Improving Central Sterile Supply Productivity

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OSU Wexner Medical Center

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Final Report

Executive Summary

The Central Sterile Supply (CSS) performs instrument sterilization for the Wexner Medical Center on The Ohio State University medical campus. When the CSS cannot keep up with demand and has to fast track critical items, suboptimal sterilization methods are used, or surgical procedures could be delayed. The goal of this project was to provide key insights, tools, and recommendations regarding productivity and workflow to help reduce inefficiencies and thus decrease the need for suboptimal sterilization.

The project had three main objectives:

1. Create and implement tools that improve tracking of key processes indicators.
2. Analyze capacity and demand data to make staffing and work organization recommendations for the decontamination process, and
3. Provide qualitative recommendations for improvement based on observations.

Excel VBA was used to create two tools to improve key tracking processes within the department. One of these tools, the Needs List, is used by the packing area to track different cases necessary for upcoming surgeries that do not have containers already in stock. It is also used for containers needed in OR backup. The other tool, the CSS Scoreboard, is used to track quality deviations and provide metrics that can be analyzed by date. Both tools were designed using an iterative design process that heavily incorporated user input and feedback. The Needs List is already in use by the CSS, and the CSS Scoreboard is ready to be implemented.

In order to assess the department's capability to meet demand during peak hours, a simulation model of the decontamination area was built and its output was analyzed. The model was created using process knowledge, time study data, and existing data on the number of case carts the CSS processes. The output of the simulation indicated that, in its current state, decontamination cannot keep pace with demand during its peak period of 10:00 a.m. to 3:00 p.m. Furthermore, even adding an extra sink, cart washing machine, or more workers only result in modest productivity increases. Ultimately, for the CSS to be able to keep pace with demand during peak hours, it would have to install another satellite location outside of the central department.

Finally, a number of observations were made throughout the project that identified areas of opportunity for the department. Key observations included low morale, lack of compliance with standard operating procedures (SOPs), and unnecessary clutter. Several recommendations have been made to address these problems, including implementing programs that increase worker buy-in, educating workers on the correct way to perform SOPs, and reducing unneeded inventory to increase the productivity of much-needed floor space.

Ultimately, the project met its objectives by providing helpful tools, knowledge, and recommendations for improving processes in the CSS. The Excel VBA tools will improve important processes while adding analytical capabilities. The simulation and the capacity and demand analysis quantify the backlog issues that have been observed in the decontamination process, and they provide insight into how additional

resources, workers, and expanded space may help alleviate the problem. Finally, the recommendations that were provided for other issues that were noticed during the study will help the CSS continue to find new ways to improve their overall productivity and quality.

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Introduction

The Central Sterile Supply (CSS) performs instrument sterilization for the Wexner Medical Center on The Ohio State University medical campus. When the CSS cannot keep up with demand and has to fast track critical items, suboptimal sterilization methods are used, or surgeries may have to be delayed. The goal of this project was to provide key insights, tools, and recommendations regarding productivity and workflow to help reduce inefficiencies and thus decrease the need for suboptimal sterilization.

The project had three main objectives:

1. Create and implement tools that improve tracking of key of processes indicators,
2. Analyze capacity and demand data to make staffing and work organization recommendations for the decontamination process, and
3. Provide qualitative recommendations for improvement based on observations.

The approach, results, and recommendations for each of these objectives will be addressed in the following sections.

Process Tracking Tools

The goal for this part of the project was to create software tools that would improve internal tracking processes in the CSS.

Methods and Approach

Two Excel tools, a Needs List and a CSS Scoreboard, were created in conjunction with the needs of the department. They were created using Visual Basic for Applications (VBA) to create a user-friendly interface for the tools. The Needs List is used by the packing area to track different cases necessary for upcoming surgeries which do not have containers already in stock. It is also used for containers needed in the OR backup. The CSS Scoreboard software is used to track quality deviations and provide metrics that can be analyzed by date.

The tools were developed using an iterative design process that included extensive input from the users in order to maximize their usability and usefulness. For example, the Needs List program underwent eight iterations before it was finalized. Additionally, there is documentation to help department staff update or make changes to the Needs List program should the need arise. All of the VBA code for both the Needs List and the CSS Scoreboard is commented for easy future changes.

