2020 IISE-HSH Student Simulation Competition
Surgical Center Optimization Case Study

I. Introduction

On the surface, modeling a hospital's Operating Room (OR) may seem straightforward. Some modelers prefer to look at the OR as a job shop whose functions are constrained only by the variance associated with different patient cases. At a seminar not long ago, one modeler even stated that creating an OR model wasn't too different from creating a standard "line" model. However, nothing could be further from the truth. There are many different activities that both lead up to, accompany, and follow a surgical case, resulting in complexity normally associated with general medical models. In the following case study, you will examine the various aspects of OR modeling, with special attention paid to elements that either contribute to operational variance or make up significant portions of the OR process (and their resulting operational time changes or resources usages). Put another way—each of the elements discussed below should be considered for inclusion in any model of an OR:

- **The Patient Case:** Including the distribution that reflects the time to treat each patient's condition, in-facility movement requirements, and the time distributions for Pre-Op and PACU recovery.
- **Arrival Patterns:** Either scheduled cases (assigned to a specific OR at a specific date/time), add-on cases (often elective cases), or emergency cases.
- **The Facility:** Distance equals time, so the distance between the OR and supporting functions may be involved in order to have an accurate model.
- **Supporting Staff:** The surgical staff should always be considered in any OR model, but what about Central Material Services (CMS)? Or the staff assigned to clean the OR following each ease?
- **Relevant Policies & Practices:** These can affect case sequencing and prioritization, start times, specialty cases, and more.

II. Assignment

You have been given a simulation model of an OR along with access to FlexSim HC simulation software (please see Appendix B for instructions on how to download and activate FlexSim HC). Your job is to become familiar with the model, and then:

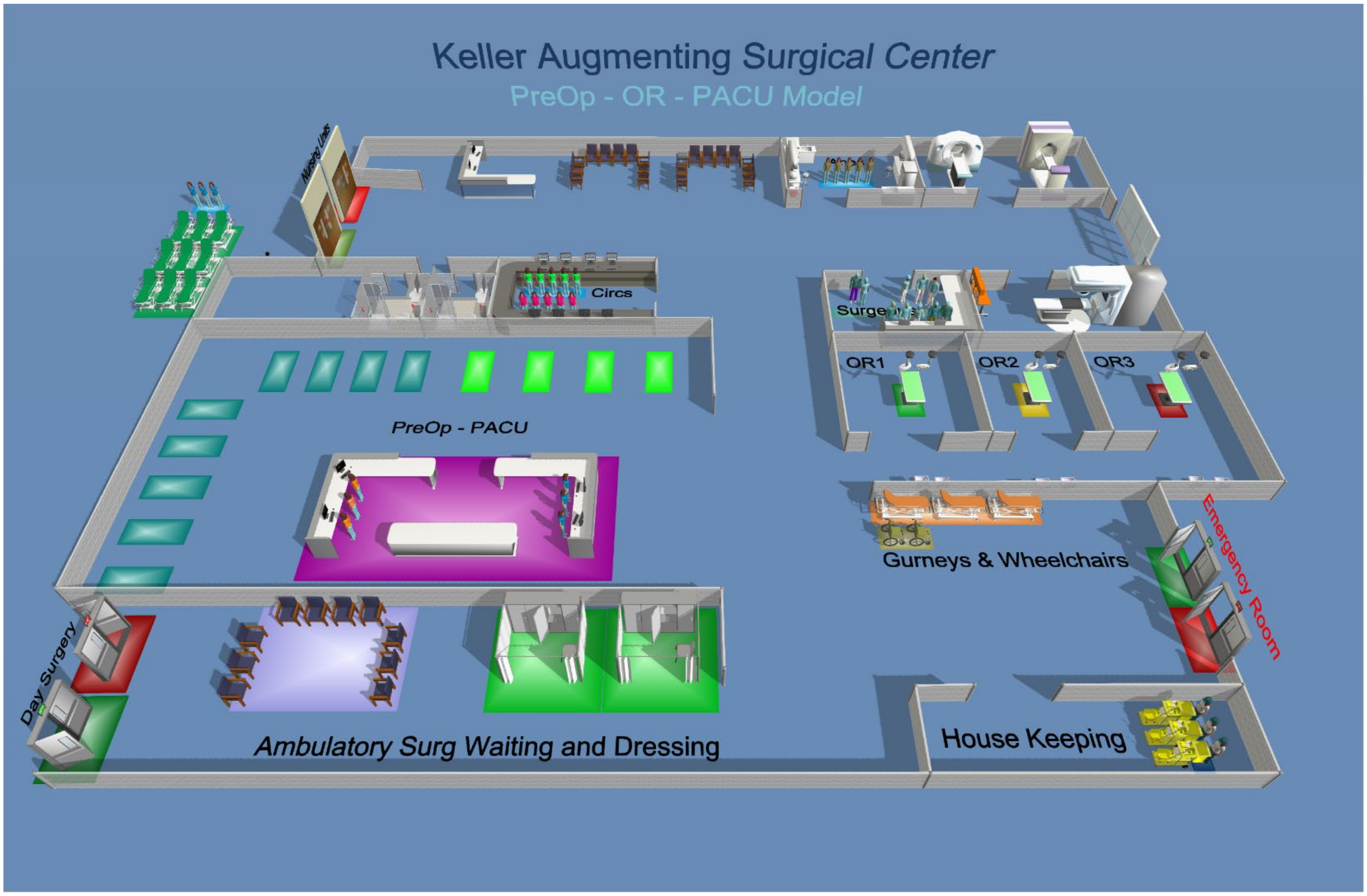
1. Identify the variables your team believes are of the greatest benefit, both to the patients and to the organization that runs the OR.
2. Test different modeling scenarios to gather data that supports or rejects your assumptions.
3. Using simulation results, recommend the most effective configuration for the OR.

