

## Healthy hospital success

With hospital projects, it is imperative that engineers get everything exactly right—after all, the lives of patients treated in the health care building may depend on it.

**CSE:** Please describe a recent hospital project you've worked on.

**Richard Heim:** I was recently part of a hospital expansion project in Mt. Vernon, Va., where RMF Engineering provided mechanical, electrical, plumbing (MEP), construction administration, and commissioning services. The existing hospital had two major needs: more private patient rooms and low-temperature orthopedic operating rooms. A portion of the building was extended into a patient tower with three new floors, one of which remained a shell space to be fit-out later, as well as a mechanical penthouse above to serve the space. Additionally, an expansion was added at ground level for two orthopedic operating rooms with a basement mechanical room below to serve the space. Similar to the patient tower, this included a shell space for future fit-out of additional operating rooms.

**Tim Koch:** The new Parkland Hospital, located in Dallas, is a \$1.27 billion health care facility replacing the existing 60-year-old community hospital. The HDR+Corgan Joint Venture team led the design for a master plan of a new 64-acre health care campus, as well as for the 2.1 million-sq-ft replacement hospital. The project consisted of an 862-adult-bed full-service acute care hospital, outpatient center, office center,

parking for 6,000 vehicles, central plant, and other support facilities to achieve a new health care campus. Our imperative was to design a health care facility that wouldn't be limited by space and function in the future. We knew we must be flexible in our designs today to meet the needs of tomorrow—new technologies, new diseases, and even potential terrorist threats to our community.

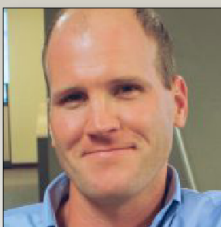
**Nolan Rome:** Most recently, I led a group that finished the design of a new emergency department, campus power service, centralized campus generator service, and parking garage at the Banner—University Medical Center Phoenix campus. These are the first phases of an urban-campus master plan that includes a 15-story vertical expansion on top of the new emergency department, separate loading dock, and central energy plant expansion to be designed in early 2016. The project was designed with an integrated co-location arrangement with Banner Health, HKS architects, DPR construction, and daily subcontractor design integration from WD Manor mechanical contractors and Cannon and Wendt, the electrical contractor.

**Kunal G. Shah:** The Kaiser Permanente Moreno Valley Medical Center emergency department expansion and remodel project includes approximately

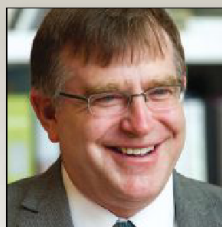
10,000 sq ft of addition and remodel to add 16 treatment bays to increase the total bays to 28.

**Tommy Spears:** Our company is currently designing a new hospital in Conway, Ark., for Baptist Health System. The new, \$26 million facility will be approximately 208,000 sq ft and features numerous innovative design elements and construction methods. The 3-story facility will consist of 100 in-patient beds, seven operating rooms, and a Level 3 trauma center emergency room. To maximize efficiency, the facility will feature a variable-primary chilled-water and heating-water system, as well as variable air volume (VAV) with unoccupied/occupied controls in areas with high air-change rates. The building will also be equipped with an energy-management system that will allow problem diagnosis and corrections remotely, as well as a fully coordinated BIM model. Patient comfort features, including flexible exam lighting elements and bedside controls for HVAC and lighting, were also a high priority in the design.

**CSE:** How have the characteristics of hospital projects changed in recent years, and what should engineers expect to see in the near future (1 to 3 yr)?



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**Figure 1:** RMF Engineering's recent project includes the new Provision Center for Proton Therapy in Knoxville, the first cancer treatment center of its kind in the state of Tennessee. Courtesy: RMF Engineering

**Raymond Schultz:** It seems that all projects are fast-tracked from a design perspective. Engineered systems design begins earlier, and elements impacting building massing and performance should be agreed upon before the building shape is set. Locating main mechanical rooms, louvers, roof-mounted air-handling units (AHUs), cooling towers, chimney stacks, oxygen tanks, transformers, and fuel tanks prior to generating the first renderings can help avoid difficult conversations later on. We are beginning to see Lean processes and techniques embedded in the design process, and contractors are integrated early on. Their insight to equipment location, material applications, staging, and prefabrication help champion MEP requirements and streamline the design/construction process.