Results

The Needs List tool has been successfully implemented within the CSS. It performs as intended, allowing the department to communicate needs and track critical items. Key features include a searchable container list, password protection, multiple sorting categories, and an archivable sheet. A screenshot of the Needs List user interface is shown in Figure 1, below.

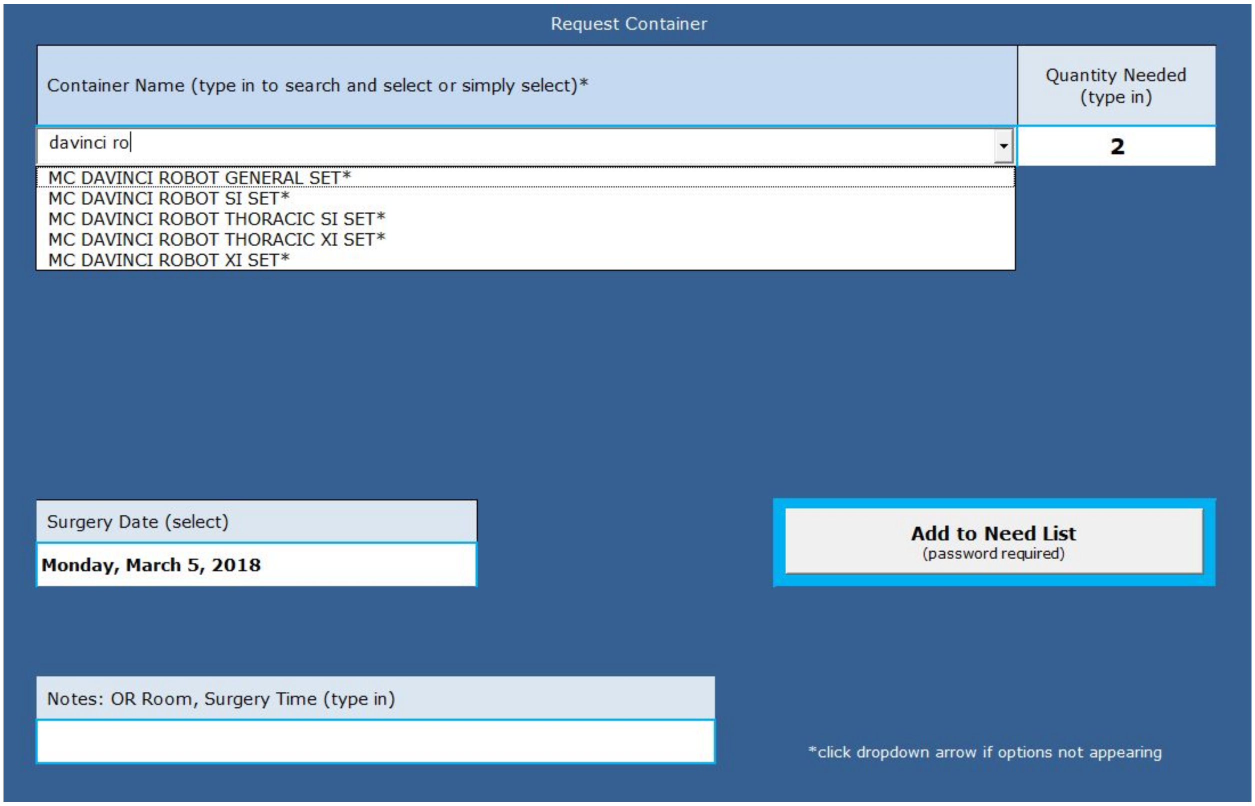

Figure 1: Screenshot of the Needs List Program

The CSS Scoreboard tool is completed and awaiting implementation. It can be used to record, track, and analyze quality issues over time. Key features of the scoreboard include filtering, auto-graphing, and the ability to look at performance on a daily, weekly, monthly, and yearly basis. A screenshot of the performance analysis interface is displayed in Figure 2.

Figure 2: Screenshot of the CSS Scoreboard

Capacity and Demand Simulation and Analysis

The goal for this portion of the project was to study the capacity and demand of the decontamination process, analyze the resulting data using a simulation, and ultimately determine if changes to the staffing levels or work organization would help decrease bottlenecks and delays.

Methods and Approach

The decontamination process was closely observed on several occasions. Then, a process map was created to document the current state of the process. This map was essential in order to think about the entire process as an integrated system. Figure 3 shows what the completed process map looks like at an overview level.