The definition of what is "most effective" is up to you. Will you optimize for revenue? Or maybe OR utilization? Or for the number of surgical cases completed? Will you try to balance several competing objectives that are each important? Either way, your report should explain how you defined effectiveness for this particular OR and what your decision criteria was. The report should also explain how your recommendations will affect other areas in the OR. (See "Appendix C: Case Study Judging Criteria" for information on how your report will be evaluated.)

III. Model Description and Instructions

The simulation model you were provided is already pre-built and ready to be analyzed and experimented upon. Your team has the ability to adjust three main elements that make up how the OR operates:

1. **The operating room the procedure is performed in.** (Keep in mind that all OBGYN procedures must be performed in OR1 due to equipment constraints.)
2. **The order that the procedures are performed in.** Block cases should take priority to AddOn Cases, as they are cases the surgeon groups requested. Not all cases will be able to be completed today, so you will need to choose which cases will be completed today. The first case to be completed will be case 1, etc. If the case has any number assigned it will be completed today.
3. **The number of staff you have for your Surgical Center.** This is not changed in the provided spreadsheet—it is changed in the "Controls" Dashboard.



The 3D simulation model above is primarily controlled by a spreadsheet provided to you (Surgical_Cases_Master.xlsx). This spreadsheet contains fields you can edit in order to change the operating room and case scheduling order for the surgical cases. It also includes additional data (in red) about each case. ***Anything that is in red cannot be changed.*** (Changing these will result in disqualification.)

OR Suite	Allotted PreOp Time	Wheels_In to Incision Time	Incision to Closure Time	Closure to Wheels_Out Time	Room Clean and Prep Time	Expected Surgical Time	Expected Turnover Time	PACU Recovery Time	Expected Earnings	Case Scheduling Order
OR2	20	normal(11,2)	normal(23,3)	normal(11,2)	normal(25,3)	59	31	normal(100,1)	$ 1,321	7
OR1	20	normal(5,1)	normal(12,2)	normal(6,1)	normal(13,1)	31	15	normal(120,2)	$ 3,116	2
OR2	20	normal(8,1)	normal(15,2)	normal(8,1)	normal(16,2)	39	20	normal(120,2)	$ 1,994	5
OR3 OR2	20	normal(10,1)	normal(7,2)	normal(5,1)	normal(13,1)	30	15	normal(120,2)	$ 4,005	1
OR1	20	normal(8,1)	normal(15,2)	normal(4,1)	normal(15,2)	35	19	normal(110,2)	$ 3,054	3
OR3	20	normal(20,2)	normal(50,5)	normal(20,2)	normal(28,3)	108	34	normal(100,1)	$ 2,443	6
OR3	20	normal(23,3)	normal(45,5)	normal(23,3)	normal(37,4)	113	45	normal(120,2)	$ 4,134	4

The fields in the spreadsheet that you <u>can</u> edit are white. There is a drop-down menu for each cell of the "OR Suite" column where you choose which operating room the case is assigned to, and the "Case Scheduling Order" column is looking for a number to represent the order in which cases will be assigned.

Finally, the 3D model contains the staffing information that you can adjust. Locate the "Controls" dashboard, which will be on the right-hand side of the model. This area has five drop-down menus that will allow you to adjust staffing levels for the maintenance group, circulating nurses, scrub nurses, PreOp nurses, and PACU nurses.

To allow your changes in your spreadsheet to affect the next model run, you need to follow these steps:

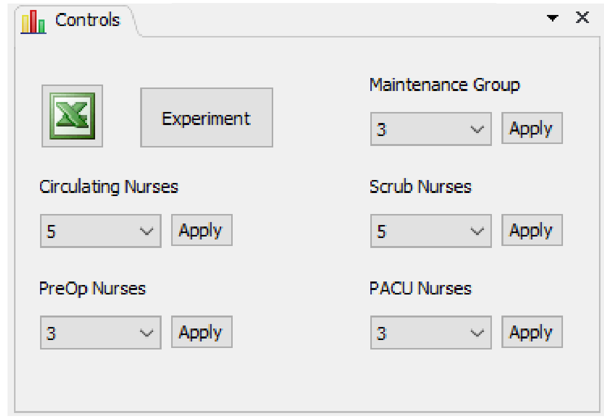
1. Save your model and the spreadsheet in the same folder on your computer. (All future saves for the spreadsheet should also be saved in the same folder.)
2. Make changes in spreadsheet. When making changes, it's recommended that you save your changes under a new name such as "Surgical_Cases_v1". This will help you keep a record of your different changes and experimentations.

