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VA Linen Distribution Optimization

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VA Linen Distribution Optimization

A Major Qualifying Project Report submitted to the Faculty of
Worcester Polytechnic Institute

In partial fulfillment of the requirements for the Degree of Bachelor of Science

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Authorship Statement

This project was accomplished by three students from Worcester Polytechnic Institute majoring in Industrial Engineering: Joaquin Serrano, Silvia Zamora-Palacios and Xuanya “Bill” Zhang. Throughout the project, each student accomplished distinct tasks based on their strengths. Joaquin Serrano led the meetings, designed the specific signals for the project and served as the primary contact for all professional communication between the team and VA staff. Silvia Zamora-Palacios conducted the majority of interviews with hospital staff, photographed current state and new design, and collected data for the project. Xuanya “Bill” Zhang calculated Par Level and safety stock, compiled the notes from meetings and created different diagrams for the project such as the Value Stream Map, SIPOC diagram and Gantt Chart, etc. The students worked as a team to conduct time studies, observe the process and identify the undesirable effects in the current system. Together, the team designed the Future State and carried out the trial implementation in pilot areas of the VA Boston Healthcare System, West Roxbury Campus. Finally, this report was completed as a team effort.

Abstract

Linen is a backstage service that is critical for a hospital's functioning. Our team created a refill and distribution system to optimize linen use at the VA Boston Healthcare System-West Roxbury Campus, by applying lean concepts to improve process efficiency with the goal of providing the best patient care. A trial implementation was conducted to evaluate the feasibility and efficiency of the design and to inform recommendations for future implementation of the project.

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1.0 Introduction

The mission of the Department of Veterans Affairs (VA) is: “To fulfill President Lincoln's promise ‘To care for him who shall have borne the battle, and for his widow, and his orphan’ by serving and honoring the men and women who are America’s Veterans” (Department of Veterans Affairs, 2010). The VA has to find the best ways to allocate its resources to provide that care to the veterans of the United States. The Veterans Health Administration (VHA) is one of the three administrations in the VA and is charged with providing medical care to veterans. The VHA manages 152 medical centers and numerous outpatient clinics in order to provide the service for veterans across the country. This administration has several divisions based on location, such as the VA New England Healthcare System (VISN 1). VISN 1 covers six New England States and has facilities located in the following cities: Togus, Maine; Manchester, New Hampshire; White River Junction, Vermont; Providence, Rhode Island; New Haven and Newington, Connecticut; and Bedford, Boston and Northampton, Massachusetts. Clinical and support services are required to keep a hospital afloat. Linen services are a crucial part of the healthcare system that requires continual monitoring and improvement.

In this project, we focused on linen distribution at the VA Boston-Healthcare System - West Roxbury Campus. Linen distribution is a service that needs to be present for a hospital to function. Limited attention or resources have historically been invested for its proper functioning, which provided the project team with great untapped improvement opportunities. Such improvements could represent cost savings for the VA as well as improved employee productivity and customer satisfaction.

Environmental Management Services (EMS) is in charge of linen distribution for the VA Boston Healthcare System -West Roxbury Campus. EMS charged with linen distribution, and additionally sanitation, waste management, pest control, uniforms, station-level signage, and limited interior design functions (Department of Veterans Affairs VA Boston Healthcare System, 2012). The department used to have 1700 ft² linen room but was relocated to a 700 ft² room due

to a new construction in the hospital. This relocation has presented several challenges for the EMS to continue providing reliable distribution of linen. The nursing staff depends on these to provide their service to the veterans. The space reduction along with various other issues has put the system under stress. A new and more efficient system is needed to help EMS to continue to providing its services to the nurses so that they can deliver the best patient care.

1.1 Project Goals and Objectives

The goal of the project was to optimize the linen distribution system in the VA Boston Healthcare System – West Roxbury Campus by eliminating waste and improving the efficiency of the process, with the primary purpose of standardizing and simplifying the process while meeting quality goals. The team set the scope of the project to be the linen distribution process within West Roxbury VA facilities, focusing on the EMS and nursing staff interaction within the process. The Laundry Service was considered out of the scope even though it can have an impact on the linen distribution process. This decision was made because the Laundry Service launders the linen for all of VISN 1, which includes 11 medical centers and numerous outpatient clinics, creating a much larger scope and greater variability. Particular areas of the hospital were selected as pilot areas of study for the project, to explore small and large units with different linen needs. A Lean problem-solving approach was employed to accomplish the project. In order to accomplish the project goal, the WPI team established three objectives for this project, as described below.

First, the team decided to understand the Current State of the linen distribution process in the hospital. This included having a complete understanding of the guidelines and policies in place and how closely these are being followed. We strived to understand the linen distribution in all the different depth levers (roles and responsibilities, measures and incentives, skills, structure, and culture) and worked alongside the nurses and EMS staff that directly interact with the process.

Second, the team designed a Future State for the linen distribution process. To accomplish this, we studied the current state of the system, identified the major issues with the system, and understood what changes would have the most impact on the system.

Third, the team implemented the future state and evaluated the outcome of the new design. This was accomplished by identifying the improvements achieved, the areas that needed further work, obtained feedback from the users as well as from the management, and determined the user and customer satisfaction.

The team created three different metrics to evaluate the system. The metrics served as measurements of the system performance and provided an understanding of the system. This understanding demonstrated the progress towards the team's goals.

1.2 Report Organization

The report has been organized into eight different sections, as follows. In Section 2, a literature review is provided, including a background study of the tools utilized in the project as well as a case study of a linen improvement process.. In Section 3-Methodology, the specific steps taken by the team to accomplish the project are explained; it also clarifies how the information provided in the Literature Review served as guidance. Section 4, the Current State of the System, details the current process in place, the main players of the linen distribution at West Roxbury Campus, and identifies the opportunities for improvement identified. In Section 5, the Future State Design, the system designed by the team to address the existing opportunities for improvement is explained. Section 6, Pilot Area Testing and Trial Implementation, presents the process, outcomes and reflection of a one-week trial implementation of the new design in two pilot areas in the West Roxbury Campus. Section 7, Conclusions, summarizes the project, and includes reflections on the learning experience and how the stated goals of the project were accomplished. Finally Recommendations, Section 8, includes the suggestions provided by the team to the sponsor about the next steps required to truly pursue the optimization of linen use within the West Roxbury Campus.

2.0 Literature Review

In order to start the project, research needed to be conducted in several dimensions. First, there is a description of the data collection methods selected based on the type of research required. This is followed by information regarding the VA culture and policies. Then, there is an explanation of how to determine the linen par levels and cart quotas for different hospital areas. This is continued by a list of the steps to successfully implement Six Sigma in an organization. Finally, a case study is presented as an example for a successful Six Sigma implementation project where linen loss was reduced and the textile resources in the hospital were optimized.

2.1 Data Collection Techniques

In order to conduct a proper scientific analysis, data and information regarding the process and involved personnel needs to be collected. Knowing what information is necessary and how to properly gather it not only saves time and resources but it also prevents “contaminating” or unintentionally altering the data. Data collection should start after determining the focus of the research, the measurable parameters, and the barriers for evaluation.

Selecting what information will be gathered is vital for a successful research. There are two types of information: descriptive and judgmental. Descriptive information is all sorts of data that illustrate objectively the historic or current state of a process. For example: demographic data, reports of project accomplishments, policies, and types of participants. On the other hand, judgmental information is the subjective data provided by people affected in anyway with the process. For example: opinions from experts, consumer preferences, and target audience’s beliefs and values. (The Ohio State University, 2010). To acquire a full understanding of the current state of the linen process at the West Roxbury Campus, both types of information were selected for the research. The descriptive information was obtained from several sources, such as: policy documentation, refill request log notebook (area of the hospital, linen item, amount, time, and day), assigned quota for each area, staff schedule, capacity of patients per area and daily linen

order to the laundry vendor. The judgmental information was mostly obtained by interviews of the current users; linen distribution staff, nursing staff and management.

The most commonly used methods for data collection are outlined in Table 1, with examples specific to linen distribution:

Table 1: Data Collection Methods

Data Collection Methods	Example for this Project
a) <u>Behavior observation checklist</u> : list of behaviors among participants being observed.	<ul style="list-style-type: none"> • EMS response to refill requests • Nursing staff’s objectivity regarding when a linen item is running “low”
b) <u>Opinion surveys</u> : an assessment of how a person or group feels about a particular issue.	<ul style="list-style-type: none"> • Most used linen items per area according to the nursing staff
c) <u>Performance test</u> : test the ability to perform a particular skill or task.	<ul style="list-style-type: none"> • EMS refill request lead time
d) <u>Questionnaire</u> : a group of questions that people respond verbally or in writing	<ul style="list-style-type: none"> • Linen average and maximum amount for one patient in each area
e) <u>Time series</u> : measuring a single variable consistently over time (daily, weekly, monthly, etc.).	<ul style="list-style-type: none"> • Daily amount of unused linen returned to the EMS storage room
f) <u>Interviews</u> : individual or group’s responses, opinions or points of view.	<ul style="list-style-type: none"> • Users and management interviews
g) <u>Physical evidence</u> : residues or physical proof observed	<ul style="list-style-type: none"> • Unused linen in side closets and carts
h) <u>Records</u> : Information from files, records or receipts	<ul style="list-style-type: none"> • Linen refill requests log notebook

(The Ohio State University, 2010)

Another aspect needed to be taken into consideration when selecting the data collection methods is to avoid any sort of issue or informative conflict. These issues are:

1. Availability: Be certain that the information soon to be collected has not yet been available to the researchers in prior records, interviews, summaries, etc.

2. Pilot testing: Test the data collection instruments or process design before using in the actual research environment.
3. Interruption potential: Avoid methods that can be constantly interrupted by any given reason; this will affect the consistency of the information collected and altered the outcome of the research.
4. Protocol needs: Make sure to have the appropriate permission or clearance before collecting certain information or contacting people.
5. Reactivity: Focus on “how” the question is being asked in order to obtain the most honest answer.
6. Bias: The researcher collecting and analyzing data has to be unbiased, otherwise, the outcome of the research will not be the most “real” one.
7. Reliability: Make sure the evaluation process is consistent; it will always measure the same thing each time it is used.
8. Validity: Make sure the information being collected is relevant and that are actually producing the information planned to be measured.

(The Ohio State University, 2010)

While collecting data, it is important to think simultaneously how the information should be organized, analyzed, interpreted and reported to the interested audience. This will facilitate future data collection for missing information and the development of the analysis itself, allowing a successful and rich outcome for the research.

2.2 VA Culture and Policy Documents

Due to the different services offered to the veterans and their families, the Department of Veterans Affairs is formed by many divisions and departments. Each division follows a well-defined command chain, where each hierarchy level has established specific responsibilities, work interactions and relationships with other departments. It is important for the project to understand the culture of the VA in order to work with them and not overstep any boundaries.

The work culture at the VA follows the guidelines of the military, because a percentage of the employees at the VA currently work for the U.S. Military or has previously worked there. Military-lingo is common among the employees; however, when interacting with civilians, employees avoid military jargon. Moreover, the authority of higher hierarchy in this entity is stronger and more perceived than in other organizations.

Each VA division has a handbook, where the purpose, policy and responsibilities of each department within the division are detailed. The proper procedures and protocols for each of the different positions are included in the handbook. These handbooks are constantly revised by upper management of each division to guarantee that the best practices are being used to satisfy the needs of the United States veterans.

2.3 Determining Par Level and Safety Stock

In hospitals, the significant unpredictability in the number of patients cared for throughout the day, week, month and year is well known. A regular patient could utilize pajamas, johnnies, pillow cases, fitted and flat sheets, blankets, towels, pink pads, and face cloths. The usage of each individual item fluctuates significantly compared to each other depending on the illness that each patient has. Due to this variability, the linen distribution centers in hospitals must determine a par level that will sustain the maximum amount of linen needed on a daily basis at each area without increasing wastes and costs. A common practice for the hospital Linen Industry is to calculate the par levels of linen (The Laundry Forum, 2012). The coefficient for safety stock varies according to the specific facility it is being used in. The Chief of Laundry Services VISN 1, states that the formula to determine the par level is:

$$Usage = Avg. usage of each linen item per bed$$

$$Changes = Avg. changes of bed per day$$

$$Beds = Total beds in unit/ward$$

$$Par Level = Usage \times Changes \times Beds \times 1.33 \quad \text{where } 0.33 \text{ is the safety factor}$$

Even though the quota is a good approximation of the maximum demand of linen in an area, in reality, some items do run out before the end of the day and refills must be requested. Nonetheless, the nursing staff cannot wait to request the linen refill until their area has completely run out of this item. The nursing staff must request the linen refill when they have reached their safety stock. In order to determine the safety stock for each item of linen of a specific area in the hospital, many analysts use the following formula:

\bar{L} = average lead time (refill delivery time)

\bar{D} = average periodic sales

σ_L = standard deviation of lead time

σ_D = standard deviation of periodic demand

z = service factor

$$\text{Safety Stock Level} = SS = z\sigma_{SS} \text{ where } \sigma_{SS} = \sqrt{\bar{L}\sigma_D^2 + \bar{D}\sigma_L^2}$$

(Resources Systems Consulting, 2011)

2.4 Successful Implementation of Lean Six Sigma

Six Sigma has proven to be a successful management strategy focused on improving quality of a product or service by removing defects, minimizing variability in the process and gaining customer satisfaction. Even though this approach has led many organizations to succeed, it has also condemned organizations that failed to implement it correctly. Before implementing Six Sigma, it is important that managers and executives fully understand and support this method. It is equally important they understand their own company or organization. (Gupta, 2001).

A common misconception is that Six Sigma simply improves quality; it actually focuses on improving profitability as well. It is for this reason that one of the first aspects a manager needs to learn about the company is the cost of poor quality (COPQ). The COPQ is the initial financial analysis performed for a Six Sigma project, which seeks to identify the four costs of poor quality in a company: internal failures, external failures, appraisal and prevention (Sharma, 2010). By understanding the waste streams in a system, it facilitates the identification of the

areas that have direct impact on profitability. After detecting these areas, managers must create a plan to reduce or eliminate the waste streams and variability in the process.

There are several characteristics in an organization that indicate that implementing Six Sigma would not be beneficial, unless there is a drastic change. The most important characteristics are:

- a) The quality focus and objectives are not clearly defined and communicated along all the employees.

Possible solutions:

- Weekly informative meetings with all staff members
- End of the month individual goals evaluation

- b) There are no measurements to track operation performance (COPQ, reject rate, rolled yield, cycle time, inventory levels, employee skills development, financial performance, design effectiveness, etc.).

Possible solution:

- Implement a system to track process cycle time

- c) Centralized decision-making; executives are the only ones making the decisions without the input of the employees dealing with the problems on a daily basis.

Possible solution:

- Managers request weekly/monthly input of their department staff

- d) Employees are afraid of management.

Possible solutions:

- Create a “trust” and open environment
- Incentives program for efficient/outstanding employees

In order to overcome these negative characteristics in an organization, the executives must establish a focus for the organization, a business initiative and implement performance measurements. Moreover, all the employees must understand the direction to where the organization is moving and have passion to achieve improved results (Gupta, 2001).

“Lean” is a widely used term referring to the methodology for process improvement. It consists of a comprehensive set of techniques to eliminate the seven wastes, improve quality, add value for customers, and reduce production time and cost. Taiichi Ohno, the father of Toyota Production System, defined the seven wastes as following: Defects, Overproduction, Transportation, Waiting, Inventory, Motion, and Over Processing. In order to eliminate these wastes and increase the productivity of a system, major tools are utilized such as, Continuous Process Improvement (Kaizen), Root-cause Analysis (Fishbone diagram), and Error-proof Design (Poke-yoke) (Wilson, 2010).

