

# Simulating Evolutions in Emergency Department Design:

## Three Case Studies

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Kenneth has specialized in hospital planning and design for over 16 years. He serves as healthcare studio leader, directing project teams through conceptual design, master planning, schematic design and design development. Kenneth has been an integral part of the design and planning of projects of all types and sizes throughout the U.S. and abroad. His expertise includes working closely with medical professionals and consultants in planning state-of-the-art healthcare facilities that enhance patient care and improve operations. Kenneth utilizes his value-driven leadership skills to create innovative healthcare facilities that assist caregivers in working more effectively while providing an environment focused on user experience.

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Sheila Ruder has specialized in healthcare facilities planning for 13 years. She graduated from Texas A&M University with a master's in architecture and a Certificate in Health Systems and Design. She is a member of the FGI Healthcare Guidelines Revision Committee and a Lean Six Sigma Green Belt. Sheila has completed work on a number of high-profile projects such as the MetroHealth Campus Transformation in Cleveland, Ohio, focusing on efficiency in operational and design processes.

### **David Klahn**

David is a graduate of the University of Manchester, School of Architecture in the U.K. and started his career in Healthcare Architecture in London, working on National Health Service projects. Since moving to Richmond, Virginia in 2004, David has focused on Medical Planning and Facility Master Planning, working on a wide variety of healthcare projects, many with Academic Medical Centers. In recent years he has worked on a number of Emergency Department projects ranging from smaller community based ED's to urban Medical Center facilities.

### **Kate Renner**, AIA, EDAC, LSSCE, LEED AP BD+C

Kate Renner, an architect and medical planner at HKS, specializes in healthcare with a focus on the fusion between health, wellness and prevention. She works with several of the top healthcare systems in the US and abroad to develop solutions to the many complex challenges encountered in healthcare while creating a healing space for patients, staff and the community. In addition to her project work, Kate has been leading HKS's transformation of its Functional Performance Evaluation (FPE) process. Kate is a graduate of the University of Kansas, where she earned her Masters of Architecture and her Masters of Art.

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## **Abstract**

Simulation can accurately show the quality of interactions between processes and people and provides a depth of insight and accuracy into the validation of results during the early design process. Future-state designs can predict responses to changing factors and justify design decisions. Simulation ensures that estimated savings are realistic, reveals additional savings, and quantifies the implications of decisions on the customer/patient experience. In Emergency Department (ED) design, simulations help to solve many of the challenges within these complex environments during the design phase. These 3 case studies of ED expansion and renovation took unique approaches to simulation.

### **Wake Forest Baptist Medical Center ED**

At the early concept phase of the project, a Paper Simulation was conducted to test the patient flow, placement and staffing allocation throughout a typical busy day. The simulation revealed the higher than typical percentage of ESI 2 & 3 patients, resulting in the addition of more Major Treatment rooms to accommodate these patients to maximize the throughput of the department.

### **WellSpan York Hospital ED**

To ensure proper flow of patients between key areas in the ED and adequate staffing, a dedicated Lean Process Improvement team simulated conditions in real-time using card board mock-ups of the department. Hired actors simulated several scenarios, with the design team onsite to reconfigure the department as the scenarios revealed the design challenges.

### **Christiana Care Health System ED**

Challenged with treating more patients in less time and in less space, the project team analyzed a recently completed Freestanding Emergency Department to simulate the key design and operational concepts in a physical space. New concepts were tested using live simulation to test possible processes and strategies for system improvement, and quantify their resulting impact.

These projects will be analyzed post-occupancy to understand the actual impact of design strategies tested through simulation.