   Again, you will notice that on the Excel document some columns and rows are highlighted red and others white. Any information in red should **NOT** be changed. All other information in white is what you will be tasked with changing in order to come up with the optimal settings to run your model. Remember:

   a. Not every cell in column 'S' will have a number. That is something that you will decide to change in order to achieve your desired optimization goal.
   b. If you provide a number in column 'S' – 'Case Scheduling Order' then you **MUST** have an OR listed in column 'I' – 'OR Suite' of the same row.

I	J	K	L	M	N	O	P	Q	R	S
OR Suite	Allotted PreOp Time	Wheels_In to Incision Time	Incision to Closure Time	Closure to Wheels_Out Time	Room Clean and Prep Time	Expected Surgical Time	Expected Turnover Time	PACU Recovery Time	Expected Earnings	Case Scheduling Order
OR2	20	normal(11,2)	normal(23,3)	normal(11,2)	normal(25,3)	59	31	normal(100,1)	$ 1,321	7
OR3	20	normal(5,1)	normal(12,2)	normal(6,1)	normal(13,1)	31	15	normal(120,2)	$ 3,116	2
OR2	20	normal(8,1)	normal(15,2)	normal(8,1)	normal(16,2)	39	20	normal(120,2)	$ 1,994	5
OR2	20	normal(10,1)	normal(7,2)	normal(5,1)	normal(13,1)	30	15	normal(120,2)	$ 4,005	1
OR1	20	normal(8,1)	normal(15,2)	normal(4,1)	normal(15,2)	35	19	normal(110,2)	$ 3,054	3
OR3	20	normal(20,2)	normal(50,5)	normal(20,2)	normal(28,3)	108	34	normal(100,1)	$ 2,443	6
OR3	20	normal(23,3)	normal(45,5)	normal(23,3)	normal(37,4)	113	45	normal(120,2)	$ 4,134	4
OR1	20	normal(28,3)	normal(55,6)	normal(28,3)	normal(57,6)	135	69	normal(180,2)	$ 1,020	8
OR1	20	normal(9,1)	normal(18,2)	normal(9,1)	normal(18,2)	44	22	normal(110,2)	$ 4,423	15
OR1	20	normal(10,1)	normal(20,2)	normal(10,1)	normal(20,2)	48	24	normal(110,2)	$ 2,516	
OR2	20	normal(15,6)	normal(70,15)	normal(15,5)	normal(52,5)	124	62	normal(120,2)	$ 6,675	17
OR2	20	normal(13,1)	normal(18,2)	normal(12,3)	normal(23,2)	55	27	normal(110,2)	$ 5,122	14
OR2	20	normal(10,1)	normal(7,2)	normal(5,1)	normal(13,1)	30	15	normal(120,2)	$ 1,829	
OR2	20	normal(10,1)	normal(20,2)	normal(10,1)	normal(20,2)	48	24	normal(110,2)	$ 2,887	
OR3	20	normal(15,2)	normal(30,3)	normal(15,2)	normal(31,3)	74	37	normal(100,1)	$ 4,876	16
OR3	20	normal(12,2)	normal(31,4)	normal(12,2)	normal(30,3)	71	36	normal(120,2)	$ 1,721	
OR3	20	normal(23,3)	normal(45,5)	normal(23,3)	normal(34,3)	113	40	normal(120,2)	$ 1,882	
OR2	20	normal(15,2)	normal(30,3)	normal(15,2)	normal(26,3)	74	32	normal(110,2)	$ 1,533	
OR1	20	normal(15,2)	normal(30,3)	normal(15,2)	normal(31,3)	74	37	normal(110,2)	$ 2,122	
OR1	20	normal(5,1)	normal(10,1)	normal(5,1)	normal(11,1)	26	13	normal(90,9)	$ 6,122	9
OR3	20	normal(5,1)	normal(10,1)	normal(5,1)	normal(17,2)	26	21	normal(90,9)	$ 2,010	
OR1	20	normal(25,3)	normal(50,5)	normal(25,3)	normal(35,4)	122	43	normal(180,2)	$ 1,883	
OR1	20	normal(19,2)	normal(38,4)	normal(19,2)	normal(27,3)	92	33	normal(120,2)	$ 2,675	
OR1	20	normal(23,3)	normal(45,5)	normal(23,3)	normal(20,2)	113	24	normal(120,2)	$ 1,760	
OR3	20	normal(8,1)	normal(19,2)	normal(8,1)	normal(18,2)	43	22	normal(90,9)	$ 3,669	
OR1	20	normal(5,1)	normal(7,1)	normal(5,1)	normal(10,1)	23	12	normal(90,9)	$ 4,435	12
OR3	20	normal(5,1)	normal(23,3)	normal(5,1)	normal(18,2)	43	22	normal(90,9)	$ 6,327	10
OR1	20	normal(15,2)	normal(30,3)	normal(15,2)	normal(22,2)	74	26	normal(90,9)	$ 4,371	18
OR2	20	normal(15,2)	normal(30,3)	normal(15,2)	normal(31,3)	74	37	normal(90,9)	$ 7,482	11
OR1	20	normal(8,1)	normal(15,2)	normal(8,1)	normal(16,2)	39	20	normal(90,9)	$ 1,249	
OR3	20	normal(8,1)	normal(15,2)	normal(8,1)	normal(24,2)	39	28	normal(100,1)	$ 1,667	
OR2	20	normal(8,1)	normal(15,2)	normal(8,1)	normal(18,2)	39	22	normal(100,1)	$ 1,557	
OR1	20	normal(8,1)	normal(15,2)	normal(8,1)	normal(19,2)	39	23	normal(90,9)	$ 2,166	
OR2	20	normal(23,3)	normal(45,5)	normal(23,3)	normal(36,4)	113	44	normal(90,9)	$ 3,345	
OR3	20	normal(5,1)	normal(12,2)	normal(6,1)	normal(13,1)	31	15	normal(100,1)	$ 4,221	13