**Rome:** The integrated project delivery (IPD) approaches that we have been involved with in projects across the nation are showing proven improvements for the use of project capital and

quality of work. Studies on building envelope and comparative energy analysis for equipment are helping to make informed decisions earlier in the process and to make better use of project capital upfront. I believe the next 1 to 3 yr and beyond will show integrated involvement from the owner's consultants. Integration of owner-furnished equipment, furniture, low-voltage systems, etc. to the design process will provide for better decision making for capital expense and construction coordination.

**Spears:** What we are seeing now, and expect to continue for several years in hospital construction, is a fairly even mix of new construction, renovation, and facility infrastructure projects. For many projects, hospitals are moving away from the traditional design-bid-build process to IPD and Lean construction, as these work better for many of our clients to maximize value. Design-build project delivery also has been popular for some clients due to a fast-track nature and quick delivery of the

project to owners. The continued increase in facility infrastructure projects is due to the growing maintenance requirements of antiquated systems and a stronger focus on energy cost savings as hospitals struggle with the never-ending challenge of providing quality health care with rising costs and tightened budgets.

**Shah:** We have seen that schedules and budgets are compressed intensely. With the limited funding and resources that many medical facilities have, they have to make each dollar go further. Thus, we must ensure that our designs are meeting the programmatic goals, but at the same time allowing flexibility to allow for expansion or further development as funds flow. Further, we see a much more integrated team approach to the hospital projects, where the design team and contractor are engaged early and regularly to ensure a project is efficiently designed and built. This early teaming allows the entire construction team to be collaborative and remove the contentious stigma



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# MEP Roundtable

associated with design team-contractor interactions. We have been fortunate to be a part of many great design-build teams where this relationship flourished and resulted in a successful project.

**Heim:** The biggest difference I've seen recently is an effort to not just satisfy the function of the space, but to do so in an energy-optimal manner. Hospitals are occupied 24/7, making it important to reduce energy costs and usage. It was not long ago that it was common to design a constant air volume system, which would satisfy the code requirements, but would not provide significant energy savings. I'm now seeing owners more open to energy-efficient systems, such as VAV and chilled beams, which is providing new design challenges, but the end result is a more efficient building.

**Koch:** Designers and owners will be continuing to discover the advantages and drawbacks of light-emitting diode (LED) lighting for many years to come. While it was a slow but familiar transition from T12 to T8 and T5, LED technology adoption has been very rapid and is very different from the lamp and ballasts of the past. LED introduces huge benefits in terms of energy and maintenance reduction—but the lack of standards can introduce new and unforeseen maintenance issues to a campus. Now, along with the design of a lighting system, it is also beneficial to educate owners on the development of facility design and maintenance standards and new strategies for replacement stock. Using LED is a decision driven by economics and quality of light and it requires adopting a new way of thinking about lighting. Over the past 5



**Figure 2:** The new Parkland Hospital in Dallas is a \$1.27 billion health care facility built to replace a 60-year-old facility. The project consisted of an acute care hospital, outpatient center, office center, parking for 6,000 vehicles, central plant, and other support facilities to achieve a new health care campus.

Courtesy: Dan Schwalm/HDR Inc.

## Annese Electric Completes Multi-Phase Retrofit Project of Fitchburg State University Library with Connectrac



“It was a huge project that had a lot of variables that came with it,” said Connectrac Director of Sales Steve Batchelder. “We’re happy Connectrac’s flexibility worked well for the job Annese Electric put together.”

The services of Annese Electric – an electrical contractor based in Weymouth, Massachusetts—were selected as the most viable bidder for a multi-phase retrofit at Fitchburg State University’s central student hub, Hammond Hall.

In preparation of the project, Annese researched for a product that could affordably accomplish this goal without intruding on student activities and was flexible to work with future renovations. With multiple options presented to them, the team at Annese selected Connectrac Wireways.

Fitchburg State wanted to provide connectivity along the window railing in an upper floor in Hammond Hall where a study area is placed along a large glass window looking out over the campus. Using Connectrac’s In-Carpet wireway, Hughes and his team brought the carpet all the way up to the window for a near-invisible aesthetic.

“It was easy to install everywhere,” recalls Annese Electrical Foreman, John Hughes. “Connectrac gave us the flexibility to give power and data anywhere without core drilling or saw cutting and spending a bunch of money.”

Annese Electric pulled off the multi-stage project seamlessly, so much so that they have brought in Connectrac for further cable management renovations within the library.

