Operating Room Design:
Four Steps for Success

As in a precision command center, images from surgical microscopes are projected on flat screens in real-time; a nurse calls up digital files and scans from medical records, giving the surgeon instantaneous access to critical data. Hundreds of miles away, a video stream of the operation is relayed to the monitor of a consulting specialist.

No longer a scene from science fiction, operating rooms can be wired with the most advanced technology available. Video and voice have taken their place along with scalpels and sutures as essential tools. Data is communicated in real time to equipment and systems inside and outside the operating room. Booms support equipment with operational precision. Patients, staff, and materials move in a well-orchestrated flow; resources and support cross between departments. Ergonomic design, state-of-the-art mechanical and electrical systems, adaptability and flexibility for the future are prerequisites.

The need for top performance and the complexity of equipment and systems place exacting demands on the design of operating rooms today. Meeting these challenges requires a multidisciplinary team and a well-planned process that addresses a myriad of elements, from long-term goals to exacting details.

Four key steps help ensure that your next operating room project results in a surgical center of excellence that increases efficiency, safety, patient satisfaction, and the ability to attract and retain employees.

1. Select the right professionals for the right job

Just as surgeons have their areas of specialties, design and construction firms apply experience and expertise to handle the intricacies of an operating room. Select an architect and construction manager with considerable health care experience—including surgical suites and operating rooms—and a track record of delivering complex projects on time and within budget. Architect, engineer, equipment planner, construction manager, and key equipment vendors should all be included on the team.

The design and construction team should have the ability to work together with mutual trust and respect. Communication among the owner, architect, and construction manager is crucial. The architect/engineer and construction manager should provide the owner with a project schedule that outlines each phase of the project. During each phase, there should be a thorough review of the timetable and budget. There should be a running list of outstanding issues that need to be addressed to meet the next milestone in the project. A method for project documentation and communication should be defined before the project begins.

2. Do your preoperative exam

Seek multidisciplinary input
Like any health care facility project, the design of operating rooms must begin with a thorough understanding of goals, objectives, timetable, and budget. This is best achieved with input and review from professionals within and outside the facility. Define the stakeholders and decision makers for the project and include them in the design process. The participation of surgeons, nurses, anesthesiology, central processing, and recovery is essential to developing and testing design concepts and identifying equipment and service needs. Multidepartmental input includes facilities, clinical engineering, purchasing, information systems, radiology, risk management, and infection control, among others. During the predesign and planning phase, conduct brainstorming sessions with staff to determine best practices, areas for improvements and upgrades, and provisions for future needs. Get issues out in the open before they become a major concern. Also review preliminary questions and concerns for local authorities and regulatory agencies early to avoid major changes during construction.

New construction versus renovation
Does this project involve new construction or renovation? A project involving renovation may have some built-in limitations. For renovations, the architect should conduct a field investigation to determine whether there is adequate ceiling height and space for new equipment, for example.

What procedures types will be performed?
Is the operating room being designed for one specialty procedure such as open heart or orthopedic surgery, or does the design need to accommodate multiple surgical procedures? The amount of flexibility and the configuration of ceiling-mounted equipment and workstations will vary depending on the types of procedures performed.

Who will be responsible for assessment of new technology?
Is the assistance from an outside equipment-planning consultant required? A preliminary equipment list and budget should be established, including existing, relocated, and new equipment. The budget should include the cost for fixed and moveable medical equipment as well as surgical instruments and supplies. Keep in mind the long-term cost of maintenance and adaptability for future upgrades.

What systems and equipment would improve efficiency? Is there an opportunity to plan now and install later? Operating room renovations are costly; if there are insufficient funds for equipment upgrades within the project budget, plan and provide for the necessary building infrastructure to add them later.

Plan site visits and meet with equipment vendors
Visit existing surgical centers with staff, paying close attention to the equipment and how it is utilized. Meet with equipment vendors and discuss features that improve efficiency. Ask vendors for a list of references and installations in your area. Visit vendor sites and ask users what they would have done differently if they had the opportunity.

A thorough preoperative exam places the owner, design, and construction team in a proactive position to make decisions quickly without disrupting the project timetable and budget.

3. Look at the Big Picture

Design review allows you to look at the big picture with your design team. Rather than considering how you do things now, focus on the processes and methods that will improve efficiency, productivity, and outcomes through thoughtful space design and equipment placement.

Review departmental adjacencies
The first step in the design review process is a thorough review of departmental adjacencies. With the rapid advancement of technology, there are no longer clear-cut distinctions between departments such as radiology, surgery, and interventional cardiology. The advent of minimally invasive procedures, interventional procedures, robotics, and image-guided surgery has resulted in a shifting and sharing of responsibilities between departments that were separate entities in the past. This includes the sharing of procedural and exam spaces, as well as patient, staff, and public support spaces.

Consider flow of patient, staff, and materials
Take a close look at the flow of patients, staff, and materials. Identify possible bottlenecks and areas for improvement.

- Will the preoperative area and recovery have the capacity to handle the increased volume of procedures?
- Does central processing have adequate sterilization equipment?
- Will a case cart system be utilized?
- What supplies will be stored in the operating room?
- Check with the local authorities and state regulators to verify what equipment and supplies are allowed within the operating room. Some equipment and storage devices generate and harbor dust that is not acceptable for indoor air quality requirements.

Review the relationship of the clean core, substerile, and scrub stations with respect to the operating room.