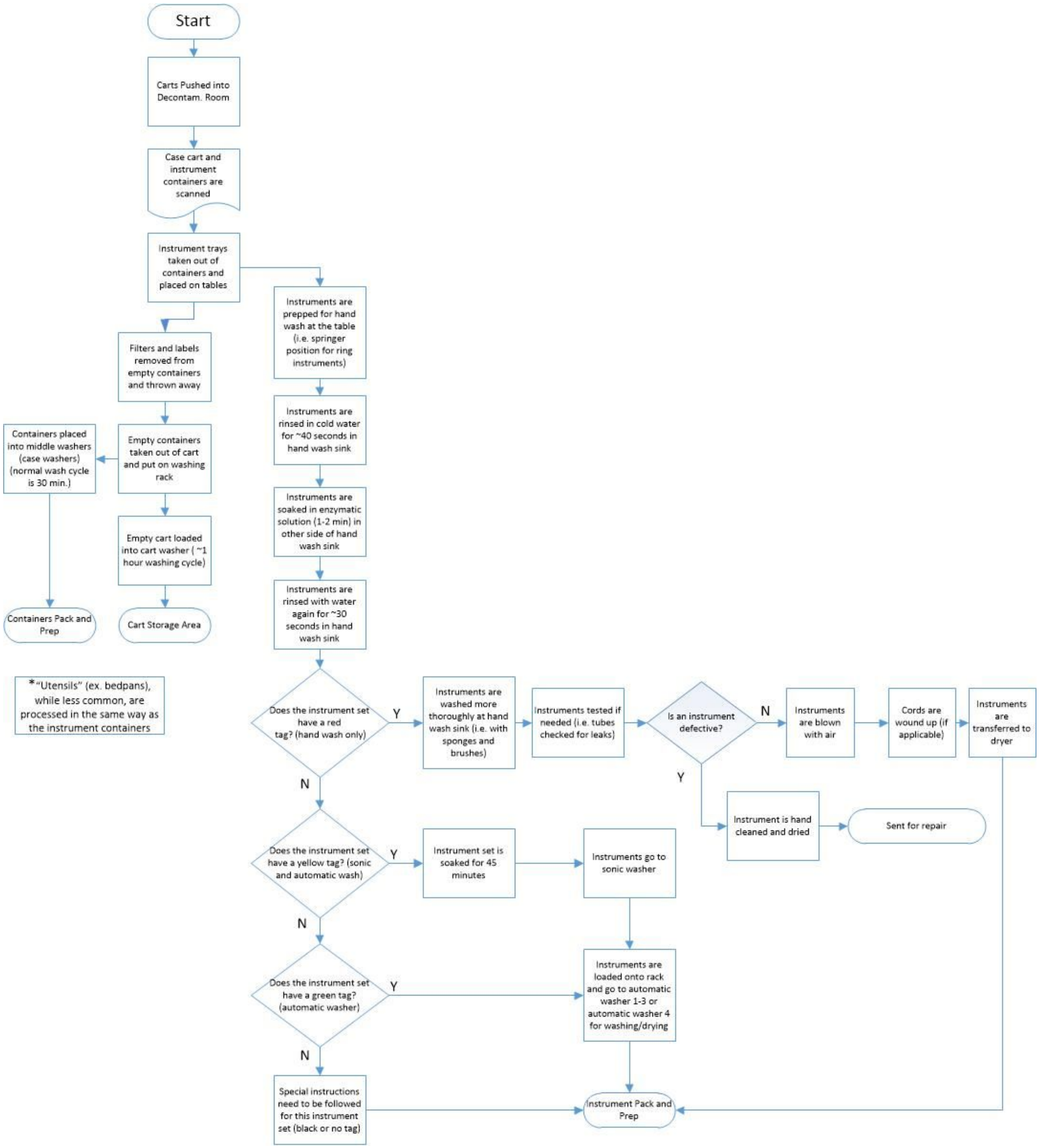

Figure 3: Decontamination Process Map

Next, the layout of the decontamination area was measured and a diagram was created. Like the process map, the layout was needed to understand the operation of the system. The layout diagram is shown in Figure 4.