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**Figure 3: RMF Engineering recently worked on the complete renovation and modernization of The Johns Hopkins Hospital Nelson/Harvey Patient Building. Shown here is one of the private patient rooms renovated, one of 136 patient rooms in the building. Courtesy: RMF Engineering**

yr, hospital projects have started to implement more energy-efficient measures in an effort to minimize operating costs as well as environmental impact. In addition, the development of new and different technologies for use in hospitals has led to greater requirements for information technology (IT) spaces and coordination.

**CSE: Describe your experience working with the contractor, architect, owner, or other team members in creating a BIM model.**

**Rome:** I have been fortunate that my last three projects embraced a “draw-it-once” integrated delivery model. We determined what our contracting partners needed to create BIM fabrication-ready drawings, and we provided enough information in our Revit model to deliver the engineering needed for the BIM model. We stay involved through the BIM process to verify the model is delivering the best routings for energy use and owner access. At the end, we can verify our calculations against the model and then remove design contingencies reserved for field routing and more accurately select equipment that matches the fabrication model for better performance. The team must be carefully

selected for collaboration abilities. Otherwise, the effectiveness is lost.

**Shah:** As previously stated, we feel it is imperative for a successful project to have early and constant engagement with the contractor, architect, and design team. Understanding and developing a model is one thing, but understanding construction feasibility as it relates to construction budgets is another. The contractor and the subcontractors are critical to providing feedback on construction feasibility and BIM model development. Many projects now have a BIM execution plan outlined at the kickoff of the project. The level of detail is established to ensure the contractor understands what the design team is preparing and what they will need to develop. Having this clear understanding of scope and effort allows everyone to work efficiently and collaboratively for the success of the project. For larger-scale projects, we have been a part of co-located offices where the contractors and design team are in the same office/trailer. This allows designs to progress and issues to be resolved in real time and in a team manner. Further, the contractor’s BIM model is updated in real time with the weekly updates of the design team model.



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are not integrated, it is more difficult for maintenance staff to know the best time to complete the work orders in a particular room or area.

**Rome:** The main consideration is the goals of the hospital facility staff and

keeping in mind that end users will monitor and maintain the systems being controlled. Will the end user have any continuing education beyond the initial original equipment manufacturer (OEM) training provided with the project? Are

there energy goals? What makes it usable and future-proof for troubleshooting and analyzing systems use? We can design very intricate and complex systems, but the user has to be able to understand and use them properly. It is extremely important that we tailor our designs to the capability of the owner/user.



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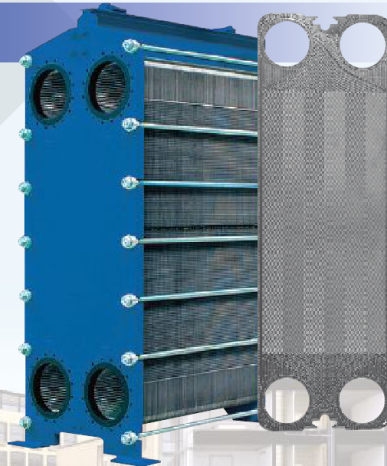
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“It is important to have an open-architecture controls protocol backbone. This allows the HVAC, electrical, and plumbing systems to all seamlessly communicate and report their statuses to the facilities manager.”

—Kunal G. Shah

**Shah:** For monitoring and controls, it is important to consider expandability and compatibility. In many cases, the intent is to have an open-system infrastructure that can allow multiple inputs of systems and allow the facilities manager to be able to manage the overall function of the hospital. With the size of hospitals and the critical infrastructure associated, it is important for facilities managers to have real-time data on their components. Further, the system needs to be dynamic and flexible to accept various systems. Thus, it is important to have an open-architecture controls protocol backbone. This allows the HVAC, electrical, and plumbing systems to all seamlessly communicate and report their statuses to the facilities manager.

**Heim:** Information is incredibly important, especially in hospitals where people's lives are dependent upon the accuracy of the information being shared. With that said, it is critical that the monitoring and control systems be reliable and informative. It is also critical to have alarms and troubleshooting monitoring points to give the hospital engineering staff the tools needed to solve problems.