## **Keywords:**

Emergency Department, Simulation, Mock-Up, Operational Improvement, Patient Experience

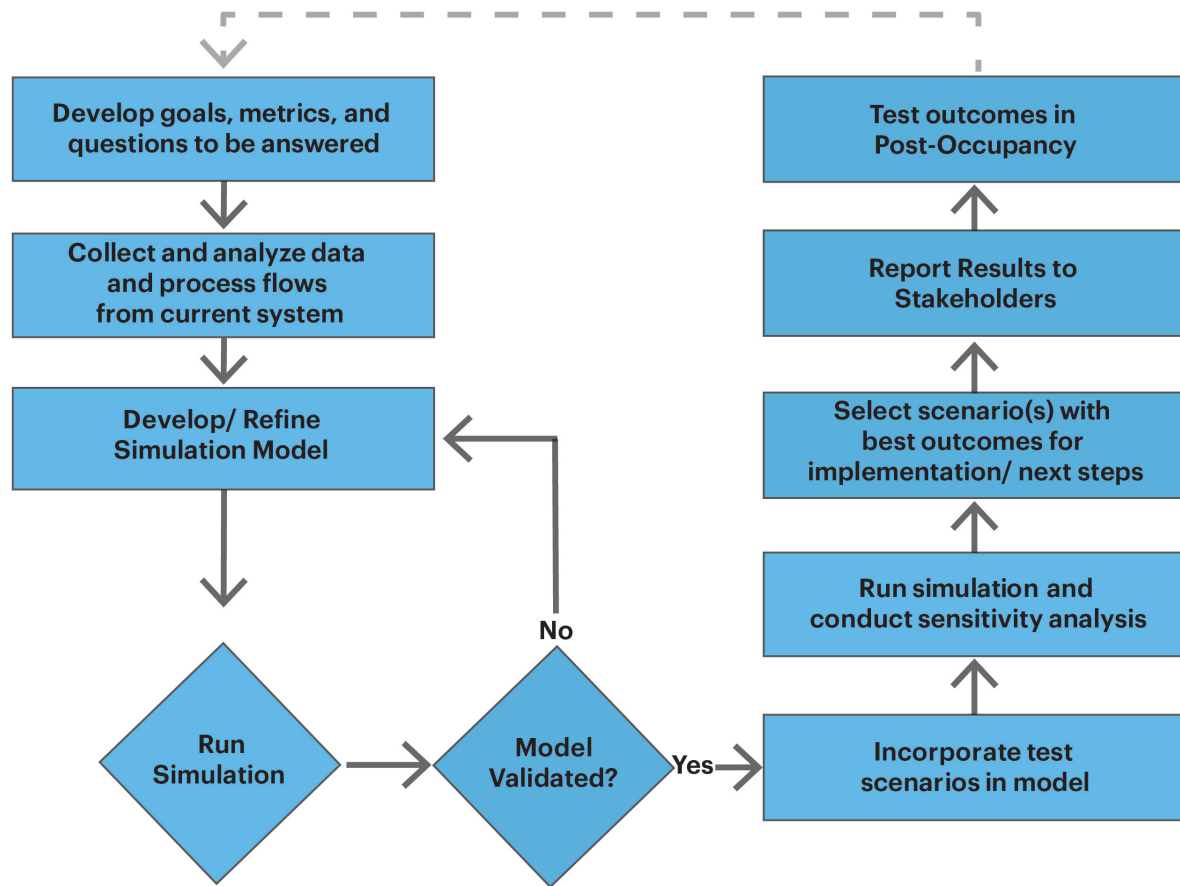
## **Category:**

Experience

## Introduction

The built environment of health care systems plays a crucial role in patient safety, optimal health, patient experience, staff satisfaction and overall efficiency. Many hospitals that have been renovated or expanded no longer support today's evolving clinical roles or the needs of current patient populations. The results are designs that do not address staff stress levels, ultimately reducing productivity and effectiveness in the delivery of optimal health care ([Ulrich, Quan, Zimring, Joseph, & Choudhary, 2004](#)). Studies to date suggest that characteristics of the patient's environment can impact stress ([Ulrich, Zimring, Quan, & Joseph, 2006](#)), staff injuries and patient safety ([Carayon, 2007; Reiling, 2007; Institute of Medicine, Committee on the Work Environment for Nurses and Patient Safety, Board on Health Care Services \[IMa\], 2004](#)), operational efficiency ([Hendrich, Fay, & Sorrells, 2004; Hendrich, 2005](#)), staff satisfaction and nursing turnover ([Tumulty, Jernigan, & Kohut, 1994](#)) and medical errors ([Institute of Medicine, Committee on Work Environment for Nurses and Patient Safety \[IMb\], 2001; IMa, 2004](#)).

