Mock-ups: Do You See What We See? Tools To Communicate Design.

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Mindy F. Goodroe, Associate Principal, HKS Inc, has shaped the human experience through innovative design and planning leadership. Her work represents over 10 million square feet and more than 2 billion dollars in domestic and international projects, ranging from luxury resorts in Mexico to medical cities in the Middle East. A licensed architect with 18 years' experience, her passion is creating inspiring places where people work, play and heal. As the Practice Leader of HKS's Atlanta Health studio, she has designed projects for renowned healthcare systems such as Children's Healthcare of Atlanta, Emory University Hospital and Piedmont Healthcare.

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A native of Brazil, Camilla Moretti is passionate about creating spaces that are catalysts for human interaction, enhance the built environment and improve the processes that happen within. Her resume includes planning, design and research for large-scale healthcare facilities around the world. A Lean Six Sigma Green Belt, she studies and facilitates workshops on operational, logistical and functional issues to enable the team and user groups to make design decisions that promote operational best practices and evidence-based design strategies. In addition to her project work, Camilla is heavily involved in applied research projects and how they can lead to innovative design. As Director of Planning for the Midwest region, she is a trusted advisor to many prominent healthcare systems, such as ProMedica, Piedmont Healthcare of Atlanta, and the University of Wisconsin Health system.

Alexandra Bernetich, Associate, AIA - HKS, Inc.

Alexandra Bernetich is a multidisciplinary designer and researcher at HKS who leverages an array of analog and digital tools to generate conversations around space and efficient processes. She earned her B.S. in Architecture from the University of Virginia and her Master of Architecture from the University of Michigan. Specializing in planning and conceptual design, Alex has contributed to new construction and renovation healthcare projects around the world. She is passionate about working directly with the end-users of a space and participating in architectural projects from start to finish. While at HKS, Alex has contributed to the development of patent-pending innovations in the design of patient rooms that accommodate Continuous Renal Replacement Therapy (CRRT).

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Abstract

Full-scale mock-ups are powerful tools that allow architects, contractors, and users to actively engage in a holistic and three-dimensional design process. From rudimentary cardboard models to photorealistic virtual reality renderings and performance tests of constructability, each type of mock-up provides significant value to projects when employed at the proper time. The upfront investment of time and materials into the construction of mock-ups, provides project teams with opportunities to reduce errors and optimize design, ultimately producing a smarter building that responds to all stakeholders.

This case study will overview the various types of mock-ups utilized at the Piedmont Atlanta Hospital Tower, a 408-bed, sixteen-story, diagnostic and treatment platform and patient tower located in the heart of Atlanta.

KEYWORDS:

Integrated project delivery, Technology, Mock-ups, Virtual reality, Lean process

CATEGORY:

Environment

Project Background

HKS was retained in December 2015 to plan and design a bed tower for Piedmont Atlanta Hospital. A 16-story, 903,671 square foot tower, the initial phase of a 10-year expansion plan, was the largest healthcare construction project in the history of the state of Georgia as stated in the *Atlanta Business Chronicle, (Hensley, 2016)*. The tower is planned to house 408 patient beds when completed. The initial phase includes 90 acute care beds and 42 critical care beds, including 13 operating rooms, eight cardiac catherization labs, four cardiac electrophysiology labs, a 400-car parking garage and 45,583 square feet of renovation. Project drivers included: increasing patient care volume, strengthening the hospital's reputation as a premier destination for cardiovascular care, enhancing community involvement and expanding critical care services (Hensley, 2016).

Figure 3: The future view of the Piedmont Atlanta Hospital Marcus Heart and Vascular Center expansion from the corner of Collier Road and Peachtree Road.

Piedmont is busier than ever, serving nearly two million patients in 2017. Piedmont Healthcare's core promise is "to make a positive difference in every life we touch." With this promise, Piedmont solicited participation and input from staff and community members, patient advocates, and hospital leadership. This interdisciplinary group was paramount to the success of the project; more than 1,000 people – patients, clinical and

support staff, neighbors, authorities having jurisdiction, and the design and construction teams – provided input on the vision of the project through workshops and advisory meetings. This included:

- A design and construction team composed of over 122 professionals from 33 firms;
- Digital survey responses from 543 Patient and Family Advisory Council members;
- Neighborhood Advisory Councils and one-on-one meetings with the boards of the local homeowners' associations, and residents representing over 37 neighborhoods and businesses;
- 400 Piedmont physicians and staff participated in experience workshops to map the future workflow; design workshops to design the building and plan the facility's medical equipment and information technology.