**CSE:** Please explain some of the codes, standards, and guidelines you use as a guide.



**Heim:** One of the most important guidelines is the Facility Guidelines Institute (FGI) Guidelines for Design and Construction of Hospitals and Out-patient Facilities. This guideline provides detailed requirements for many aspects of health care design including ventilation of health care facilities. FGI directly references ASHRAE Standard 170: Ventilation of Health Care Facilities, which is another important standard we follow on all health care projects that defines ventilation requirements. When we get into our energy modeling, we look closely at ASHRAE Standard 90.1: Energy Standard for Buildings Except Low-Rise Residential Buildings, which states all minimum requirements for building energy efficiency. Often, this has a large impact when designing U.S. Green Building Council LEED-certified buildings.

**Rome:** In addition to local codes and standards required by the country, city, or state, we use the design guideline accepted by the Dept. of State Health Services of the state in which the project is located. The national standard is the FGI Guidelines for Design and Construction of Healthcare Facilities. Many states we regularly work in have their own guidelines that replace or supplement the FGI, such as Texas, California, Missouri, etc. In our international work, those countries that do not have a standard typically ask us to use the FGI guidelines.

**Shah:** For us, the most important codes for hospital design are the requirements of the Office of Statewide Health Planning and Development (OSHDP). These regulations are based on the California Building Standards Code and have their own review process. Understanding their requirements and methods to compliance are imperative to a successful MEP design of a California hospital.

**CSE:** Describe a recent electrical/power system challenge you encountered.

**Spears:** During a recent hospital renovation project, the largest problem we encountered, not just electrically, was

how to completely renovate an entire operating suite with 23 rooms while keeping them operational. Because many of the rooms were very specific to certain types of procedures, only one or two of them could be shut down at a time. Our

team was tasked with figuring out how to build a new distribution system in a limited amount of space, while keep the existing one up and running and switching various elements over to the system as it was completed.

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**Shah:** One recent challenge we have faced on a hospital renovation project was with respect to the segregation of power between the normal, critical, and life safety branches. The facility had done many renovations in the past, and many circuits had been cross-connected between the code-required segregation. When doing our project, our team had to be aware of these violations and ensure as we designed the project that we rectified the pre-existing inconsistencies in the circuiting. In some cases, we found the existing infrastructure to be insufficient to support the re-circuited loads. In these cases, we did evaluations of the loads and tried to find cost-effective measures

with the nurse-call system and motorized shades allows the patient to use the pillow speaker to control multiple zones of lighting within the room, as well as the motorized shades.

**Spears:** In addition to the energy efficiency considerations that are given to every project design, the lighting and lighting-control systems that TME designs for health care institutions take patient comfort greatly into consideration. Direct/indirect lighting in patient exam rooms, flexibility in lighting levels, and placement of fixtures for various departments are all taken into consideration. Recently, the ability for patients to control HVAC and lighting at their beds

system that was integrated with the BAS and also the financial patient-tracking system. Instead of the nursing staff or an occupancy sensor informing the lighting system when the room is occupied or unoccupied, the patient-tracking system sets the room occupancy without providing any patient information to the building management system (BMS).

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**CSE: Describe any unusual detection, suppression, and notification systems you've specified in hospitals. What drove the design?**

**Rome:** One of the recent women's health centers we designed had a Level I and II neonatal intensive care unit (NICU) area where the owner wanted to limit sound in the area for babies, even in the event of a fire alarm, so that they could move the babies without creating extra stress on them. We have coordinated with the local AHJ and our fire/life safety group to provide a fire alarm system that played classical music instead of the typical horn provided with the combination fire alarm device.

**Koch:** Air-aspirating systems have been used in large ducts in lieu of traditional duct detectors and fresh air ducts where humidity is causing false alarms. Air-aspiration systems also are considered in elevator shafts where spot detectors would otherwise be used, providing a more manageable routine-test procedure.

**Spears:** The VESDA system provides overlapping detection for suppression systems. In addition, for other types of specialized facilities like generator plants, TME has used UV flame detection to operate the pre-action system to minimize downtime or damage to the facility. This type of detection system reacts to fires in their most incipient stages and avoids setting off overhead sprinklers for the entire facility. Early notification is crucial for facilities that contain high-value items or potentially flammable materials, such as generator plants. This allows for the facility to initiate the necessary

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*"Recently, the ability for patients to control HVAC and lighting at their beds has been a unique element of design. We are also in the process of exploring the ability to simulate natural daylighting to control patient circadian rhythm with artificial light." — Tommy Spears*

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to consolidate or provide new infrastructure to support the distribution.

**Rome:** The amount of technology that owners are requesting for operating rooms and the requirements for receptacles and circuit length are starting to require additional isolation panels.

