COMPUTER SIMULATION MODELING OF EMERGENCY DEPARTMENTS

QUANTIFYING FACILITY DESIGNS AND OPERATIONAL IMPROVEMENTS PRIOR TO IMPLEMENTATION
How do healthcare providers find answers to common questions around appropriate numbers of treatment rooms, sizes of waiting areas, and numbers of staff? There is danger in not knowing for certain that a proposed solution is the right solution: having too much or not enough of anything is unnecessarily burdensome in a capita\(\text{\textit{l}}}^{\text{\textit{ly}}}\) constrained environment.

Too much space results in increased construction costs. Not having enough space, staff, or equipment transfers the burden to staff, who must work inefficiently to compensate for a suboptimal workplace, resulting in increased staffing and operational costs.

Since nearly every problem in healthcare is complicated and expensive and few can afford unnecessary expenditures, how should providers determine a rightsized solution that will meet their needs for years to come?

Computer simulation models assimilate several variables to model pertinent scenarios and to determine efficient operational models and the right size for your environment, even if a physical design is not part of the solution (or budget).
You may have heard about simulation modeling before: that it takes too long or is too complicated, too expensive, and excessively detailed. However, when the cost of one simulation model is a small fraction of the cost to build an unnecessary treatment room, how can you afford to be uncertain about your design solution? We posit that robust simulation models can generate results quickly.

A good, thorough simulation model can:

- **Quantify the amount of staff** needed by type and by hour of the day relative to various operational models and physical designs. This approach can save thousands of annual operational dollars.

- **Test equipment utilization and location** and provide the most efficient use and volume needed to support that equipment. Excess or insufficient equipment is costly.

- **Ensure that you have rightsized your facility** relative to projections, staffing models, operational models and proposed physical designs or physical design constraints.

- Quantify the changes you need to make in your current environment to maximize the space your have.

- Allow you to test various projection scenarios and align the most efficient staffing model, operational flow and physical capacity needed to meet whatever budget goals you have. Modeling brings all of the variables together.
As unusual as it may sound in today's environment, there is a potential to overbuild. Often it will not be obvious – staff and the process will fill up any space allotted – but through analysis it is possible to determine appropriate utilization.

Computer simulation models can address all these issues and the interconnections within the whole system. They create a basis for understanding complex systems and allow for objective testing and comparison of scenarios.

THE FREEMANWHITE COMPUTER SIMULATION TEAM

Kristyna Culp MBA
Kristyna creates workflow mapping and computer simulation models to validate, test, and quantify various scenarios to help clients make informed decisions about operational and physical design improvements.

Delia Caldwell MBA
Delia works with clinicians to establish the systems and processes they need to improve care and save lives. Through simulation modeling, process mapping, and dashboard tools she helps departments reduce LOS, improve patient outcomes, and streamline operations. With more than 85 operational studies completed, her efforts have redefined the way that providers deliver care.

David White MBA LEAN/DFSS
David takes a scientific approach to challenging problems, creating analytical tools that provide customized solutions. He specializes in innovative intelligence that helps clients draw meaningful conclusions, with a talent for interactive tools that support decision-making.
OPERATIONAL SOLUTIONS TO FACILITY CHALLENGES

BROWARD HEALTH NORTH  Deerfield Beach, FL

TIME STUDY

Results of a our time study conducted during 36 three-hour periods clearly demonstrate the impact of configuration on staff travel distances and patient care. The new architectural concept locates support functions in close proximity to patients to improve walking distances over the current layout.

SCOPE

To develop future building concepts around efficient operations

PROCESS

Engaged staff in identifying deficiencies and developing redesign options for a new ED

OUTCOME

A physical design that is quantified and proven to meet the needs and budget at least 10 years into the future

Existing processes and a disparate functional organization created bottlenecks, reduced privacy, and limited efficiency and flexibility of staff in providing patient care.

Through improved intake procedures, FreemanWhite eliminated the bottleneck and triage, thereby reducing patient wait times and overall length of stay by nearly 20% Computer simulation modeling demonstrated reduced space needs for the new department due to enhanced operations and improved patient flow.