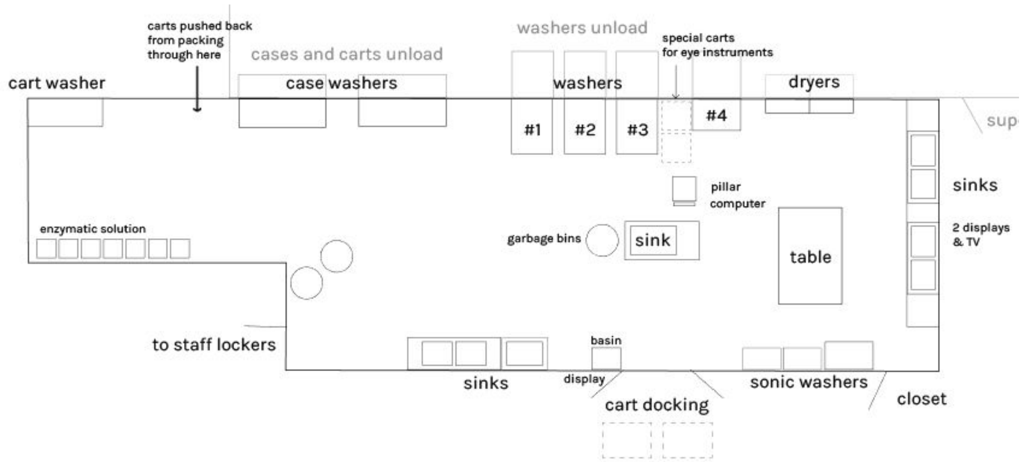

Figure 4: Decontamination Layout

The process map and the layout were used to understand the current state of the decontamination process and were instrumental in designing a time study. Each task in the decontamination process was defined, then added to a standard time study form. The time study form and stopwatches were used to collect and record time samples for each of the tasks in the decontamination process.

The time study data were paired with process knowledge and demand data to construct a simulation of the process. Note that the demand data consisted of the number of carts being sent to the CSS **during peak time periods** over the course of one month. The peak time period was identified to be from 10:00 a.m. to 3:00 p.m., and the simulation analysis focuses only on keeping pace with this level of demand.

The simulation model was constructed in Arena. First, process blocks were created to represent each task and the flow of materials in the decontamination process. Next, Arena's "Input Analyzer" feature was utilized to assign statistical distributions to the demand data and the time study data for each of the tasks (see Figure 5 for an example). The resulting distributions, summarized in Table 1, were then assigned to their corresponding process blocks, thus completing the simulation model. The model is shown in Figure 6.