Process Influencing Technology

Lean processes have been recommended for use in healthcare facility design (Hicks, et al., 2015). With an aggressive schedule, the team utilized an integrated project team approach. The integrated project delivery process provided the team real-time feedback on design and pricing. Collaborating with the contractor from the beginning resulted in less waste and established a level of trust that is often difficult to form in the traditional design-bid-build process.

Lean planning and the latest available software were used to garner feedback and enable collaboration among the many design and construction partners located across the country. These tools included: Gemba walks, A3 decision making, choosing by advantages matrices, pull plan scheduling and iterative full-scale room mock-ups. Design meetings were held in a Big Room, a lean concept that collocates all major project stakeholders for facilitating and enhancing communication. Locating the project hub on the hospital campus allowed for easy access for user groups and fostered consistent participation from busy physicians and clinicians. Additionally, the room provided a central, consistent location for all meetings, a place to visually display the latest project details, promoted a collaborative team approach and enhanced project understanding.

The team created a virtual jobsite using Cloud for Revit (C4R), a new Autodesk technology. C4R allowed the team to store the project's Revit models on the cloud. This technology was key in promoting a truly integrated design process with the contractor and design team. Bluebeam Studio allowed real time online coordination with consultants and was also utilized in workshops to track design changes.

Mockups and Virtual Reality

Lean collaboration and production software provided the team with tools to communicate design concepts, improve patient experience and optimize operational efficiencies. Ranging from simple cardboard models to photorealistic virtual reality renderings and constructability performance tests, these tools brought significant value to the design process. Hospital stakeholders, service line leaders, as well as the integrated design and construction team, benefited from the use of these tools throughout the project.

Mock-ups and virtual reality were key to engaging hospital leadership and project stakeholders in the design process. Virtual reality has been an effective means of understanding the implications of design decisions (Dunston, et al., 2011) as have mockups (Lu & Hignett, 2006). As is the case in many design projects, key decision makers from the owner's side were not trained to read floor plans or elevations, and struggled to visualize spaces from two-dimensional drawings. These three-dimensional tools helped the end-users experience the design intent, provide feedback and offer approval during key decision junctures.

