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## Adaptable Design

Designing Complex Facilities to Support Long-term Capacity

Times Change. Businesses and organizations change. Can buildings change as well?

That's a particularly difficult challenge for facilities that house manufacturing, research and development, healthcare, and other technologically advanced activities. Their complex layouts and building systems must meet specific demands for preserving the integrity of various processes and the safety of workers.

When change occurs or even appears imminent, the organization must be ready to act quickly. Adjusting staffing and activities may be relatively simple to accomplish, but transitioning the facility can be both expensive and time-consuming. And the ultimate cost may well be that of an opportunity lost, or the difficult sacrifice of other much needed resources and assets.

With thoughtful planning and design, a complex building can become highly versatile and responsive to the needs of the most technical and scientific organization. Carter & Burgess Facilities Program Manager, David Reese explained that the goal should not be one of making the building more flexible, but rather enhancing its adaptability.

"Flexibility implies accommodating things to be added later, something that would likely involve some degree of construction, new equipment, and space reconfiguration," Reese said. "Adaptability, on the other hand, is the ability to accommodate changes with only minor modifications, even if the needs are substantially different than anticipated."

Reese added that "adaptable" doesn't mean designing in excess. For

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example, "some professionals try to design heating and cooling systems with an extra load greater than the projected short-term demand indicates," he said. "That's unrealistic because it's difficult to predict how much additional capacity may be needed in the future, and for what reasons. And over time, people often forget that the additional capacity is built in."

*"Adaptability... the ability to accommodate changes with only minor modifications, even if the needs are substantially different than anticipated."*

**David Reese**
Carter & Burgess

"Although designing for adaptability seems like a simple concept, it's actually difficult to apply because each building's needs, processes, and business objectives are different," said Shawn Doyle, a Carter & Burgess program manager in the Facilities Unit. "Designers should begin by looking at the basic infrastructure-the structural and system components that may be the hardest to change. When adaptability is maximized, effecting change in other elements is easier to do."

**Layouts on the Line**

There is an appropriate parallel between incorporating adaptability into a complex building, and the rapidly evolving biogenetic and pharmacological research that many of them support. Just as DNA and amino acids are the basic building blocks of life, modular laboratory and process area layouts are fundamental to a facility's long-term capacity to support change.

"The most basic buildings are also the easiest and most cost-effective to adapt, particularly if the owner can anticipate future changes," said Frank Rascoe, Carter & Burgess Facilities Unit manager. "You can build in the ability to make simple changes easily, such as new equipment or processes, or even a major transformation such as converting research areas into classrooms."

Modularity does not equate to a "cookie-cutter" concept, however. "The programming phase of a building's design can identify optimal dimensions for modules designed for specific processes, as well as those designed for more general purposes," explained Dale Ball, P.E., a senior engineer in the Facilities Unit of Carter & Burgess. "Each basic module should always include multiple taps for future utility access, making it easier to rearrange equipment as needs change."

Ball added that wall systems between the modules should not be viewed as a barrier to adaptability. "After all, these facilities are not office buildings," he said. "The walls are there to provide compartmentalization and prevent cross-contamination. Any changes could complicate the floor and ceiling systems. A thorough programming process will yield appropriate dimensions, wall systems, and finish systems, making the need for future reconfiguration moot."

While most adaptable building design is basic, it does not have to be boring. "Laboratory and process areas with odd-shapes and unusual configurations not only limit adaptability, but also disrupt thought processes," Rascoe said. "Augmenting modular labs with creative lobby designs, lounges, and even hallways can enhance the physical work environment, and also foster collaboration and the exchange of ideas."

**System Support**

Adaptable laboratory and process modules are optimally configured around a full-length service corridor, preferably located in the center of the lab building. Inside the corridor are "loops" of electrical and mechanical services including gases, HVAC, and water systems serving each lab module. The wall separating the lab from the corridor can double as a module for fume hoods and exhaust systems, providing the flexibility to add additional components as future needs dictate.

The service corridor also allows personnel to transfer equipment, change filters and make repairs without entering the lab spaces. Depending on the hazards present, a service corridor can also help meet building code requirements for emergency access.