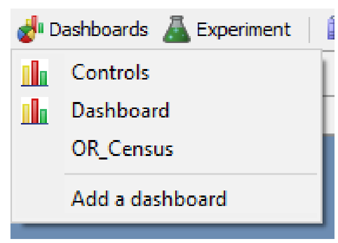
3. Save the spreadsheet file. The file must be saved for the new information to be adjusted in the simulation model. (Again: All future saves for the spreadsheet should also be saved in the same folder.)
4. Import the spreadsheet into FlexSim HC. Within FlexSim HC, locate the "Controls" dashboard on the right side of the screen and click on the Excel icon. Then select which file you want to upload. (Ex. "Surgical_Cases_Master" or "Surgical_Cases_v1".)



To verify that your information uploaded, on the left-hand side of the screen under the Run button will be your Toolbox.

Click on the tools and then look for the Global Tables. Click on the plus to expand the tables and double click on the table titled 'AllCases'. Double check your information.

Important: If you cannot see the Controls Tab, you can re-open it by clicking on the Dashboards button in the Toolbar, and then clicking on 'Controls'.

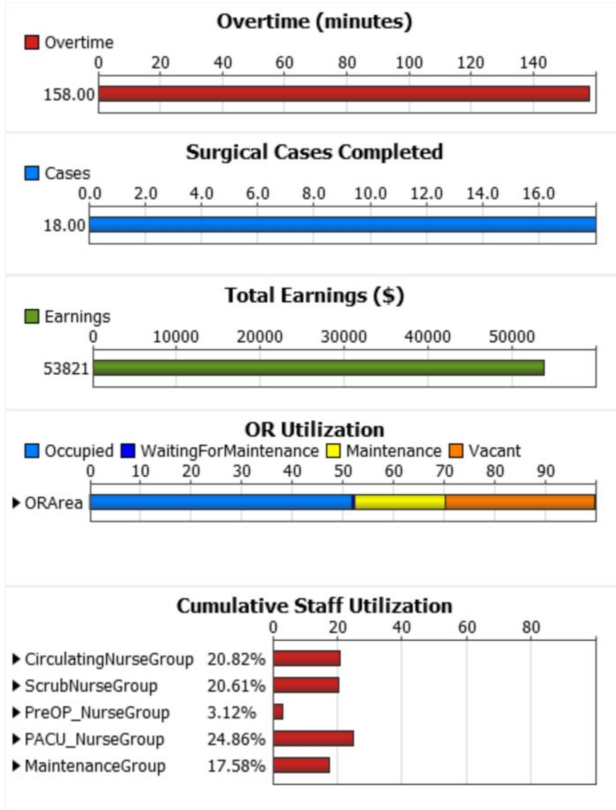


5. Click the Reset button, located in the Toolbar.
6. Click the Experiment button **two times**. This button is found in the "Controls" dashboard.

After a short wait while your experiment scenario is executed, you'll see that the charts are populated with fresh data to analyze.

IV. Analyzing the Data

The model contains several pre-built charts to help you analyze your simulation results and judge the effectiveness of your choices.



The five charts in the main dashboard (named "Dashboard") contain each of the five basic metrics that your team will use to evaluate the effect of your choices:

1. **Overtime Minutes Worked:** How do you think an increase in overtime work for surgical staff might affect patient safety? Or what about staff morale?
2. **Number of Surgical Cases Completed:** The model is only considering a single day, so how do you think patients will feel if their case is backed up and delayed to the following day?
3. **Total Earnings:** Calculated as expected earnings for each completed case minus cost penalties for overtime and additional staffing.
4. **Operating Room Utilization:** How often were operating rooms occupied, or actively attending to a surgical case? These rooms are expensive, and any time they are vacant or being maintained does not add value.
5. **Staff Utilization:** Surgical and support staff are also expensive, so it's important to make sure staff aren't being under-utilized. However, extremely high utilization isn't necessarily a good thing either.

Your team should focus on one or more of these metrics to help you explain and justify your team's model configuration.

Note: You can also export the raw data to analyze externally in a spreadsheet, by going to Statistics > Export Dashboard Data in the FlexSim HC menu bar, and then selecting which dashboard widgets (or charts) you would like to export the data tables for.