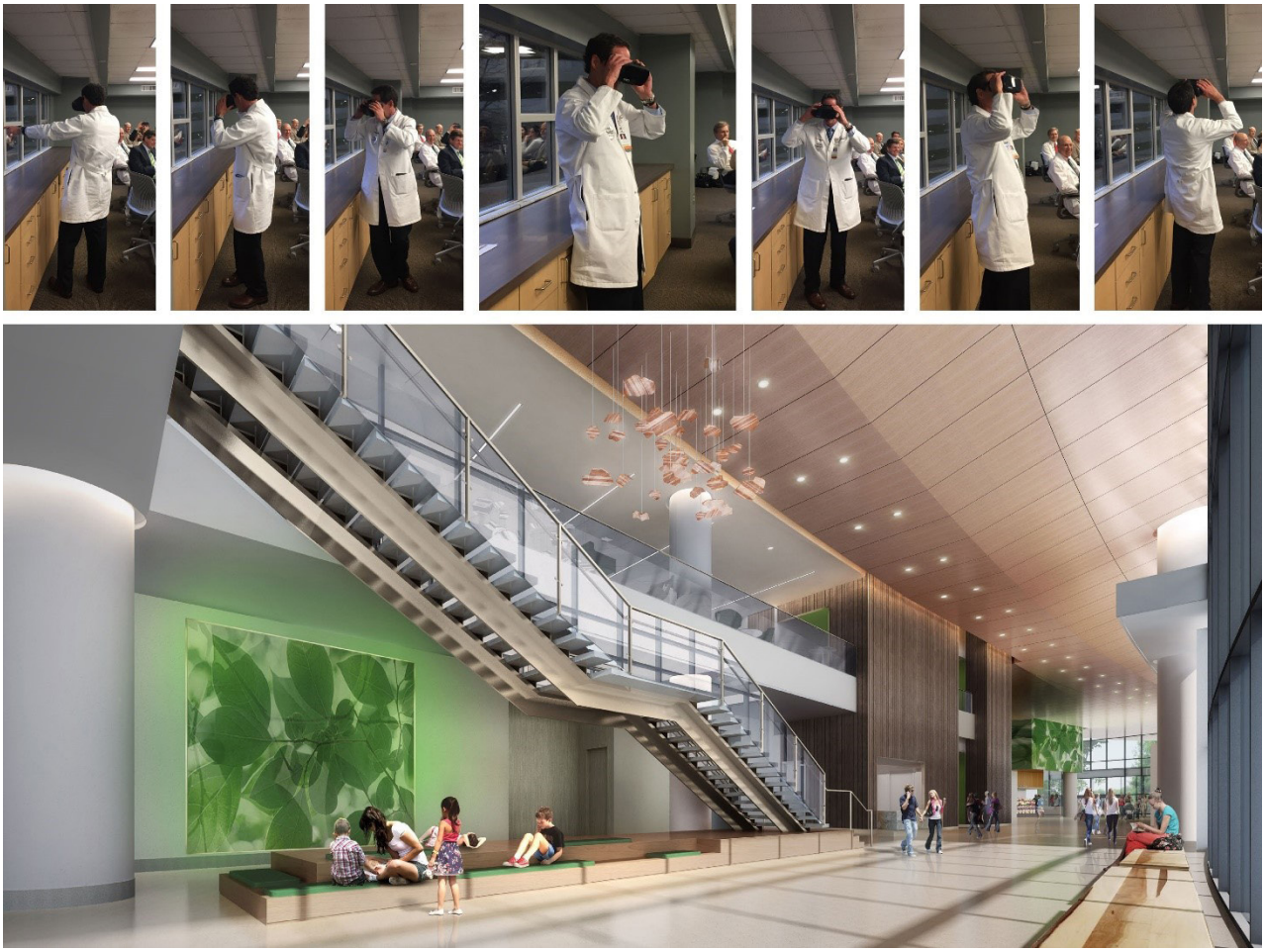

Figure 1: Top: Dr. Battey, CEO of Piedmont Atlanta Hospital, reviews the lobby design during Design Development meetings. Bottom: A rendering of the lobby and monumental stair connecting the first and second levels.

Design Concepts and Cardboard Mockups

Cardboard mock-ups of key spaces were designed for the users to help determine the appropriate size of each room. The contractor built a full-sized patient room, catherization lab, hybrid and general operating rooms, surgical prep rooms and post-anesthesia recovery bays, as well as a trauma elevator. Hospital users, department leads and representatives were encouraged to tour the mock-ups, while the design team recorded and analyzed the feedback. Locating the mock-ups in an accessible on-campus building allowed staff more opportunities to visit the space and offer feedback. When possible, actual medical equipment and furniture was utilized to run simulations and gave the visitors a more accurate sense of scale. The elevators in the building where the mock-ups were housed, were too small to accommodate transport beds or equipment, so the contractor constructed detailed models of the equipment from specifications provided by the client.

One example of how the design was improved through the cardboard mock-ups was in the patient transport elevators. After simulating a patient transport during the first review of the space, staff determined that the trauma elevator needed to be twelve inches deeper to accommodate an ECMO circuit at the foot of the bed plus the six staff members who would typically accompany a patient.

During the review of the patient room mock-up, staff expressed concerns about the most dangerous workplace exposure relative to the nurses in the cardiovascular intensive care unit, the handling and disposal of fluids in the Continual Renal Replacement Therapy (CRRT) bags. After careful consideration and research, the design team found that no product existed to reduce the exposure to splashing and resulting infection.

As there were no other solutions available to address their concerns, the team designed a custom plumbing fixture. The contractor developed and manufactured a prototype and the fixture was tested in the hospital system's existing facilities. The design was altered to serve two functions, allowing budgeted funds to be used to develop this innovation. This solution is now patent pending and will be installed throughout the intensive care units in the Marcus Tower Expansion.