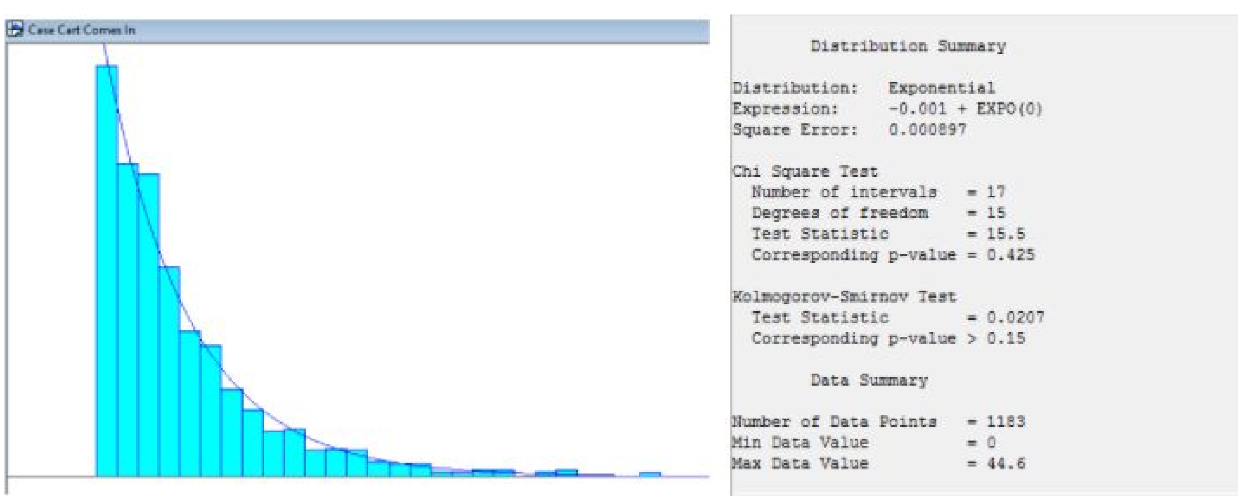

Figure 5: Input Analysis Distribution Result for Cart Interarrival Times

Table 1: Simulation Distributions Summary

Final Arena Expression	
Cart Arrives	-0.001+EXPO(5.36)
Cart Brought in	CONT(0,20,0.0857,40,0.2571,60,0.4857,80,0.7714,100,1,120)
Cart Unloaded	NORM(172, 67.3)
Cart Queued to Washer	CONT(0,25,0.1778,40,0.5333,55,0.7111,70,0.8222,100,0.8222,115,0.9111,130,1,145)
Stringing Ring Instruments	UNIF(29, 280)
Green tray	53 + EXPO(196)
Red tray	UNIF(145, 499)
Yellow tray	CONT(0,0,0.2222,200,0.5556,400,0.8889,600,0.8889,800,0.9556,1000,1,1200)
Move Rack to Tray Washer	CONT(0,10,0.1111,30,0.4444,50,0.6222,70,0.8667,90,0.9111,110,1,130)

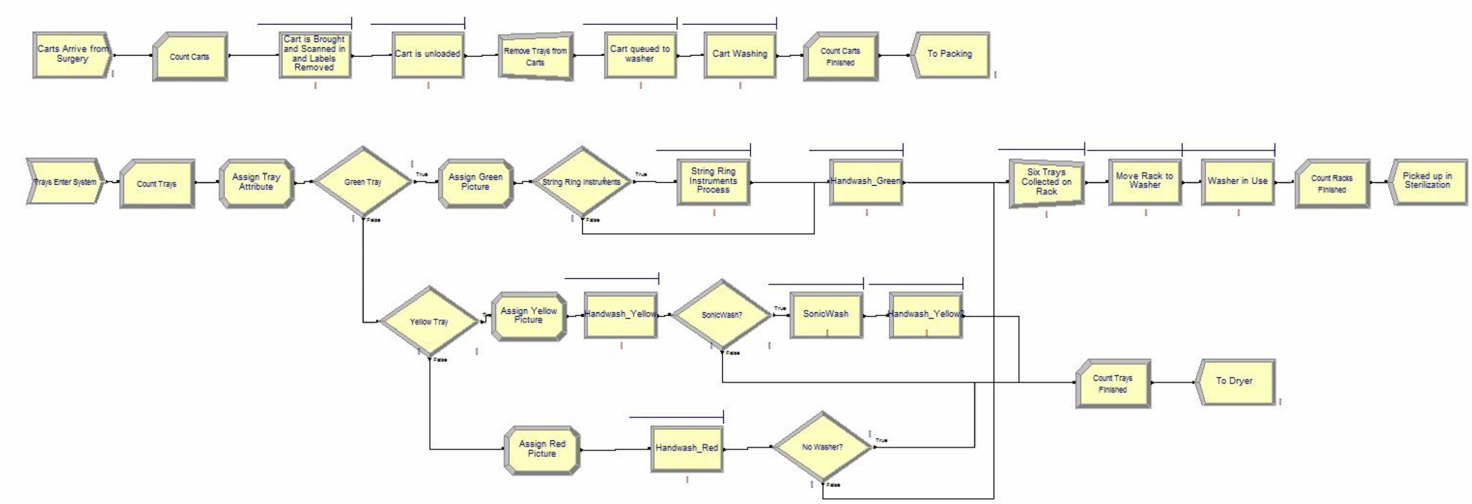

Figure 6: Arena Simulation Model

Once the model was completed, several scenarios were run (see Appendix A for details on running the simulation). The scenarios varied the number and placement of workers in the process, specifically the number of workers attending to case carts, the number of workers at the hand washing sinks, and the number of workers stringing instruments at the table. Additionally, these scenarios varied the number of sinks and cart washing machines to determine the impact of investing in additional equipment. The results of the simulation allowed for these varying scenarios to be compared.

Results

Table 2, below, shows the results of the simulated scenarios comparison. Note that the first column gives the scenario name, columns 2-6 identify the type and quantities of workers and equipment, and the final two columns (in the bold box) display the scenario outputs in terms of the number of case carts and trays that were completed.