Lean was originally derived from the Toyota Production System (Wilson, 2010). Then it was widely adopted by companies in manufacturing industry as Toyota dominated the automobile market utilizing Lean production practice. In the recent decade, the impact of lean has expanded to service industry as well. Due to its variability, healthcare industry has great opportunities for improvement (Institute for Healthcare Improvement, 2005). Many healthcare organizations have actively implemented Lean approach to conduct process improvement projects, providing better and more cost-effective care to the patients.

A successful implementation of Lean requires a systematic approach to understanding the processes before changes are made. The DMAIC method used in Six Sigma is a common method for guiding Lean implementation, by breaking down the tasks into five major steps: define the goals of the project, measure the performance of the system, analyze the data collected, improve the existing processes, and control the implementation to ensure the sustainability of success (DMAIC Tools - Six Sigma Training Resources, 2013). Other commonly used technique for Lean implementations is the A3-PDSA Problem Solving approach. PDSA stands for Plan-Do-Study-Act. This simple technique not only presents the root cause of the problem, but also analyzes the steps needed to solve the problem and evaluates future improvements for the process (ASSEMBLY Magazine, 2013). Six Sigma and Lean are two strategies focused on continue improvement in a process; however, these two strategies are frequently combined into one single program to enhance the improvement of a system (University of California - Irvine, 2013).

Visualization of the process is helpful for the analysis of the system. One of the most efficient ways is to include all the steps into a map, which also takes into account the value for the customers. Value stream mapping (VSM) is usually utilized by a Lean Implementation team

to position process improvement strategically. A Current State Map provides an effective visual representation of the existing system (VHA Office of System Redesign, 2011). Within the map, the opportunities for improvement, also known as undesirable effects (UDEs), are specifically marked; their solutions represent the major design parameters for the next step, the Future State Map. The Future State Map depicts the ideal system. An implementation is created as the guideline to transition from Current State to Future State. An example of a Value Stream Map is found in Figure 1.

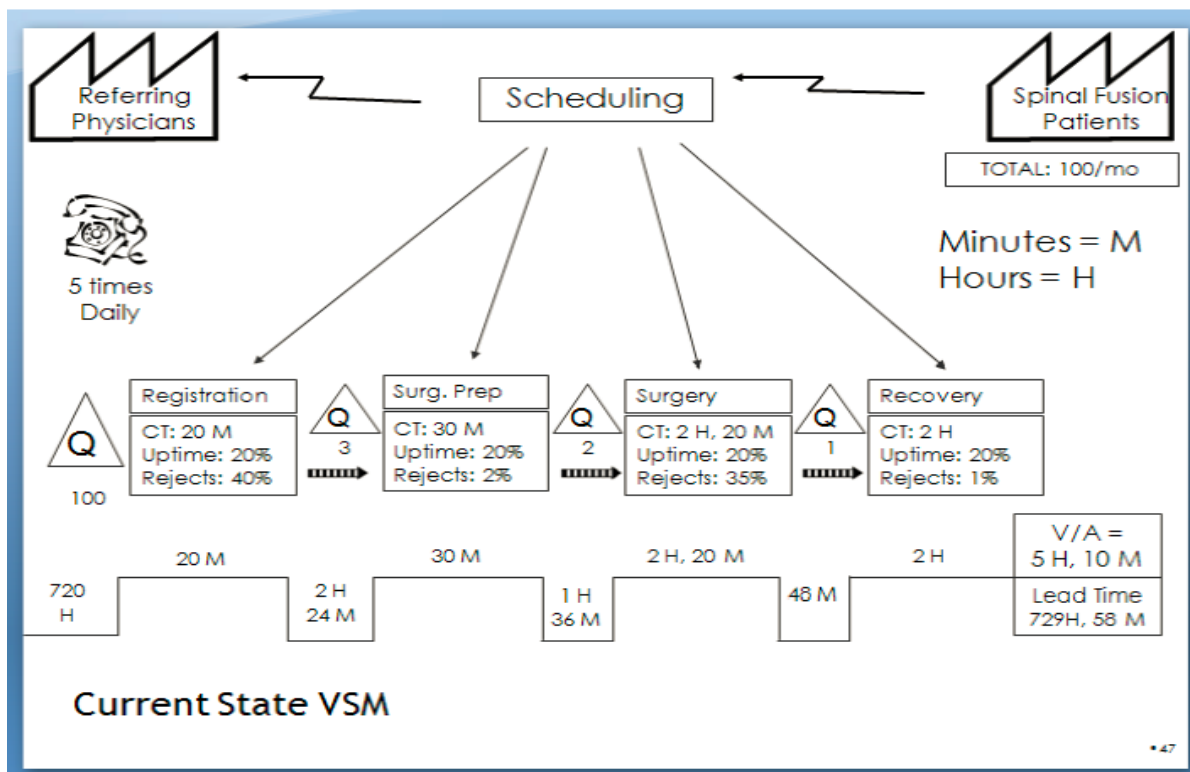


Figure 1: Value Stream Map Example

Besides a systematic approach, process owners and champions are crucial to the success of a Lean Implementation. The process owner is in charge of the designing, measuring, guiding and advocating for the Lean Implementation (Hammer, 2011). This role is commonly played by the functional manager of the process in place. The champion plays a supportive role that ensures the proper resources and management commitment (Process Excellence Network, 2013). This

person is a senior manager that is invested in making the process change happen in the organization.

2.5 5S/6S Application

In a workplace, much of the time is lost due to lack of organization. According to an estimate from VA Healthcare, nurses spend more than 40% of their time trying to locate information, equipment or materials required for patient treatment (VA TAMMCS, 2011). Finding necessary documents, important inventory or tools could be a time consuming process which does not add any value to the product/services. 5S is one of the Lean tools specifically aimed at eliminating waste and variability by better organization of the workspace. The scope of the 5S projects is typically small and the duration short. However, such a simple and practical approach could greatly improve the performance.

The 5S are respectively: Sort, Set in Order/Straighten, Shine/Scrub, Standardize, and Sustain (VHA Office of System Redesign, 2011). These could be applied to implementation in linen distribution as follows:

- Sort: Nursing and EMS staff in the workspaces (EMS storage rooms, clean linen room, soiled linen room and linen closet) needs to categorize all items and place them into appropriate locations.
- Straighten: Nursing and EMS staff define designated and convenient locations near point of use for regular used items (linen, linen related tools), and move these items to these locations. Visual Controls are created for these locations. Potential tools could be: labels, signage, dashboard, or tape.
- Shine: Staff cleans the workspace and clears all the trash, dirt, scraps, leaks, dust, etc. A schedule of cleaning needs to be created considering the priority of the areas. (Waste baskets should be emptied regularly.)
- Standardize: Nursing and EMS staff define and agree on the standard work instructions together for the tasks related to linen usage. Regular reporting will be required to monitor the implementation of the standard work. Staff should also be trained in order to start the implementation of standards.

- Sustain: Head Nurses and EMS Directors will be engaged in the implementation and maintain of the 5S projects. Incentives for the employees will be provided and audit of certain frequency will be conducted.

The 6th “S” is Safety. It is originally not included in the 5S technique but the awareness of employee and customer safety is raised. In a healthcare organization, such matter is extremely important since the services are closely related to the health of patients. Therefore, including safety as part of 6S is necessary and appropriate for our project. Additionally, this also aligns with VA’s goal of building a robust health care system (Department of Veterans Affairs VA Boston Healthcare System, 2012). During the 5S projects, safety was a major consideration in every step. After the implementation of 5S, all the changes in the workspace were evaluated against safety standards.

2.6 Case Study: Applying Lean Six Sigma to reduce Linen Loss in an Acute Care Hospital

As mentioned previously in this chapter, linen loss is very common problem in hospitals. For this reason, a case study was developed by a student of the Southern Polytechnic State University focused on reducing the linen loss of a hospital by implementing Lean Six Sigma practices into the system (Furturer, 2011). The study was conducted in 2011 at the Holy Cross Hospital, in Ft. Lauderdale, FL, USA., explained the current state and strategy development along the five different phases of the DMAIC (Define-Measure-Analyze-Improve-Control) methodology and other key lean concepts.

In the *Define* phase of the problem statement, the goals and the SIPOC (Supplier-Inputs-Processes-Outputs-Customers) diagram are established. In the problem statement, the two main problems are mentioned: the baseline soil to clean linen ratio is 3.86% and the goal is 5%, and in a period of 6 weeks in 2010, the hospital lost \$18,101 in linen. Therefore, goals were focused into solving these two major problems. The SIPOC diagram (Figure 2) developed in the case explains in great detail who is involved in handling the linen and how the process works.

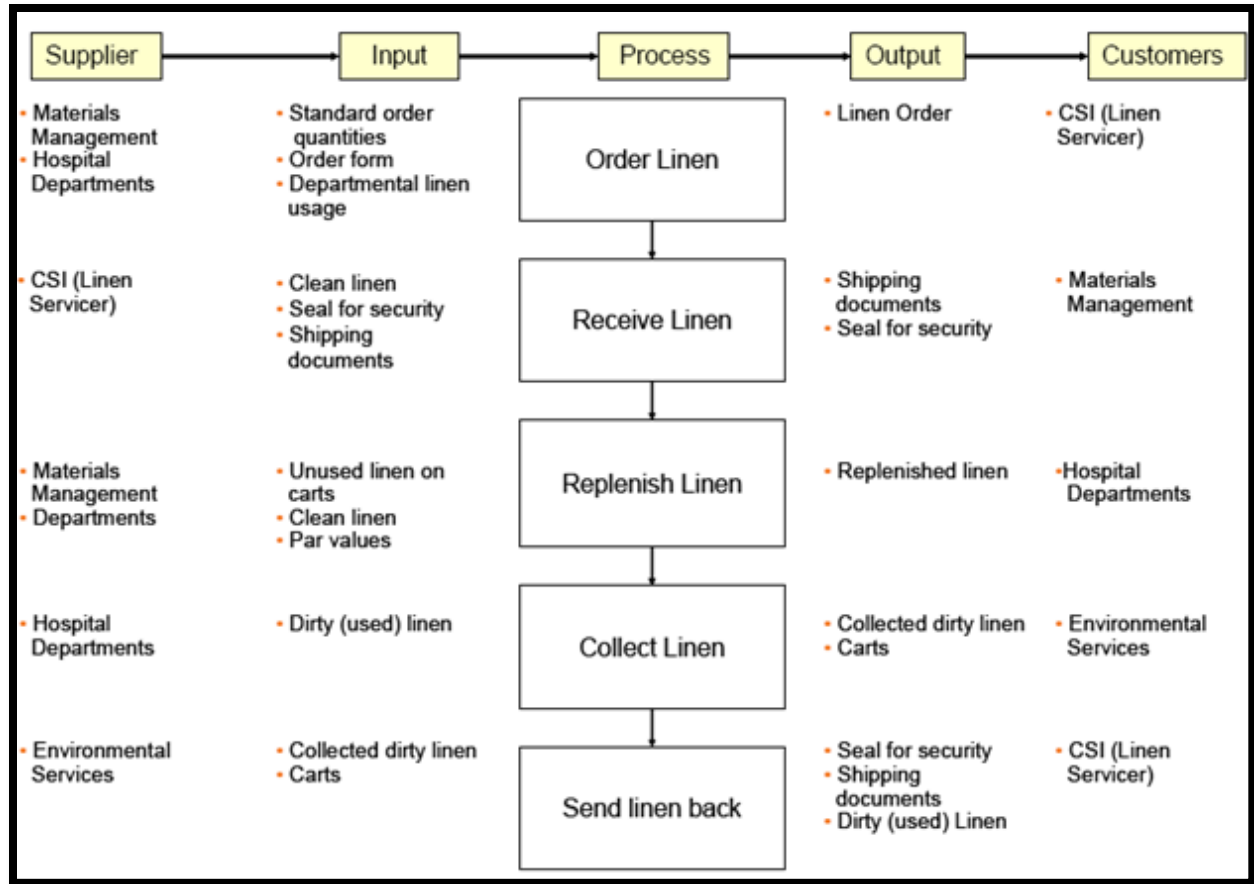


Figure 2: SIPOC Diagram (Furturer, 2011)

The *Measure* phase, Furterer defined the current process, the detailed voice of customer (VOC), the voice of process (VOP), the current performance, and validated the measurement system to make sure it was accurate. Figure 3 illustrates the current state for a part of the process and Table 2 displays the data collection plan.

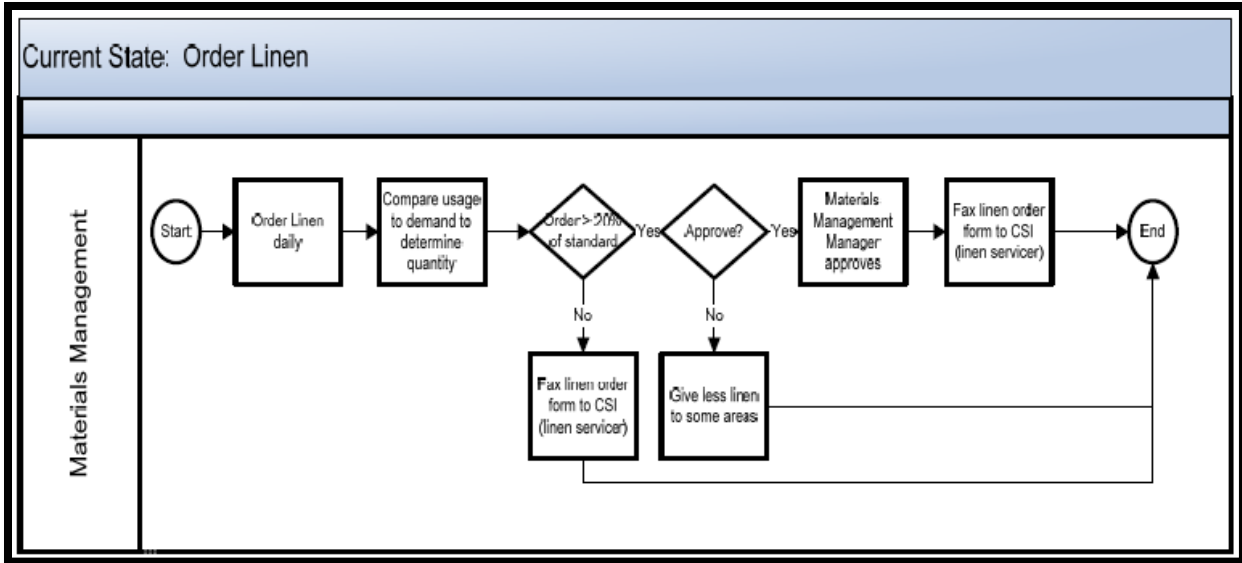


Figure 3: Current State Chart (Furturer, 2011)

Table 2: Data Collection Plan (Furturer, 2011)

Critical to Satisfaction	Metric	Data collection mechanism	Analysis mechanism	Sampling plan	Baseline
Linen loss	Soil to Clean Ratio: $(1 - (\text{Clean} / \text{Soiled})) * 100\%$	CSI linen service provides these numbers	Basic statistics	1 st quarter 2010	$(1 - (434,737/452,183)) = 3.86\%$
Linen usage: appropriate use of linen	Pound per adjusted patient days: Pounds linen delivered / adjusted patient days * 100%	CSI linen service provides these numbers	Basic statistics	April 2010	10.46%
Annual linen replacement cost	Annual cost of replacing linen	CSI linen service provides these numbers	Basic statistics	Q1 and Q2, 2010	Scrubs: \$27,271 Linen (not scrubs): \$347,750 Total: \$375,462
Annual linen processing cost	Cost of processing linen	CSI linen service provides these numbers	Basic statistics	Q1 and Q2, 2010	Scrubs: \$17,004 Linen: \$600,674 Total: \$616,677

For the *Analyze* phase, Furturer explained the different formulas to calculate the soil to clean linen ratio as well as cause and effect relationships were developed. An interesting diagram in this phase is the “Why-Why Diagram”. In this diagram (Figure 4), the paper presents the different possible scenarios that explain why linen is lost in the hospital.