In collaboration with Synergy, FreemanWhite worked with ED staff and management to review and improve operations with the end goal of creating a new physical plan to support efficient patient processes and future patient volume. To improve operations and physical design flow, the team:

- Completed a 5-day time study to fully understand patient, staff, equipment, and material flow
- Validated existing marketing, including 10-year projections
- Developed process maps for both existing and proposed operations
- Conducted exhaustive data analysis
- Performed detailed computer simulation modeling to test and quantify operational scenarios and physical design scenarios to ensure efficient operational and programmatic outcomes
- Produced a conceptual plan based on simulation results and proposed operations
- Delivered ROIs for the department redesign
FreemanWhite created the future operational concept in response to volume pressures, poor configuration, and the need to improve patient flow. Having completed a series of computer simulations, we compared the operational effectiveness of the baseline model, future volume increases with no physical or process change, just process change at current volumes, and the future concept with process change.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Baseline + 20%</th>
<th>Interim Changes</th>
<th>Future Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOS</td>
<td>222 minutes</td>
<td>253 minutes</td>
<td>149 minutes</td>
<td>168 minutes</td>
</tr>
<tr>
<td>Patient Volume</td>
<td>61,000</td>
<td>73,000</td>
<td>61,000</td>
<td>75,000</td>
</tr>
<tr>
<td>Main Utilization</td>
<td>56%</td>
<td>61%</td>
<td>39%</td>
<td>42%</td>
</tr>
<tr>
<td>Hallway Utilization</td>
<td>20%</td>
<td>34%</td>
<td>11%</td>
<td>None</td>
</tr>
<tr>
<td>Vertical Utilization</td>
<td>17%</td>
<td>18%</td>
<td>20%</td>
<td>44%</td>
</tr>
<tr>
<td>Door to Room</td>
<td>32</td>
<td>46</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Door to Doc</td>
<td>67</td>
<td>85</td>
<td>19</td>
<td>34</td>
</tr>
<tr>
<td>Provider Utilization</td>
<td>58%</td>
<td>62%</td>
<td>62%</td>
<td>71%</td>
</tr>
<tr>
<td>RN Utilization</td>
<td>55%</td>
<td>60%</td>
<td>50%</td>
<td>51%</td>
</tr>
<tr>
<td>Impact to Staffing</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>No additional RN + 12 hours provider</td>
</tr>
</tbody>
</table>

The proposed ED concept organizes treatment spaces around a central work core. The layout allows staff to flex between three patient care zones, operating in the areas closest to triage, the ambulance bay, and other support areas overnight.

**PROPOSED OPERATIONAL IMPROVEMENTS**

- 100% bedside registration
- Brief triage
- Evaluation and orders within 60 minutes
- Team approach to patient care, inclusive of geographic staffing, nurse backup, team evaluation/assessment

**BEST PRACTICES FOR A NEW FACILITY**

- Improved intake/triage process
- 24/7 access to rapid care
- Team staffing
- Streamlined admission process
- Using IT to facilitate communication
- Priority on patient discharge process
Sometimes We Recommend, “Don’t Build”

Metro Health Hospital  Wyoming, MI

Because physical changes were beyond the budget, FreemanWhite developed operational changes that could be implemented at nearly no cost.

At the first meeting with Metro Health in 2011, more rooms were requested to relieve pressures stemming from lengthy patient wait times. Extensive physical renovations were not possible on a $500,000 budget. Already at full capacity, the department tasked FreemanWhite with maintaining throughput in conjunction with a steadily increasing census. Using computer simulation to test several scenarios, we were able to recommend staffing models and registration procedures to reduce LOS.

Simulation Scenarios: Adding More Rooms Doesn’t Always Reduce LOS.

<table>
<thead>
<tr>
<th>Admission Wait</th>
<th>Baseline</th>
<th>Baseline plus volume increase</th>
<th>Operational Improvements plus volume increase</th>
<th>Adding rooms plus volume increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (k)</td>
<td>58</td>
<td>60 62 65 65 70 75 80 65 70 75 80 65 70 75 80</td>
<td>60 62 65</td>
<td></td>
</tr>
<tr>
<td>Total Time</td>
<td>130</td>
<td>138 146 157 126 128 135 163 116 119 131 138 110 114 119 131</td>
<td>137 144 157</td>
<td></td>
</tr>
<tr>
<td>Arrival to Triage</td>
<td>7</td>
<td>11 18 27 0 0 0 1 0 0 1 1 0 0 1 1</td>
<td>12 18 27</td>
<td></td>
</tr>
<tr>
<td>Arrival to Room</td>
<td>18</td>
<td>22 28 37 7 9 14 36 6 7 15 21 6 7 9 17</td>
<td>22 27 37</td>
<td></td>
</tr>
<tr>
<td>Arrival to Doctor</td>
<td>25</td>
<td>29 36 45 15 17 23 47 14 15 24 31 13 14 17 26</td>
<td>29 35 45</td>
<td></td>
</tr>
<tr>
<td>Admission LOS</td>
<td>211</td>
<td>211 216 231 331 334 341 364 254 260 269 275 214 221 227 235</td>
<td>211 216 231</td>
<td></td>
</tr>
</tbody>
</table>