In columns 2-6, the color scheme is used to identify changes in the number of workers/equipment relative to the current state: green indicates 1 resource has been added and blue that two resources have been added. Note that Cart Workers and Washing Workers are the two categories indicating the total number of workers—"stringers", on the other hand, denotes the maximum number of workers who break from their cart work (or less often, their hand washing work) to go to the table and string instruments.

In columns 7-8, the highest levels of output are highlighted in yellow.

Table 2: Output Results from Simulated Scenarios [1]

Scenario	Cart Workers	Washing Workers	# of Sinks	Max # of Stringers	Cart Washers	# Case Carts Finished	# Trays Finished
Current	1	4	4	1	2	18	119

Add 1 Cart Worker	2	4	4	1	2	18	120
Build 1 Cart Washer Machine	1	4	4	1	3	22	119
Build 1 Cart Washing Machine, Add 1 Cart Worker	2	4	4	1	3	27	120
Add 2 Cart Workers, 2 Stringers	3	4	4	2	2	18	90
Build 1 Sink, Add 1 Washing Worker	1	5	5	1	2	18	121
Build 1 Sink, Add 1 Washing Worker, Add 1 Cart Worker	2	5	5	1	2	18	197
Build 1 Sink, Build 1 Cart Washing Machine, Add 1 Washing Worker, Add 1 Cart Worker	2	5	5	1	3	27	197
Build 1 Sink, Add 1 Washing Worker, Add 2 Cart Workers, 2 Stringers	3	5	5	2	2	18	145
Build 1 Sink, Build 1 Cart Washing Machine, Add 1 Washing Worker, Add 2 Cart Workers, 2 Stringers	3	5	5	2	3	27	145
Build 1 Sink, Add 1 Washing Worker, Add 1 Cart Worker, 2 Stringers	2	5	5	2	2	18	197
Build 1 Sink, Build 1 Cart Washing Machine, Add 1 Washing Worker, Add 1 Cart Worker, 2 Stringers	2	5	5	2	3	27	197

Average total during peak demand (5 hrs)	
Carts	Trays
54	308

Analyzing the above table leads to some valuable insights on the impact that varying numbers of workers and equipment have on decontamination output, as discussed in the next section.

[1] Note regarding the interpretation of table output: Adding a cart worker increases the number of green trays in the system because cart workers help with stringing green tray instruments in addition to cart duties. This increases the number of green trays in the system relative to red trays. Green trays take longer to leave the system than red trays because they have to go through the tray washing machine, whereas most red trays leave the system once they are finished being hand washed. Thus, the table appears to show that adding a cart working slightly decreases the tray output, but that is not the correct interpretation since the tray mix has changed. The data in Appendix B gives additional information that shows that other metrics, like tray queue levels, are in fact better with the addition of a cart worker.

Recommendations

The simulation results show that the CSS currently cannot handle their peak demand efficiently. There are large bottlenecks throughout the system, particularly in unloading and washing carts. The current number of cart washing machines cannot keep pace with the number of carts coming in during peak demand periods. Specifically, the current 2 cart washing machines can only process 18 carts during the peak demand period (5 hours), while the average number of carts arriving during this time is 54. Even when an extra cart washing machine and an extra cart worker are added to the system, still only 27 carts can be processed during this 5 hour period.

As for tray output, simulation results show that if another sink was built and another hand-washing worker and another cart worker were added, the system would output an additional 15.6 trays/hour. However, this improved level would still not be able to keep pace with the flow of trays coming in.

Ultimately, the simulation shows that best scenario (most carts and trays processed) would be to build another sink and cart washing machine, and then add another hand-washing worker and another cart worker. However, this scenario would require substantial investment in equipment and changes to the current layout, and even then, it is incapable of keeping pace with demand during the department's peak period (10:00 am - 3:00 pm). There is no scenario that is significantly better than the "current" scenario that doesn't involve capital investment.

Given these results, it is recommended that the CSS open up another satellite facility, if possible, to spread out the demand and prevent back-ups in the main facility. The current facility seems as if it is not sized appropriately to handle the needs of several large hospitals.

Empirical Observations

Methods

Frequent observations of the system as well as conversations with workers resulted in identifying other areas of opportunity. While it was outside the scope of this project to do a full analysis on these areas, they are included here as suggestions for further examination.