Simulation has long been used in many industries to improve operational processes and environmental layouts. Simulation accurately shows the interactions between processes and people and provides a depth of insight and accuracy into the validation of results during the early design process ([Miller, Dias, & Kittredge, 2011](#)). Future-state designs can predict responses to changing factors and justify design decisions. Simulation ensures that estimated savings are realistic, reveals additional savings and quantifies the implications of decisions on the customer/patient experience. In Emergency Department (ED) design, simulations help solve many of the challenges within these complex environments during the design phase. This paper will explore three ED expansion and renovation case studies, each utilizing a unique approach to simulation in the design process.



**Figure 1: Simulation Process Map**

Simulation is a tool in architectural and process design, used to make determinations on future states, to evaluate existing layouts and processes, or to serve as a prediction model for performance of proposed designs. The development of a simulation model is similar for each of these modeling types. The project team performs data collection through database queries, staff interviews, process shadowing and observations. The data is then used to construct simulation models. The simulation models are thoroughly verified and validated to ensure not only the right model was built, but that the model was built right. The verification of the model confirms that the model is correct, or void of errors, and validation confirms that the model represents the actual system and behaves realistically. Once the model is developed, scenarios can be tested, strategies for improvement developed and results quantified (Figure 1). Multiple methods of simulation can be used. This paper focuses on the following three:

1. Paper-based Simulation Interactive Workshops utilize staff members who spend one day working within the space and with patient data, which then becomes the basis for loading the two-dimensional proposed floor plan for testing.
2. Physical mock-ups utilize cardboard, allowing staff members and design teams to simulate patient scenarios in the three dimensional built environment, and enable rapid prototyping of the space layout. This form of simulation allows observers to experience the space and challenge the design, resulting in an effective layout solution.
3. Live simulation utilizes previously designed and constructed layouts in active, operational environments to analyze processes and provide continuous feedback for improvements in future construction projects.

## Wake Forest Baptist Medical Center ED

As a part of the programming and conceptual design phase of a major expansion and renovation project for an adult ED at Wake Forest Baptist Medical Center, the design team utilized paper simulation techniques to assess the volume and flow of patients and staff members through the department. The purpose of this simulation was to avoid grouping patients based on acuity level. The intended result of this operational and built environment shift is a more balanced work environment, with team members experienced in the care of patients from all acuity levels. The enhanced team care model will have multiple zones, each containing treatment space to meet the needs of all patient types.

The paper-based simulation interactive workshop was conducted to help test the concept. Large-scale concept plans were printed, and data was collected for a typical busy day in the ED. Patient information, including arrival time, medical complaint and discharge, were written on Post-it Notes, and the day was simulated one patient at a time. Patients were assigned to certain rooms based on acuity and care team balance. Photos were taken at each hour of the simulated day as a record (Figure 2). The key purpose of the paper-based simulation was to stimulate conversation among the care team members as they made decisions about the patient assignments in the new operational model. It generated discussions about the utilization of recliner positions within each care zone and patient acuity level assignment to vertical patient stations versus those that may be moved to that location after an initial exam was performed. The design of the new vertical patient stations generated discussion around the location and configuration of these spaces.

The simulation revealed that this facility saw a higher percentage of higher-acuity patients than typical, and in the program, four treatment rooms were enlarged to provide major treatment rooms for higher acuity patients. Different scenarios were simulated to investigate how the patient assignments should be made during key shift change periods in the new operational model. The simulation also enabled the facility to evaluate their current staffing model and team composition so that in the future, both the built environment and the operations could align to provide effective and efficient patient care.

