Chapter 4
Simulation Applications in a Healthcare Setting

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ABSTRACT

What is simulation? Most management engineers define simulation as the attempt to predict aspects of the behavior of some system by creating an approximate (mathematical) model of it. Most of the time the engineer writes a special-purpose computer program or uses a more general simulation package, probably still aimed at a particular kind of simulation.

Developing a simulation is often a highly complex mathematical process. Initially the engineer specifies a set of rules, relationships, and operating procedures, along with other variables. The interaction of these phenomena creates new situations, even new rules, which further evolve as the simulation proceeds.

The chapter will broaden the engineer's perception in regards to the gamut of simulation implements. These range from paper-and-pencil and board-game reproductions of situations to complex computer-aided interactive systems.

This proposed chapter will answer the following questions: Why is simulation modeling beneficial as a decision-making tool? When should engineers use simulation modeling as a decision-making tool? Which situations are a good fit for simulation modeling? When is not good to use simulation modeling? Which simulation modeling methods should engineers use? What are other alternatives to simulation modeling? What steps should engineers take in order to develop a sound simulation? Who should be part of the simulation modeling development team? Where are the common pitfalls of simulation modeling? How the engineer can overcome these modeling pitfalls? What should the engineer do when confronted with lack of reliable data?

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The author will attempt to answer the questions above by means of examples, anecdotes, real-case simulation models, and experiences while developing problem-solving models for a healthcare system. Some of the problem-solving models discussed include labor and delivery room utilization, neonatal intensive care unit expansion, emergency department staffing and process improvement, radiology process improvement, patient transport, operating room elective case surgery optimization, partial pediatric unit conversion to Intermediate Medical Care unit, family practice, and women's health clinics.

INTRODUCTION

The purpose of this chapter is to broaden the reader's knowledge in regards to the gamut of *simulation* implements. This chapter is guided towards engineers, neophyte simulation practitioners, analysts and technical staff who, in their daily undertakings, encounter uncertain situations. During their quest for answers to these events or undertakings, the analyst ends with incomplete or inconclusive results. These inconclusive results may be related to the extent of the initial hypothesis. The following real case demonstrates a situation where an inconclusive result showed the need for a simulation:

On a major southeast teaching hospital, an analyst was tasked with determining the optimal space needed to store specialty beds, such as burn, bariatric, orthopedic or other specialty beds, at a storage area of the hospital. These specialty beds are delivered from a rental company when a nursing floor requests it. The standard beds needs to be removed and stored until the specialty bed is no longer needed. A straight forward method, using *static simulation* or analyzing this problem at a finite time, is to account and verify the total number of specialty beds requested at the end of each day. With the total number of beds requested on a daily basis, the analyst can determine the space needed for storage. But, did the analyst perform the most suitable analysis for this situation? In a short answer, no, the analyst failed to take into consideration the dynamic aspect of this specific situation, such as a *dynamic simulation* or analyzing the problem and how it behaves over a known period of time. The analyst may under or overestimated the space needed.

Based on the initial assumption in which beds are requested on a daily basis and are accounted for does not provide the real picture. Specialty beds rental, seen as an independent entity, fails to illustrate the rental process complexity and the relationship to other entities, namely patients. Each specialty bed is allocated to a patient and to the patient's length of stay in the hospital. Using a Gantt chart and plotting each specialty bed's length of stay, gathered from patient's information, will show that some days there are more stored beds on the hospital than beds ordered on the same day.

Following the dynamic simulation analysis performed by the analyst, Figure 1 shows a Gantt chart where two beds were ordered on day 1, an additional two beds were ordered on day 2, one bed on day 3 and one bed on day 4. So, the maximum number of beds ordered on any day is two beds. If the analyst utilizes this process, he will be underestimating the real need. Analyzing this problem from a different perspective by taking into consideration patient's length of stay, the analyst will realize that the number of beds is higher. For instance, there are two beds on day 1, four beds in day 2 (an additional 2 beds compared to the prior method), and three beds on days 3 and 4 (an additional 2 beds each day). Now, the maximum number of beds ordered on any day is four beds instead of two.

The real case analysis, in which the above figure is based on, showed that there was a need for 19 beds at any time instead of the expected 30 beds needed. Savings related to the reduction