Results and Recommendations

The following is a list of observations that were made during the study, followed by recommendations for improvement:

Observation: *Low morale.* Observations and conversations with workers indicated that there is low morale issue amongst some employees. Additionally, many employees have ideas on how to improve the process.
Recommendations:

1. Hold a meeting with workers to identify ways to improve processes within the department. Allow workers to speak openly about their experiences and encourage brainstorming of new ideas.
2. Implement or reinforce company/department culture and values system. Being unified around a common goal and understanding the importance of the work being done can increase buy-in.
3. Implement or reinforce an awards/recognition system to encourage a higher level of performance.
4. Take part in team building activities to build a culture of teamwork and increase buy-in.

Observation: *Lack of standard operating procedures (SOPs).* After observing numerous employees in the decontamination area, it was clear that there is either a lack of SOPs or a lack of compliance with SOPs. Each worker had a different way of doing things, which can lead to inefficiencies, miscommunication, and poor quality work. Additionally, some workers were observed skipping critical steps (i.e. not using the ultrasonic process for yellow trays because they "weren't that dirty").

Recommendations:

1. Create SOPs where needed by identifying and documenting the correct process for key tasks.
2. Educate workers on new SOPs and retrain on old ones. Stress the criticality of performing tasks to standard.

Observation: *Clutter.* An extensive amount of old and unused equipment was observed in the sterilization area and the satellite room. In sterilization, there are old case parts being switched out to a newer standard. The clutter limits the view sterilization workers have of the tray washer. As a result, they do not always notice when the washers are done, which delays their unload process. This also disrupts flow in decontamination because the tray washer must be unloaded before they can load it again. The satellite room also has many pieces of outdated equipment. This creates a storage cost, because the space is not being used productively. It also creates a safety cost, because when a high number of carts are being docked for surgery, there is not enough space in the satellite room to store all of them due to the unused carts storing outdated equipment. The excess carts for surgeries then need to be stored in the packing area, but space there is limited as well and having too many carts in there disrupts work flow in decontamination as carts are unable to be unloaded from the washer.

Recommendations:

1. Remove all equipment that is unlikely to be used within the next year.
2. Organize remaining equipment and store in an area that is not as crowded.

Observation: *Alarm unresponsiveness.* The automatic washing machines in decontamination are prone to encountering errors, which triggers an alarm and stops the washer from running. These are normally false alarms or easy to fix alarms (i.e. securing a door or adjusting the position of equipment on the racks). However, they occur often, and workers are often slow in responding. This may be because they are unable to hear the alarm due to the noise in the room, or because they expect someone else (like in sterilization) to handle it, or simply due to alarm fatigue. This can cause the washers to sit idle even during the department's busiest periods.

Recommendations:

1. Identify who is responsible for responding to alarms (i.e. sterilization or decontamination) and educate employees accordingly.
2. Implement visual signals to alert employees to the alarm going off.
3. Work with the equipment vendor to identify the source for false alarms and implement a remedy.

Observation: *Poor layout in decontamination.* The layout in decontamination is not conducive to efficient processes. Ideally, the space would be laid out as an assembly line, with equipment entering one end and flowing in one line until it exits the system.

Recommendations:

It would be difficult to change the current layout without significant capital investment. Moving sinks to one area may alleviate some, but not all, issues.

Observation: *Poor practices in the OR affect CSS efficiency.* Currently, the OR often sends biohazardous materials, such as blood or used gloves, to the CSS which disrupts flow as such materials are not supposed to be sent down. In addition to being hazardous to the health of the decontamination workers, it adds an extra step to the work process that is not supposed to be there. Another issue is the haphazard manner in which the OR sends the instruments down to the CSS. The OR often sends down instruments that are not secured in the case. While they do not need to be perfectly separated, some separation between instruments in the case will not only decrease prep time in decontamination, but would also reduce instrument damage (and thus instrument repair or replacement costs) that may occur by rough handling from the OR.

Recommendations:

1. More communication between the OR and CSS would help decrease excess workload.
2. Provide a clear division of responsibility level and range between the OR and CSS departments.

Summary

The project met its objectives and was able to provide helpful tools, insights, and recommendations for improving processes in the CSS. The two Excel VBA tools will help track and analyze key processes in the departments. The process simulation and analysis resulted in important insights into the department's capacity. It was determined that, in the current space, adding extra equipment and workers may result in a modest increase in productivity, but ultimately, to truly keep pace with peak demand another satellite facility would have to be installed. Finally, recommendations were made regarding other opportunities for improvement, including the suggestions to implement SOPs and remove unneeded inventory for a more productive use of space. Overall, these findings and recommendations will help the CSS continue to improve its productivity and its quality.