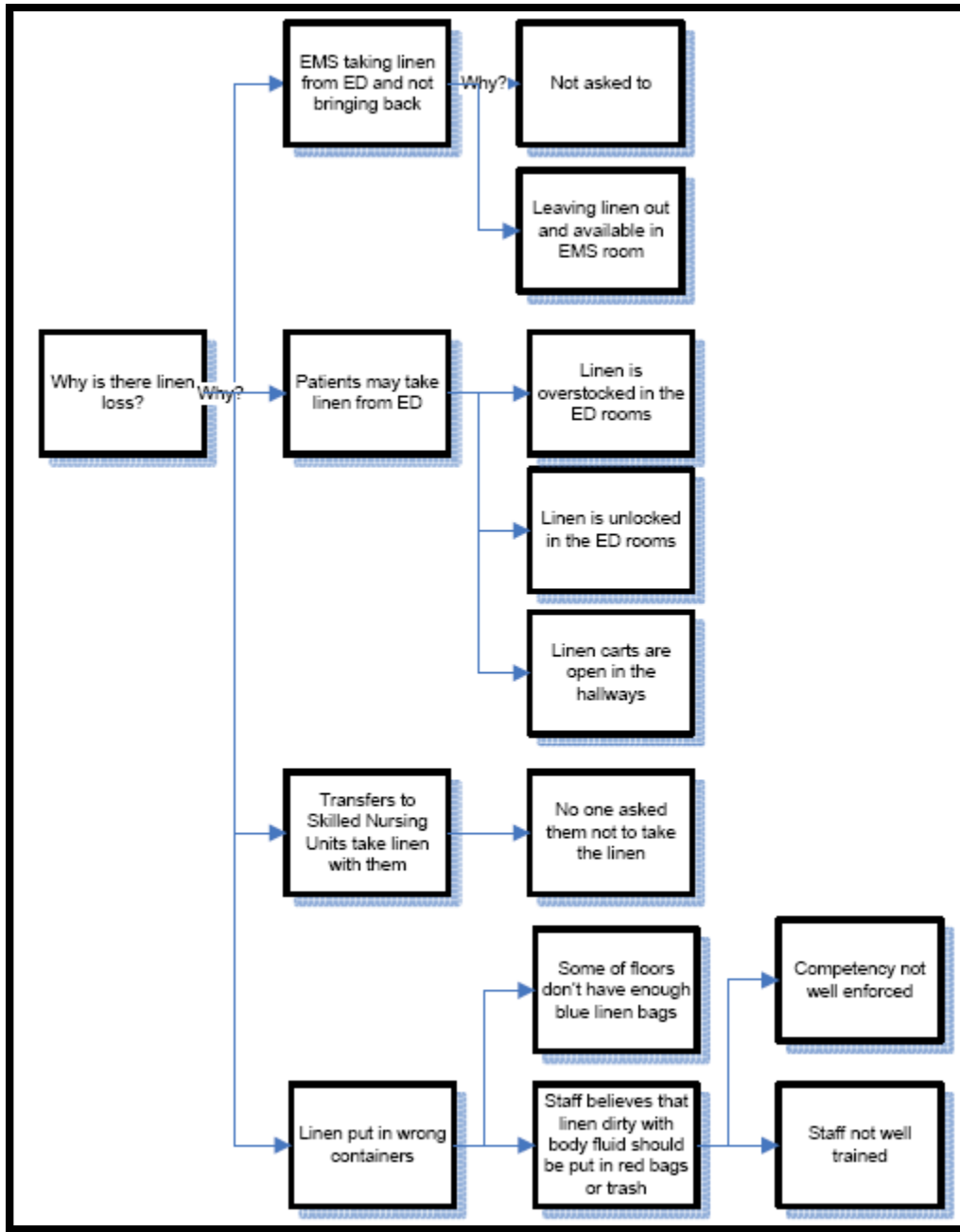


Figure 4: Why-Why Diagram (Furturer, 2011)

After concluding with the *Analyze* phase and identifying the root causes of linen loss and low soil to clean linen ratio, the *Improve* phase was set in motion. In this fourth phase, different improvement opportunities and plans were identified, a cost/benefit analysis was conducted, a future state was designed, performance targets and project scorecards were established, and pilot improvements were implemented.

In the fifth and last phase, the *Control* phase, the outcomes of the implemented pilot activities were measured. Moreover, a control plan was developed to monitor the system throughout time and avoid the previous situation from happening again. The control plan is shown in Table 3.

Table 3: Control Plan (Furturer, 2011)

Metric	Control Mechanisms	Actions to be taken if problems occur	Responsibility
Soil to Clean Ratio	Measure soil to clean ratio quarterly	Linen Committee implements further improvements	Linen Committee
Pounds per Adjusted Patient Day	Measure pounds per adjusted patient day		
Annual Linen Replacement Cost	Measure linen replacement cost quarterly		
Annual Linen Processing Cost	Measure linen processing cost quarterly		

One year after implementing Lean Six Sigma into the linen process, the hospital saved \$77,480 and reduced the soil to clean linen ratio by 16%. This case exemplifies how successful an organization can become by properly implementing Lean Six Sigma in their process. By carefully analyzing the given data and understanding the performance of the organization, root causes for problems will be identified and an appropriate improvement plan can be developed. This case study provided us with many key ideas and steps to follow in order to accomplish a similar outcome.

3.0 Methodology

The goal of this project was to improve the linen distribution system of the VA Boston Healthcare System - West Roxbury Campus. We accomplished this goal through the following objectives:

1. Understand the current state of the linen distribution process
2. Design a future state linen distribution process, and
3. Work towards the implementation of the future state process and evaluate possible outcomes

These objectives were met using three Lean tools: Value Stream Mapping, 5S techniques and a SIPOC chart. Multiple Value Stream Maps were created for both Current State and Future State conditions of the system. 5S projects were conducted in pilot areas to help organize the Linen Storage locations. The SIPOC approach was utilized to have a high level understanding of the entire process. In addition to these three tools, we also conducted data collection (time study), process observation and personal interviews to incorporate the input as well as feedback from VA nursing and EMS staff.

The team recognized that it was not practical to study the whole hospital due to the size of the hospital and the 21-week duration of the project. In order to address this, we strategically selected three focus areas based on the data collected and the guidance of the EMS Assistant Chief. After careful analysis we selected the following areas: CT Scan, PCU and 3 North. These areas were recommended because the nursing staff was interested in collaborating towards improvement. Moreover, each area represents one of the three types of areas in the hospital: a small area, a unit, and a ward. Focusing on these areas allowed us to learn and obtain a general idea of the current linen distribution process in the entire hospital. The team sought to test and implement aspects of the future state design in two of these pilot units.

The project group identified the major stakeholders to be the nursing staff, linen staff, housekeeping, and patients. Attitudes of major stakeholders were taken into account through the Value Stream Mapping sessions, with the exception of the patients and housekeeping. Due to the time constraint for the project, the team was capable of interacting mostly with head nurses and the staff from the EMS morning shift. A weekly timeline can be found in Appendix A detailing the schedule followed to implement the following methodology.

3.1 Determining the Current State

The first step of our plan was to understand the current state of the linen distribution process at West Roxbury Hospital. A Value Stream Map (VSM) was created to understand the detailed steps of the linen distribution as well as to identify existing improvement opportunities in the system. The VSMs can be found in the Appendix section. In order to create the VSM, we first shadowed the EMS linen staff during their distribution rounds and linen cart preparation during the first two visits, while interviewing them about the process and current problems in the system. Based on the linen staff's and EMS Assistant Chief's input, the EMS VSM was created. Then, the team did group interviews with the nursing staff of each selected area. During the group interviews, we created the VSM using their input from post-its on a white cardboard. This method was also an effective communication tool between the project team and the staff. It demonstrated our understanding of the current process and collected knowledge about the existing system from the hospital's employees. We completed the Current State Value Stream Map at the end of the 14th week of the project.

3.1.1 Data Collection, Observation, and Metrics

A valid VSM should have the input from the front-line staff but it should be based on observations and data to support it. Some may argue that these measurements of the system may slow down improvement projects. However, many studies have shown that a systematic improvement plan generated from accurate data analysis is much more effective and efficient than “fire-fighting” problems without a well-structured approach (VHA Office of System Redesign, 2011). Additionally, basing our decisions for the improvement areas on data analysis helped us focus on the problems that are more urgent and have a greater impact on the system.

The team determined what data was necessary to understand and improve the process. For the linen distribution process, we were interested in understanding the following:

- Linen inventory amount for each area
- Real linen demand by area
- Linen usage by area
- Delivery time of the process
- Linen refills lead time
- Linen refill request frequency by area
- Linen refill request process
- Linen distribution staff working hours and capacity
- Quality information about linen
 - Stock-out frequency for linen in different areas
 - On-time delivery rate of the linen

Data collection in the project focused primarily on the process. Each individual team member followed one of the linen distribution staff through their morning delivery trips. During the shadowing, times were recorded when they picked up the clean linen from EMS Storage Room, delivered to the linen closet, and the time they spent in the linen closet before returning to EMS. The same time studies were used during the morning clean-up process where the linen staff brought container carts for soiled linen.

Observation of the process was also utilized to understand the current system. During the shadowing trips with the linen staff, team members took notes about potential opportunities for improvement. Without interrupting the process, these direct observations served as the first hand information about the system. They were compiled and compared to the results from meetings and interviews.

The refill of the linen closets was taken into consideration as another focus of the project. Based on the interviews with the nursing staff and EMS linen staff, we determined this was the most important problem in the distribution system. This part of the process reflected the lack of trust in the system as well as a lack of standardization in the refill process.

The team established three metrics for evaluating the system throughout the project. These metrics are Linen Order/Delivery Ratio, Linen Usage per Area, and Linen Refill Lead Time. The Order/Delivery Ratio provides insights on the supply of linen received from Brockton Laundry Facility. The Usage per Area indicates what the demand for linen is in each area. Finally, the Refill Lead Time demonstrates the capacity of the EMS Linen staff for the refill process. Table 4 below contains details for each of the three metrics explained in this section.

Table 4: Project Metrics

Metric	Formula	Control Mechanisms	Actions to be taken if Problems occur	Responsibility
Linen Order/Delivery Ratio	Ordered / Delivered	Inventory reception of linen from delivery	Contact Brockton immediately and implement further improvements with Linen Committee	Immediately: EMS Supervisor Future: Linen Committee
Linen Usage Per Area	Morning Delivery + Refill + Afternoon Delivery - Returned	EMS data collection and counting	Contact Linen Committees	Immediately: EMS and Head Nurse Future: Linen Committee
Linen Refill lead time	Time of Delivery - Time of call = Hotline time to pass message + EMS Staff time to deliver	Data collection point throughout refill process	Help Desk and EMS Supervisor	Immediately: EMS and Head Nurse Future: Linen Committee

3.1.2 Interviews and Focus Groups

The data and observation results provided the team with a general idea about the linen distribution system. However, visiting the hospital several times was not enough to give us the entire picture of the system. By incorporating the knowledge of the staff into the data, value was added to the Current and Future State Value Stream Maps created by the team. For this reason, informal interviews were conducted during the visits with the EMS staff and nursing staff. A pool of questions was prepared before the visits and team members asked them during the visit. Further questions were added during the conversations when the team members found it necessary.

3.1.3 Mapping of the Current State

After collecting process data information and completing the current state VSM, several meetings were held with focus groups of the different stakeholders in the system to investigate the accuracy of the map and its details. In these meetings, we showed our current state VSM to both the EMS staff and the nursing staff and requested for their feedback and any missing data points. This ensured the real system was well reflected on the VSM. With both value-added and non-value-added steps, the team was able to streamline and simplify the linen distribution process to increase its efficiency. Our goal was to eliminate non-value-added steps as much as possible without impacting the robustness of the system. It was a crucial section of the project since all downstream designs were based on this Current State as the foundation.

3.2 Designing the Future State

With the Current State VSM, we were able to identify several improvement opportunities and unnecessary steps in the system. The Future State VSM was created by examining the opportunities for improvement and considering the constraints of the system to create feasible solutions to address these opportunities. We completed the future state value stream map at the end of the 15th week of the project.

3.2.1 Identifying Opportunities for Improvement

The Current State VSM as well as the input from the process owners was utilized as the main source for identifying opportunities for improvement. The potential solutions were created

based on the opportunities for improvement. To determine the potential solutions, the team conducted several brainstorming sessions amongst the group as well as with the process owners and stakeholders at the VA.

3.2.2 SIPOC Approach

After coming up with potential solutions, the team used a SIPOC approach next. SIPOC stands for: Supplier, Input, Process, Output, and Customer; the five important components of a system. This process-oriented tool is a systematic way to investigate a system and map its flow. A high-level view of the process was created by dividing the system into these five significant elements. Suppliers to the process are those who provide the materials, services and information. Inputs are the actual materials, services and information provided by suppliers which go into the process. Process steps are how the system adds value to the inputs and yields outputs. Outputs are the final product/service of the process. Finally, Customers of the process are the ones benefiting from or receiving the outputs. The process steps are where the greatest potential for improvement lies. For this project, the VSM and SIPOC were combined and utilized for the analysis. The SIPOC approach helped the team in creating a more detailed future state that would take into account all the parts of the system. This approach helped the team create the key elements of the process such as the refill process, the par levels, and cart quota. Figure 5 illustrates the SIPOC chart for our study.