Other smaller space considerations are no less important. Individual or central vestibules may be needed to preserve proper negative or positive pressurization-conditions that can be adjusted and monitored easily with sophisticated control systems. Horizontal and vertical shafts should be sized for augmenting existing lines, particularly for data and communications.

With the advent of wireless networks, simply incorporating cable trays is not enough. "Potential locations for wireless antennae must be assessed to ensure maximum coverage throughout the space, and away from potential interference sources," Reese said.

Good design can also maximize the adaptability of the building systems themselves, by incorporating multiple valves and taps that allow users to access the loops without the need for a total shutdown. "This is particularly important for certain services such as USP [U.S. Pharmaceutical Grade] water, because it is not always practical to place a tap for that just anywhere," Ball noted. "However, appropriately placed valves will make it easier to access the piping when needs dictate."

**Adapting to the Environment**

Incorporating adaptability into the building systems can also help owners of complex facilities address other long-term issues such as energy use and sustainability. While minimizing energy costs and environmental effects is a growing concern for all types of buildings, conventional conservation approaches are rarely suitable for laboratory, research, and manufacturing facilities due to their operational and safety requirements.

However, some system specifications not only exceed what is needed, but also compromise future adaptability. For example, ventilation systems are often over-designed based on the incorrect assumption that all equipment operates simultaneously, however, in most cases, these systems operate at only 60-70 percent of capacity.

Eliminating this excessive capacity with an "n+1" redundant configuration of modular units can increase reliability; reduce both initial and operating costs; recapture duplicated space for other uses; and provide a sound foundation for change when appropriate space and/or access is allowed for future units.

"Rather than have one unit to provide 100 percent of your needs, it is better to have two or three smaller units with 50 percent of that capacity," Reese explained. "If one unit goes down or requires maintenance, the building will still be able to handle most functions. To a certain extent, the additional cost of reliability and size goes down as the 'n' number goes up. And if additional

capacity is needed in the future, it's much easier and less costly to add one or more smaller units than it is to make a single system-wide upgrade."

Likewise, small, high-efficiency boilers can be installed in series as needed to match the system to the load. These cold-start boilers operate only upon demand, cutting standby energy losses by up to 60 percent compared to conventional boiler plants.

"As a whole, the laboratory may still consume an above average amount of energy," said Reese. "Yet, the owner will be assured of having a 'right-sized' building infrastructure for current needs and the ability to adapt to long-term needs, along with mitigating the facility's environmental impacts through other sustainable design elements and practices."

**Optimum Design**

As with adaptability, assessing sustainable options is best accomplished in the planning programming stage when some of the most important and least changeable decisions are made. "Admitting natural light into offices, common areas, and even work spaces is a widely recognized way to improve the quality of the work environment; and when properly introduced, can even help reduce heating and cooling needs," said Rascoe. "But too much direct light in the wrong places will have the opposite effect-overheating and glare. That's why orienting the building on the site is such a critical decision."

In fact, Rascoe added, focusing on the future should be a part of the master planning process. "A careful evaluation of the site will help owners make better decisions about optimizing their building needs for the present and future, and with the least amount of disruption to other sites."

Although these and other approaches can substantially improve a facility's adaptability to changing needs, they are by no means universally applicable. Designing complex buildings requires specialized expertise. As a discipline, it's as dynamic as the knowledge and technology it helps to create. There is

no such thing as a one-size-fits-all solution.

"The design team should be adept at understanding the owner's needs, business objectives, and processes," Rascoe said. "The degree of success in the design of buildings as different as laboratories and data centers and is similar in that they both rely heavily on modular planning and integrated complex support systems, but equally important is the awareness that their difference found in functional and system requirements as well as the significant variation in their growth patterns and future needs."

Design practices for complex facilities will benefit from a growing emphasis on sustainability, which has fostered an active exchange of ideas and information. "Up until now, there has been little or no history of benchmarking these buildings for these considerations," Reese said. "Tapping combined wisdom of a particular industry through benchmarking will be of tremendous value for planning and incorporating adaptability because all clients and designers are not at the same stage of development. Examining organizations that are further along in terms of growth can help validate a program by comparing it with those who have reached that point, including their projections for the future."

The ability to draw on more knowledge for adaptable design will also benefit organizations as they strive to expedite the process of change. "After all," said Doyle, "Time is more than just money, it could be the difference between success and failure." Gary N. Bowen

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