Better than current  Current / baseline  Worse than current  Much worse than current
Achieve the goals of:

- Immediate bedding until treatment spaces full, door to room decreased by 70%.
- Empty waiting room, improved patient flow, process within regulation criteria

Reported Operational Issues:

- Triage process is lengthy and confusing to patients
- Bedside registration process inconsistent, staff not always aware MSE complete
- Primary care nursing model delay patient care for some patients

Operational Recommendations:

- Implement rapid triage and quick registration process
- 100% bedside registration, Reg. staff part of clinical team, working together to set registration priority and awareness of MSE initiation
- Implement 2RN+1Tech per 8 bed model

Achieve the goals of:

- Improved patient flow and treatment speed, decreased throughput time 16%, decreased door 2 doc 50%

To help with the financial analysis an interactive model was creating that allowed the client to immediately see the impact that key assumptions may have on the financial viability of this project. These assumptions included inpatient and outpatient payor mix, contractual adjustments, gross revenue per inpatient/outpatient, variable and fixed cost data, inflation rates, capital costs, volumes and percent of patients admitted.
THE JOURNEY TO TOP DECILE PERFORMANCE
NORTHWESTERN MEMORIAL HOSPITAL   Chicago, IL

The goal of the project was to optimize the Emergency Department care models, operational processes and physical space in order to achieve top decile performance in operational efficiency and the patient experience.

CHALLENGES TO ADDRESS

• Existing throughput rates cannot keep pace with increasing demand for care in the ED. Patient volume is projected to increase to potentially 108,000 annual visits by 2025.
• Changes to the current Care Delivery Model are necessary to better manage anticipated patient volume increase within current space constraints, and yet be flexible to absorb what might be a short lived surge, then a flattening, or even a decline as healthcare reform matures.
• Current space constraints and the functional layout of Psychiatry, ED Triage, and locations of radiology do not support current ED care processes and hamper effective ED care delivery.

While Option 1 offers superior operational performance, it was also the most expensive alternative with significant disruption during renovation. Option 2 offered operational performance slightly above top decile goals but with significantly less cost and construction impact.
FreemanWhite services included a review of the current operating model and facility conditions of the ED area, developing a patient care model that optimizes delivery and staffing to position NMH for the Affordable Care Act, and outlining a facility plan for the renewal, upgrade, and if required, expansion of the current, 2-level ED that includes cost estimate, schedule, and phasing implementation plan.

FreemanWhite developed two physical layouts with associated care delivery models and used simulation modeling to measure the operational and staffing impacts for each. In both options, a new Critical Decision Unit streamlines patient care pathways for observation, high social needs, scheduled return, and diagnostic imaging patient populations. We also measured the impact of a “no build” scenario.

### DISCHARGE LOS SAVINGS (IN MINUTES)

<table>
<thead>
<tr>
<th>Volume:</th>
<th>90,000</th>
<th>95,000</th>
<th>100,000</th>
<th>105,000</th>
<th>110,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1: Master</td>
<td>91</td>
<td>91</td>
<td>84</td>
<td>77</td>
<td>69</td>
</tr>
<tr>
<td>Option 2: Alternative</td>
<td>80</td>
<td>77</td>
<td>66</td>
<td>48</td>
<td>33</td>
</tr>
<tr>
<td>Option 3: Operations Only</td>
<td>(10)</td>
<td>(39)</td>
<td>(64)</td>
<td>(129)</td>
<td>(551)</td>
</tr>
<tr>
<td>Current State</td>
<td>(21)</td>
<td>(46)</td>
<td>(100)</td>
<td>(312)</td>
<td>(1,451)</td>
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</table>