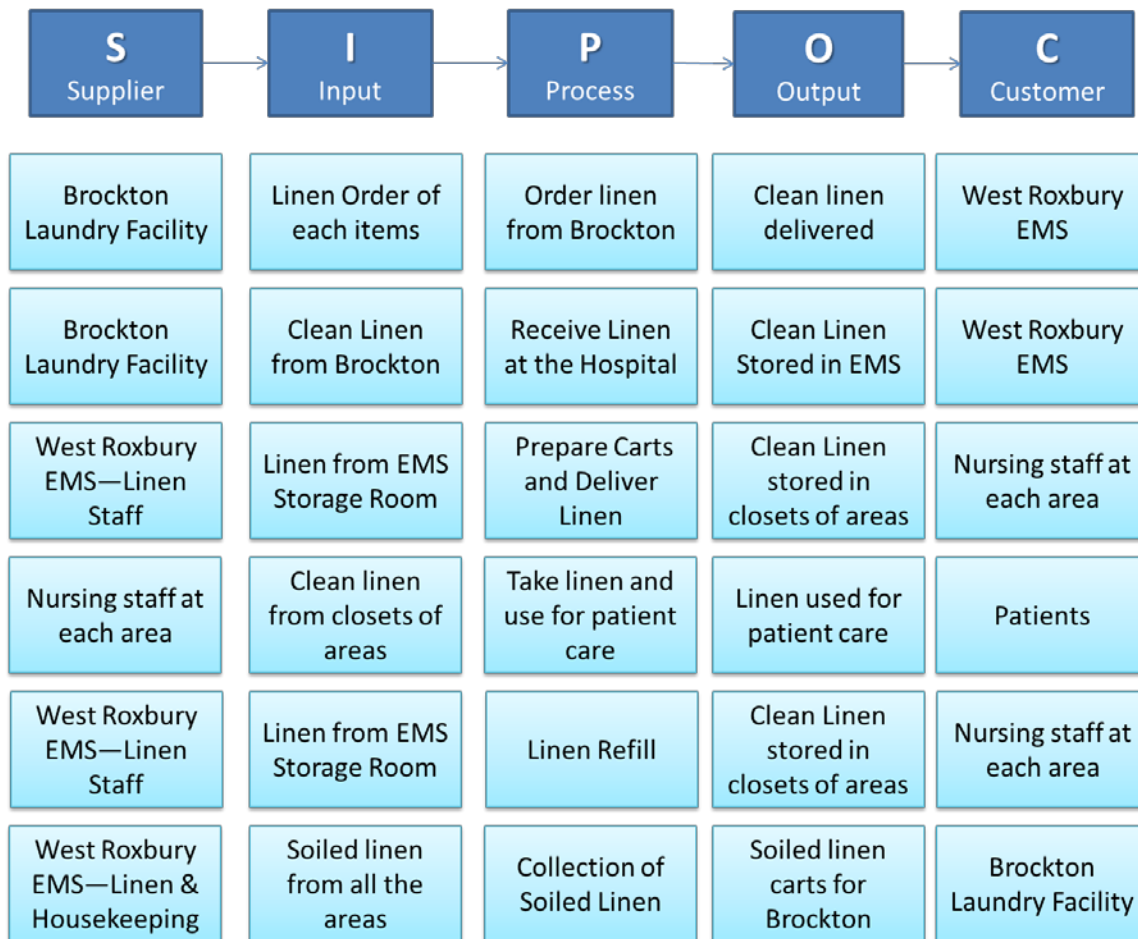


Figure 5: SIPOC Chart

3.2.3 Determining the Par Level and Cart Quota

Accounting for the variability of the linen demand in a hospital was a challenging part in the design of the Future State. The SIPOC analysis helped the team look at the system in a holistic manner and understand how everything was interconnected. Determining the Par Level was a vital step that helps understand the demand for linen in each area enabling the team to determine a Cart Quota for each area. In order to determine the new par and cart quota for the three pilot areas, the team used the following data:

- Number of beds per area
- Amount of each linen item used per patient in average and in outstanding situations that required a larger use of linen (maximum amount), and
- Average changes per day per area

The second and third data points were given to the team by the nursing staff of each area.

The par levels were calculated using a formula provided by the Chief of Laundry Services for VISN1. This formula is:

$$\text{Par level} = \text{daily consumption} \times \text{number of beds} \times \text{avg. changes per day} \times 1.33$$

where

$$1.33 = \text{safety stock}$$

As previously mentioned, the daily consumption of linen varies per item and area. The average changes per day can fluctuate between 1-3 changes per day depending of the type of area in the hospital: wards, units, or small areas. In case of 3 North, the selected pilot area representing the wards, the value used was 2. For PCU, the pilot area representing the units, the value used was 1.5. For CT Scan, the pilot area representing small areas, the value used was 1.

To calculate the cart quota, we divided the par level by half and evaluated if this amount would fit in the current linen carts. After running this test, we estimated a preliminary quota. We then took into consideration the amount of linen found in each bundle of linen (e.g. a bundle of towels has 24 towels). By working with sets of bundles, the linen cart preparation process will be faster, easier and more accurate. By taking these factors into consideration, the team was able to determine an accurate and efficient cart quota for each pilot area to be used in the Future State.

3.3 Testing and Implementing Aspects of the Future State

After developing the Future State VSM, the team chose particular elements to test and implement. For the trial implementation phase of the project, we utilized 5S lean techniques. Carrying out all proposed changes at the same time may not be most favorable strategy since each change has an impact in the system and affect its results. Due to the time constraints, the team decided to work towards preparing the environment to successfully implement the future state, and tested the trial implementation in pilot areas. This process was started during the 18th week of the project and continued until the end of the project in week 21.

4.0 Current State of the System and identification of Improvement Opportunities

The current state of the linen distribution system when we started the project was convoluted and confusing. People knew how it worked because they used it on a daily basis, but the system as a whole had never really been looked at and understood. Several revisions of the current state map were required in order to get a full understanding and representation of what was actually going on and how things were done. In this chapter, we describe the general process of the linen distribution system and then break down the general process into the detailed processes that happen within the different areas involved in the system. We conclude by identifying the opportunities for improvement within each specific area that were discovered as a consequence of describing the current state.

4.1 General Process

In order for each bed at the hospital to be prepared with a clean set of linen, three different departments work together to make it happen. These three departments are the Laundry Service, the Environmental Management Service (EMS), and the nursing staff. VISN 1 shares many resources and laundry is one of them. All linen for the VISN is washed at Brockton and then transported back to the respective medical centers. EMS at West Roxbury places a daily order every weekday to the Laundry Services in Brockton, ordering the linen for the next day. These orders could include up to sixteen different linen items. A truck arrives from Brockton on the following day with the clean linen that was ordered. This linen is used by the linen staff to fill up the carts for each unit and ward with their respective quotas that same afternoon. The carts with the clean linen are then delivered by the linen staff the next morning, and the linen is used by the nurses and housekeepers as needed. The lead time from when the linen is ordered until the time it could get to the nurses for usage is at least three days. Whenever the nurses see that the linen levels are running low, they call EMS staff to request a refill. Finally, when the linen is used and becomes soiled, it is disposed of and sent back to Brockton for washing, completing the linen cycle. The locations where linen is stored throughout the system are the following: EMS

Storage Room (located in the ground floor of the West Roxbury Campus), linen carts, and linen closets and side closets. The general outline of this process is shown in Figure 6.



Figure 6: Process Outline

4.2 Specific Process Divided by Area

As mentioned before, three different departments work together throughout the linen distribution system; these departments are the Laundry Services, the EMS, and the nursing staff. After careful consideration, we decided to set the scope of our study to be the EMS and the nursing staff interactions within the linen distribution process. The Laundry Services are out of the scope of our study because they process the linen for all of VISN 1 which includes the 11 medical centers in New England. The focus of our project was to understand and optimize the linen distribution within the West Roxbury Campus, so we determined Laundry Services was out of the project scope because it worked within a much larger area. The EMS and nursing staff interact constantly throughout the process in order to get clean linen to every bed and patient in the hospital. Each department has several internal processes involving linen, and several processes related to interactions between each other as well. These can be broken down into the reception of linen from Brockton and the delivery to each area of the hospital by EMS, the usage of that linen by the Nursing staff, and finally, the refill and collection of the soiled linen by the EMS to send back to Brockton again. These interactions are depicted in Figure 7.

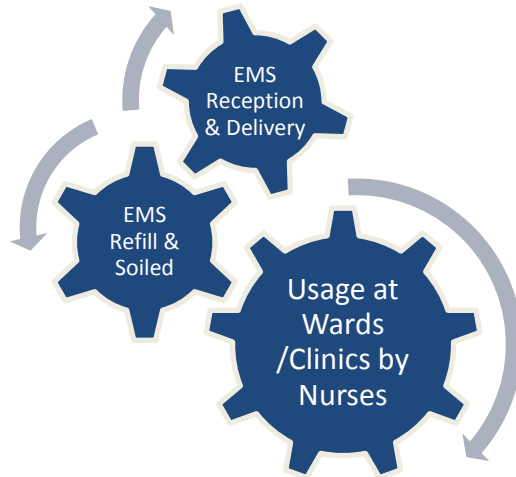


Figure 7: System's interactions

4.2.1 EMS Linen Reception

In order for the linen to be delivered every weekday, the EMS Linen Supervisor places a daily order by phone to Brockton requesting the linen to be delivered the following day. The order for Tuesday is placed on Monday, the order for Wednesday is placed for Tuesday, the order for Thursday is placed on Wednesday, the order for Friday, Saturday, and Sunday is placed on Thursday, and finally, the order for Monday is placed on Friday. Clean linen arrives by truck to West Roxbury from Brockton in big tubs with transparent plastic covers to protect the linen inside from possible contamination during transportation. The EMS staff receives the linen at the docking area and transports it to the Linen Storage Room, where it is sorted into the respective shelves or left in the tubs if the shelves are full. This process is depicted in the process flowchart in Figure 8.

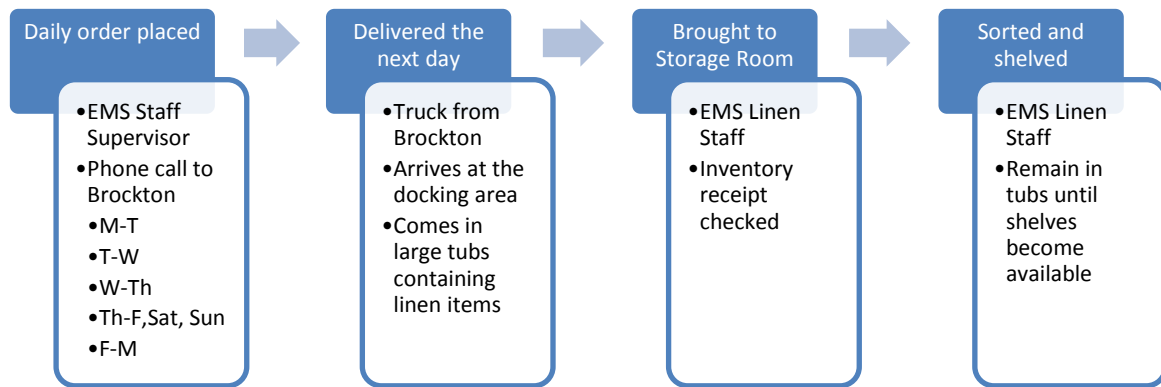


Figure 8: EMS Reception Process Flowchart

4.2.2 EMS Linen Delivery

Once the linen that was delivered from Brockton is brought down to the Linen Storage Room, it is ready to be distributed to areas of the hospital. The linen staff on first shift fills up the carts for each area with their respective quotas and leaves those carts ready to be distributed the next morning. The linen carts are delivered to each area between 6 am – 9 am each weekday morning. There are two carts for every area, one that is always in the linen closet of that area, and one that is in the Linen Storage Room. In the morning, when the carts are delivered, the ones with clean linen are swapped with the cart that was delivered the previous day. The used cart in the closet is then brought down to the Storage Room to be refilled so that it can be exchanged the next day. The linen staff then goes out to all areas and refills the isolation gown tubs between 7 am – 9 am every weekday morning. A process flowchart of this can be found in Figure 9.

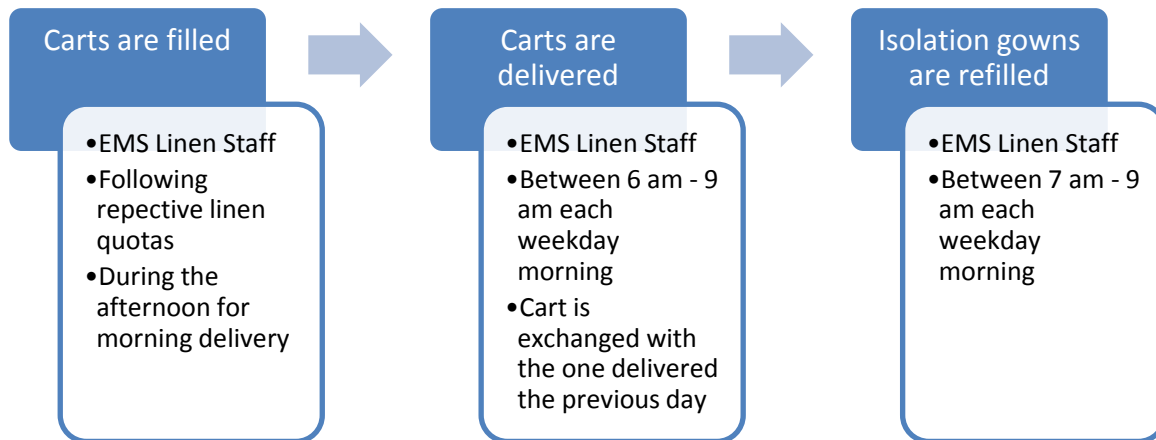


Figure 9: EMS Morning Linen Delivery Process Flowchart

4.2.3 Linen Usage by the Nursing Staff

Once the clean linen is delivered at each area’s closet, it is ready for use by the nursing staff when needed. The nursing staff refills the side carts and side closets after the clean linen is delivered. The nurses and nursing assistants refill drawers outside each room with yellow prevention gowns after the large tubs are refilled. Nurses, nursing assistants, and housekeepers then utilize the linen as needed throughout the day by taking it from the side carts or closets, and bringing it to the patient who needs it. When the linen gets soiled, the nursing staff or Housekeeping disposes of it in the soiled linen bags located in each individual room. Housekeeping is responsible for taking the soiled linen bags every day to the soiled linen closet and placing them inside the empty tubs located there. Finally, whenever the nurses believe that the linen is running low, they call EMS to request a linen refill. A process flowchart of this can be found in Figure 10.

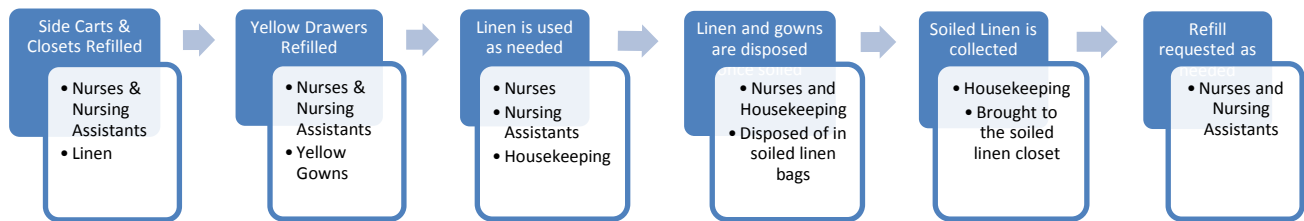


Figure 10: Linen Usage Flowchart on Nursing Unit

4.2.4 EMS Soiled Linen Process

Once the linen is utilized, becomes soiled, and is deposited in the soiled linen closet in every area by housekeeping, the linen staff collects it in the afternoon. The soiled linen bags should be placed inside the empty tub left in the closet, but currently there are not enough tubs to have one in every area. The linen staff brings the tubs filled with soiled linen to the entrance of the EMS Storage Room, and the tubs are brought to the docking area before the truck from Brockton is due to arrive. At the docking area, a green cover is placed on top of each tub to help identify that they all come from West Roxbury. When the truck arrives with clean linen tubs, these are exchanged with the soiled linen tubs and taken back to Brockton for washing. A process flowchart of this can be found in Figure 11.

