frequencies of sound reflect off of (or are absorbed by) wall, ceiling, and flooring surfaces differently. Although the human ear cannot discern all these frequencies, the microphones of the TelePresence system might. Therefore, measuring the reverberation of all these frequencies ensures that we understand the acoustic behavior of the room for all types of sounds, from the low frequency sounds generated by building machinery, through the frequencies of human speech and music, up into the higher

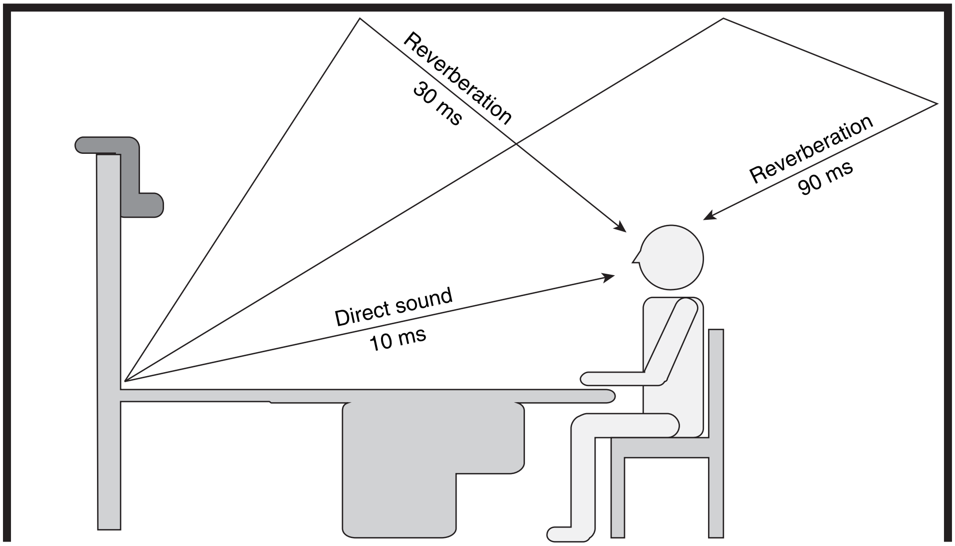

Figure 8-38 *Reverberation illustrated*

pitched sounds generated by electronic devices. For each of these tests, you want to measure from the center of the room, as illustrated in Figure 8-39.

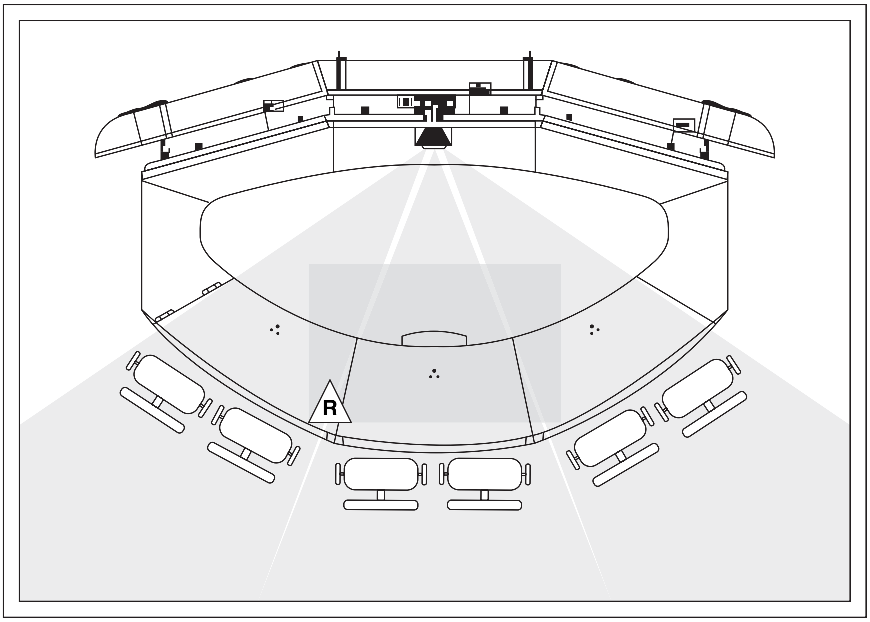

Figure 8-39 *Reverberation zone: top down view*

To measure reverberation, place the decibel meter in RT60 mode in the center of the room on a table surface approximately 5 feet (1.5 meters) off the floor. Use a tone generator and amplified speaker to completely fill the room with > 70dB of white or pink noise for several seconds and then instantly silence the tone generator. The decibel meter measures the time it takes (in milliseconds) for the noise to decay by 60dB. Repeat the test for each of the six frequency levels. For accuracy, several measurements should be taken with the tone generator and amplified speaker at different locations within the room for each of the frequency ranges to ensure that your measurements represent a true average for the room.

