Laundry System Analysis

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The purpose of this project is to gain a global understanding of the laundry system at The University of Michigan Hospital and to eventually find a remedy to the existing problem. The problem is that at certain times during the week the inventory levels of linen get extremely low because there are only five days of laundry cleaning for seven days of service. The underlying purpose of this project is to find a way to keep inventory levels of linen substantial at all times in every department.

Our goal is to propose recommendations to improve customer satisfaction. These recommendations should minimize cost and maximize service to the customer, which of course is the hospital and all of its departments. Some of these recommendations may include acquiring more linen and equipment, rescheduling of distribution times, suggesting a new sequence of processes, and/or rescheduling workers (specifically those in material service and housekeeping).

To gain an understanding of the problem, the background and environment affecting the project must be discussed. There are multiple departments that work together in making the laundry system work. In the past, the clean laundry would come into the hospital and get loaded onto the bulk carts. The bulk carts contained all types of linens such as towels, scrubs, gowns, and other various pieces. These bulk carts were then circulated throughout the hospital to different departments by material services, where each department took what was needed to refill their supply. Once the carts were empty, they were taken back down by material services to get refilled. This was called “The Exchange Cart System”. It proved to be inefficient and the system needed a change. This system has changed and there is now a distribution center utilized inside the hospital. This new system is called “The Bulk Delivery System”. The clean incoming laundry is taken to the distribution center and distributed into bins organized by the bulk distribution people. The internal distribution then fills delivery carts according to the departments’ needs and takes them to the designated department. All deliveries are scheduled. This system has proven to be more efficient that “The Exchange Cart System”.
PROJECT PLAN

There are multiple departments that are being dealt with. To begin with, every department uses laundry, so all are involved. The departments that deal with taking care of and distributing the laundry are Material Services, the actual Laundry Center that cleans the laundry, and housekeeping. The Laundry Center and housekeeping fall under the Environmental Department. Other operating entities that are involved are the internal distribution, receiving, bulk distribution, and transportation services.

There are multiple key issues affecting the project. One of the issues affecting the project is the fact that every Monday morning inventory levels are extremely low, in addition to some other times throughout the week. Another issue is that the laundry cleaning system currently does not operate during weekends.

SCOPE OF PROJECT

There are many important issues included in the project that must be taken into account for project. Some of these important issues are the timeliness of the project, sequence of processes, laundry production, bulk distribution, internal distribution, collection and transport, rescheduling and restaffing of distribution, how the departments work together, end user issues, and receiving.

There are multiple issues that will be excluded from this project. Some of the excluded issues are the study and calculation of par levels and inventory levels, the different range of products, whether there is the correct type of product or not, advice or direction on how to manage the system, and the soiled collection subsection of the system.

APPROACH and METHODOLOGY

In this project, we have used several approaches.

Interviews

First, we have conducted interviews with Thomas Peterson, our client manager, who has guided and supported us with needed information on our project. During the interview, Tom Peterson gave us a brief introduction of the whole laundry system within the
University Campus explaining to us who and what is involved, and what is the current problem with the system. After the first meeting, we also scheduled multiple meetings with Tom to report findings, ask further questions, and report our progress on project.

Tour
A tour of the entire laundry system was conducted where Tom Peterson walked us through the entire process early in October. We began our tour at the loading docks in the hospital where the clean linens come in. We then went on to see the internal distribution in the bulk laundry room where the clean laundry was sorted and put onto push carts. The amount of laundry put on each cart was determined by the current need of each department. These carts were then circulated throughout the hospital to their pre-determined destinations. Once the carts arrived at their destinations, the proper amount of linen was deposited. Once the carts were empty, they were sent back down to the bulk distribution room to get refilled. The soiled linens get collected by housekeeping and are put into blue push bins that get sent down to the truck docks en route to the laundry facility on North Campus. The next part of our tour was visiting the laundry production facility to get an understanding of how the laundry was actually cleaned. This is a part of the process that we will not be concentrating on. After this tour, we were able to better understand how the entire laundry system worked.