Incorporating Virtual Reality

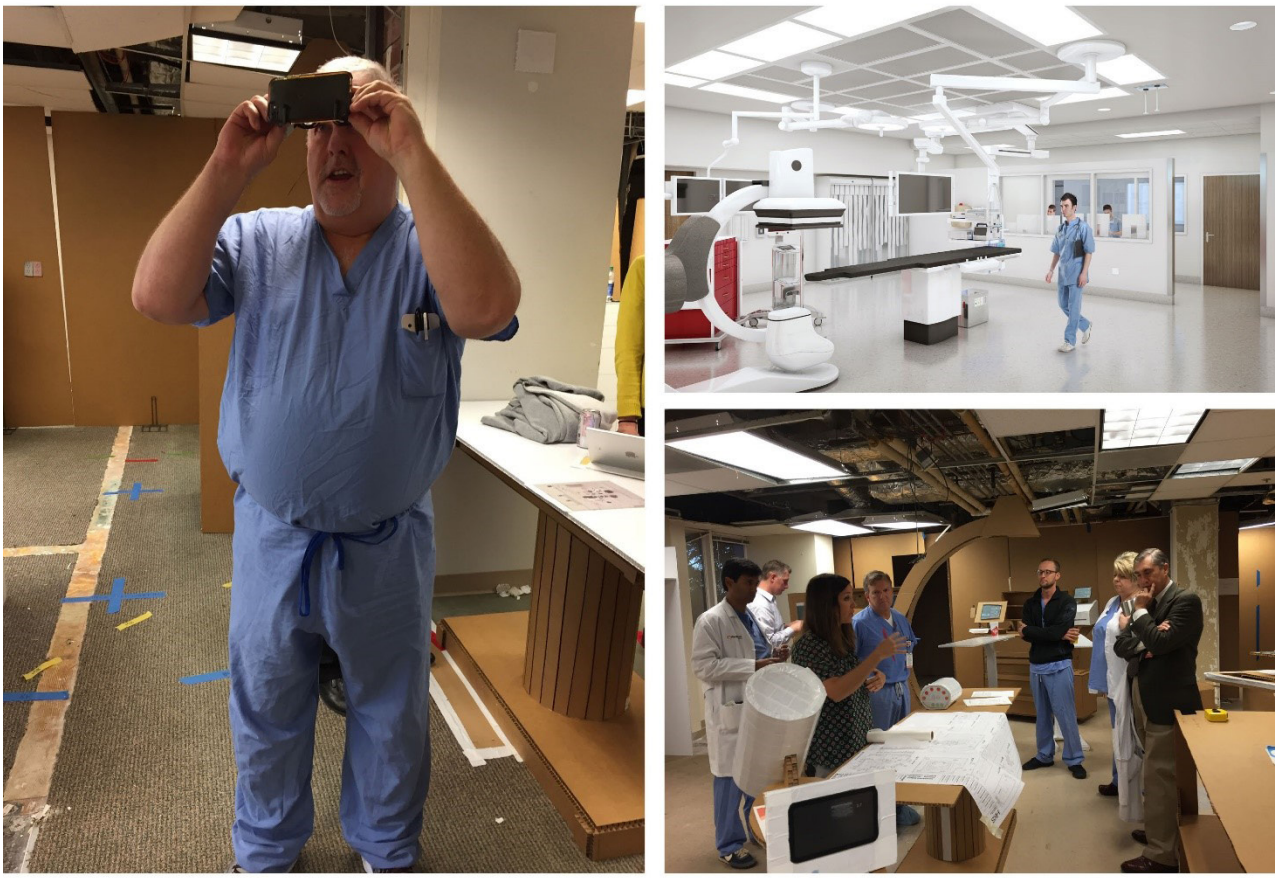

Figure 2: In the design of specialty rooms such as catherization labs and operating rooms, ceiling layouts are key for the functionality of the space. The cardboard mock-ups were constructed in an existing building with low ceilings. Virtual reality goggles were used to more accurately represent ceiling heights and locations of ceiling mounted equipment and lighting.

The building where the mock-ups were housed had low ceilings and items such as ceiling mounted equipment were not able to be installed. Virtual Reality was utilized to accurately represent ceiling heights, the configuration of ceiling mounted equipment, and the lighting layout. In designing specialty rooms, ceiling plans are key for the functionality of spaces such as catherization labs, hybrid and general operating rooms. The virtual reality goggles helped the clinical staff experience the comprehensive design.

The entire project was modeled in Revit, which allowed seamless incorporation of virtual reality as a tool. Enscape and Autodesk 360 were utilized to produce panoramas and walk-throughs in schematic design through construction documentation. Two-dimensional drawings were shared in Bluebeam Studio to allow real-time communication and coordination of all disciplines. PDFs with embedded links to panorama views were used in design meetings, and when local WIFI allowed, the Revit model was presented real-time.