Tip White and pink noise are patterns of sound produced by a tone generator for the purpose of testing reverberation. They sound like static to the human ear. Pink noise is generally used for TelePresence RT60 tests because pink noise more accurately emulates the way the human auditory system works and, therefore, provides a more precise measurement of how reverberation would be detected by the human ear.

Targeted and Maximum Ambient Noise and Reverberation Levels

Table 8-4 summarizes the targets and thresholds for ambient noise and reverberation.

Table 8-4 *Target and Maximum Ambient Noise and Reverberation Levels*

Measurement	Target	Maximum	Notes
Ambient Noise Floor Average (A-Weighted)	36dB	42dB	Within each of the six zones
Ambient Noise Floor Average (C-Weighted)	56dB	62dB	In the front of zone 5
Specific noise source (@ 1 meter from the source)	36dB	42dB	Air-conditioning vents, light fixtures, or any other specific device such as the fan on a UPS or Ethernet switch
Reverberation (RT60)	150ms–300ms	500ms	For each of the six frequency levels

Controlling Ambient Noise and Reverberation Levels

The primary method of controlling ambient noise and reverberation levels within the room is to use the appropriate wall, flooring, and ceiling building materials. All types of building material have ratings associated with them for the following three acoustic properties:

- **Noise Reduction Coefficient (NRC):** The NRC is a rating that represents the amount of sound energy absorbed upon striking a surface. An NRC of 0 indicates perfect reflection; an NRC of 1 indicates perfect absorption. NRC generally pertains to sound within the room and, therefore, applies to wall, flooring, and ceiling surfaces. The target NRC for a TelePresence room is .60.

- **Sound Transmission Class (STC):** The STC is a rating that represents the amount of sound energy required to transfer through a surface or structure. An STC of 40 requires greater than 40 decibels of sound energy to transfer through the structure. STC generally pertains to sound leaking into the room from adjacent rooms and corridors and, therefore, pertains to wall and ceiling surfaces and items such as doors and windows that can leak audio. The target STC for a TelePresence room is 60 for internal walls, doors, and windows and 90 for external walls, doors, and windows.
- **Impact Insulation Class (IIC):** The IIC is a rating similar to STC but pertains specifically to flooring surfaces. IIC measures the resistance to the transmission of impact noise such as footfall, chairs dragging, and dropped items. This measurement is especially important in multifloor buildings and with plenum flooring. The IIC represents the amount of sound energy required to transfer sound through a surface or structure. An IIC of 40 would require greater than 40 decibels of sound energy to travel through a surface or structure. The target IIC for a TelePresence room is 60.

Table 8-5 summarizes the target and maximum ratings for common construction surfaces within the TelePresence room. The Notes column provides examples of the types of materials you can use to achieve these ratings.

Table 8-5 *Target and Maximum NRC, STC, and IIC Ratings*

Material	Acoustic Property	Target	Maximum	Notes
Walls	NRC	.40	.30	Acoustic fabric on gypsum or moderate-weighted curtains
	STC	60	40	1/2-in. gypsum drywall on both sides with heavy insulation or acoustic panels
Flooring	NRC	.40	.30	Padded carpeting over cement
	IIC	60	40	Standard commercial construction practices
Ceiling Tile	NRC	.80	.70	Commercial acoustic ceiling tile
	STC	60	40	Commercial acoustic ceiling tile
Doors	STC	60	40	Solid core door with gasket on top, bottom, and sides
Interior Windows	STC	60	40	1/4-in. double pane windows or acoustical treated coverings
Exterior Windows	STC	90	70	Location near high traffic or airports might want highest ratings

Scenarios for Mitigating Ambient Noise and Reverberation

This section concludes with a few common scenarios for how these ratings apply and what type of remediation tactics you can use.

First, by far the most common problem encountered by customers is the noise created by the HVAC registers. The challenge is that because the TelePresence equipment and the human bodies within the room produce so much heat, either a high level of air flow or a low temperature air flow is required to achieve a comfortable temperature within the room. Finding the proper balance of temperature, air flow, and SPL can be tricky. On one hand, increasing the air flow generally causes the SPL of the register to go well above the maximum of 46dB, either as a result of the air flow through the register or the machinery noise created by the motors and fans traveling through the ducting. On the other hand, decreasing the temperature can cause the air flowing out of the register to be uncomfortably cold for people who happen to stand or sit directly beneath it. It is recommended that you consult an HVAC specialist for assistance in finding the proper balance for your room. However, one general piece of advice is to always use NC30-rated air registers, which diffuse the air flowing out of the register to reduce the air flow noise. The next section "HVAC" reviews the BTU requirements and recommended types and locations of HVAC registers in greater detail.

The second most common area of problems are ambient noise and reverberation levels caused by low NRC and STC values of walls, doors, and windows. Noise can also come up and over the walls from adjoining rooms and corridors and permeate through the ceiling. Figure 8-40 illustrates some of these common scenarios.