Appendix A: IISE-SHS Student Simulation Competition Guidelines

1. General Information. Again, welcome to the 2020 IISE–SHS Simulation Competition, sponsored by FlexSim! Please take time to read the guidelines shown below as each segment is designed to support elements of your execution of the case study.

2. Competition Coordination. The following individuals have been designated as key contacts for any questions that may arise concerning the competition.

A. For information and questions concerning the SHS General Rules and Guidelines, Important dates, competition prizes and all general information, you should contact Bonnie Cameron at bcameron@iienet.org or (770) 449-0461, ext. 105.

B. For all matters concerning the FlexSim HC software and the model/spreadsheet, please contact the FlexSim support team—simply visit https://answers.flexsim.com/ and post a question.

3. Significant dates: All case study solutions should be submitted to education@flexsim.com no later than close of business (8:00pm EST / UTC -5) on the 17th of December.

4. FlexSim HC software downloading and installation. All necessary information needed to download and install the software you'll need is included in Appendix B.

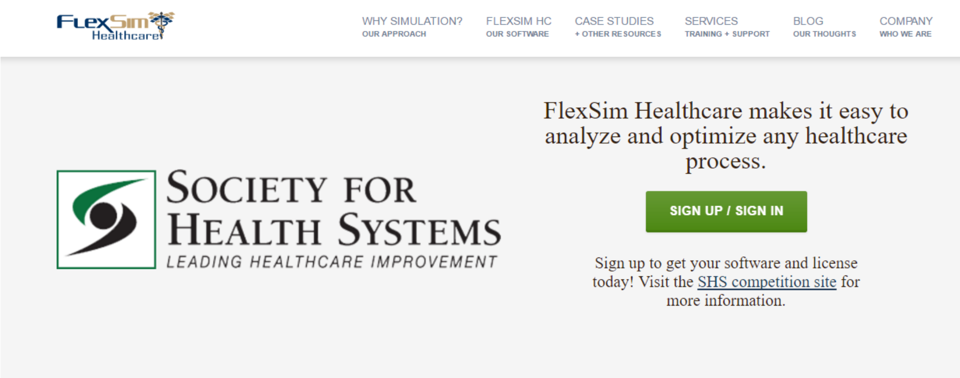
5. Judging Criteria. The criteria for the evaluation of your case study, analysis and overall work is shown in Appendix C. We will allocate a total of 70 points to your solution and report. The remaining 30 points are reserved for allocation by the panel of judges at the conference where you work will be presented.

6. Bibliography. A short annotated bibliography of modeing projects is provided in Appendix D. The purpose of the bibliography isn't to limit your research but rather to give you an idea of the availability of information that pertains to healthycare systems modeling and a few ideas concerning performance values found throughout the modeling field. As such, some of the references won't pertain to your project at all. They're just there to represent the spectrum of what has been done and add to your knowledge base.

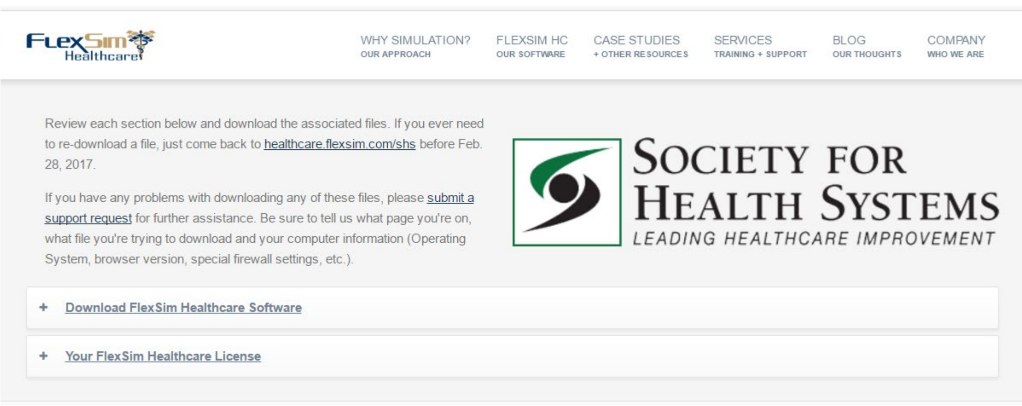
Appendix B: Downloading and Installing FlexSim HC

Go to the web address, **https://healthcare.flexsim.com/shs-license/**.

Click on the "SIGN UP / SIGN IN" button to either sign in if you already have a FlexSim account or to create an account using your email address if you don't.



Once you've logged in or created a FlexSim account (make sure you navigate back to **https://healthcare.flexsim.com/shs-license/** after you create a new account), you'll be redirected to the download page (shown below) to download and install your software.



Download and install your copy of Flexsim HC and then click on "Your Flexsim Healthcare License" and follow the instructions to activate your license.

Note that the version of Flexsim HC that you will be licensed to use is unlimited in its capacity. In other words, it is the same commercial version used by clients worldwide. As such, by downloading and installing the software, you agree that it will be used for the sole purpose of the SHS competition. Moreover, when the expiration date of 3/30/2020 is reached, the software will revert to a demonstration version.

