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SIMULATING SIX SIGMA IMPROVEMENT IDEAS FOR A HOSPITAL EMERGENCY DEPARTMENT

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ABSTRACT

A large hospital in the southeast United States utilized simulation to aid project leaders in advancing to the next level of sophistication with Six Sigma. The project produced an ongoing, workable model from which to simulate potential process improvements in their Emergency Department (ED). Project leaders tested several scenarios in the ED Simulation to quantify their value proposition. The simulation model also enabled the hospital to test design ideas of a planned new facility.

1 CLIENT OVERVIEW

1.1 The Client's Business Challenge

Ever increasing costs of medical services are shrinking hospital profits, despite continued growth in the number of ED patient visits (Advisory Board 1998). Hospitals usually operate with a limited number of special skilled resources and activities (e.g., physicians, nurses, radiology tests, etc.). As such, processes tend to include a large number of handoffs so that all patients have access to these resources (i.e., the process behaves like an assembly line). Since handoffs inherently breed process delays, the patient cycle time, or Length of Stay (LOS) in the ED can become large (Bale and Krohn 2000). Much of this time is non-value added time, such as waiting in queue. This problem can get much worse when large volumes of patients enter the ED.

Many hospitals handle the increased volumes of patients by simply building larger hospitals. This is an expensive alternative. Will the same inefficient processes cause the same problems to occur in a larger setting? Other hospitals increase their patient capacity with faster throughput.

A large hospital in the southeast United States wanted to implement major changes in their main emergency department. The current LOS for patients at the hospital was unacceptably long. The hospital wanted to achieve world class performance, so they contracted with Chip Caldwell and Associates, LLC (CCA) in collaboration with Business Prototyping Inc. (BPI) to implement a Six Sigma quality initiative.

A key component of Six Sigma projects includes Design of Experiments (DOE), whereby process improvements are planned and implemented. Traditionally, organizations will implement process improvements on varying levels of sophistication. At the lowest level, organizations "shoot from the hip" and implement what executives feel is the right thing to do. A more common approach is to implement best practices, assuming what works well for one hospital will work well for another. However, not all processes should be improved in the same way (Keen 1997) There are many published examples of success stories where process redesigns caused improvements in LOS. Truly, these efforts were wise investments. However, it is unknown how much is invested in efforts which did not yield an improvement in LOS because these stories are typically never published. Is there a way to determine if process redesigns will improve patient LOS? This leads us to one of the most sophisticated DOE approaches, which is to simulate, or prototype, the proposed process improvement idea prior to implementation. This client chose CCA and BPI over its competitors because of our ability to create dependable simulation models of business processes.

1.2 The Client's Process Challenge

The client wanted to improve its patient experience to world class levels. To do this, Six Sigma Teams were created to review and analyze discrete sub-processes of the overall patient experience (e.g., greet to triage, ED bed to diagnosis, etc.). These teams consisted of staff at all levels of the organization and included physicians. Numerous improvement ideas were proposed. The most promising ideas needed detailed analysis due to the inherent risk associated with patient care. These ideas became simulation scenarios. The simulation provided quantifiable performance data which provided input to executive decision making.

Generally, you can think of the ED LOS as the time it takes getting into an ED bed and the time it takes to get out of an ED bed (i.e., to go home or be admitted as an inpatient). Some reasons it takes so long just to get into an ED bed (Advisory Board 1998):

- large volume of patients in the ED,
- sicker people are seen first,
- more stable patients are seen on a first come, first served basis,
- both a triage nurse and triage physician must see each patient to assess priority,
- patient illness requires special rooms with special equipment.

The Emergency Department's main goal is to find out what's causing the patient problem. Some reasons it takes so long to get out of the ED are:

- ED physicians order multiple tests, such as blood tests, EKG, or x-rays to help diagnose the problem,
- Sometimes it takes hours to perform tests,
- ED Physicians need to consult specialists to diagnose the problem,
- ED Physicians need to observe patients long enough to determine if treatments are working,
- It takes hours to admit the patient or transfer them to another care facility.

This project reviewed and identified problem areas with patient flow, patient arrival, department policies and procedures. Specific areas of investigation included:

- How much impact will discharging inpatients earlier have on ED LOS?
- Will an additional 30 inpatient beds relieve the ED patient backlog?
- How much bigger should the Transitional Stay Unit (TSU) be to have an impact on ED LOS?
- How much do we need to reduce lab test turnaround time to significantly affect overall patient LOS?

2 PROJECT APPROACH

The project approach included two levels of hierarchy. The overall Six Sigma project encompassed the simulation project. The Six Sigma project included an initial transformation project and three waves lasting 100 days each. Since the simulation model was used in Wave 2, the simulation project therefore occurred concurrently with the project team's Wave 1 100-Day Action Plan implementation. This paper will focus on the simulation project approach which included five major phases:

1. Develop conceptual model,
2. Programming,
3. Testing (Verification and Validation),
4. Experimentation,
5. Presentation.

3 TOOLS AND TECHNIQUES APPLIED

The conceptual model phase included creation of process maps and documentation. Occasionally, process maps enlighten the client because they typically have never seen their processes modeled end-to-end. They tend to only know fragments of the process and are unaware of how what they do fits into the overall outcome. The conceptual model was documented with Microsoft™ Visio® (see figure 1). The model included trigger objects to show patient arrival. It also showed activities, which describe inputs, outputs, required re-sources, activity durations and business rules. Finally, the model included decision points for routing patient and objects to show the end of the process.