Simple tactics for remediating these issues include increasing the thickness of the walls (for example, installing a second layer of gypsum drywall to double its thickness), adding sound-absorbing insulation within the walls, installing an acoustic blanket or foam tile inserts above the ceiling to eliminate the sound traveling up and over the wall, and using ceiling tiles with high NCR and STC ratings. Figure 8-41 illustrates some examples of these materials.

For rooms that exhibit high levels of reverberation, the best remediation tactic is generally to cover the wall surfaces with acoustically dampening materials, such as small fabric panels placed in strategic locations on one or more walls in the room. Refer back to the "Wall, Floor, and Ceiling Surfaces" section earlier in this chapter for additional considerations.

HVAC

The HVAC design goals for Cisco TelePresence rooms boil down to three primary criteria:

- Generating enough air flow to keep the temperature of the room comfortable for the participants. This is measured in terms of British Thermal Units per hour (BTU/hr) and is a function of the heat generated by the TelePresence system and other electronic devices within the room, plus the heat generated by the human bodies within the room.

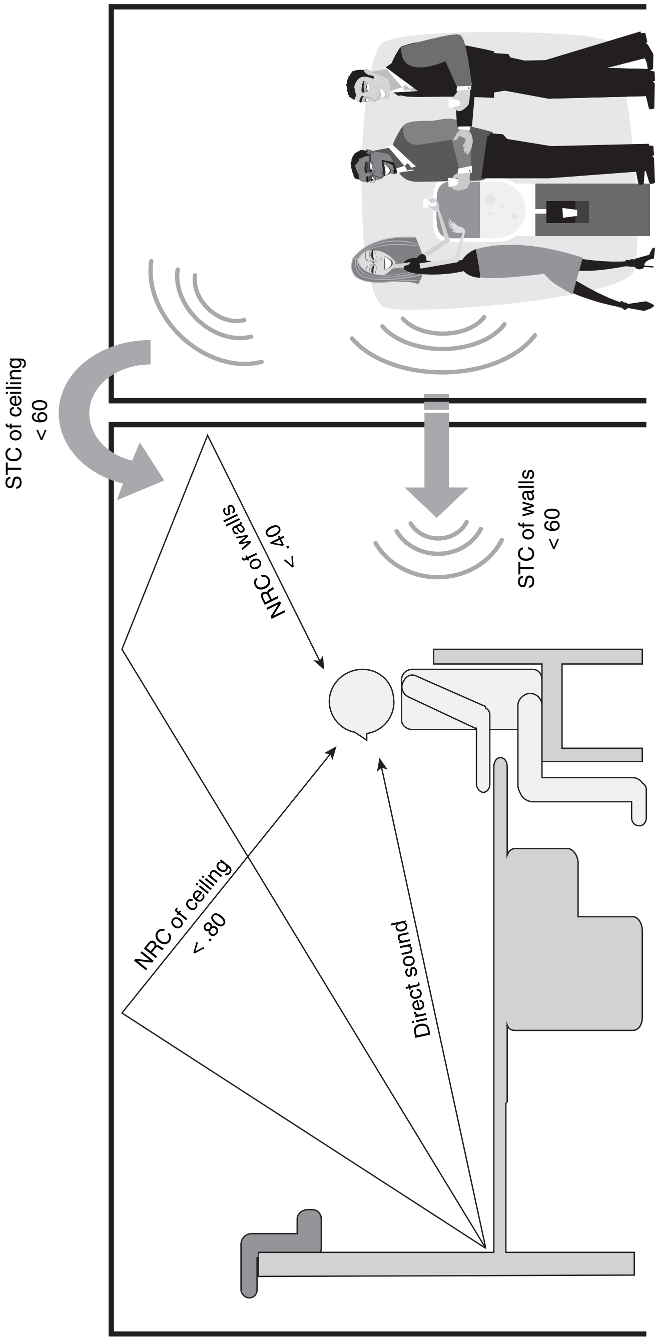

Figure 8-40 *Example NRC and STC scenarios*

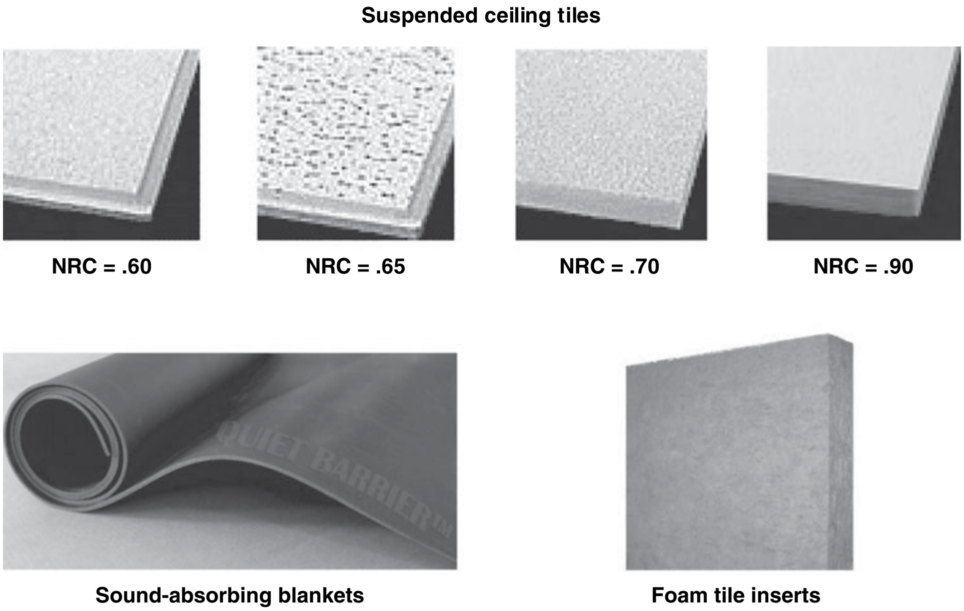

Figure 8-41 *Example ceiling materials used to increase NRC and STC ratings*

- Achieving the above BTU/hr performance without generating high levels of ambient noise. Simply cranking up the air conditioning is rarely the best solution because it can result in a higher volume of wooshing sound coming through the HVAC registers (the vents that supply air to the room). You must strive to achieve a balance of the air flow:noise ratio.
- Positioning the HVAC registers to maximize the efficiency of the air flow between the supply registers and the return registers. This is critical as it can effectively reduce the total amount of BTU/hr capacity required by as much as 25%, thereby reducing or eliminating the costs associated with upgrading the capacity of the HVAC system.