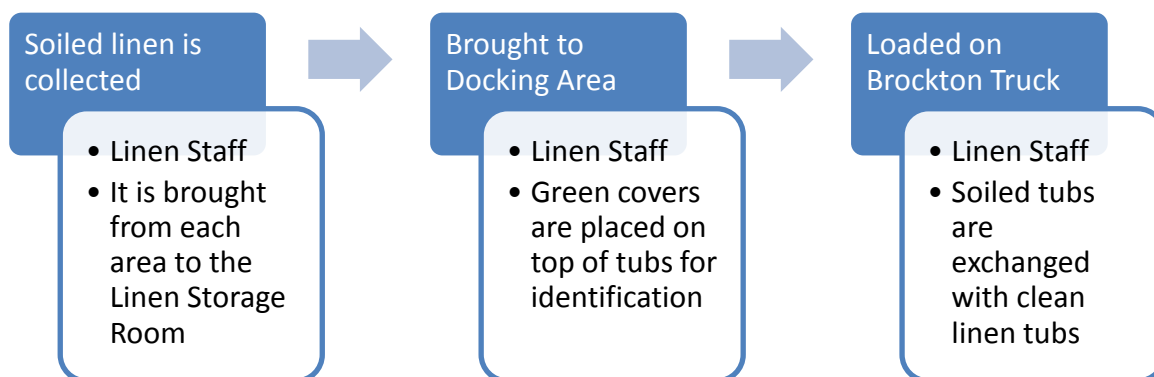


Figure 11: Soiled Linen Process Flowchart

4.2.5 EMS Linen Refill Process

In the processes described so far, there is no direct interaction between the nurses and the EMS. Each of them rely on the other's work to be able to perform their daily duties; nurses depend on EMS being able to deliver clean linen in order to provide adequate care for veterans, and EMS depends on the nurses utilizing the linen so they would need to restock it again. However, the linen refills require a direct interaction between the two departments. When the nurses deem that the linen levels are running low, they call the EMS to request a refill. The call could be made to the EMS Help Desk for all the facilities in VISN 1 or to the EMS Storage Room if the request is in the West Roxbury facility. If the call is made to the EMS Help Desk, the person in charge creates a ticket for each call and contacts the Linen Staff personnel to inform them about the request. This contact could be made by the following seven methods:

- Stopping the EMS Linen Staff as they walk in front of the EMS Help Desk
- Walking down to the Storage Room
- Calling the phone in the Storage Room
- Contacting a supervisor
- Paging the linen staff
- Leaving a note hanging on the EMS Storage Room.

Once the linen staff is contacted, they proceed to collect the linen that was requested, record the linen item and the area it is going to, and bring it up to the respective area. If the call goes to the Storage Room, then the linen staff will log the same information in the linen log notebook located in the EMS Storage Room and take it up to the respective area. The afternoon linen shift will check the linen levels only for the hospital's wards and refills them as necessary. A process flowchart of this can be is shown in Figure 12.

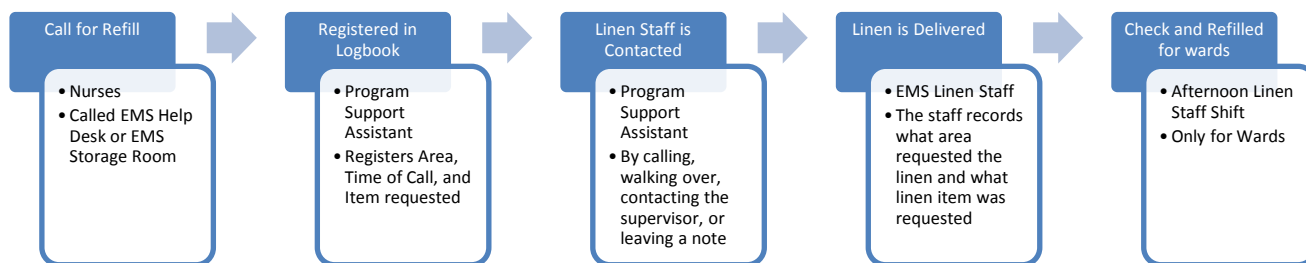


Figure 12: EMS Linen Refill Process Flowchart

4.3 Data Collection

The system has very little to no data collection in place, which created difficulties when trying to understand the process. In order to understand the system, the team attempted to create a data collection plan. One of the major components of this plan was conducting time studies to understand the lead time of the morning delivery of linen. After three sessions of data collection and shadowing of the EMS Staff, it became clear that the lead time for the morning delivery of linen was not critical to the project so the team stopped the data collection efforts. Valuable data was provided by the EMS log notebook, where all the linen refills are documented. This provided the team with a better understanding of the amount, time, and frequency of the refill orders in the pilot areas.

4.4 Opportunities for Improvement

The process maps of each sub process helped the team to understand the current state of the linen distribution process. At the same time that we were studying the process and understanding exactly what happened to make it function, we were able to discover opportunities for improvement within the system. These opportunities could be categorized into undesirable items in the system, poor practices by the different departments, constraints within the system, and miscommunication throughout the system. In the following section, we will detail the opportunities for improvement found in each specific step of the process explained in the previous section. The EMS delivery and soiled linen sections are not mentioned below since they did not show any substantial opportunities for improvement.

For receiving linen, there is no standard or metric by which to validate or indicate how much linen should be ordered in the daily phone call to Brockton. The EMS supervisor places the order every day based on some set standards in some cases, personal observations, and experience of the fluctuation of linen that day in the Storage Room. There is an opportunity for improvement here by creating a systematic way of ordering the linen that will reflect the actual inventory and current usage of the linen. There is no specific system to bring down the tubs and to organize them in the Storage Room. Even though the EMS's space is limited, having an organized and systematic way of placing the tubs and rotating them to fill in the shelves with clean linen would be beneficial in many ways. By having an organized system for the tubs, the supervisors will clearly know how much linen they have on inventory and could place more accurate daily orders to reflect the demand and usage of the linen. The shelves that are located in the EMS typically have an assigned item, but this practice is not followed at all times and shelves are not labeled.

There are several opportunities for improvement in the linen usage by the nursing staff. To begin with, there is no standard as to how much linen should be taken from the linen closet for every bed change-over. Since it is left for personal interpretation, it inevitably varies from nurse to nurse. This allows for situations where nurses take extra linen into the rooms that is not used and has to be rewashed unnecessarily. There is also high fluctuation in the demand for linen in two dimensions: from one area to another and within each area from day to day. This affects the usage of the linen and makes the system even more complex and harder to serve. It was also discovered that some of the items delivered in the carts do not reflect the actual need of the specific wards or areas, indicating that the quotas have not been updated recently. Finally, the linen inside the carts was cluttered and unorganized when delivered. This lack of organization makes it hard for the nurses to extract the linen items from the carts as well as makes it harder to predict how much linen is actually in the carts at any given moment.

For the linen refills there were several opportunities for improvement since it involved the most complex part of the system where both departments directly interacted. The nurses call for a refill whenever they feel that the linen levels are running low. There are no parameters to measure this or a standard of what "low" indicates. It was also not established who was responsible for calling and to whom they should be calling. There was very limited

communication throughout the system making it impossible for the nurses to know whether the EMS had already been contacted, resulting in multiple calls made for the same request, wasting nurses' and EMS's time. Ultimately there was a lack of trust in the system as a whole. The consequences of this lack of trust are that nurses hoard linen when they fear certain items are running low as well as borrow linen items from other wards or units. Sometimes housekeepers would be asked to go directly to the Linen Storage Room to obtain the required linen from the Storage Room instead of calling the EMS Help Desk for linen refill. Please refer to the Appendix section to find the Value Stream Map referred to in this section.

5.0 Future State Design

After a careful study of the opportunities for improvement described in the Current State chapter, we designed a Future State for the linen distribution system that would address each opportunity. The Future State describes the way the new system ideally would operate within the following four areas: Quota, Organization, Signal System for the Refill Process, and Standard Practices. A trial implementation of elements of this proposed future state is described in Section 6. This section first explains the tools we propose be implemented in the future state, and then an explanation of how these tools would be used by the different stakeholders in the process is provided. The Future State Value Stream Map can be found in the Appendix section of the report.

5.1 Modified Quota

As mentioned in the Methodology, the par level is the maximum daily usage of linen in a certain area and is calculated utilizing a formula based on demand and safety stock. The baseline calculations for each area's quota are determined based on the input of the experienced nursing staff, the calculated quota, the capacity of the linen carts, and the previous working quota. The quota is revised as needed at the quarterly meetings between EMS and nursing heads to ensure that the nurses are able to provide the best care for the veterans.

5.2 Environment Organization (5S/6S)

To facilitate the standardization processes, it is important to have a clean, organized, and efficient working environment. The different areas that are encompassed in the material flow of the system are the EMS Linen Storage Room, the linen carts, and the linen closets located in each unit. In the following section, we describe how each of these areas is organized following a 5S approach. In order to sustain the organization throughout all the different areas, the EMS supervisors conduct a bi-yearly audit to each of the areas.

5.2.1 EMS Linen Storage Room

The EMS Storage room has a designated area for each different linen item stored in tubs as well as a rotation system. The designated areas are clearly marked on the floor so that each tub is easily located in its corresponding location. A rotation system is in place to ensure a First In

First Out (FIFO) movement of the tubs through the system. FIFO is a practice that guarantees the proper rotation of items in a system where the first item to go into the system will be the first one to be extracted. Moreover, there is designated shelf space for each type of linen item, which is clearly labeled and clearly visible. Once shelf space becomes available, the linen items are moved from the tubs to the shelves so that they can later be utilized to fill the carts or for refill requests. Having a systematic rotation system and an organized EMS Storage Room facilitates the ordering process for linen from Brockton by providing the supervisor with a clear picture of the inventory levels in the Storage Room.

5.2.2 Linen Carts

The linen carts are customized to reflect the quota for each area. Each linen item has a separate, labeled compartment that contains enough space to store the assigned amount. The cart only contains the linen items that are utilized in its area and no more. The cart also has the flexibility to be customized to adjust for any changes in the quota. The orientation of the linen items is taken into consideration when placing them inside the cart. The folded part of the linen is facing outwards so that it is easier to access and extract. The fitted sheets, as was mentioned in the current state, are the most problematic item because of its irregular shape. The way that they were stored could also lead to infection control issues. By wrapping them around themselves into a round shape, they become easily accessible, organized, and more compact. In the areas where a side closet exists, the distribution of linen is decided with the input of the respective head nurse. The amount of linen to be distributed is marked on the carts so that it is easily identifiable by the nursing staff and the side closets are consistently restocked. An example of this is found below in Figure 13.

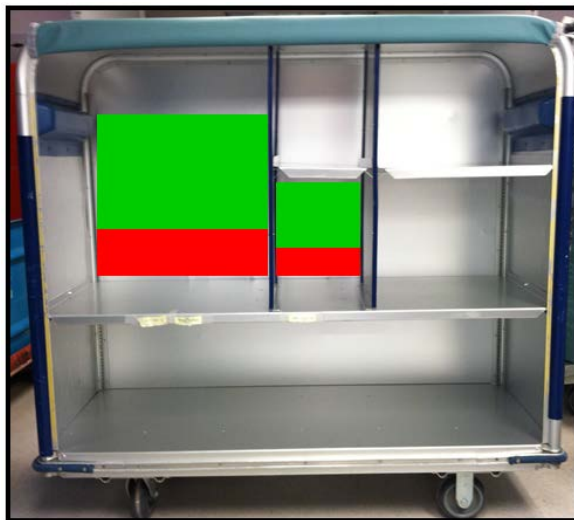


Figure 13: Sample of Linen Level Indicators in Linen Cart

5.2.3 Linen Closets

The linen closets are cleared of all clutter and organized to the greatest extent possible. All extra shelves and storage locations are eliminated or locked so that the only location where linen could be found or placed is in the linen cart. The linen cart also has a designated area inside the linen closet so that it is always found and placed in the same location.

5.3 Refill Process Signal System

To foster communication throughout the different departments involved and provide an accurate representation of the linen levels available, a color coded signal system is implemented to aid the refill process. The color coded signal system is utilized in the linen closets in every ward and unit of the hospital as well as in the EMS Storage Room. This section explains how a color coded signal system is implemented in each area of the hospital and it also explains how the whole refill process works and how the signal system is utilized within the refill process. The design of these elements as they were implemented in the pilot areas is described in the next section about the implementation of the process.

The color coded signal system consists of the colors green and red. Green represents adequate conditions, where no action is required from the staff. Red represents inadequate

conditions, where the refill process is initiated; an action needs to be made by the staff. This color coded system is utilized in the linen carts, the linen closets, and the EMS Storage Room.

Each separate compartment of the linen cart has a linen level indicator divided in green and red portions. The length of the whole indicator represents the height of the linen item corresponding to the quota for that area. The height of the red indicator represents the safety stock calculated for each item. The space from the safety stock to the top of the level is colored in green

The signal system in the linen closets consists of a laminated poster hung at a visible spot. The laminated poster has a green side and a red side. The green side indicates that there is an adequate amount of linen in the cart. The red side indicates that the linen levels of at least one item are running low; this side has a table to record the information of the refill request. Figure 14 shows an example of the laminated poster.



Figure 14: Laminated Poster

The color coded signal system is also implemented in the EMS Storage Room with a laminated poster hanging at a visible spot directly above each of the linen carts. The green side of the poster indicates that the cart is filled with the assigned quota. The red side of the poster indicates that there are missing items in the cart to fulfill the required quota.

To guarantee effective communication between EMS and nursing staff regarding the refill request, an EMS contact schedule is located next to each telephone in the area. The schedule specifies what time the EMS should be contacted by calling the EMS Help Desk or by utilizing the pager.

The refill request process is initiated when a nurse takes an item from the linen cart and the linen level reaches the red indicator. This immediately triggers the refill process to start. The nurse flips the laminated poster in the linen closet from green to red, writes down the required information in the red side of the poster (nurse's name, item(s), time) and proceeds to contact the EMS. Depending on the time of the day, the nurse contacts the EMS Help Desk or pager accordingly. EMS proceeds to obtain the linen from the cart that requested the refill. The amount of linen taken is the equivalent of the green level. Before the linen is taken, the laminated sign is flipped from green to red. The EMS staff delivers the requested linen, go back to the Storage Room and restock the cart back to its full quota. The sign is flipped back to green after it is restocked. If there is not enough linen on the shelves or in the tubs to refill the cart, the EMS staff records the missing items on the red side of the laminated sign. Having the laminated poster with the information about when the refill was placed and by what nurse helps inform the other nurses of what the state of the refill request is. A process lead time is established and the EMS commits to delivering within that time frame. This system eliminates having multiple refill requests for the same item and also gives the nurses a peace of mind knowing that if the linen is running low and there is a request placed, the linen will be on its way. Ultimately, this creates trust in the nurses for the linen distribution and refill system. A graphical representation of the refill process and signal system can be found in Figure 15.