Data Collection
Since one of our approaches is Simulation, we need to collect data in order to build our simulation model. First, we asked Tom Peterson about data that were needed and he supported us with as much relevant data that he had concerning our needs. He supplied us with laundry production reports, profile counts, bulk distribution reports, shortage reports, and distribution staff schedules. Also, we asked some of the staff from internal distribution to supply us with past demand data per department. The raw data that we actually collected by ourselves was the time data. The time data that we collected includes internal distribution fill time, actual delivery time, restock time (per department) and anything else that may have happened once they material services left the bulk
distribution room. This time data was collected using stopwatches. The next couple of paragraphs get into our data collection in more detail.

The demand of linens varies according to patient arrivals at the usage locations. Since different units/departments have their own policy on how to use the clean linens, it is difficult to approximate it into a mathematical data. After we collected Tom Peterson’s expert opinion, we tried to model location usage time as an exponential distribution since patient or customer always comes along with this kind of distribution.

The type and number of departments/units that can represent the whole hospital system are listed here. Since there are many departments/units in the hospital, Tom Peterson recommended the following 11 departments that will best represent the hospital system as a whole: Mott 5 East, Mott 5 West, Clinic A, Clinic B, Clinic C, ICU 8A, ICU 8B, ICU 8C, ICU 8D, Burn Trauma, and Emergency Room.

The following set of data is that which we collected at the hospital manually: The travel times of the linens between the distribution center and departments/units of the hospital are outlined here. Travel time includes the time linen take to be delivered to each unit and the time linens take to be unloaded at each unit. We collected the data by following the hospital employees with their linen cart and timing how long it takes to make deliveries from the distribution center to their respective units. We also timed how long the employees took to unload the linens. In addition, we took the time for employees to return to the distribution center from their respective units. We collected 10 sets of data in one week and we took the average between this data to be the estimated arrival time.

We also learned that before employees deliver the linens to the different departments, each employee checks the inventory level of linens of their respective departments. This is done every Monday through Sunday, once per day in the morning.

Simulation

One of the approaches that we used is a simulation of the process. A simulation model randomly reflects a given scenario, that “model”, or scenario being the laundry system in this case. We have tried to simulate the entire laundry system as accurately as possible within the confines of one semester. With an accurate simulation of the current process, countermeasures were tested to see what the best solution to the problem was. A flow
diagram of the laundry system has been included in appendix B. This part of the project took the most time because we tried to best model the situation within the confines of the simulation software, being ProModel 4.0. Building a simulation required us to identify exactly what the problem is, collect all of the needed data, build the actual model, accurately represent the current situation, and implement proposed countermeasures. In order to simulate the process, many different types of accurate data were required. For example, we needed time data (further defined later), staff schedules, meetings with different departments, demand data, and a very thorough understanding of the entire process. Every department will be involved, especially distribution (bulk and internal), material services, and laundry production.

Assumptions & justifications:

- **Assumption:** Eleven different departments can represent the whole hospital system.
  
  *Justification:* We assumed that the eleven different departments would best represent the hospital system because our contact, Tom Peterson, informed us that those units represent the highest, middle and lowest demand of linens within the hospital system.

- **Assumption:** The efficiency of cleaning facility does not affect the scheduling of deliveries to the distribution center.
  
  *Justification:* We assumed that the efficiency of the cleaning facility does not affect the delivery schedule to the distribution center because the hospital demands that the cleaning facility must make those deliveries on time. In addition, our contact informed us that the cleaning facility has not failed to make those deliveries even if the facility suffers a “setback”.

- **Assumption:** One entity will represent the most demanded linen.
  
  *Justification:* We assumed that an entity would represent the most demanded linen because it is too difficult and too complicated to capture all the different types of linen being used by the hospital.

- **Assumption:** “Black-boxing” the laundry facility outside the hospital is feasible.
  
  *Justification:* We assumed that “black-boxing” the cleaning facility is feasible because our main parameter of interest is the distribution of linens within the hospital system.
Assumption: The availability of laundry bins/carts is not constrained.

**Justification:** We assumed that the availability of the laundry bins/carts is not constrained because there are always plenty of bins/carts available when personnel deliver the linens.

The final model:

Our model simulates the hospital laundry system, which is divided into four major parts: the cleaning facility, the bulk distribution center, the different departments/units, and the collection of soiled linen. Each part has its own location and sub-location parts. We are now going to describe each part in detail.

**Cleaning Facility**

The cleaning facility only consists of one location and is named cleaning facility in our model. The cleaning facility is linked between the bulk distribution center and the soiled linen collection. The main task of the cleaning facility is to clean all soiled linen delivered from the hospital.