The programming phase included coding the process model into appropriate simulation software. For this project, Extend® by Imagine That Inc™ was chosen because of its capabilities and affordability. Animation was developed directly in Extend using hierarchical blocks and bit-maps (see figure 2). This simulation used actual hospital layouts as a

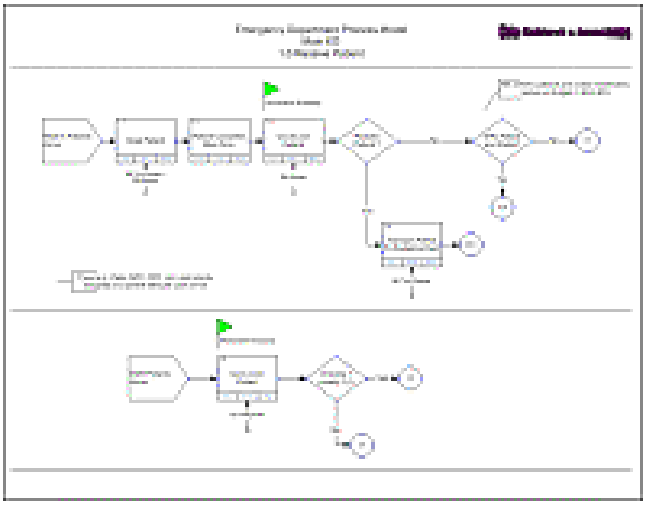

Figure 1: Conceptual Model for ED Simulation

Figure 2: Animation Background of Hospital Emergency Department

background and entity movement and queues were animated on top of the layouts. Finally, figure 3 shows a graphical user interface, or control panel, which was developed using Microsoft™ Access® to efficiently manage input parameters to the ED Simulation. For example, the baseline scenario can be copied with the click of a button and a input parameters can be changed for a new scenario.

Testing of the simulation model included verification and validation. Verification ensured the simulation behaved as intended in the conceptual model. Validation ensured the simulation model behaved similar to the actual Emergency Department.

The experimentation phase included development of specific scenarios to test. Some of these scenarios only required small changes to data, such as turnaround time for Lab or Radiology. Other scenarios required more extensive coding changes. The project budget only allowed for a limited number of scenarios to test.

The simulation team presented the results during the final phase of this project. The presentation to hospital executives included a review of the project scope, approach, deliverables, scenarios tested, experimentation results and recommended next steps.

Figure 3: Control Panel for ED Simulation

4 BENEFITS

Each of the deliverables was instrumental in bringing a complete solution to the client. The process model provided an end-to-end view of the Emergency Department. Team members were able to visualize how their piece of the process impacts the overall customer experience. The simulation provided a quantitative comparison of process improvement ideas and showed hospital executives which will likely yield the most improvement. Experimental results indicated:

- Discharging inpatients about five hours earlier each day reduces ED patient LOS by a third,
- Adding 30 more inpatient beds will potentially cut the ED patient LOS in half,
- Doubling the TSU size didn't significantly reduce ED patient LOS but increasing the TSU to 50 reduced the ED patient LOS by a third,
- Reductions in lab test turnaround time didn't significantly affect overall patient LOS until it was reduced by at least 20%,

Finally, despite increasing TSU and inpatient bed capacity, the simulation showed that the hospital will not meet their future goals for patient LOS. The Six Sigma teams will need to implement more profound process changes to reduce the patient LOS. Fortunately, a simulation model is now available to help provide the teams with a direction to meet their goals.

5 LESSONS LEARNED

5.1 Scope Management

Making model changes late in the project lifecycle, such as changing model input parameters, can cause wasted time and effort. Investing more time early in the project lifecycle developing the conceptual model and securing subject matter expert buy-in will save time during the coding and experimentation phases. This project saw over 20 iterations of conceptual model changes. Also, when simulation is used to aid in the decision making process of the system, control of the scope and complexity of the simulation model can sometimes be lost. This can result in an overly complex model which adds little or no value to the output of the simulation. Therefore, it is necessary to work closely with the design team and/or decision makers to manage their understanding of the model and agree on solutions which satisfy their needs and objectives. It is also necessary to allow flexibility in the work-plan to accommodate changes in client needs and objectives during the project.

5.2 Team Dynamics

Each of the simulation project team members came from different offices: Miami, Chicago and Tampa. This broad

geographic structure required special considerations for working together. The project team typically worked from their home offices in order to reduce project expenses. Tools such as email, mobile communications and instant messenger services enabled team members to resolve issues and maintain normal progress toward goals. Even more important was regular communication with the client to ensure they were comfortable with team progress.

6 CONCLUSION

Modeling and simulation enabled the client to better understand the patient experience, process performances and staffing inter-relationships for their proposed emergency department. The team brought clarity to difficult internal debates. The client now owns a powerful tool which can be utilized repetitively to aid the decision making process as system changes occur. Finally, it is important to regularly verify if client expectations are being met. An open and proactive communication is always the best way to ensure the success of a project.

REFERENCES

Advisory Board Company, The. 1998. Emergency Care Reform, *Executive Briefing for Clinical Leaders*. Washington, D.C.

Bale, J. and Krohn, R. 2000. Redesigning Under-Performing Physician Organizations [online], Available online via <http://www.healthsystemsdirect.com/article8.html> [accessed July 22, 2003].

Keen, P. 1997. *The Process Edge: Creating Value Where It Counts,* Boston: Harvard Business School Press.

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