Tables 8-6, 8-7, and 8-8 summarize the BTU requirements for the CTS-3000, CTS-3200, and CTS-1000. These values include all the equipment and lighting provided with the system and the participants within the room. Note that the CTS-500 is designed to be deployed within an existing room with no HVAC modifications, and, therefore, a power consumption table for that model is not provided here.

Tip The total BTU/hr provided at the bottom of each table can be reduced by 25% (multiply by .75) if the HVAC registers are positioned properly, as illustrated in Figure 8-42. This is because we can take advantage of the efficiency of the HVAC system to displace the warm air generated by the TelePresence System and the people, thereby reducing the amount of BTU capacity required, potentially saving the customer thousands of dollars in HVAC system upgrades.

Table 8-6 *BTU Requirements for the CTS-3000*

Component	Maximum[1]	Typical[1]	Minimum[1]	Idle[1]
Plasma Displays	2,880w	2,658w	2,658w	9w
Primary Codec	120w	113w	113w	113w–120w
Secondary Codec (108w max / 101 average each)	216w	202w	202w	202w–216w
Light Façade	348w	348w	348w	0w
Laptop Power (240w max / 144w average each)	1,440w	864w	144w	0w
Projector	288w	225w	0w	0w–5w
Auxiliary LCD[2] (325w max / 230w average each)	975w	230w	0w	0.6w
Auxiliary Document Camera[2]	200w	200w	0w	0w
Total Wattage	6,467w	4,840w	3,465w	324w–350w
Total Amperage (wattage / volts)	54A @ 120V 27A @ 240V	41A @ 120V 21A @ 240V	28A @ 120V 14A @ 240V	3A @ 120V 2A @ 240V
People (450 BTU/hr each)	2,700 BTU/hr	2,700 BTU/hr	450 BTU/hr	0 BTU/hr
Total BTU/hr (wattage * 3.413) + people[3]	24,772 BTU/hr	19,218 BTU/hr	12,276 BTU/hr	1,106–1,195 BTU/hr

Table 8-7 *BTU Requirements for the CTS-3200*

Component	Maximum[1]	Typical[1]	Minimum[1]	Idle[1]
Plasma Displays	2,880w	2,658w	2,658w	9w
Primary Codec	120w	113w	113w	113w–120w
Secondary Codec (108w max / 101 average each)	216w	202w	202w	202w–216w
Light Façade	348w	348w	348w	0w
Laptop Power (240w max / 144w average each)	4,320w	2,592w	144w	0w
Projector	288w	225w	0w	0w–5w
Auxiliary LCD (325w max / 230w average each)	975w	230w	0w	0.6w
Auxiliary Document Camera[2]	200w	0w	0w	0w
Total Wattage	9,347w	6,368w	3,465w	324w–350w
Total Amperage (wattage / volts)	54A @ 120V 27A @ 240V	41A @ 120V 21A @ 240V	28A @ 120V 14A @ 240V	3A @ 120V 2A @ 240V
People (450 BTU/hr each)	8,100 BTU/hr	5,400 BTU/hr	450 BTU/hr	0 BTU/hr
Total BTU/hr (wattage * 3.413) + people[3]	40,000 BTU/hr	27,134 BTU/hr	12,276 BTU/hr	1,106–1,195 BTU/hr