Appendix C: Case Study Judging Criteria

1. Problem Statement: Is the statement clear, concise, appropriate for the study and reflective of the intent of the study team. Is the statement structured in such a way as to facilitate a comparison between what the study intends to evaluate and the results that are produced? – ______ points
2. Experimentation and Conclusions: Are experiments conducted to evaluate alternate solutions to the problem? Is the purpose of each experiment documented and explained in sufficient detail to permit ease of comprehension? Do the experiments seem appropriate for the problem under study? – ______ points
3. Quality of Study-based Recommendations: Are conclusions drawn for the study succinctly explained? Are conclusions appropriate, reasonable and supported by the model's performance? Are recommendations in accordance with the study's initial problem statement? – __ points
4. Verification and Validation: Was a comparison made between the any of the model's operational characteristics and the actual facility's performance? Were the selected performance variables appropriate for the study and explained in sufficient detail? Do the conclusions drawn from the comparison attest to the model's validity? – ______ points
5. Executive Summary: Does the executive summary correctly and accurately reflect the study's outcomes and findings? – ______ points
6. Presentation: Was the presentation supported by appropriate visual aids? Was the discussion of results reflective of the study's true findings? Was the presentation succinct, easy to follow, and professionally conducted? – ______ points
7. Overall Project Quality: Does the project reflect the level of care, attention to detail, and professionalism expected of a project of this nature? – _______points
Total Points:

Appendix D. Discrete Event Simulation Applications in Operating Room Management

The following article citations and summaries were taken from on-line references that can be accessed through MedLine search at www.medscape.com and www.ncbi.nlm.nih.gov/pubmed.

1. Discrete-event simulation applied to analysis of waiting lists. Evaluation of a prioritization system for cataract surgery.

Value Health. 2008; 11(7):1203-13 (ISSN: 1524-4733)

Comas M; Castells X; Hoffmeister L; Román R; Cots F; Mar J; Gutiérrez-Moreno S; Espallargues M
Evaluation and Clinical Epidemiology Department, Hospital del Mar (IMAS), Barcelona, Spain.

OBJECTIVES: To outline the methods used to build a discrete-event simulation model for use in decision-making in the context of waiting list management strategies for cataract surgery by comparing a waiting list prioritization system with the routinely used first-in, first-out (FIFO) discipline. METHODS: The setting was the Spanish health system. The model reproduced the process of cataract, from incidence of need of surgery (meeting indication criteria), through demand, inclusion on a waiting list, and surgery. "Non-expressed Need" represented the population that, even with need, would not be included on a waiting list. Parameters were estimated from administrative data and research databases. The impact of introducing a prioritization system on the waiting list compared with the FIFO system was assessed. For all patients entering the waiting list, the main outcome variable was waiting time weighted by priority score. A sensitivity analysis with different scenarios of mean waiting time was used to compare the two alternatives. RESULTS: The prioritization system shortened waiting time (weighted by priority score) by 1.55 months (95% CI: 1.47 to 1.62) compared with the FIFO system. This difference was statistically significant for all scenarios (which were defined from a waiting time of 4 months to 24 months under the FIFO system). A tendency to greater time savings in scenarios with longer waiting times was observed. CONCLUSIONS: Discrete-event simulation is useful in decision-making when assessing health services. Introducing a waiting list prioritization system produced greater benefit than allocating surgery by waiting time only. Use of the simulation model would allow the impact of proposed policies to reduce waiting lists or assign resources more efficiently to be tested.

2. Optimizing patient flow in a large hospital surgical center by means of discrete-event computer simulation models.

J Eval Clin Pract. 2008; 14(6):1031-7 (ISSN: 1365-2753)

Ferreira RB; Coelli FC; Pereira WC; Almeida RM
The Luiz Alberto Coimbra Institute, Federal University Rio de Janeiro - COPPE/UFRJ, Rio de Janeiro, Brazil.

OBJECTIVE: **This study used the discrete-events computer simulation methodology to model a large hospital surgical center (SC)**, in order to analyze the impact of increases in the number of post-anesthetic beds (PABs), of changes in surgical room scheduling strategies and of increases in surgery numbers. METHODS: The used inputs were: number of surgeries per day, type of surgical room scheduling, anesthesia and surgery duration, surgical teams' specialty and number of PABs, and the main outputs were: number of surgeries per day, surgical rooms' use rate and blocking rate, surgical teams' use rate, patients' blocking rate, surgery delays (minutes) and the occurrence of postponed surgeries. Two basic strategies were implemented: in the first strategy, the number of PABs was increased under two assumptions: (a) following the scheduling plan actually used by the hospital (the 'rigid' scheduling - surgical rooms were previously assigned and assignments could not be changed) and (b) following a 'flexible' scheduling (surgical rooms, when available, could be freely used by any surgical team). In the second, the same analysis was performed, increasing the number of patients (up to the system 'feasible maximum') but fixing the number of PABs, in order to evaluate the impact of the number of patients over surgery delays. CONCLUSION: **It was observed that the introduction of a flexible scheduling/increase in PABs would lead to a significant improvement in the SC productivity.**