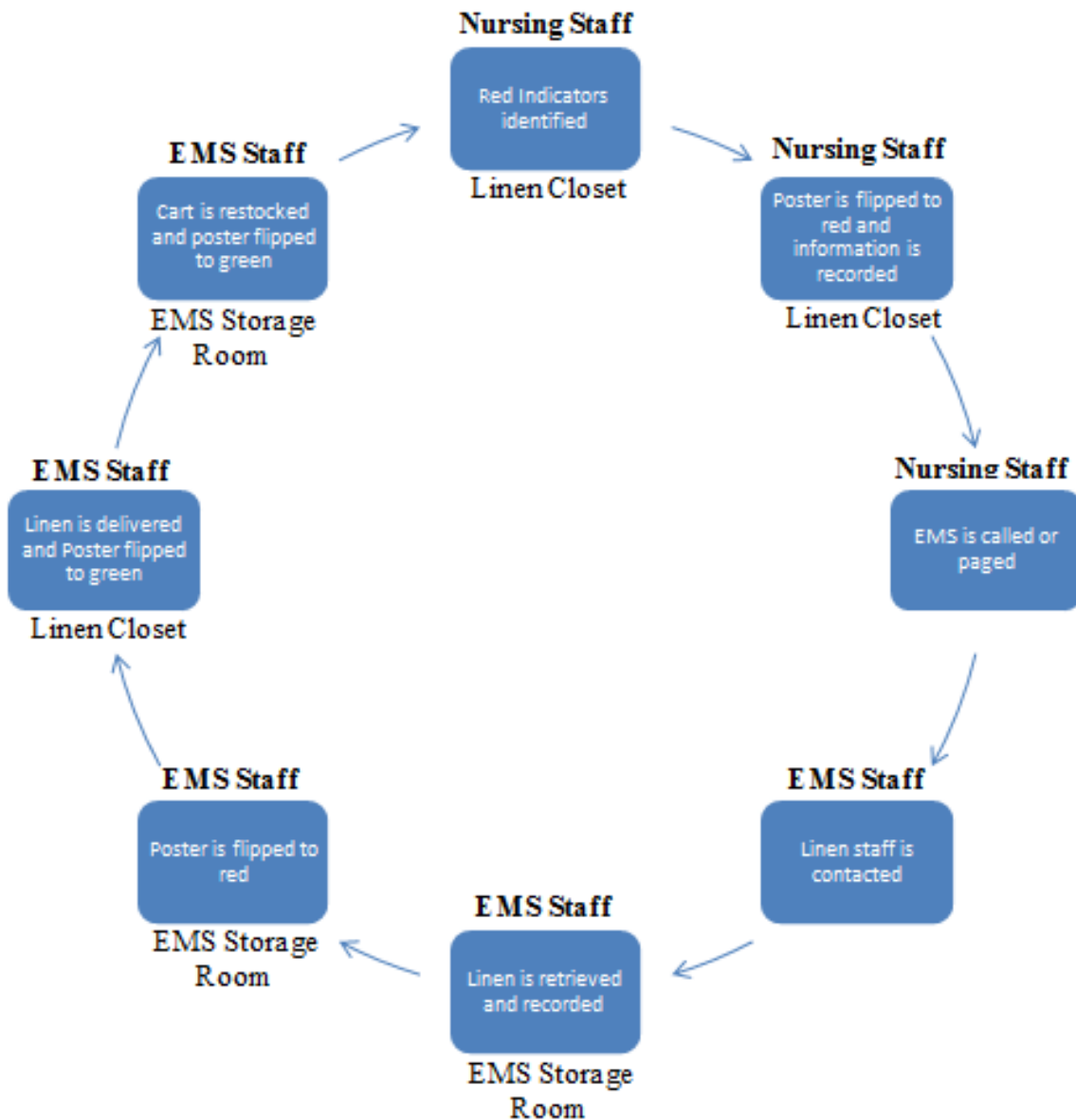


Figure 15: Refill Process Signal System Cycle

5.4 Standard Practices

The linen distribution system follows standardized work and standardized practices within each area that is involved with the process as well as with every supporting process in the system. By having standard work and standard practices in place, the system does not depend on any individual worker's experience to function, and new workers can easily be trained when

needed. Standard practices have been created for the nursing staff, linen staff, EMS Help Desk, linen supervisors, and EMS Assistant Chief, as described in the following subsections.

5.4.1 Nursing Staff

The standard linen usage is determined by the head nurse for every area based upon the specific needs of the area. The exact number of each different linen item required for a whole bed change is specified by the head nurse in order to assure consistency in the usage of the linen. Similar standards are set for the rest of situations where linen is required for each area in order to maintain consistency for the uses of all linen.

Nurses are reminded of nursing best practices for linen every month by the head nurse. In these meetings, the proper usage of the linen refill system as well as the correct refill request calling process is reviewed. The correct usage of the refill system includes only calling when the linen level of the item(s) is red and the side closets are empty and recording the necessary information for each refill request. The correct refilling process for the side closets are followed by only taking the established amount of linen from the main cart to the side closet. Other best practices are reviewed in the monthly meetings to eliminate issues such as extra storage of linen in the patient rooms. Nurses have a space to communicate any concerns or further opportunities for improvement with the linen distribution to the head nurse.

5.4.2 EMS Linen Staff

The EMS Staff conducts refills of linen following First In First Out (FIFO) practices and provides the required documentation. FIFO is implemented to ensure the timely rotation of linen through the system to minimize infection control of the linen. The required documentation includes:

- Recording the amount of linen each cart was provided with.
- Recording the linen that is taken out from the EMS Storage Room for refills in the linen log notebook, and
- Recording the required information in the linen closet room control tables.

Every morning, after the carts are delivered to the storage room and the staff is filling up the empty carts to be delivered the next day, they record if each cart received the full quota. If

the full quota was not matched, they record the area, and items that are missing. The information for the linen log notebook includes:

- The area that requested linen
- The items of linen that were requested
- The time of recording, and
- The name of the linen staff.

The information that is required for the linen closet room control charts includes: copying the linen refill request information from the nurses (name, item, time) as well as their name, time of delivery, and report of nurse compliance. The compliance is just a Yes/No checkbox that indicates if the linen level for the requested item was actually in red. The purpose of this is to make sure the nurses are following the system and are only calling when they should. An example of this table can be found below at Table 5.

Table 5: Linen Closet Table

Linen Delivery Record Sheet				
Time of Call (Date, Hour, Minute)	Time of Delivery (Date, Hour, Minute)	Items Requested	Name of Linen Staff	Request Compliance (Yes/No)

5.4.3 EMS Help Desk

The Program Support Assistant, who is the person in charge of the EMS Help Desk, documents the refill requests and communicates the requests to the EMS linen staff following a standard procedure. The documentation for the refill requests includes the time the request was made from nursing, the area it came from, the linen item(s) requested, and the time the linen staff was contacted. The standard procedure utilized to contact the staff consists of the following:

- 0 – 5 minutes: Waiting for the linen staff to walk by the office to contact them.

- 5 – 10 minutes: Page the linen staff to inform them about the refill request.
- Greater than 10 minutes: Contact the EMS shift supervisor to inform him/her about the refill request.

The times displayed above represent the time elapsed from the moment the refill request was received. These measures standardize the way the linen staff is informed of the refill requests and provide data to understand the capability of the process and measure the effectiveness of the system.

In case there is a complete stock-out of any linen item(s), the Program Support Assistant informs the head nurses of affected areas.

5.4.4 EMS Supervisors

EMS supervisors are in charge of collecting all the documentation from EMS staff and analyzing it. They collect the following documentation:

- Linen refill request tickets from the Program Support Assistant with the refill order documentation.
- Linen refill log notebook.
- The closet room refill control table information.
- Quota completion for morning delivery information.
- Daily linen delivery inventory from Brockton

Based on the information collected, the supervisors monitor the process and the performance of the linen staff and refill process. The Supervisors are in charge of analyzing the metrics mentioned in the Methodology section 3.1.1, to provide them with the tools to evaluate the performance of the system. The information collected is utilized for the monthly meetings with the EMS Assistant Chief.

5.4.5 EMS Assistant Chief

The EMS Assistant Chief is in charge of conducting monthly meetings with the EMS supervisors as well as quarterly meetings with the head nurses of the hospital. For the monthly meetings with the supervisors, these are some topics that should be evaluated and discussed:

- Lead time for the refill process by shift.
 - Time it takes for the Program Support Assistant to inform the EMS linen staff from the time the request was made.
 - Time it takes for the EMS linen staff to deliver the request.
- Control and Run charts for frequency of item request by area.
- Nurse compliance with the refill system.
- Revise and adjust the linen order placed to Brockton according to the demand.

For the quarterly meetings with the head nurses, all the information discussed in the monthly meetings with the supervisors is presented. The EMS Assistant Chief presents the major issues and the greatest accomplishments of the EMS linen performance. The head nurses provide any feedback for the system as well as the quota they are being delivered. Revisions and adjustments of the quotas are considered in the discussion.

6.0 Pilot Area Testing and Trial Implementation

After acquiring a clear understanding of the Current State and constructing a more efficient and robust Future State, we focused on testing and implementing proposed solutions from the Future State. As explained in the Section 4 (Current State), the trial implementation was focused only in PCU and 3 North at the VA Boston Healthcare System West Roxbury Campus. CT Scan, the small area that the team studied showed that it did not have any linen supply issues. The variability of the demand was very low and the usage of linen is low as well, compared to the wards and units. For these reasons, the team did not dedicate further time to CT Scan. Due to time and capacity constraints, we unfortunately could not test all proposed solutions. In order to create a significant impact on the system, we implemented the most influential solutions with the fewest obstacles. All the solutions were ranked by their impact and ease of implementation. The matrix and the explanation for each solution ranked are provided in Figure 16.

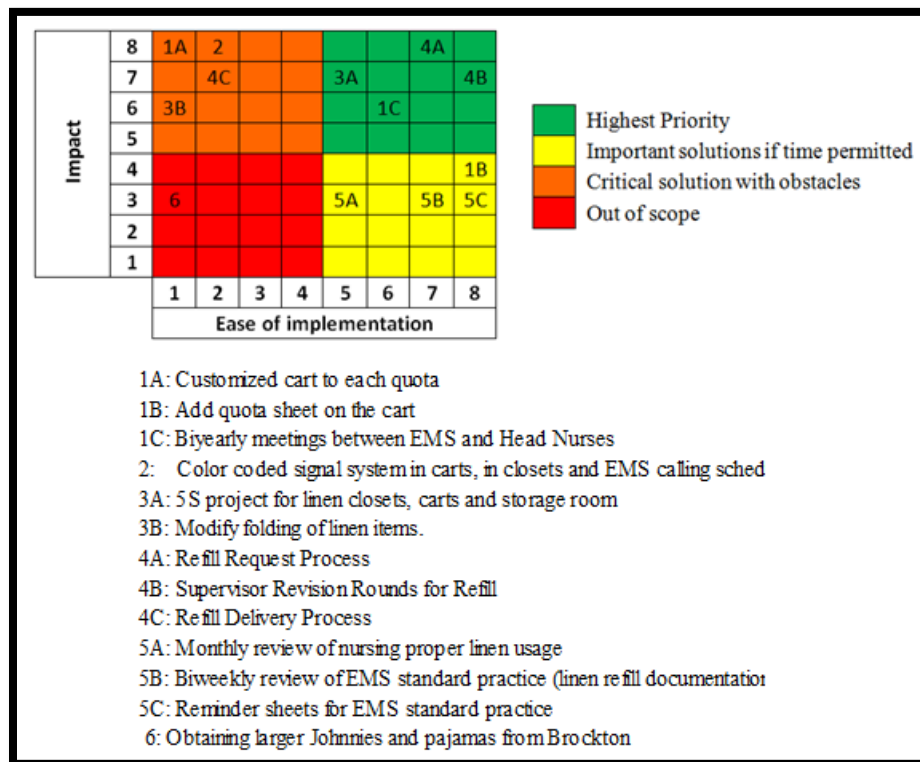


Figure 16: Impact Analysis Matrix

The numbers and letters symbolize the different solutions considered. There were six general solutions specifically targeting the existing system. Taking into consideration the ranking matrix above and the time span of the project, we tested and implemented the following measures to address the most urgent existing opportunities for improvement:

- Par levels and cart quota were updated utilizing the knowledge of the frontline nursing staff. The updated par levels and quota reflected the actual usage of each unit or ward more accurately.
- The revised refill request process was tested, by creating and implementing the three tools of the signal system; the laminated posters, the linen level indicators, and the EMS contact schedule. The system was streamlined and documented at multiple points for data collection purposes.
- The layout of the linen cart was modified by creating a separate, labeled and color coded compartment for each linen item. The method of stocking items into the carts was also changed.
- 5S projects were conducted for both the linen carts and linen closets to ensure that they are well organized.

6.1 Goals for the Trial Implementation

The team designed the Trial Implementation with the following three goals in mind.

1. Find any design errors and determine the feasibility of the designed system.
2. Obtain feedback from the stakeholders of the process.
3. Understand the challenges to implementing the system in order to develop recommendations for the actual implementation of the system.

The trial implementation is judged against these goals in the final subsection to evaluate its success.

6.2 Updated Par Level and Cart Quota

As discussed in section 5.1 of the Future State, we decided to collect further detailed information about the daily usage for 3 North and PCU. Such information is the collective knowledge of the entire nursing staff in both areas. We interviewed and discussed with the nurses possible scenarios for linen usage in their assigned areas. With that information, we recorded the daily usage of each linen item per bed. This information is found in the Table 6.

Table 6: Linen Item per Bed

Linen Type	3 North Daily Usage per Bed	PCU Daily Usage per Bed
Blankets	1	1
Flat Sheets	2	1
Pillow cases	4	1
Towels	2	4
Facial Towels	1	1
Pajamas	1	1
Snap Johnnies	1	1
Pink Pads	1	2
Fitted Sheet	1	1

Using the formula described in methodology, we calculated the Par Level for both areas. The results are shown in Table 7.

The par level for 3 North is much higher than that of PCU. This is because 3 North has 24 patient beds while PCU only has nine. 3 North has two bed changes per day on average whereas PCU only has 1.5 bed changes on a daily basis. These differences were generated from the different patient turnover rates of the two areas. In addition, the previous table does not specify the exact pajama types/sizes to use. We considered the total demand and divided the par level between four types/sizes of pajamas evenly to accommodate possible variation of demand for pajama sizes. The EMS and nursing staff agreed on meeting biannually to review the par level and cart quota together.

Table 7: New Par Levels

Linen Type	3 North Final Par Level	PCU Final Par Level
Blankets	64	18
Flat Sheets	128	18
Pillow cases	255	18
Towels	128	72
Facial Towels	64	18
Brown Pajamas	16	4
Yellow Pajamas	16	4
Blue Pajamas	16	4
Red Pajamas	16	4
Snap Johnnies	64	18
Pink Pads	64	36
Fitted Sheet	64	18

With the par level updated, we attempted to optimize the cart quota for each area based on this data. The maximum capacity of a linen cart was the major constraint to be taken into consideration. The space constraint was not as serious for the PCU linen cart; on the other hand, it was considerable for 3 North due to its greater demand for linen. Ideally, a larger linen cart may be more appropriate for wards as we mentioned previously. It would also be beneficial to have extra division panels for the linen carts so that they could be easily modified. During the implementation phase of our project we attempted to purchase the division panels from the original manufacturer of the linen carts. We were not able to do this due to the time required for purchasing within the VA as well as the supplier's delivery time frame. As a consequence, we utilized alternative materials to accomplish similar solution. The quotas for 3 North and PCU were adjusted to fit the size of the linen cart. The cart quota results are presented in Table 8. After implementing the calculated quota and carts, the team discovered three additional issues that were not addressed in the new quota implementation. These issues are discussed below and the solutions or actions taken to address them are described.

Table 8: New Cart Quotas

Linen Type	3 North Cart Quota	PCU Cart Quota
Blankets	18	12
Flat Sheets	30	24
Pillow cases	60	24
Towels	40	24
Facial Towels	30	12
Brown Pajamas	6	4
Yellow Pajamas	6	4
Blue Pajamas	6	4
Red Pajamas	6	4
Snap Johnnies	20	12
Pink Pads	18	24
Fitted Sheet	27	12

The first issue involved the lifting pads used for transportation of certain patients, which are provided by Brockton Laundry Facility on a daily basis along with other linen items. The usage of the lifting pads is very limited. The lifting pads were not included in the calculated quota, and no space was created for them in the carts. Furthermore, the lifting pads present a separate issue since they are not allowed to stay in the EMS Storage Room so the linen staff distributes them throughout the hospital in the linen carts. In the two areas we studied, these green lifting pads were barely used and occupied precious space for linen. Therefore, further communication with Brockton facility is necessary and a revision of their usage and distribution should be examined.

The second issue involved female pajamas. Although there is a limited demand for this item, the demand still exists. The team was not able to gather enough information to propose a solution to this issue.