In addition, more detailed simulations are planned to test the design and operational model, including computer simulation and full-scale cardboard mock-ups for scenario testing.





Figure 2: Paper Simulation at Wake Forest Baptist Medical Center

## WellSpan York Hospital ED

Early in the conceptual design process, the core leadership at WellSpan York Hospital was committed to instituting Lean process improvement concepts into the design of the expanded and renovated ED at the York Hospital Campus. To arrive at an informed design solution, cardboard mock-ups were developed to test patient, staff and facility workflows in a warehouse environment. These mock-up spaces were modified during clinical simulation events to refine the design through real-time scenario testing.

At the outset of the engagement, the departmental leadership team identified the following key goals to be evaluated and tested within the conceptual design:

- Build teamwork/consensus in and out of the ED
- Gain staff input through the testing of flows and bottlenecks
- Confirm that processes fit the design
- Understand the priorities of varying users

To initiate the process, the WellSpan Performance Improvement team was systematically engaged with clinicians, clinical and ED leadership, equipment vendors and the core design team in a series of simulation work session events. These sessions tested the full scale mock-up of the conceptual design (Figure 3). A full week of carefully defined and simulated patient scenarios addressed multiple episodic and routine patient events consistent with the typical ED census at York Hospital.



**Figure 3: WellSpan York Mock-Up Simulations**



Each scenario was built around the clinical roles and standard work involved in providing proper treatment within the particular care environment, while focusing on reducing waste, optimizing efficiency and enhancing the patient experience. Additionally, the scenarios were scripted to analyze the design via simulation and allow the staff to engage early in the design process, to help them develop a better understanding of future-state processes within the context of the actual space. Video documentation allowed for follow-up analysis of the recorded simulation events.

Events were scheduled in four-hour time blocks, and included simulation and simulation debriefs. Actors were hired as patients, while the design team remained nearby during the simulation to capture operational or facility-driven limitations to providing patient care. Systematic documentation of each of the three simulation events captured hundreds of comments by location and were organized around the assumed impact to process, facility or a combination of the two. Simulation Round One captured over 700 comments, 48% of which were facility based, 31% process oriented and 21% process and facility oriented. The design team made immediate changes to the layout, and the group then retested the simulation in the redesigned space. The three simulations saw a drastic reduction in the comments until Round Three, which provided approximately 60 comments for review by the team. The first round of simulation provided the greatest amount of feedback on potential space revisions and allowed for the team to access the clinical and operational changes that would be required to operate within the new departmental layout. This simulation allowed the team to address current practices that could be streamlined in the existing department and would be administered within the future emergency department.

These real-time design modifications were instrumental in refining the conceptual layout and testing the design under realistic clinical situations. This process gave both the design team and the clinical team confidence that all design decisions clearly addressed the fundamental project goals: to reduce door-to-doctor time and establish efficient patient disposition to avoid queues of untreated patients in the waiting room.