3. What is the best workflow for an operating room? A simulation study of five scenarios.

Health Care Manag Sci. 2009; 12(2):142-6 (ISSN: 1386-9620)

Marjamaa RA; Torkki PM; Hirvensalo EJ; Kirvelä OA
Department of Anesthesia and Intensive Care Medicine, Helsinki University Central Hospital, Helsinki, Finland. riitta.a.marjamaa@helsinki.fi

Parallel induction of anesthesia improves operating room (OR) efficiency. To support decision-making as to optimal facilities and optimal use of resources, we compared the cost-efficiency of several workflow models of parallel induction to that of the traditional model, using discrete-event simulation. For each scenario, average number of procedures performed, surgery time, daily over- and underutilized time, and staffing costs per operation were assessed. **We also studied whether scheduling short and long procedures in separate rooms would amplify the effects of the parallel processing. All parallel work-flow models demonstrated better cost-efficiency than the traditionally sequenced working pattern. Staffing costs per procedure were 7% lower in the best induction model than in the traditional model. When short procedures were scheduled separately, differences between induction models were small.**

4. Cardiac surgery productivity and throughput improvements.

Int J Health Care Qual Assur. 2007; 20(1):40-52 (ISSN: 0952-6862)

Lehtonen JM; Kujala J; Kouri J; Hippeläinen M
Laboratory of Industrial Engineering and Management, Helsinki University of Technology, Helsinki, Finland.

PURPOSE: The high variability in cardiac surgery length--is one of the main challenges for staff managing productivity. This study aims to evaluate the impact of six interventions on open-heart surgery operating theater productivity. DESIGN/METHODOLOGY/APPROACH: A discrete operating theater event simulation model with empirical operation time input data from 2603 patients is used to evaluate the effect that these process interventions have on the surgery output and overtime work. A linear regression model was used to get operation time forecasts for surgery scheduling while it also could be used to explain operation time. FINDINGS: A forecasting model based on the linear regression of variables available before the surgery explains 46 per cent operating time variance. The main factors influencing operation length were type of operation, redoing the operation and the head surgeon. Reduction of changeover time between surgeries by inducing anaesthesia outside an operating theater and by reducing slack time at the end of day after a second surgery have the strongest effects on surgery output and productivity. A more accurate operation time forecast did not have any effect on output, although improved operation time forecast did decrease overtime work. RESEARCH LIMITATIONS/IMPLICATIONS:

A reduction in the operation time itself is not studied in this article. However, the forecasting model can also be applied to discover which factors are most significant in explaining variation in the length of open-heart surgery. PRACTICAL IMPLICATIONS: The challenge in scheduling two open-heart surgeries in one day can be partly resolved by increasing the length of the day, decreasing the time between two surgeries or by improving patient scheduling procedures so that two short surgeries can be paired. ORIGINALITY/VALUE: A linear regression model is created in the paper to increase the accuracy of operation time forecasting and to identify factors that have the most influence on operation time. A simulation model is used to analyze the impact of improved surgical length forecasting and five selected process interventions on productivity in cardiac surgery.

5. How many patient transfer rooms are necessary for my OR suite? Effect of the number of OR transfer rooms on waiting times and patient throughput in the OR - analysis by simulation.

Anaesthesist. 2015 Dec;64(12):958-967. Messer C[1], Zander A[1], Arnolds IV[1], Nickel S[1], Schuster M[2].

STUDY OBJECTIVE: In most hospitals the operating rooms (OR) are separated from the rest of the hospital by transfer rooms where patients have to pass through for reasons of hygiene. In the OR transfer room patients are placed on the OR table before surgery and returned to the hospital bed after surgery. It could happen that the number of patients who need to pass through a transfer room at a certain point in time exceed the number of available transfer rooms. As a result, the transfer rooms become a bottleneck where patients have to wait and which, in turn, may lead to delays in the OR suite. In this study the ability of a discrete event simulation to analyze the effect of the duration of surgery and the number of ORs on the number of OR transfer rooms needed was investigated.

METHOD: This study was based on a discrete event simulation model that studied the effects of the number of OR transfer rooms on the processes in an OR suite of a community hospital by varying the number of ORs from one to eight and using different surgical portfolios. Probability distributions for the process duration of induction, surgery and recovery and transfer room processes were calculated on the basis of real data from the community hospital studied. Furthermore, using a generic simulation model the effect of the average duration of surgery on the number of OR transfer rooms needed was examined.

RESULTS: The discrete event simulation model enabled the analysis of both quantitative as well as qualitative changes in the OR process and setting. Key performance indicators of the simulation model were patient throughput per day, the probability of waiting and duration of waiting time in front of OR transfer rooms. In the case of a community hospital with 1 transfer room the average proportion of patients waiting before entering the OR was 17.9 % ± 9.7 % with 3 ORs, 37.6 % ± 9.7 % with 5 ORs and 62.9 % ± 9.1 % with 8 ORs. The average waiting time of patients in the setting with 3 ORs was 3.1 ± 2.7 min, with 5 ORs 5.0 ± 5.8 min and with 8 ORs 11.5 ± 12.5 min. Based on this study the community hospital needs a second transfer room starting from 4 ORs so that there is no bottleneck for the subsequent OR processes. The average patient throughput in a setting with 4 ORs increased significantly by 0.3 patients per day when a second transfer room is available. The generic model showed a strong effect of the average duration of surgery on the number of transfer rooms needed.