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**CSE: What unique lighting or lighting control systems have you completed?**

**Koch:** On a recently completed women's hospital, a small networked lighting control panel was provided for each patient room to allow for intelligent lighting control as well as easy integration with the room's motorized shades and nurse-call system. Historically, the major control issue in patient rooms is the number of light switches, typically at the room entry, which leads to utter confusion for both the staff and family. By implementing an intelligent control solution, it presents the user a single keypad with labeled buttons to allow for much more intuitive control. Integration

has been a unique element of design. We are also in the process of exploring the ability to simulate natural daylighting to control patient circadian rhythm with artificial light.

**Shah:** With California Title 24 requirements, most engineers are well-versed in the implementation of energy-efficient lighting strategies. Although OSHPD facilities in California are not required to document compliance with Title 24 lighting, most of our designs use the code as a basis. Thus, using LED strategies and daylight harvesting to implement an energy-efficient system is critical for maintaining budgets and operating costs. Further, having appropriate controllability of the system is critical to appropriate function and end-user comfort. In a recent project, we had explored several methods to improve the overall lighting in an existing facility, including new lamping strategies, new fixture-specific controls, and zoning flexibility for dynamic spaces.

**Rome:** Most recently, we completed the design and construction administration on a patient room lighting controls

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protocol to potentially eliminate the fire before damaging equipment.

**CSE: What types of fire/life safety systems have you designed for high-rise hospital structures? Discuss elevator evacuation, refuge floors, etc.**

**Koch:** NFPA 70: National Electrical Code (NEC) Article 700.10.D has gone through multiple iterations since its introduction in 1996, and now the 2014 NEC applies to health care high-rise. Careful attention needs to be applied in spaces with emergency feeder circuit wiring to assure that the assembly is 2-hr-rated per NFPA 13, the NEC, and UL 2196.

**Rome:** We have designed a number of high-rise hospitals in jurisdictions that required floor-by-floor pressurization, stair pressurization, and elevator pressurization. Most recently, for a hospital in Texas, I had the IBC requiring elevator pressurization because there were elevator lobbies to provide an area of refuge, but the Texas Dept. of State Health Services required the elevator to

be negatively pressurized. We met with the city and state to agree on a method of pressurization, then followed up with a review of the calculation method that both authorities agreed with.

**Spears:** The systems designed for high-rise structures are typically voice-evacuation fire alarms that allow direct and real-time communication with staff, patients, and other occupants of the facility. This not only allows specific directions to be given to occupants for evacuation in the event of a fire, but also for other major events, including tornados and other natural disasters, as well as intruder alerts in the event that someone entered the building that endangered the other occupants. These systems also allow rescue workers to communicate with one another and with hospital staff in emergency situations to attend to the most pressing issue in a timely manner.

**CSE: What indoor air quality (IAQ) or indoor environmental quality (IEQ) challenges have you recently overcome? Describe the project, and how you solved the problem.**

**Schultz:** Protective environment rooms for oncology patients require a high air-change rate as well as nonaspirating laminar flow panels near patient beds. A primary concern is patients' comfort, as they are sensitive to fluctuations of air temperature and movement. To minimize the discomfort, the laminar flow panels should be located adjacent to the bed's footprint and the supply air rate-of-change can be strictly controlled to minimize fluctuations in room temperature. Additional perimeter radiant heat can be applied to address skin loss at windows or help minimize condensation on window frames.

**Rome:** Pharmacies are tested annually to the U.S. Pharmacopeial Convention standards and guidelines. The particle concentrations demand a combination of systems and strategies using high air changes, HEPA filtration, and air-device delivery. We recently have effectively reduced air changes by using strategies employed by our containment laboratory group to improve air distribution in the space. This saved energy, overall system effect, and first cost.

**Heim:** Recently, we were challenged to design orthopedic operating rooms to maintain a space condition of 58 F at no more than 55% relative humidity. All of this had to be done using standard chilled water of 44 F. Our solution was to provide a dedicated AHU that would produce standard discharge conditions of 55 F. That air was used to serve the support spaces, and the remainder was sent through a desiccant wheel dehumidification unit, which drew additional moisture out of the airstream and conditioned the air back down to 50 F for delivery to the space. **cse**



**Figure 4:** The Parkland Hospital in Dallas is an 862-adult-bed full-service acute care hospital. Courtesy: Dan Schwalm/HDR Inc.

**i** Read more about hospital design at [www.csemag.com/archives](http://www.csemag.com/archives):

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