The third and final issue found involved the johnnies' size and type. The team decided to utilize snap johnnies for the demand in PCU and 3 North as it is one of the most utilized items according to the nursing staff. The snap johnnies are strongly preferred over tie johnnies in our two areas of study because they facilitate the nursing job when treating patients. The snap and tie johnnies are delivered separately from Brockton making it easy for the linen staff to deliver either of them. The team requested that only snap johnnies be delivered in the areas for the implementation phase.

6.3 Refill Process—Lead Time

In the newly designed system, the goal is have the EMS linen staff be able to consistently deliver the requested linen within a certain timeframe. In order to understand what that time frame might be, we identified all the steps that are involved in the refill process. These steps are as follows:

- As soon as the linen levels hit red either a call is placed to the EMS Help Desk (from 8:00 am to 4:30 pm during weekdays) or the pager is reached (afternoons, nights, and weekends)
- The linen staff is contacted from the EMS Help Desk or the pager
- Linen is retrieved from the linen storage room, and finally
- Linen is delivered at the area that requested it

It is important to understand what the lead time of the refill process is in order to establish the safety stock level marked by the red level indicators and to inform the nursing staff so that they know when to expect the delivery.

The refill system depends on information transfer in order to notify the staff to transfer the material from the Linen Storage Room to the requested area. The team established three control points to measure the performance of the system. These points were located at the EMS Help Desk, the EMS Storage Room, and the linen closet at each area. The information collected at each of these three locations would demonstrate the time required for the EMS Help Desk/Pager to contact the linen staff after the request was made and for the linen staff to deliver the linen after they were contacted by the EMS Help Desk/Pager. The information that would be obtained from each of the control points is the following:

- EMS Help Desk:
 - Time linen request received
 - Item requested
 - Area requested
 - Time linen staff was contacted
 - Name of linen staff
- EMS Storage Room:
 - Time of request

- Item requested
- Unit/ward requested
- Linen staff responded
- Linen Closet:
 - Time of call
 - Time of delivery
 - Item Requested
 - Name of linen staff

The Program Support Assistant and the linen staff were briefed about the project goals and objectives and were requested to record the information outlined above during the 18th week of the project. The plan was to collect the data for a period of a week in order to get a general understanding of the process lead time before implementing the whole refill process. The collected information would provide the team with an estimate of the baseline lead time for refill, which would be communicated to the nurses. Then, when the refill process was fully implemented in week 19, data would be collected for an additional week to gain a more accurate measure of the system lead time.

Unfortunately, the requested data was not collected by the EMS Help Desk or the EMS staff. For this reason, the team was not able to estimate a baseline for the process lead time, and recommends that this is an important early step as implementation proceeds.

6.4 Refill Process—Cart Signal

The greatest issue in the Current State regarding the linen refill process is the absence of standards for when to order linen. The system utilized is completely subjective and up to the personal interpretation of each nurse, resulting in great variation of when the refill is requested. The team created a system with clear standards emphasized by color coded signals to standardize when the refill process should be initiated.

For the implementation of the color coded signal system in the cart, due to monetary constraints for the project, the team was only able to modify one cart out of the two carts for each pilot area. In order to accommodate the signal system implementation in one cart per area, the linen staff was requested to conduct an extra step. The step is filling the unchanged cart in the

EMS Storage Room, bringing it to the area and transferring the linen to the modified cart. The carts were divided in separate, labeled and color coded compartments as shown in Figure 17.



Figure 17: Linen Level Indicators

The safety stock was calculated using the method discussed in the Methodology section. The results of such calculation were compiled in the Table 9.

While implementing the signal system, a new concern regarding the lack of communication between the three different EMS shifts was brought to the team's attention. Inconsistencies in practices between the shifts constrained the system and limited the successful test of the new system.

Table 9: Safety Stock

Linen Type	Red Level for 3 North	Red Level for PCU
Blankets	2	1
Flat Sheets	4	1
Pillow cases	8	2
Towels	4	4
Facial Towels	2	1
Brown Pajamas	1	2
Yellow Pajamas	1	
Blue Pajamas	1	
Red Pajamas	1	
Johnnies (snap)	2	1
Pink Pads	2	2
Fitted Sheet	2	1

The linen closets at PCU and 3 North have side shelves for extra storage room for linen items. These side shelves were removed from the linen rooms in order to guarantee that the new signal system, quota, and refill process would be utilized. During the visit on the 20th week, the team found that 3 North had brought in one of the extra shelves that had been removed from the room and was storing the linen on the shelf and flat surfaces in the closet. The process was not well understood overall, and the signal system and cart quota were not utilized. PCU did not use the side cart for the weekly trial period, having the linen cart as the only source of linen as specified in the future state. However, there were complaints about the system and they requested their Housekeeping staff to borrow linen from other areas or pick it up from the storage room. It was clear that the team needed additional time to work with the nursing staff training them in what the system was and how it worked.

6.5 Refill Process—Laminated Posters

The refill process relies both on the color coded levels in the linen carts as well as the laminated posters in the linen closets. The laminated sign was originally placed inside the linen closet immediately next to the linen cart. When the team presented the implemented signs to the head nurses, PCU’s head nurse suggested that the laminated posters be relocated on the outside of the door of the linen closet where they would be more visible. This suggestion was incorporated in 3 North as well due to its greater effectiveness and visibility. Figure 18 shows the

laminated posters in the pilot areas. During the trial implementation, they were not used, likely because of the overall lack of understanding and use of the carts and new process.



Figure 18: Laminated posters on pilot areas

6.6 Refill Process – Calling Schedule

The EMS contact schedule was created and placed by every phone in the two pilot areas for nursing staff. As mentioned in the Future State, the schedule will streamline contacting process by the nurses to the EMS. The schedule was originally printed on plain white paper. When the team implemented them, the schedule got lost in between all the other signs that were pasted around the phones. In order to increase the visibility of the schedule, the schedules were printed on blue paper instead. Figure 19 shows the difference between the white and blue papers utilized. After visiting the hospital on the 20th week of the project, one out of the six schedules that were implemented had been removed from their place and none were properly utilized.



Figure 19: EMS Contact Schedule

6.7 Linen Cart Design & 5S

As mentioned in the Future State, the linen carts need to be redesigned to utilize all the space available and facilitate the extraction of the linen. Division panels were used to create individual compartments for each linen item. These division panels were improvised for a two-week period for an implementation trial with office supplies that served the required function. The required division panels and their locations were the following and this division can be seen in Figure 20, arrows point towards the major changes in the organization of the cart, as well as an image of the current linen cart layout:

- Vertical panels between different colors of pajamas, top right compartment.
- Vertical panels between pink pads, flat sheets and towels, bottom compartment.
- Horizontal panels between facial towels and pillow cases, middle top compartment.

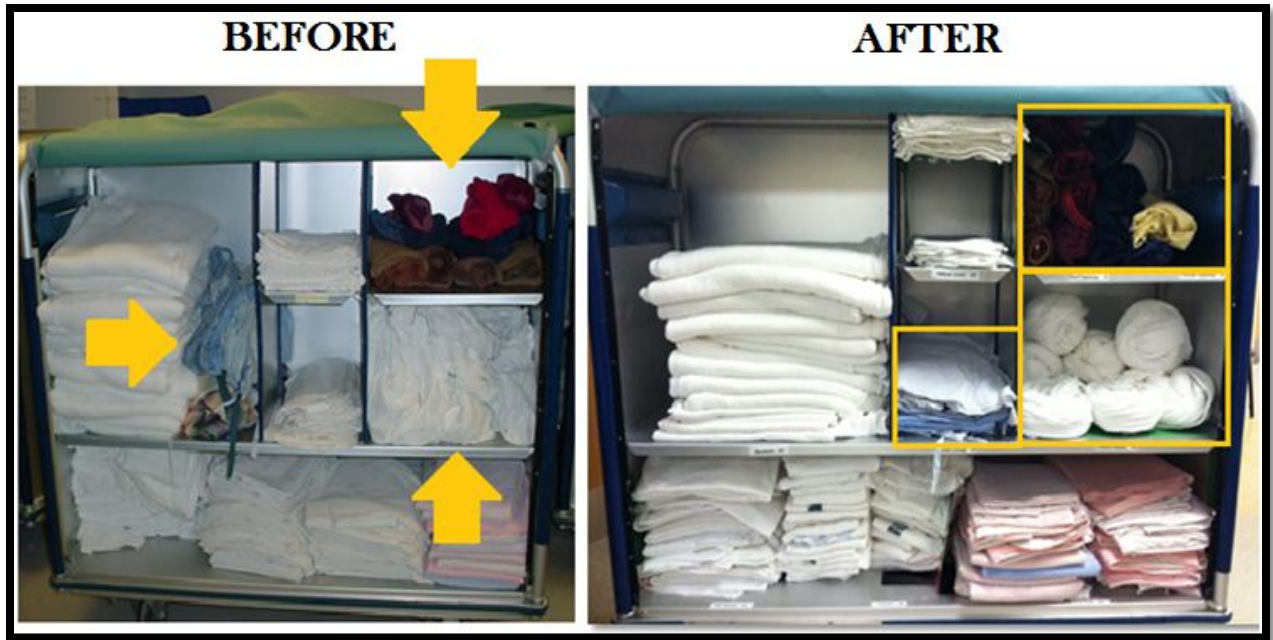


Figure 20: Current and Modified Cart Design

Besides the separation of linen items, we also took the user-friendliness of the linen placement into consideration in Future State. The linen items will be placed into the cart with the folded side facing outwards and the seams facing inwards. The linen staff was consulted about the feasibility of this practice in their daily operation, and they stated that it was only a minor change that could be easily implemented. Figure 21 shows an example of this practice with blankets.



Figure 21: User-friendly Linen Placing

The folding of fitted sheets was also examined due to its irregular shape. As noted in section 5.2.2 of the Future State, the fitted sheets were rolled into a spherical shape and tucked at the end so that they would remain rolled up. By folding the fitted sheets this way, the capacity of the fitted sheet compartment of the cart was increased by 58 %, from 17 fitted sheets to 27. This folding method was presented to the EMS Assistant Chief and gained his approval. The team proceeded to teach the linen staff the folding technique and the Assistant Chief requested that this folding practice become a standard practice in West Roxbury during the 17th week of the project. The team revisited this subject during the 18th week of the project and encountered issues since the fitted sheets were becoming unfolded during transportation. The issue was due to the linen staff failing to tuck the sheets in after rolling them up. This was emphasized to the staff during the 18th and 19th week visits, however, the fitted sheets were found unfolded during the visit on the 20th week. Figure 22 shows the folded fitted sheets utilizing this new folding practice.



Figure 22: Fitted Sheets Folding

6.8 Assumptions for Trial Implementation

In moving forward with the implementation of the selected solutions in the two pilot areas, the team made a series of assumptions about the system. The assumptions were an important part of the implementation phase because they provided direction and reduced attention to the variability in the system that the team was unable to control or unaware of. These

assumptions were made based on the knowledge we had of the system at the time of implementation. Some of these assumptions turned out to be true, and others did not. The assumptions that the team made are listed below.

Correct assumptions:

- The delivery of linen from Brockton would not be any more sporadic than the usual.
- Both EMS and nursing staff would be willing to actively adopt the new system. There would be no major staff changes for the key players in the system.

Incorrect assumptions:

- Because head nurses had bought into the system, they would be successful in championing it to the nursing staff. However, due dedication to patient care and lack of time, the head nurses were not able to successfully communicate the new system to their staff.
- The average number of patients and the demand for linen would not fluctuate dramatically.
- Nurses would properly communicate with the EMS following the schedule provided.
- The weekend and weekday shifts for nursing would have the same attitude and understanding of the system.
- The morning, afternoon, and night EMS staff shifts understood the system, and would work as a team and cooperate to achieve the established goals.

The team's lack of experience with implementing such projects, the limited control the team had over the system, as well as the limited presence the team had at the hospital were the main reasons for the team to have incorrect assumptions.

6.9 Final Outcomes of Testing and Trial Implementation

After implementing the system, and testing it for a week, it was clear that the environment was not ready for such a change. The main obstacle encountered in the trial implementation was the inability of the team to devote the required time for training of the EMS

and nursing staff in the newly implemented system. As a consequence of this lack of training, a number of obstacles were encountered in the trail.

In one nursing unit, the head nurse was only able to communicate the system to the nursing staff via email and had no opportunity to explain it in person or dedicate more time to it. As a consequence, the nursing staff did not understand the system and so did not use it. The other unit invested effort into the system on the first day; however, when linen reached red levels at night, nursing failed to follow the schedule calling the EMS Help Desk for a refill. As the schedule shows, no one is available to answer the phone at night and that is why the pager is used. Since the nursing staff got no response, they returned to the old habits of borrowing linen from other areas or sending their housekeeper to obtain linen. This unit also experienced unprecedented demand during the trial implementation week. The morning shift of the EMS linen staff did make an effort to utilize the system. However, they encountered problems when the afternoon and night shifts did not follow the new practices of the system. This resulted in extra work for the morning shift that would try to remediate the previous night's alterations of the newly implemented system. The issues with the afternoon and night shifts were a consequence of a lack of the team's presence and effective communication with these shifts. The team learned valuable lessons that can be utilized in the future implementation of the system, to guarantee its success. The main learning outcomes from this trial implementation include:

- Ensuring a stable input of linen from Brockton before changing the internal processes of West Roxbury Campus will significantly reduce system uncertainty and create the conditions for an effective internal linen distribution process
- Before implementing the system, it is vital to train the involved personnel and get their buy in to the system.
 - Details of the system have to be thoroughly explained to everyone involved in the system, with additional explanation and help as questions arise.
 - There should be a practice run through of the system with involved parties to assure everyone understands the changes required.

- Feedback from the users of the system should be considered and incorporated into ongoing implementation.
- Acquiescence of the staff should be looked out for.
- A process champion and a process owner are imperative for pushing the system forward to successful implementation. The project team's role should be clearly defined, and changes as the project proceeds. Particularly as implementation nears, the role shifts to that of facilitators. The team acted on certain occasions as process owners and process champions. This negatively affected the adoption of the new system during the trial phase from the real process owners, and made it harder to find a process champion within the system.

The team's trial implementation successfully accomplished the three goals identified. Design errors were pinpointed, such as the location of the laminated poster in the linen closet. The location was initially inside the closet by the cart where it was not the most visible. The location of the laminated poster was changed to the outside of the door of the linen closet based on the feedback from the nurses. The feedback from EMS staff and nurses confirmed that the designed system is feasible for implementation, with additional training and explanation of the system. Many challenges for implementation of the system were understood and are incorporated in the next section as recommendations.

7.0 Conclusions

The goal of the project was to optimize the linen distribution system in the VA Boston Healthcare System – West Roxbury Campus by eliminating waste and improving the efficiency of the process, standardizing and simplifying the process while meeting quality goals. In order to accomplish the goal, the team used a lean approach throughout the project. To understand the current state of the system, the team conducted interviews and observed the system. Through these interviews and observations, the team was able to create a Current State Value Stream Map identifying opportunities for improvement. Features in the Future State such as the Signal System and Standard Practices will solve the main undesirable effects: miscommunication among the EMS and nursing staff, and the lack of standardization in the procedures regarding linen and its distribution. Finally, the team carried out a trial implementation in pilot areas, of to test the most influential parts of the proposed Future State solutions and identify obstacles for implementation.