- How will case carts, supplies, and equipment be transported to and from the operating room?
- What is the ideal location for the scrub station and through which door will the staff enter the room after scrubbing?
- Consider whether the patient will enter the room feet first or head first.
- What is the ideal orientation of the patient in relation to the sterile setup area, circulating nurse, surgeon, and anesthesiologist?
- Define the areas within the operating room that will be utilized for documentation, storage, and sterile setup.

Plan for the advancement of technology
The rapid change of technology makes flexible building design imperative. Operating room design must incorporate the necessary space, capacity, and infrastructure that will adjust for future trends, relationships, and advancements in technology. This includes interstitial spaces for structural, mechanical, electrical, and information systems, which need special layouts to allow for system upgrades and modifications. Flexible designs include accessible ceiling systems, grouping of similar modalities, and sharing of control/equipment spaces. Building owners should not only consider building costs but also the cost and impact of technology upgrades. Renovations to accommodate new technology are inevitable. With careful planning and innovative design, the cost of these renovations can be dramatically reduced.

4. Scrutinize the details

After a thorough review of the big picture items, the team must examine the intricate details concerning equipment and services within the operating room during design review with owner, architect/engineer, and equipment planner.

Ideally, an equipment planner is involved before the project begins. With the equipment planner, determine the equipment schedule, budget, delivery lead times, and utility/space requirements. These items must be included in the design review process as soon as possible to ensure the optimal integration and placement of equipment and services in the operating room.

Determine strategic equipment placement
Strategic equipment placement is essential to increase efficiency and safety within the surgical space. Equipment booms and other ceiling supported equipment are used increasingly in operating rooms because of the advantages they offer. Equipment booms are ceiling-mounted, articulating arms that support equipment, electrical, gas, and communication services that would otherwise be placed on mobile carts. The booms significantly reduce clutter and interconnect equipment by utilizing the space above the finished ceiling. Sterile setup is enhanced, and there is less maintenance as a result of cable breakage.

Booms, however, require a significant amount of structural support that must be coordinated with the lighting, mechanical, and electrical systems above the finished ceiling. Booms are popular for supporting laparoscopic/endoscopic equipment for minimally invasive procedures, such as insufflators, light sources, cameras, electrosurgical generators, monitors, and flat panel displays. This equipment is electrically interfaced to a control station within the operating room. This control station has the capability to route voice, video, data, and physiological information to and from the surgical suite. This capability is achieved through strategic equipment placement and an electrical infrastructure that allows the distribution of power and low-voltage wiring. Information is not only distributed within the operating room but also to remote locations

such as image archiving systems (PACS), pathology, offices, and conference rooms. Future capabilities may include providing distance surgery via high-speed networks and robotics. These advancements are part of the trend to provide real time patient data, images, and physiological information to the caregivers when and where they need it.

Make decisions about lighting and room finishes

Different levels of lighting are necessary at the surgical site, control workstation, and throughout the room. The viewing of flat panel displays within the space requires the installation of dimmable lighting to create optimum light levels. Lighting levels for cleaning and sterile setup must also be provided. Enhancements may include voice-activated control of room lighting, surgical lighting, and surgical table positioning. Other items for discussion during design review include room finishes, flooring, and wall coverings that are aesthetically pleasing while meeting the demands of the operating room for cleaning, maintenance, and durability.

Consider specialty equipment

With the increase in minimally invasive procedures has come an increase in the use of robotic equipment in operating rooms. These robotic devices allow surgeons to perform precise movements with special instruments through small incisions. Robotic equipment typically consists of a surgeon's workstation and a remote instrumentation pod placed close to the surgical site. There should be adequate space, power, and low-voltage connections available for robotic equipment.

The advent of image-guided surgery requires special design considerations, which may include the installation of imaging systems such as MRI scanners, typically weighing 10,000 to 35,000 lbs. If the operating room is above grade level, the floor must be designed to support this weight. The floor slab must also be designed with minimal amounts of ferrous reinforcement that could be detrimental to the scanner performance. MRI scanners require radiofrequency (RF) shielding and, in some locations, magnetic shielding. There must be thoughtful planning when selecting a MRI site so there is minimal impact on the scanner and adjacent equipment. With this type of equipment, the physical size of the operating room must always be evaluated.

Document equipment locations

It is essential that the architect and equipment planner develop ceiling and equipment plans to accurately document equipment locations within the space. These ceiling and equipment plans must be part of the architectural documentation to ensure coordination with the architectural, mechanical, electrical, and structural disciplines. The ceiling plan must include the coordination of supply air diffusers, lighting, speakers, cameras, equipment booms, display arms, and gas/electrical ceiling columns. The equipment plan must include robotic equipment, lasers, control stations, storage cabinets, warming cabinets, inventory control cabinets, and all wall-mounted equipment. These documents should be supported with elevations and ceiling sections to enhance coordination during installation.

Plan for ceiling access
The increased complexity of ceiling-mounted equipment requires means of access to above-ceiling services. Incorporating ceiling systems available for this purpose not only provides ease of access for maintenance but also reduces the time required for upgrades. *—Daniel R. Beney, PE, LEED AP*

See related article on William Beaumont Hospital under Case Studies.

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HarleyEllis is a 350-person, full-service architecture, engineering, interiors, landscape architecture, and construction services firm with offices in Chicago, Cincinnati, Detroit, and Los Angeles. The firm's health care studio has a core group of 75 design professionals that dedicate 100% of their time to health care projects. HarleyEllis has designed and completed over 200 operating room projects.

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