**Bulk Distribution**

When the linen arrives at the bulk distribution center, the linen is distributed. An entity called checker is an entity whose responsibility is to send information on the amount of linens that the entire department needs. This entity will first check that amount at each department and then send the information to the distribution center. This checking process is scheduled periodically once a day. The linen at the bulk distribution receives a signal and the linen is routed to the different departments within the hospital. The moving time of linen is different from each department. This moving time includes the loading time of soiled linen onto the trucks as they are leaving the distribution center.

**Different Departments**

We modeled 11 departments to represent the hospital system. Each department consists of two locations. One location represents the inventory and the second one represents the usage of linen. An entity called patient goes to the usage location to request a linen entity. After using the linen, the patient leaves the system and the soiled linen remains in the usage location to wait until it is routed to the soiled linen collection. Inventory in each
department decrease and at a scheduled time period, the checker sends the request information to the bulk distribution in order to replenish the inventory again.

**Soiled Linen Collection**

Soiled linen collection is the location where soiled linen is collected. Solid linen is transported to the cleaning facility by trucks.

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**CURRENT SITUATION**

The problem that frequently occurs within the laundry system is that the levels of linen get severely depleted or certain linens stock out before the material services department restocks. Many times, the demand for clean linens is higher than the clean inventory level in the bulk distribution room. That means the remaining inventory levels of some of the linens are equal to zero, which constitutes stock outs. Monday mornings typically have the lowest levels of inventory. Often, departments cannot get restocked for a period of time because, there was no laundry production over the weekends. It takes time on Monday morning for the clean laundry to hit the Hospital too. If the demand during the weekends is especially high, the inventory of clean linens on Monday morning is almost sure to be very low along with multiple stock outs.

Due to this situation, the patients and doctors may only receive a clean set of linens or clothing over a period of one to three days, patients may have to dry off with sheets instead of towels, and multiple sets of soiled linens may have to get reused. This is a serious issue because soiled clothing has potential health threats to the patients (and doctors) and law suits are just waiting to happen.

Since the hospital has not employed any measures to currently solve this problem, we are trying to find some immediate solutions to temporarily remedy the problem. We will call any immediate solutions, "short term solutions", and then we will move on and recommend what the "long term gradual solution" will be.

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**Alternatives**

**Short-term solutions**
Safety Stock
The idea of safety stock is retrieved from the concept of inventory control. It is a backup supply that is used to fulfill the extra demand of a product. In this project, we treat linens as the product and the departments and patients are the customers. Since it is very difficult to forecast the extra demand, safety stock can be functioned as a back-up supplier when the inventory level of the linen is low. Therefore, a safety stock in the laundry system should be accessed by material services only when inventory levels in the bulk distribution room are low.

Share system
Another alternative is the implementation of a "share system". Such a system would allow departments in need to share inventory from other departments that have sufficient levels. A system such as this would be set up in a simple manner where the departments in need would just put in a call to material services, and material services would do the deliveries between the departments. We will go into greater detail later about how to implement such a system in the action plan. This is the idea of the share system.

Long term solution
Adjusting the par level
The par level is a predetermined amount of linen. After a restocking, the level of linens in any given department should equal the par level. Occasionally, certain types of linens stock out due to the fact that the par levels for some departments are too low. If the par level of one type of linen is lower than the demand for that linen, this linen will easily stock out. Moreover, if the par level of one type of linen is more than the demand, this linen will be over stocked at most times. Therefore, adjusting the par level after studying which linens usually stock out, or are usually overstocked, can solve the long-term problem of the linen shortages.

Findings and Conclusions
A total of three scenarios were simulated. Each one of these simulations represents a worst case scenario. We were able to simulate the worst case scenario by setting up our model in such a way that demand is always high. We did not actually simulate actual demand within the laundry system, but rather included distributions within the model that simulate high demand scenarios. With these high demand scenarios, we simulated the current situation and provided a graph of results showing the number of stockouts given in hours. We also simulated one of our solutions, which was to include a safety stock, and have included its graph of results. Finally, we simulated another solution, which was adjusting our par levels and have also included its results. We have created a variable within the simulation that counts the total number of stockouts, so we can quantitatively compare our different solutions.

First, we simulated the current situation, where very low inventory levels and stockouts occur often.