Team Page

JoJo Lu is seeking opportunities in concept art and design for games and working on personal projects.

Carrie Gerding will be a Process Engineer at Honda of America Mfg. following graduation.

Yawen Han will go to graduate school for further data science study.

Appendix

Appendix A: Additional Details on Simulation Model

This section explains how to view the simulation model while it is running in Arena.

The animation of the simulation model shows the processing status for each task, and provides a direct view of the bottlenecks of the decontamination system. The simulation model consists of two parts: the upper part for the processing of case carts, and the lower part for the processing of trays.

In the upper processing line for case carts, long queues are formed in the “Carts brought in and labels removed”, “Carts unloaded”, “Carts queue to washer”, and “Cart Washing” tasks, which suggests adding more cart workers or cart washers is a possible solution to decrease the queue length and improve the case carts washing productivity.

In the lower processing line for trays, long queues are formed in the "String ring instruments process" and "Handwash_Green" tasks, which indicates the processing of "Green" tag trays is the bottleneck for trays washing. In other words, the improvement of total cycle time and queue length for "Green" trays may help improve the whole trays washing productivity. Therefore, adding more handwash workers, sinks or available stringers is a possible solution to solve the bottleneck problem and improve the productivity for trays washing.

Appendix B: Simulation Output Additional Details

Table 3 provides additional simulation outputs that may help provide context to some of the values highlighted in the report.

Table 3: Additional Simulation Outputs

Scenario	# Trays waiting to be washed	# Trays waiting to be stringed	Average time Case Cart in system (hour)	Average time Tray in system (hour)	# Carts waiting to be unloaded	# Carts in Queue to Washer
Current	1.463	13.306	1.941	0.202	4.998	2.384
Add 1 Cart Worker	19.772	27.817	1.843	0.496	0.308	17.659
Build 1 Cart Washer Machine	1.463	13.306	1.802	0.202	4.998	0.256
Build 1 Cart Washing Machine, Add 1 Cart Worker	19.772	27.817	1.494	0.496	0.308	12.501
Add 2 Cart Workers, 2 Stringers	39.453	3.191	1.85	0.736	0.131	18.038
Build 1 Sink, Add 1 Washing Worker	0.513	13.003	1.926	0.167	4.843	2.43
Build 1 Sink, Add 1 Washing Worker, Add 1 Cart Worker	5.96	27.497	1.87	0.253	0.269	18.076
Build 1 Sink, Build 1 Cart Washer, Add 1 Washing Worker, Add 1 Cart Worker	5.96	27.497	1.526	0.253	0.269	12.9
Build 1 Sink, Add 1 Washing Worker, Add 2 Cart Workers, 2 Stringers	20.427	3.164	1.889	0.442	0.131	18.612
Build 1 Sink, Build 1 Cart Washing Machine, Add 1 Washing Worker, Add 2 Cart Workers, 2 Stringers	19.675	3.164	1.547	0.442	0.131	13.42
Build 1 Sink, Add 1 Washing Worker, Add 1 Cart Worker, 2 Stringers	7.164	5.604	1.872	0.268	1.236	14.084
Build 1 Sink, Build 1 Cart Washing Machine, Add 1 Washing Worker, Add 1 Cart Worker, 2 Stringers	7.164	5.604	1.535	0.268	1.236	9.015

Note that the values are averages and are often interconnected, so scenarios that have improvements in one part of the system may cause decreased productivity in other parts. For example, the average time a tray spends in the system may increase if carts are unloaded faster, thus increasing the number of trays in the system, increasing the average wait time per tray. You can notice this relationship by looking at the 5th and 6th columns. The number of carts waiting to be unloaded and the number of carts waiting to go through the washer are also related. In some scenarios, it may seem there are fewer carts waiting to go through the washer, but in reality they are still waiting to be unloaded. This relationship can be seen by looking at the 6th and 7th columns. Ultimately, it is important to maintain a systems viewpoint when analyzing and comparing different scenarios.

Appendix C: Excel Tools Documentation

See next page for the Excel tool documentation.