Table 8-8 *BTU Requirements for the CTS-1000*

Component	Maximum[1]	Typical[1]	Minimum[1]	Idle[1]
Plasma Displays	960w	886w	886w	3w
Primary Codec	120w	113w	113w	113w–120w
Light Façade	80w	80w	80w	0w
Laptop Power (240w max / 144w average each)	480w	288w	144w	0w
Auxiliary LCD[2]	325w	36w	0w	0w–5w
Auxiliary Document Camera[2]	200w	0w	0w	0w
Total Wattage	2,165w	1,403w	1,223w	116w–128w
Total Amperage (wattage / volts)	19A @ 120V 10A @ 240V	12A @ 120V 6A @ 240V	10A @ 120V 5A @ 240V	2A @ 120V 1A @ 240V
People (450 BTU/hr each)	900 BTU/hr	450 BTU/hr	450 BTU/hr	0 BTU/hr
Total BTU/hr (wattage * 3.413) + people[3]	8,289 BTU/hr	5,238 BTU/hr	4,624 BTU/hr	396–437 BTU/hr

[1] Maximum values represent fully utilizing every possible feature to the maximum supported configurations and filling the room with people. Typical represents what most customers tend to use and also represents average load versus max load on the components. Minimum represents little to no use of auxiliary LCD displays, document cameras, laptops, and number of participants in attendance and average load on the components. Idle represents what the system uses during nonbusiness hours when the displays are put into sleep mode and the lights are turned off.

[2] Varies by model. Table 8-9 provides the maximum and idle power requirements for certain models that Cisco has specifically tested.

[3] Reduce by 25% (multiply by .75) if HVAC registers are positioned properly.

Table 8-9 *Power Requirements for Auxiliary Displays and Document Cameras*

Vendor – Model	Maximum	Idle
NEC LCD1770NX	36w	<3w
NEC LCD2070NX	50w	<3w
NEC LCD4010	230w	<5w
NEC LCD4020	240w	<5w
NEC LCD4610	260w	<5w
NEC LCD4620	240w	<5w
Samsung 400PXN	230w	<1w
Samsung 460PXN	310w	<1w
Sharp PN-525U	325w	<1w
WolfVision VZ-9plus	55w	0w
WolfVision VZ-C12[2]	200w	0w
WolfVision VZ-C32	200w	0w

HVAC Air Noise Diffusion Considerations

As mentioned previously in the "Acoustics" section, to meet these BTU requirements without exceeding the ambient noise threshold of 46dB, the recommendation is that you always use NC30-rated air registers, which diffuse the air flowing out of the register to reduce the air flow noise. To maximize the efficiency of the air flow through the room, you should locate the supply registers behind the participants and the return registers directly over the 65-inch plasma displays of the TelePresence system. Doing so can reduce the capacity requirements of the HVAC substantially. Figure 8-42 illustrates such an arrangement for a CTS-3000 room.

Finally, measure the temperature of the air flowing out of the register. (Use a laser thermometer pointed directly at the register from 3 feet [1 meter] away.) If the temperature of the air is warmer than 70-degrees Fahrenheit (21-degrees Celsius), it is probably too warm to be effective, and your HVAC system might need to be recharged. However, if the tem-