This graph represents the results from the simulation of the current situation in Burn Trauma. From this graph, notice the points that almost touch the x-axis. This particular graph represents a stock out with these low points at an extended period of time.

The second scenario was the simulation of implementing a safety stock into the
system.
This graph represents the simulation of implementing a safety stock in Burn Trauma. Notice that the low points on the graph representing low inventory situations have quickly jumped back up to a level of increased inventory instead of remaining stocked out. This means that implementing such a system (safety stock) will reduce the chances and effects of stock outs.
The third scenario was simulating the adjusted par levels.

This graph represents the simulation of implementing adjusted par levels in Burn Trauma. Notice again that the low points representing low inventory situations and stock outs have been significantly raised. Again, this means that implementing such a system (adjusting par levels periodically) will reduce the chances of stock outs. Again, there was no data or model that we followed for adjusting the par levels. The point of our adjusted par levels simulation is to show that with increased par levels, the probability of a stock out gets greatly reduced.
We have, though, included within our action plan, a continuous par level study program that could get implemented.
From our simulation we have learned that implementing a safety stock and adjusting par levels will reduce stock outs. Implementing a safety stock is more of an immediate, short-term solution because at some time, the levels of safety stock would have to get re-evaluated also. We believe that the long term solution will come through a “Par Level Adjustment System”. This system would be set up is such a way using statistical quality control techniques to monitor stock out trends over chosen intervals of time.
We also conducted a study using profile counts data to extract information on which departments always have substantial levels of inventory. Here is a list of all the departments that we evaluated:

These are the departments that rarely or never stock out:

- 6A, 6B, 6C, and 6D
- Nuclear Medicine
- PICU/A
- Mott O.R.
- 4 EMCHC
- Holden 4 MCHC
- Neurology
- Pediatric Surgery
- Physical Therapy
- Neurosurgery
- 5C
- 5 Mott

These are the departments that would be called upon by Material Services to share their inventories if needed in the “Share System”. Appendix A shows our studies.

**Recommendations**

From our findings and conclusions, we recommend implementing a safety stock into the system. This will reduce or potentially solve the stock outs problem, there will be no need to re-evaluate the par levels, there will be no need to severely modify the existing laundry system, and this will solve a shortage problem during times of laundry production downtime.

We also recommend the implementation of a “Share System”. This will reduce or potentially solve the stock outs problem, there would be no capital expenditures, it is a very simple system, and it will solve a shortage problem during times of laundry production downtime.

In addition to all of that, we further recommend implementing a “Par Level Adjustment System”. This will reduce if not remedy the stock outs problem, there will be no need to implement any other remedy or system, and it is also relatively simple.

Realistically, we think that the “Share System” should be implemented because of its simplicity, and low investment costs. Actually implementing a system such as this is outlined in our action plan. We believe that the next recommendation that should be seriously considered is the “Par Level Adjustment System”. We think this because there are potential low costs. Actually implementing a system such as this is outlined in our
action plan. Finally, we think the "Safety Stock" solution should be considered last because there is cost associated with it. Actually implementing a system such as this is outlined in our action plan.

**Limitations**

We should advise that there are limitations associated with each one of these recommendations. The "Share System" could potentially create a need for a new position within Material Services called "A Runner" who makes deliveries to and from different departments. To remedy this potential situation though, we have thought up a remedy, which will be outlined in the action plan.

The "Par Level Adjustment System" solution has potential disadvantages also. There could be an expenditure of buying more linen, there may need to be increased laundry production levels, and more transportation may be needed.

The "Safety Stock" solution has potential disadvantages too. There would be a capital expenditure for more linen, it is possible for safety stock to stock out, and there could be potential abuse of safety stock. For example, material services may pull inventory from the safety stock when not needed, thus depleting the system.

**Action Plan**

The "Share System" action plan involves multiple, simple steps for implementation. First, a list of departments that rarely or never stock out will be devised and given to material services for reference. These departments will be listed in order from least likely to stock out, to most likely to stock out (though each department was chosen because of its low probability of stocking out). A procedure will be distributed to all departments on how to properly utilize the share system. This procedure will outline that material services is to be contacted and how to put in an order for more linens. Finally, there are two options to choose from on how to deliver the linens from one department to another. The first and least desirable option is to create a new position called "A Runner". This person would work under material services and be responsible
for transferring linen from one department to another. This is least desirable though because of the costs involved with an added employee. The second option is to give everybody in the material services department pagers. When a delivery is needed, and material services has decided which department it is going to pull inventory from, the material services employee closest to the involved departments will be paged. From there the employee calls material services back and finds out where he needs to go. From there, a delivery must be made. In addition, before inventory is actually pulled from a certain department, material services needs to get permission from the department in which they would like to pull from. If inventory eventually gets pulled from a department, this must be dated and documented for the purposes of keeping a record and to exclude those days in the reassessment of par levels.