### AGGREGATE LOS REDUCTION FROM CURRENT BASELINE PERFORMANCE (IN HOURS)

<table>
<thead>
<tr>
<th>Volume:</th>
<th>90,000</th>
<th>95,000</th>
<th>100,000</th>
<th>105,000</th>
<th>110,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1: Master</td>
<td>136,500</td>
<td>144,083</td>
<td>140,000</td>
<td>134,750</td>
<td>126,500</td>
</tr>
<tr>
<td>Option 2: Alternative</td>
<td>120,000</td>
<td>121,917</td>
<td>110,000</td>
<td>84,000</td>
<td>60,500</td>
</tr>
<tr>
<td>Option 3: Operations Only</td>
<td>(15,000)</td>
<td>(61,750)</td>
<td>(106,667)</td>
<td>(225,750)</td>
<td>(1,010,167)</td>
</tr>
<tr>
<td>Current State</td>
<td>(31,500)</td>
<td>(72,833)</td>
<td>(166,667)</td>
<td>(546,000)</td>
<td>(2,660,167)</td>
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</table>

### FTE IMPACT (ASSUMES 4:1 RN STAFFING RATIO)

<table>
<thead>
<tr>
<th>Volume:</th>
<th>90,000</th>
<th>95,000</th>
<th>100,000</th>
<th>105,000</th>
<th>110,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1: Master</td>
<td>16</td>
<td>17</td>
<td>17</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>Option 2: Alternative</td>
<td>14</td>
<td>15</td>
<td>13</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Option 3: Operations Only</td>
<td>(2)</td>
<td>(7)</td>
<td>(13)</td>
<td>(27)</td>
<td>(121)</td>
</tr>
<tr>
<td>Current State</td>
<td>(4)</td>
<td>(9)</td>
<td>(20)</td>
<td>(65)</td>
<td>(319)</td>
</tr>
</tbody>
</table>
ACCELERATING INTAKE TO MANAGE VOLUMES

EMORY UNIVERSITY HEALTHCARE  Atlanta, GA

SCOPE

The design increases the department from 9,600 to 20,000 square feet and from 19 to 34 treatment rooms.

With approximately 35,000 patient encounters annually, the department expected an increase to 42,000 by 2018.

As an academic teaching facility, Emory attracts a high-acuity patient population drawn by its reputation for having advanced treatment capabilities.

FreemanWhite streamlined the intake process to reduce the ‘Patient to Provider’ time and to direct the patient to the appropriate location for their level of care.

Our team conducted operational analyses to identify bottlenecks of patients receiving or awaiting treatment and admission using process mapping to document the flow of patients, staff, materials and information.

PROCESS MAPPING

Lower acuity patients are processed through vertical treatment areas while critical patients are expedited to beds, examined by a physician, and begin treatment earlier.

A reorganized Care Initiation Area (CIA) begins patient medical evaluations concurrently to starting treatment so acute patients are not left sitting in a waiting room when beds are not available.

All patients are quick registered upon arrival by clinical staff at the ambulatory entrance while all other patients experience a combination of a quick and bedside registration.
FreemanWhite used simulation modeling to compare ALOS for four design options.

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Admits</th>
<th>Discharge</th>
<th>Time to Provider</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>325</td>
<td>395</td>
<td>295</td>
<td>38</td>
</tr>
<tr>
<td>Simulation</td>
<td>335</td>
<td>407</td>
<td>297</td>
<td>39</td>
</tr>
<tr>
<td>Option 1A</td>
<td>310</td>
<td>380</td>
<td>275</td>
<td>36</td>
</tr>
<tr>
<td>Option 1B</td>
<td>300</td>
<td>374</td>
<td>262</td>
<td>35</td>
</tr>
<tr>
<td>Option 1C</td>
<td>302</td>
<td>376</td>
<td>265</td>
<td>35</td>
</tr>
<tr>
<td>Option 2</td>
<td>313</td>
<td>384</td>
<td>277</td>
<td>36</td>
</tr>
<tr>
<td>Option 3</td>
<td>304</td>
<td>376</td>
<td>268</td>
<td>36</td>
</tr>
</tbody>
</table>

An additional goal was to eliminate hallway treatment caused by insufficient space and move to an all-private room model. FreemanWhite created simulation models to test room configurations, patient volumes and staffing levels, providing quantitative data to support Emory’s architectural design and operational decisions.

**PROPOSED OPERATIONAL CHANGES**

- Continue with CIA process focusing on ESI Level 4-5 patients – keep “vertical patients vertical”
- Consistently utilize patient care protocols triage/bedside
- Plan for identified physician zoning
- Universal treatment rooms
- Use sub-wait space to manage patient intake process
- Decrease Admit Time, lab, imaging
- Physician Scribe
- 100% bedside registration and cash/co-pay collection utilizing technology
During the course of a five-visit design and consulting study, FreemanWhite defined short-term and long-term physical planning options for emergency services.