CONCLUSION: There was no linear correlation between the number of transfer rooms and the number of ORs. The shorter the average duration of surgery, the earlier an additional transfer room is required. Thus, hospitals with shorter duration of surgery and fewer ORs may need the same or more transfer rooms than a hospital with longer duration of surgery and more ORs. However, with respect to an economic analysis, the costs and benefits of installing additional OR transfer rooms need to be calculated using the profit margins of the specific hospital.

6. Efficiency of the operating room suite.

Am J Surg. 2003; 185(3):244-50 (ISSN: 0002-9610) Weinbroum AA; Ekstein P; Ezri T
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BACKGROUND: The need to control high costs of running operating rooms while providing for timely patient care led us to assess the time wasted in the operating room (OR). METHODS: OR use by two general surgery and two orthopedic departments in a metropolitan public hospital were analyzed, and the time elapsed when a scheduled OR remained unused or the patient was still awaiting surgery was measured. RESULTS: **OR "time-waste" defined as the time in which the scheduled OR was not busy with the scheduled patient amounted to 79 hours over the 30-day study period (15% of total time). It was wasted owing to inappropriately prepared patients (12%), unavailability of surgeons (7%), insufficient nursing staff,**

anesthesiologists, or OR assignment to emergency surgery (59%), congestion of the post-anesthesia care unit (10%), and delay in transport to the OR (2%) Another issue delineated was the frequent occurrence of surgical cases running longer than their scheduled time (termed "spill-over"), outrunning the staffing expectations after 3:00 PM and delaying admission of add-on and emergency procedures, adding 33% to the time wasted. A quality-assurance committee review resulted in implementation of new guidelines, and within 3 months several underlying causes were rectified, and time-waste and spill over time was reduced by 35%. Surgical time predictions were also improved. Shortage of nurses and anesthesiologists, and OR emergency reassignment remained the major causes of OR waste time. CONCLUSIONS: Continuous surveillance on OR suite-patients' prompt care, repeated evaluation, and wise staff deployment-could maximize OR efficiency.

7. Increasing operating room efficiency through parallel processing.

Ann Surg. 2006; 243(1):10-4 (ISSN: 0003-4932) Friedman DM; Sokal SM; Chang Y; Berger DL Department of Surgery and the Center for Clinical Effectiveness in Surgery, Massachusetts General Hospital, Boston, MA 02114, USA.

OBJECTIVE: Because of rising costs and shrinking reimbursements, hospitals must continually find ways to improve efficiency and productivity. **This study attempts to increase caseloads in ambulatory surgery operating rooms while maintaining patient satisfaction and safety.** SUMMARY BACKGROUND DATA: In most hospitals, patients move through their operative day in a linear fashion, starting at registration and finishing in the recovery room. Given this pattern, only 1 patient may occupy the efforts of the operating room team at a time. **By processing patients in a parallel fashion, operating room efficiency and patient throughput are increased while costs remain stable.** METHODS: Patients undergoing hernia repairs under local anesthesia with intravenous sedation were divided into a control group and an experimental group. Patients in the control group received their local anesthesia in the operating room at the start of the surgery. The experimental group patients received their local anesthesia in the induction room by the surgeon while the operating room was being cleaned and set up. RESULTS: **While operative time for the control group and the experimental group were nearly identical, the turnover time and the induction time were significantly shorter for the experimental group. The cumulative reduction in time during the operative day was sufficient to allow the addition of new operative cases. CONCLUSIONS: This study**

demonstrates a system of increasing operating room efficiency by changing patient flow rather than simply working to streamline existing steps. This increase in efficiency is not associated with the expansion of hospital budgets or a decrease in patient safety or satisfaction.

8. Operating room efficiency and hospital capacity: factors affecting operating room use during maximum hospital census.

J Am Coll Surg. 2007; 204(5):865-71; discussion 871-2 (ISSN: 1072-7515) McGowan JE; Truwit JD; Cipriano P; Howell RE; VanBree M; Garson A; Hanks JB
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BACKGROUND: Academic medical centers are faced with increasing volumes, higher acuity, and, as a consequence, capacity issues. These affect operating room (OR) use and patient throughput, with negative impact on finances and patient and physician satisfaction. **We evaluated our experiences in dealing with OR efficiency at a time of maximum hospital capacity and occupancy.** STUDY DESIGN: Using a multidisciplinary approach, **we put in place seven agreed-upon strategies: daily communication, improved bed planning, discharge by noon program, internal staffing pool, special assignments for a patient transition unit, incentives, and stepped up environmental services.** RESULTS: After institution of these strategies, we were able to realize a gain in OR patient volume of 8% and a decrease in OR holds of 37%. This resulted in a decrease in canceled OR cases from 4.3% to 3.1%. CONCLUSIONS: **Academic medical centers face occupancy issues that are not likely to go away and will have an impact on OR volume and productivity. To improve the situation in a short-term fashion, a multidisciplinary approach involving several alternatives used in the analysis.**