The "Par Level Adjustment System" action plan also involves multiple steps for implementation. Statistical analysis must be utilized here to determine the needed change in par levels. The statistical analysis used would be random sampling of historically affected departments on every Monday morning spanning over a period of every three months. The data that would be collected would be a count of the number of times certain linen stocks out. This data would be plotted on X bar and R charts. This would show whether or not there is an acceptable level of stock outs, by showing either an in or out of control chart condition. Management, such as Tom Peterson will set the acceptable levels. By using a tool such as this, management would be able to determine if the set par levels are adequate. In addition, management would be able to monitor how other recommendations have had an effect. Another tool that could be utilized is an inventory control model method. This methodology utilizes the probability of stock out situations, setup costs, lead-time, and the demand. Using this methodology will help aid in recalculating the par level.

The "Safety Stock" action plan also involves multiple steps for implementation. First of all, an area within the laundry production facility would need to be set up for the extra stock. We have determined this because of the fact that there is very little room in the hospital and there is under utilized room in the laundry facility. Next would be to invest in a pre-determined amount of new linens. Thirdly, setting up a system on how to actually call for and transport the linens must be accomplished. For example, when
internal distribution gets low on inventory, material services would have call the laundry facility and arrange for a delivery of more clean linens to the hospital. Finally, a memo must be devised and distributed to all departments on how to properly utilize the safety stock system.
<table>
<thead>
<tr>
<th>DEPARTMENTS STUDIED</th>
<th>Stock outs?</th>
<th># of days there was no stock out</th>
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<tr>
<td>1 OB/GYN</td>
<td>Yes</td>
<td>0</td>
</tr>
<tr>
<td>2 5 MOTT</td>
<td>Yes</td>
<td>2</td>
</tr>
<tr>
<td>3 Dermatology Clinic</td>
<td>Yes</td>
<td>0</td>
</tr>
<tr>
<td>4 Pediatric Clinic</td>
<td>Yes</td>
<td>0</td>
</tr>
<tr>
<td>5 6A, 6B, 6C, 6D</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>6 Burn</td>
<td>Yes</td>
<td>0</td>
</tr>
<tr>
<td>7 E.R.</td>
<td>Yes</td>
<td>0</td>
</tr>
<tr>
<td>8 5A</td>
<td>Yes</td>
<td>0</td>
</tr>
<tr>
<td>9 5B</td>
<td>Yes</td>
<td>0</td>
</tr>
<tr>
<td>10 5C</td>
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</tr>
<tr>
<td>11 5D</td>
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</tr>
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<td>12 7A, 7C, 7D</td>
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<tr>
<td>15 UH Recovery</td>
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</tr>
<tr>
<td>16 Nuclear Medicine</td>
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<tr>
<td>17 Neurology</td>
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</tr>
<tr>
<td>18 PICU/A</td>
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<tr>
<td>19 Mott OR</td>
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<tr>
<td>20 Pediatric Surgery</td>
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<tr>
<td>21 4EMCHC</td>
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<tr>
<td>24 Recovery Room/Radiology</td>
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<tr>
<td>25 Holden 4MCHC</td>
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<tr>
<td>26 4B, 4C, 4D</td>
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<tr>
<td>27 Orthopedics Surgery</td>
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</tr>
<tr>
<td>28 Neurosurgery</td>
<td>No</td>
<td>3</td>
</tr>
</tbody>
</table>

The rows with a star next to them indicate that there were no stock outs at all between 10/26 and 10/28. The rows with an O.K. next to them indicate that there was only one stock out between 10/26 and 10/28.
Flow diagram for system simulated

Eleven Departments within Hospital

DIRTY LINENS STORAGE

CLEANING FACILITY Outside Hospital

RECEIVING Arrival of clean linens

BULK DISTRIBUTION