Planning for 110,000 annual visits, FreemanWhite recommended the development of a new department able to flex as needed to accommodate patient volumes and acuity. At the time of the conceptual planning study, only 49 of the 57 existing treatment spaces were being used regularly. The proposed design option provides for an open ED concept with all private treatment rooms and the flexibility to address surge capacity. Three larger treatment rooms are planned as “flex” rooms that can semi-privately treat two patients when needed. The team developed a streamlined intake process using flow through triage rooms supported by vertical/protocol rooms and backed up to private treatment rooms to treat lower acuity patients. This space flows into the main side ED with overflow treatment spaces located across a main egress corridor.

Utilizing data-driven tools, including process mapping, interactive dashboards, and computer simulation modeling, FreemanWhite developed recommendations that encompass operational, staffing, and facility design issues. Key considerations for physical planning included Lean patient operations, efficient staffing patterns, and improved technology applications.

Create a nurse first intake process. Patients should immediately be seen by RN staff. Ensure Triage RN in the middle of triaging another patient can see the entrance and waiting areas in case an acute patient requires immediate attention.

Streamline patient to provider. Until the new department is operating at capacity, patients should only be identified at Intake or enough data gathered so that the patient can be assigned to the appropriate treatment area.

Keep vertical patients vertical. Not all patients need a bed. Keep less acute patients upright and moving forward using stretcher recliners in a subwait area staffed with a dedicated provider and nurse/tech staff to minimize length of stay.

Implement protocols for times the department is at capacity or a provider is unavailable. Includes patient protocols in subwait area and bedside treatment protocols. Use Fast Track area to expedite the care of non-urgent patients.

Work in teams. Staff every 6-8 treatment rooms with 2 RNs and 1 Tech who will work together. Registration staff should be assigned to clinical rooms to facilitate communication with clinical staff. Use physician zones to limit travel distances.

Place a priority on patient discharge. Proactively manage patient flow to ensure bed availability. Every patient may not need to “own” a bed; use Subwait for those patients awaiting discharge instructions and who no longer need to occupy a bed.

Continue to work on admission processes. Boarding patients awaiting consultations occupies ED treatment area space and diverts staff away emergency care. Limit patient wait time before transporting to an inpatient area.
FreemanWhite utilized computer simulation models to validate departmental throughput and labor utilization. These simulation models allowed stakeholders to conduct numerous what if scenarios to improve departmental adjacencies, patient and clinical flow, and labor mix model, by hour.

Establishing a baseline model to accurately reflect existing physical, operational, and staffing conditions allowed testing of needed or anticipated changes in patient volume, operational processes, staffing, and physical capacity. The baseline model confirmed several operational bottlenecks, including:

- Physical constraints that result in segregation cause staffing challenges and frequent incompatibility between needed and available bed types
- Overloaded “Fast Track” or minor care area
- Nurse staff care for direct admit patients detract time and space from ED patients requiring care

Comparing the output of all simulation models, there is the potential for ALOS reduction even with increased volume. Door to Room and Door to Doc times increase slightly due to the increased focus on seeing patients fluidly within the intake area.

<table>
<thead>
<tr>
<th></th>
<th>TotalAvg</th>
<th>AdmitAvg</th>
<th>DC Avg</th>
<th>TimeFit</th>
<th>DoorRoom</th>
<th>DoorDoc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>159</td>
<td>252</td>
<td>141</td>
<td>151</td>
<td>6</td>
<td>26</td>
</tr>
<tr>
<td>Future (95K)</td>
<td>149</td>
<td>275</td>
<td>122</td>
<td>110</td>
<td>14</td>
<td>34</td>
</tr>
<tr>
<td>Future (110K)</td>
<td>155</td>
<td>259</td>
<td>132</td>
<td>128</td>
<td>10</td>
<td>35</td>
</tr>
</tbody>
</table>

Resulting architectural recommendations support operational improvements and include the development of a phased expansion project to enlarge and modernize the existing ED. Planned to add approximately 3,030 sf to the existing space, the project will increase capacity from 57 to 66 treatment spaces. The existing ED and expansion areas will be renovated in subsequent phases, ultimately impacting 29,860 sf.
Healthcare providers currently face a dizzying array of strategic and facilities challenges. At FreemanWhite, our approach integrates data, research, and best practices into our architectural solutions to help you balance cost and value.