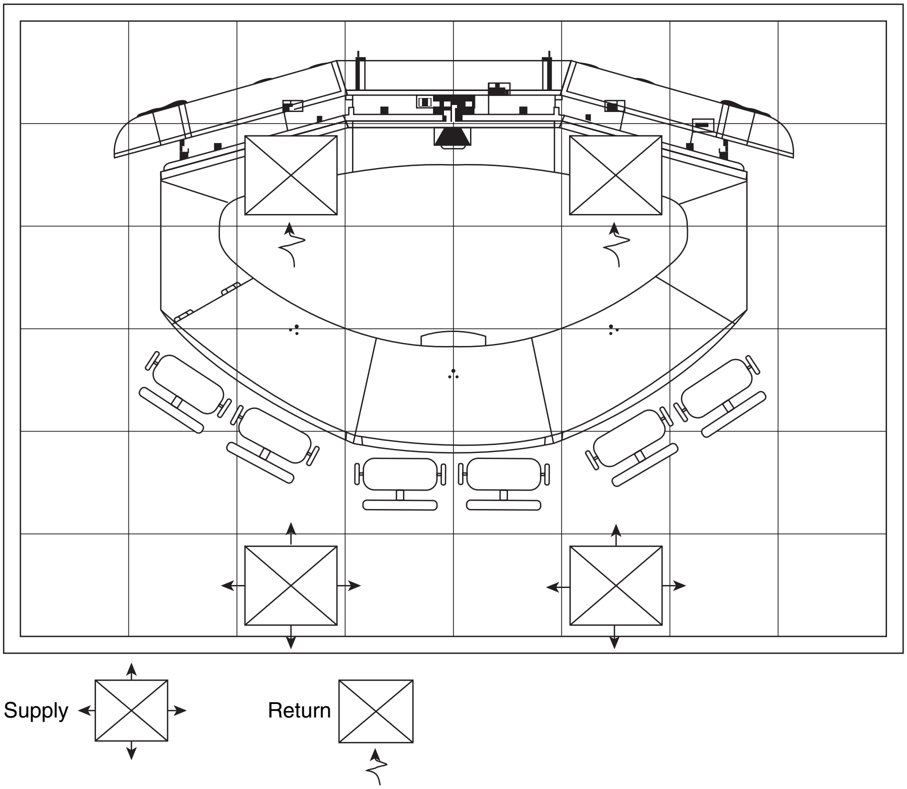

Figure 8-42 *Reflected ceiling plan showing recommended HVAC register locations*

perature of the air is colder than 55-degrees Fahrenheit (12° Celsius), it might cause discomfort for the participants standing or sitting directly beneath the register. An HVAC specialist can further assist you in measuring and designing the HVAC system.

Power Requirements

Cisco TelePresence systems—especially the larger models such as the CTS-3000 and CTS-3200—have unique power requirements that must be taken into account during the room evaluation and design phase. The chances of your room already containing the correct type and quantity of electrical circuits and receptacles are slim. Therefore, the services of a qualified electrician will be required for every room you deploy.

First, take the amount of wattage consumed by the system to ascertain the quantity and amperage of electrical circuits required to power the equipment. These calculations were provided previously in Tables 8-6, 8-7, and 8-8.

Now that you know the total wattage and total amperage required by the system, you can ascertain the number of circuits and amperage per circuit. Cisco TelePresence systems are rated for 10amps@240v or 20amps @120v. Electrical codes in use suggest that only 80 percent of a circuit's capacity should be used. Therefore, on a 20-amp circuit running at 120v in the U.S., only 16 amps of it are useable, and on a 10-amp circuit running at 240V in Europe, only 8 amps are useable. Therefore, a CTS-3000 for example that requires a total of 54amps@120V, divided by 16amps per circuit, requires a minimum of four 16amp circuits on the wall.

The components are attached to Power Distribution Units (PDU). Each PDU, in turn, is attached to one of the power circuits on the wall. The CTS-3000 requires four PDUs. Table 8-10 shows which of the four PDUs each component is attached to and, hence, how the power is distributed across the circuits.

Table 8-10 *Power Distribution for CTS-3000*

Component	PDU #1	PDU #2	PDU #3	PDU #4
Three 65-in. Plasma Displays	1 @ 960 Watts	1 @ 960 Watts	1 @ 960 Watts	
One Primary Codec		1 @ 120 Watts		
Two Secondary Codecs	1 @ 108 Watts		1 @ 108 Watts	
Three Lighting Façade Fixtures (Top)	1 @ 80 Watts	1 @ 80 Watts	1 @ 80 Watts	
Two Lighting Façade Fixtures (Sides)	1 @ 54 Watts		1 @ 54 Watts	
One Projector				1 @ 288 Watts
(optional) Auxiliary LCD displays	1 @ 240 Watts	1 @ 240 Watts	1 @ 240 Watts	
(optional) WolfVision document camera		1 @ 200 Watts		
Six Participant A/C power jacks in table legs				6 @ 240 Watts each
Total Watts	1442 Watts	1600 Watts	1442 Watts	1728 Watts
Amperage Required	12.02A @ 120V or 6.01A @ 240V	13.34A @ 120V or 6.67A @ 240V	12.02A @ 120V or 6.01A @ 240V	14.4A @ 120V or 7.2A @ 240V

Tip Always check your country's electrical regulations to determine the appropriate number of amps permitted per circuit.

Tip The circuits to which the TelePresence equipment is attached should be dedicated circuits not controlled by a light switch.

Again, remember that things can change from one product release to another, so the information in Table 8-10 is given as an example and is highly subject to change. For instance, when Cisco first released the CTS-3000, only four *dedicated* circuits were needed, and the light façade was connected to the same circuits as the other components. But that meant that the light façade remained on 24 hours a day, 7 days a week. To improve this, Cisco Technical Marketing came out with a recommendation that the light façade be connected to a fifth *switched* electrical circuit that was controlled by the same switch on the wall that controlled the overhead/ceiling lights in the room, and Cisco manufacturing started including a fifth PDU in every CTS-3000 shipment to facilitate customers doing this. However, because most ceiling light fixtures operate at 277V, additional electrical conditioning components were required to extend a receptacle of that circuit to the wall behind the system so that the light façade could be plugged into it. Now, at the time of this writing, Cisco is coming out with a third, better option—a separate, custom-designed PDU called the Auxiliary Control Unit (ACU), which is attached to a fifth *dedicated* circuit. The ACU is controlled by the Primary Codec and controls the individual receptacles on the ACU to turn the light façade on/off automatically. The system can be configured to turn the lights on/off per call, or on at the beginning of business hours (by default, at 7 a.m. local time) and off after business hours (by default, at 6 p.m. local time). These settings are configurable. The ACU also provides an RS-232 serial port, which is connected to the projector to automate the configuration of the projector settings.