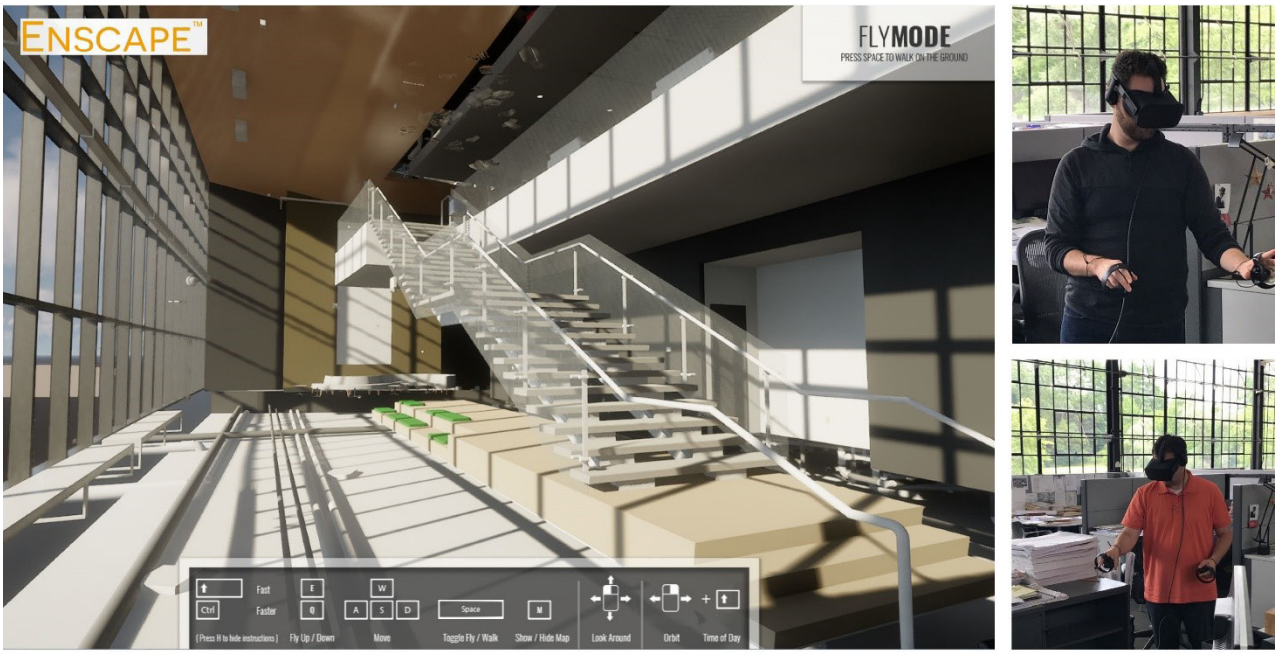

Figure 5: When touring completed buildings, designers sometimes identify areas they wish they would have detailed differently. Having the ability to "walk through" the building during design gives the team the opportunity to experience the space and identify those areas sooner and thus avoid issues in the field or worse, after completion.

Full-scale Mockups

After the completion of design development, a mock-up of the patient room, including actual fixtures, finishes and medical equipment, was built. This mock-up allowed all to experience the design details from headwall functionality, to equipment location and quality of finishes and construction detailing. Additionally, the finished patient room allowed the users to run simulations in the space, testing outlets, equipment placement, shower drainage, and nurse-call system operability. All fixtures, equipment and systems were fully vetted and streamlined in the mock-up.

The team anticipated that the upfront investment of time and materials for the different design processes mock-ups would provide the project team with opportunities to reduce errors and change orders, optimizing design, ultimately producing a smarter building that responds to all stakeholders. To illustrate the benefit, patient room mock-ups were constructed, including medical equipment, doors and windows, and functioning showers. The mock-ups were products of the final design documents, yet when the design and construction team visited, the team identified 77 additional changes to improve constructability, elevate the design, and help to train the sub-consultants on the building. Identifying these changes early reduced excess spending, as the process identified the issues prior to being replicated in more than 400 patient rooms in the tower. The expense of the mock-ups was recouped by minimizing costly changes in the field.

Lessons Learned

Full-scale mock-ups and virtual reality are powerful tools that allow architects, contractors, and users to actively engage in a holistic and three-dimensional design process. Following are a few lessons learned along the way:

- The ability to insert the users, elevating the experience in the space is invaluable. For areas too large or too complex to produce full scale mock-ups, virtual reality is the most cost-effective way to convey design.
- Virtual reality is also a prolific design tool. The ability to "walk-through" the building before construction starts, gives the design team the opportunity to experience the space and optimize constructability details, avoiding issues in the field.
- A key to the usability and success of innovative mock-up and virtual reality tools is the ease of access, whether it's physical location or ability to understand/interpret software and technology.
- Technology is an important tool, but it is not a substitute for in-person collaboration and attention to detail.