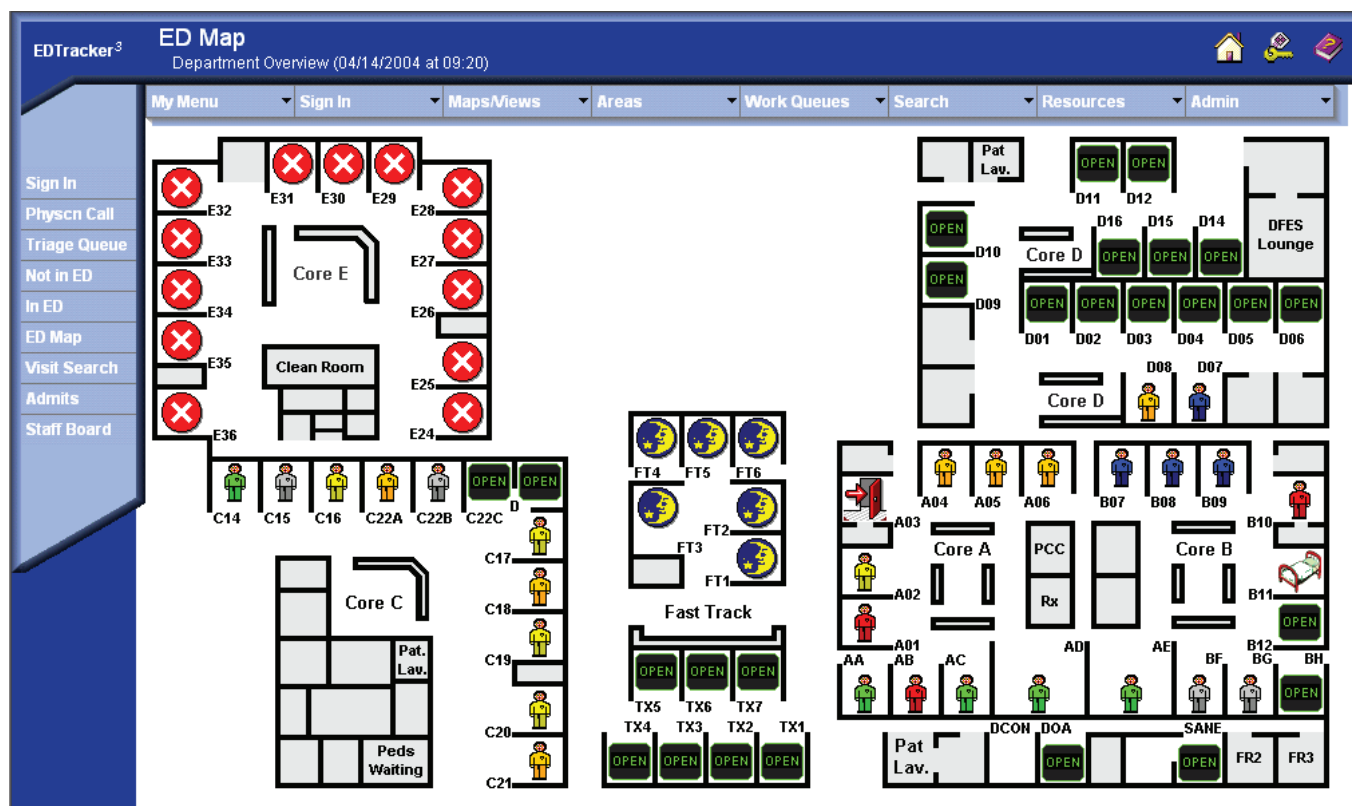
## Christiana Care Health System ED

Christiana Care utilizes various simulation techniques to inform and validate design decisions, especially for ED projects. Increasingly, they are using live simulation to improve operational processes and space configurations. The result of these simulations then becomes the baseline for the next cycle of testing. For example, when demand for emergency services at the main campus began to surpass capacity, Christiana Care utilized rapid-cycle testing to identify bottlenecks in current processes which informed design solutions for renovations to the department. These renovations then acted as the live simulation testing areas whose results informed the design of future projects, including a new-build Freestanding Emergency Department (FED) for the system.

The throughput challenges that were identified in the main campus ED included increased volume of patients, process variation and bottlenecks, resulting in increased wait times, particularly for low-acuity patients. One proposed solution was segmentation, or separation of patients into different process flows based on acuity level. This strategy can improve flow by reducing variation and service times, and can reduce space required by utilizing recliners in smaller rooms or cubicles for low-acuity patients, and reserving beds and larger exam/procedure spaces for higher-acuity needs.