Tip Don't forget to include any auxiliary components in your calculation, such as document cameras and LCD displays.

Next, when you have your calculations for the amount of amperage per circuit and the number of circuits required, the electrician needs to know where in the room these circuits should be installed. A floor plan and reflected ceiling plan is the most accurate way to specify this. For example, Figure 8-43 shows five dedicated 20A circuits installed along the wall behind the system, with additional receptacles from circuit#5 extended to the ceiling and walls for the WolfVision document camera and Auxiliary LCD displays.

Finally, remember that one of the primary goals of Cisco TelePresence is ease of use. Therefore, the system is designed to be left on 24 hours a day, 7 days a week so that people can walk in and use it anytime, without trying to figure out how to turn the system on before they can use it. To facilitate this, Cisco has introduced three improvements to reduce the power consumption during off hours:

- In the 1.1 release, the system began automatically putting the plasma displays and projector into standby mode during off hours.
- In the 1.2 release, the system began controlling the WolfVision document camera programmatically to enable us to put it into standby mode during off hours as well.

- In release 1.4, the Auxiliary Control Unit (ACU) was introduced to allow the light façade to be turned on/off automatically, as previously described.

More improvements are likely to be made in the future, so check with Cisco for the latest specifications and power recommendations.

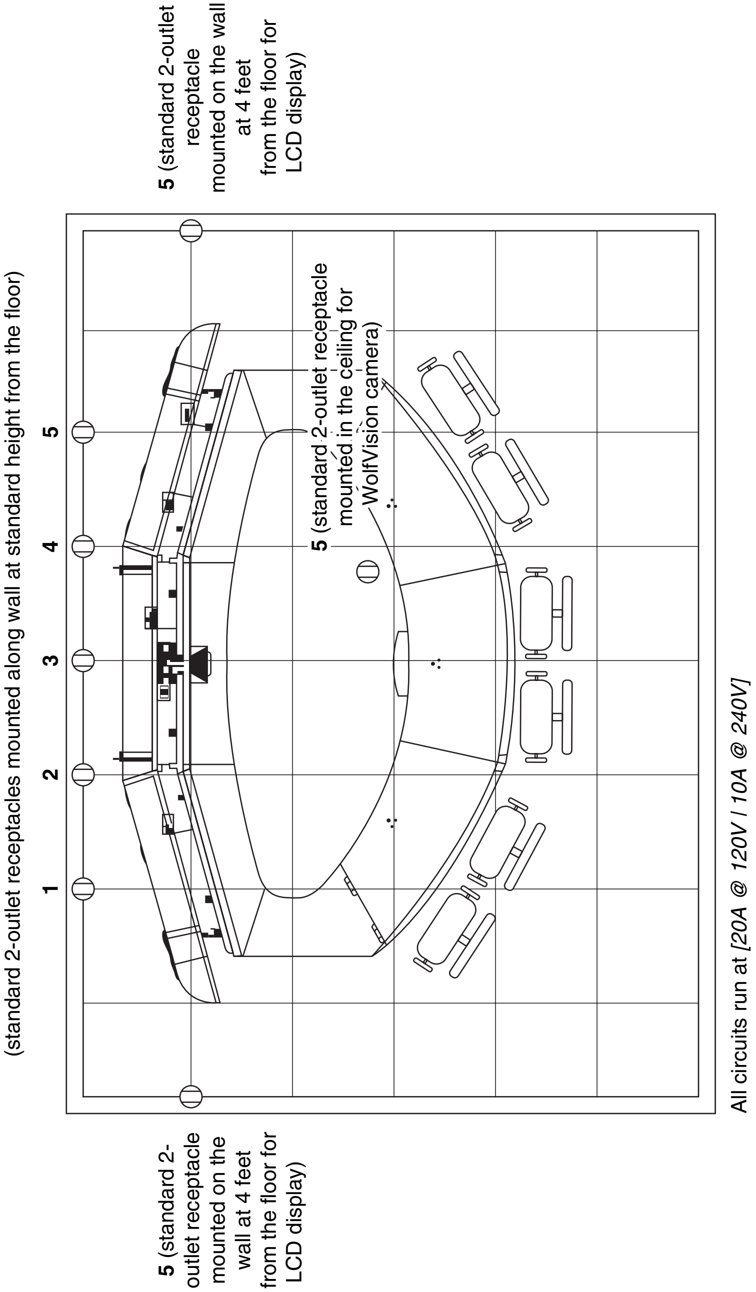

Figure 8-43 *Reflected ceiling plan showing recommended power outlet locations*

Some customers have asked whether the system can be shut down at night. Doing so will not damage the equipment in any way. The system is designed to be powered off without requiring a soft shutdown. However, it is still not advised because it will reduce the usefulness of the system. Because TelePresence promotes global meetings, it is not uncommon for users to have meetings with colleagues in another country at 10 p.m., or even at 2 a.m.