Ways Collaboration Tools Improved the Design

- Outpatients who have transradial cardiac cath procedures take less time to recover. A radial lounge was designed to allow patients to recover in a less clinical and more relaxing atmosphere. This new service was only fully understood and approved by the users with the use of virtual reality; once the staff could "experience" the space, the design team received final sign-off.

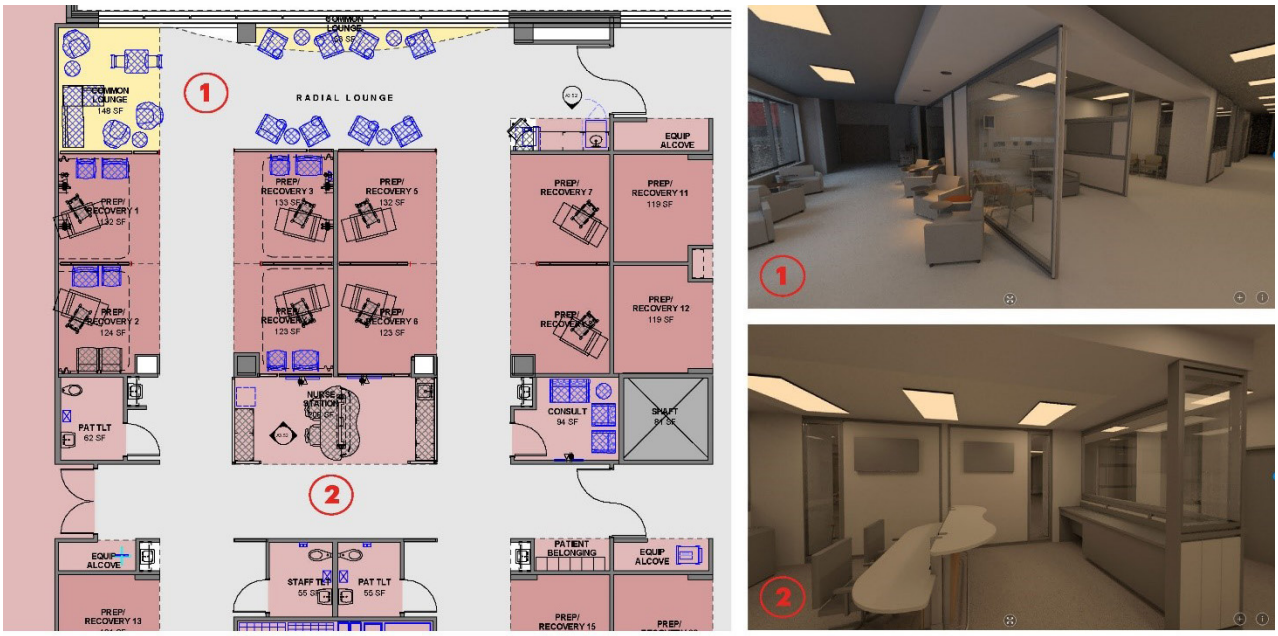

Figure 4: Outpatients who have Transradial Cardiac Cath procedures take less time to recover. A radial lounge was designed to allow patients to recover in a less clinical and more relaxing atmosphere. This new service was only fully understood and approved by the users with the use of virtual reality; once the staff could "experience" the space, the design team received final sign-off.

- Cloud for Revit allowed all the consultant teams to coordinate changes and develop the design in real-time without the burden of weekly model uploads.
- The interactive tools, as noted in this study, are essential to integrated project delivery, as they provide opportunities for process groups to better understand new concepts and designs.
- Workshops provide unique opportunities for hospital departments to focus on ways to improve their workflow. The sessions often prove to be an opportunity to solve problems beyond the scope of the project at hand.

Conclusion

The interactive nature of mock-ups and virtual reality provide an ideal platform for simulations, testing of new processes, workflow improvement, development, and buy-in of new concepts. These tools were successfully integrated into the design of the Piedmont Atlanta Hospital Tower expansion. From optimizing the design to reducing errors, saving time and money, communicating with key users to gain consensus, they proved to be invaluable to the client, design and construction team. The use of interactive technology and full-scale mockups helped the key stakeholders better understand different solutions and ultimately producing a smarter, more appropriate design solutions.

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