Process mapping and extensive analysis of segmental data identified several environmental and operational changes that could improve patient flow in the main campus ED, primarily focused on the segmentation of acuity levels, or split-flow process. Rapid-cycle testing (live simulation) was used to determine the best practice in an existing environment and to inform future designs. Implementation of a Super Track area allows low-acuity patients to remain upright and on the periphery of the care area, which minimizes length of stay, while opening exam rooms for higher-acuity patients, thereby improving the throughput time for low-acuity flow. The addition of a Results Waiting area provides a space for patients to await lab test or imaging results without occupying an exam room, again increasing throughput for both acuity-level flows. Universal exam rooms also improve throughput. Supply carts for specialties such as OB/GYN, cardiac and pediatrics can be brought into any exam room in lieu of dedicating a room to each, limiting underutilization. Dual-access exam rooms provide a support core for staff members, supplies and equipment to be in close proximity to exam rooms, minimizing steps and time wasted for staff members.

The results of the solutions implemented at the main campus were (and continue to be) collected via an automated ED tracking system (Figure 4), providing real-time performance data. These data were analyzed to inform the design of the FED, along with other process and design improvements. The strategies that have proved successful in the FED live simulation are now being implemented, along with new concepts, in the planning of further renovation and expansion projects in the main campus ED. At the Christiana Care Hospital FED, the live simulation was based on an intent to accommodate 35,000 visits per year based on a two year projected volume of 20,000 visits. After just seven weeks, the actual volume was 17,500 visits and the two-year actual volume was nearly 24,000. Based on this, the system is able to understand the actual capacity of the building and plan for future capacity increases as volume continues to increase.



**Figure 4: Christiana Care Hospital Automated Tracking System**

These case studies demonstrate the critical role that simulation has in the design of an ED. In each case, the simulation method selected enabled decision-making appropriate to the phase of the project (Figure 5). The simulations resulted in increased efficiency in the design and operations, improved patient throughput, increased staff satisfaction with the design process and confidence in the design decisions made.

	Opportunities	Challenges
<b>Paper Simulation</b>	<ul style="list-style-type: none"> <li>· Can be performed at very early stages of concept design</li> <li>· Minimal time and expense required to perform</li> <li>· Good format to simulate conversation between care providers when there will be a significant change in the operational model</li> <li>· Can be easily performed on multiple options &amp; scenarios</li> </ul>	<ul style="list-style-type: none"> <li>· Conducted using historical patient data for flow and time frames</li> <li>· Not an accurate simulation to predict number of rooms required</li> </ul>
<b>Physical Mock-Ups</b>	<ul style="list-style-type: none"> <li>· Clinician &amp; Leadership understanding of physical space vs. 2D or virtual representations</li> <li>· Real-time testing of overall portions of the department with clinicians, patients &amp; staff</li> <li>· Onsite manipulation based on scenario testing</li> <li>· Generates user and owner buy-in</li> </ul>	<ul style="list-style-type: none"> <li>· Requires large warehouse environment often offsite</li> <li>· Requires dedicated clinical and leadership team to allow for multiple offsite simulation meetings</li> <li>· Mock-up material transportation can be difficult</li> <li>· Requires contractor for construction (in-house team feasible)</li> </ul>
<b>Live Simulation</b>	<ul style="list-style-type: none"> <li>· Identify and address a greater number of issues</li> <li>· Prioritize items based on real situations in an ongoing basis</li> <li>· Allows for thorough analysis of scenarios</li> </ul>	<ul style="list-style-type: none"> <li>· Difficult to make physical changes to the built environment</li> <li>· Time between scenarios is extensive due to the time required to build or alter the environment</li> <li>· Human factor can complicate results</li> </ul>

**Figure 5: Simulation Methods Opportunities and Challenges Table**

As the next generation of simulation develops, designers and planners are now using dynamic simulations to address process variations such as patient arrival times, staffing levels and test results turnaround times. Each of these variables can be adjusted to create an informed future state that includes a balance of process improvements, such as matching resources to demand, and physical space changes to maximize patient flow and throughput. These tools provide an even more robust understanding of the future state of a facility during the design process, resulting in optimal healthcare environments.

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