Network Connectivity

Cisco TelePresence systems use a unique multiplexing technique so that even though there are multiple codecs, cameras, microphones, speakers, displays, and auxiliary accessories, the entire system requires a single Category 5e or Category 6, Unshielded Twisted Pair (UTP) Gigabit Ethernet port to attach it to the network. These topics are covered in detail in Chapter 3, "TelePresence Audio and Video Technologies," and Chapter 4, "Connecting TelePresence Systems."

In addition to the single Gigabit Ethernet port required by the TelePresence system, network connectivity must also be provided for the participants, who might want to bring laptop computers into the meeting. There are two ways to accommodate this:

- Built-in Ethernet and Power Receptacles
- Providing 802.11 wireless Ethernet coverage within the TelePresence room

First, for Cisco TelePresence systems that provide integrated furniture, such as the CTS-3000 and CTS-3200 models, Ethernet and power receptacles are provided as built into the table legs. Note that these Ethernet ports do not connect to the back of the primary codec. Instead, a separate Ethernet switch (sold separately) must be provided to terminate all these Ethernet ports and then attach upstream to the network. A 1RU high and 19-inch (48.26 centimeters) wide mounting bracket is provided with the CTS-3000 and CTS-3200 that provides a convenient location for the Ethernet switch to be rack-mounted to the back of the system, and a second Category 5e or Category 6, Unshielded Twisted Pair (UTP) Gigabit Ethernet port must be provided for this switch to uplink to the network.

When using this method, follow two important guidelines:

- For acoustic purposes, the Ethernet switch you choose must generate as little ambient noise as possible.
- This switch should provide a software feature set that meets your organization's requirements and policies for LAN security, quality of service (QoS), and manageability.

Finding this combination of features in an Ethernet switch can be difficult. On the one hand, low-cost, fanless Ethernet switches might not provide adequate security and management functions. On the other hand, a Cisco Catalyst switch with the appropriate enterprise class feature set might be too loud. At the time of writing, Cisco TelePresence Technical Marketing identified the following models of Cisco Catalyst 2960 Series switches as the most suitable for use with a CTS-3000 or CTS-3200 model system:

- Cisco Catalyst 2960G-8TC-L with RCKMNT-19-CMPCT=
- Cisco Catalyst 2960-8TC-L with RCKMNT-19-CMPCT=

Because new switch products are always coming out, you should check with Cisco for the latest recommendations.

The second method you can use is to deploy an 802.11 wireless Ethernet solution within the room. Chances are high that a customer deploying TelePresence will already have an 802.11 solution deployed, so this is the ideal way to do it, not only because it's silent, but also because it's generally easier to secure a wireless network and provide differentiated access for guest users versus regular employees. Within the Cisco internal deployment of TelePresence, this has been the method of choice. The Ethernet ports in the table legs are left physically disconnected, and wireless is provided to all users. In addition to providing reliable and secure access to Cisco employees, guestnet access is provided to customers and other guests. The guestnet provides them with a connection that is outside the corporate firewall and quarantined from the rest of the internal network.

In summary, each Cisco TelePresence system requires either two Ethernet ports (one for the system and one for the participant access switch) on the wall located behind the system, or one Ethernet port with wireless network access for the participants.

Summary

The advanced audio, video, and networking technologies of TelePresence comprise only one half of the equation. The room and environment you use it in is equally important as the technology itself to delivering a TelePresence experience. Network engineers who are familiar with deploying other Cisco technologies will find TelePresence a fascinating new venture because it incorporates environmental, aesthetic, and acoustical concepts that many network engineers might not have been introduced to before. This chapter provided a detailed view into the design considerations for the room in which a TelePresence system will be deployed. In it, the following topics were discussed, providing both the theory behind each concept along with specific examples and recommendations:

- **Room Dimensions, Shape, and Orientation:** Discussed the physical size, shape, and orientation of the room and the location of doors, windows, columns, and furniture within the room.
- **Wall, Floor and Ceiling Surfaces:** Discussed the recommended colors, patterns, and materials of wall, floor, and ceiling surfaces within the room.
- **Lighting and Illumination:** Discussed overall illumination considerations and specific lighting requirements and recommendations.
- **Acoustics:** Discussed the concepts of sound reproduction and the effects of ambient noise and reverberation within the environment and how they are measured.
- **HVAC:** Discussed the heating, ventilation, and air conditioning (HVAC) requirements and the recommended types and locations of air-conditioning registers within the room.
- **Power Requirements:** Discussed power consumption requirements for the equipment and participants and the recommended types and locations of electrical receptacles within the room.
- **Network Connectivity:** Discussed the network connectivity required within the room for the equipment and the participants and the recommended ways of providing network access to the participants.

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