After completing implementation, the proposed Future State solution can be measured and evaluated using three metrics, as described in Section 3 - Methodology. The stability of the system can be tracked by the linen order/delivery ratio to guarantee that the linen being delivered accurately reflects what is being ordered. The linen usage per area can illustrate the real usage of the system and can be used to more accurately understand the linen demand in the hospital. The linen refill lead time can be used to demonstrate the responsiveness of the refill process to help understand the efficiency of the refills. The proposed solution and recommendations have been created to improve the system's performance in terms of stability, real usage and responsiveness which can be measured with the defined metrics.

The designed Future State successfully addressed the undesirable effects identified in the Current State, ultimately helping both EMS and nursing staffs interacting with the linen distribution system. The EMS benefits from the system by having a more responsive, reliable and standardized system. With the organization of all the linen-related locations, EMS will count with a greater inventory of linen in the EMS Storage Room improving the effectiveness of their linen service. This system will also give them a better understanding of the demand for linen in each area of the hospital. The nursing staff will also benefit from a more reliable, responsive, and

user friendly linen distributions system. The standard practices of the stakeholders, along with the refill request system, will ensure the reliability of the linen distribution. The color coded Signal System, the reorganization of the carts, and the modification for the folding of the items will provide for greater responsiveness and user friendliness of the system to the nurses. Finally, the entire Future State facilitates better communication throughout the linen distribution system and lays the foundation for the stakeholders to start trusting the system again.

7.1 Team Reflection

During the time span of the project, the team invested significant time and effort to see the project successfully completed. The 21 weeks of the project were filled with site visits to the hospital, interactions with the linen and nursing staff, meetings with our project liaison and advisors, and extended discussions amongst the team members. Throughout the process, we always encountered strong support from the VA Staff at West Roxbury, as well as counseling and guidance from our project liaison and advisor. The project provided us with the opportunity to apply the knowledge we have gained throughout our four years at WPI to a real world problem. Reflecting on these 21 weeks of project work, there were many valuable lessons learned from this experience. This section contains an explanation of these lessons.

One of the most important takeaways from this experience was learning that a systematic approach is vital to obtaining successful outcomes throughout the project. Having a systematic approach provides a team with a clear goal and lays out the necessary steps to accomplish it. Real life is very unpredictable, and this holds true in the functioning of a health care provider. A systematic approach provides the team with an overarching direction to follow to guide the project through the unpredictable and uncontrollable situations encountered.

The project provided the team with the opportunity to apply a variety of the Lean and Six Sigma tools learned in our Industrial Engineering classes. Being able to implement them in a real world setting and observing their impact in the process was a rewarding experience. The team encountered several obstacles during the application of these tools and working to resolve these obstacles was a challenging task. This experience provided the team with new insight for understanding what the tools were and how they could be applied.

The project trial implementation phase provided the team with an understanding of what is required to have a successful implementation. It is important to understand the role that a process improvement team should take for a project of this nature. The team has to act as a facilitator throughout the whole process, which involves empowering the process owners to get invested in the project and make sure their concerns are considered, and their ideas are implemented. The team should also work to find and support a process champion, and obtain the support from top management for the project.

The group development cycle (Tuckman, 1965), which explains the stages every team encounters in the process of formation, was experienced both within the project team as well as within the hospital's staff. The project team experienced the four stages of group development: forming, storming, norming, and performing. Having to work through each of the group development stages was a great growth experience for the team. Being able to reach the performing stage was extremely gratifying and helped the team become extremely productive. On the other hand, we were able to observe how our project created the need for to form a group consisting nursing and EMS staff. Unfortunately, due to the time span of the project, which limited the time and scope of implementation, the team was not able to see this group develop past the forming stage.

Another important lesson is to understand the people and culture in which the process improvement project will be implemented. At the VA, there is a hierarchical culture that maintains some military structures and procedures. Learning what these structures are and being able to follow the procedures facilitates interaction with the people and the implementation of the project. Being able to understand who the workers are, and how they fall into the hierarchies in place can also help a project proceed smoothly. It is vital to gain the trust and cooperation across the entire system in order for any progress to be made. The team experienced what it was to interact with people from different backgrounds and responsibilities within the organization, and what it took to gain their trust and cooperation.

7.2 Design Reflection

In order to improve the linen distribution system, the team created a Future State Design that would make the material and information flow of the system more efficient and effective. The team created the new linen distribution system following the Engineering Design principles. Engineering Design considers the following four parameters in the design process: requirements of the design, constraints for the design, alternative solutions for the design, and an evaluation of the alternatives. This section contains a reflection on how the team approached each of the four steps in the Engineering Design process.

The team determined five requirements for the design of the linen distribution system which are listed below:

- Robustness
- Effectiveness
- Standardization
- User friendliness
- Feasibility

The created system fulfills all these requirements. The standardization of tasks performed by each stakeholder of the process explained in section 5.4 Standard Practices. The 5S projects explained in Section 5.2, Environment Organization, ensure the effectiveness and robustness of the system. User friendliness was accomplished by the modified folding and placement of the linen items as well as the responsive color coded signal system created. Finally, the feasibility of the design was tested and confirmed in the trial implementation of the project.

There were five constraints considered in the development of the linen distribution system design, which are listed below:

- Scope
- Infection Control
- Cost
- Time
- Social

The design of the system was completed within the context of the constraints. The scope of the project was bounded within West Roxbury Campus and the design of the system was considered accordingly. The design addresses Infection Control by modifying the folding of the fitted sheets as well as incorporating FIFO practices for the refill process. Cost was considered for the design and we incorporated a retrofitting of the current carts instead of suggesting purchasing new ones. Similarly, the signal system was developed utilizing low cost and readily available materials. Time was always present in the development of the new system because the team was aware of the importance for the timely delivery of linen to the nurses. This was incorporated in the design of the refill system, where by streamlining the communication of the refill requests; the system strives to make the deliveries as fast and efficiently as possible. The social constraints of the system were addressed by taking into account the role of each stakeholder and designing the system not to overstep current organizational structure boundaries.

The following paragraphs describe alternative solutions considered for the various aspects of the system and how the team evaluated these to select the optimal alternative that was incorporated in the Future State.

For the reorganization of the linen carts, the team determined that retrofitting the existing carts by purchasing the division panels from the cart manufacturer was the best option. In order to come to this decision, the team also considered purchasing new carts with greater flexibility and larger size. Cost was the major decision factor. The team evaluated the cost-effectiveness of the two options and determined it was not worth investing in the new carts.

When considering the organization of linen in the carts, the team decided that changing the orientation of the linen as well as modifying the folding of the fitted sheets was an optimal solution. The factors that were taken into consideration for this decision included: the additional operational time required from the EMS linen staff, the user friendliness of the system, infection control of the linen, and the ergonomics of the linen retrieval. The team found that the EMS linen staff's additional operational time added greater value to the system by addressing the three other considerations mentioned above.

The team considered different options to guarantee the proper rotation of the linen in the refill process. Physical solutions as well as alternative practices by the EMS linen staff were considered. The physical solution involved removable compartments that could be rotated after the refill. The alternative practice by the EMS linen staff consists of putting the remaining linen items on top of the refill pile before placing the whole pile in the assigned compartment. The alternative practice was chosen over the physical solution for its greater reliability and because it could utilize the current carts in place, without having to inquire additional purchasing costs.

The color coding of the signal system was created to be objective, intuitive, and responsive. The system was incorporated in the laminated posters, in the linen closets, in the EMS Storage Room, as well as in the linen level indicators. The initial consideration for the color coding system was based upon a traffic light signal. The team considered utilizing the three colors (green, yellow, and red). The team eliminated the yellow color because it allowed for the subjectivity that we were trying to eliminate in the first place.

Once the color coding system was in place, the team evaluated the different tools to communicate and record the initiation of the refill process. The team assessed the following alternatives for the communication tool: a white board, a laminated poster, an item checklist, and a magnetic or Velcro symbol representation of the linen items. The parameters that were considered were effectiveness, ease, and robustness of the communication system. The laminated poster was the alternative that complied with the selected parameters the best and was also the cheapest to implement.

8.0 Recommendations

This section presents final recommendations for this project, after reflecting on the Future State Design and analyzing the results and feedback from the trial implementation in the pilot areas. Four specific recommendations were identified by the team to successfully modify the linen distribution system at the VA Boston Healthcare System - West Roxbury Campus in order to make it more effective, efficient, and reliable.

In order to establish a smoothly functioning linen distribution system within the VA West Roxbury Hospital, decreasing variability and uncertainty in the input to create more stability is imperative. The linen distribution system at the VA Boston Healthcare System - West Roxbury Campus depends on Brockton, the laundry service facility, to deliver the linen to West Roxbury. There is no control and only broad knowledge of the input to the system, which is the amount of linen being delivered from Brockton every day. If the input to a system is not stable, modifications made within the system make the system more efficient but not effective. It is for these reasons the team concluded that the next step that should be taken is stabilizing and understanding the input to the system. The team recommends that the VA Boston Healthcare System - West Roxbury Campus works with Brockton to ensure that the daily linen order is accurately delivered.

A second step to be taken is to work to implement engaged work teams with the involved departments so that they are more receptive and proactive about the improvements in the system and working together. The experience the team had during the implementation phase, working with both EMS and nursing staff, demonstrated that there are miscommunications between each department and also within the departments between each shift. It is vital to foster a cooperative and trusting working environment to successfully implement changes in a system.

After the process has been stabilized and engaged work teams have formed, the team recommends implementing the described Future State of the system. Identifying the process owner and the champion must be the first step taken towards implementation. The team recommends the Future State be implemented in phases, first focusing exclusively within the EMS. Before the new system is implemented, the refill process lead time has to be measured and

established through data collection by the EMS staff. Once the refill lead time has been established, the EMS can begin to fully implement the Future State, involving the nursing staff only to seek their input on each area's linen par level. After the par level has been determined, the linen quota for each area should be calculated and the modifications to the linen carts can be made, including the separate compartments as well as the linen level indicators. This process allows glitches in the system to be identified and addressed, and acquaints the EMS staff with the system. This phase includes performing 5S in the EMS Storage Room, incorporating the laminated posters in the Storage Room, and training the staff in the system.

After the process has been successfully implemented within EMS, the next step should be to incorporate the nursing staff into the implementation. The team recommends initially implementing the system in the areas of the hospital where the nursing staff is interested and willing to test the new system. After completing the implementation in the early adopter areas, the implementation should be spread to the rest of the hospital. Differences in each area should be taken into consideration for the implementation. Factors in the system that vary depending on the size and functioning of the area are the amount of linen and the type of linen items required, as well as the existence of side closets. For the implementation with the nursing staff, thorough training should be provided to all those who use the system.

Full implementation of the linen distribution Future State then has the potential to significantly improve the system, creating the following benefits:

- The robustness and flexibility of the system will be increased, better accommodating variability in the demand for linen.
- The nursing staff will have a reliable supply of linen to perform their duties.
- The EMS staff's time will be better utilized and their tasks will be simplified.
- Trust and transparency will be established within the different departments of the hospital.
- The system will better account for safety and infection control of the linen.
- Linen waste will be reduced by eliminating poor practices using linen.

- Cost reduction throughout the whole system will be attained.
- An understanding of the demand and costs for linen in the system will be achieved.

Through these implementation activities, the team hopes that West Roxbury becomes the flagship for an effective and efficient linen distribution system, which leads other hospitals within the VA to follow in its steps.

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Appendix A

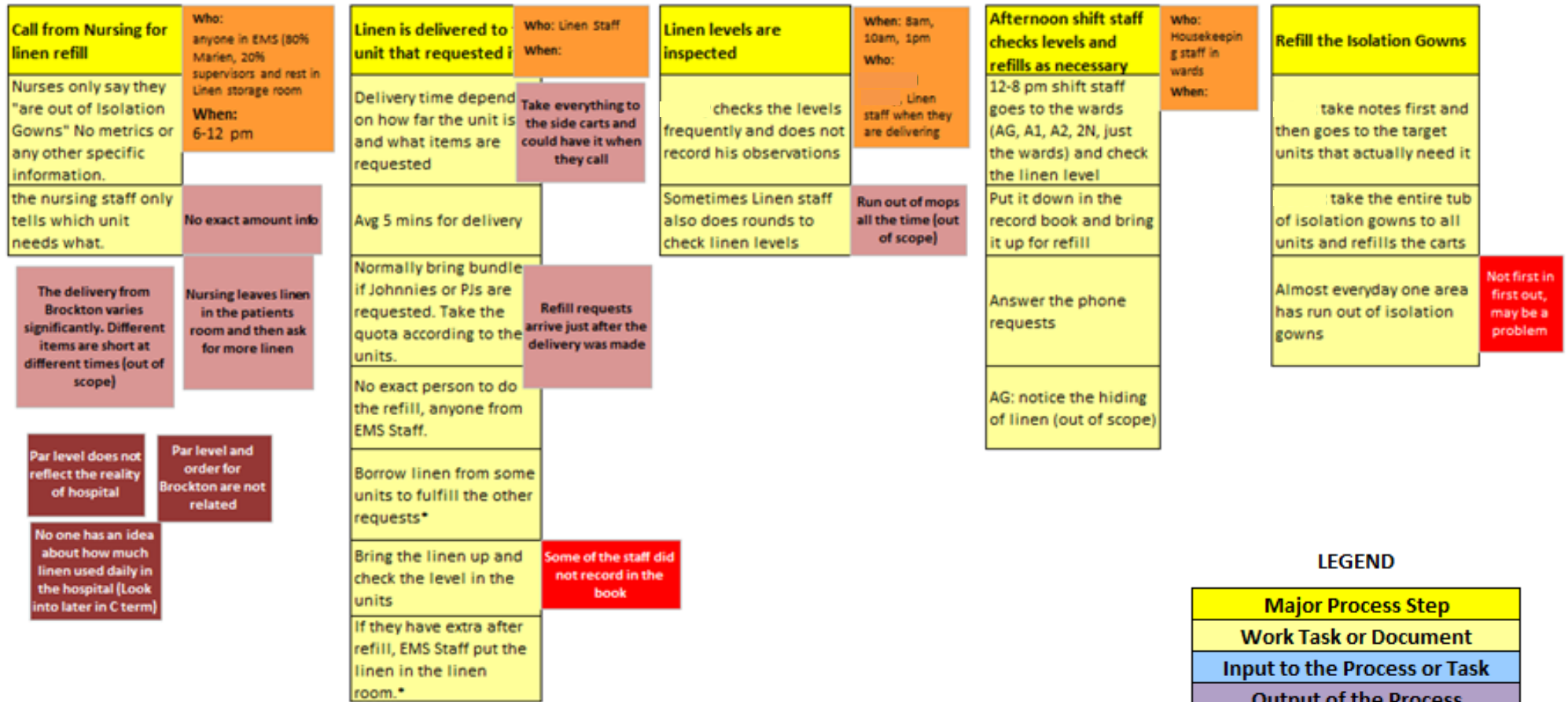
Project Timeline

Task	Duration (in weeks)	A term							B term							C term						
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20	Week 21
Research	16	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
Data Collection	11			█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
Observation	18			█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
Interviews	12								█	█	█	█	█	█	█	█	█	█	█	█	█	█
Focus Group Meeting	7								█	█	█	█	█	█	█							
Current State Value Stream Map	7								█	█	█	█	█	█	█							
Future State Value Stream Map	3															█	█	█				
5S Projects	3																					
A3-PDSA Cycles	4																					
Project Proposal	7	█	█	█	█	█	█	█														
Final Recommendation	2																					
Final Project Report	14								█	█	█	█	█	█	█	█	█	█	█	█	█	█



Current State VSM – Refill Process

VA Linen Distribution Current State VSM--Refill

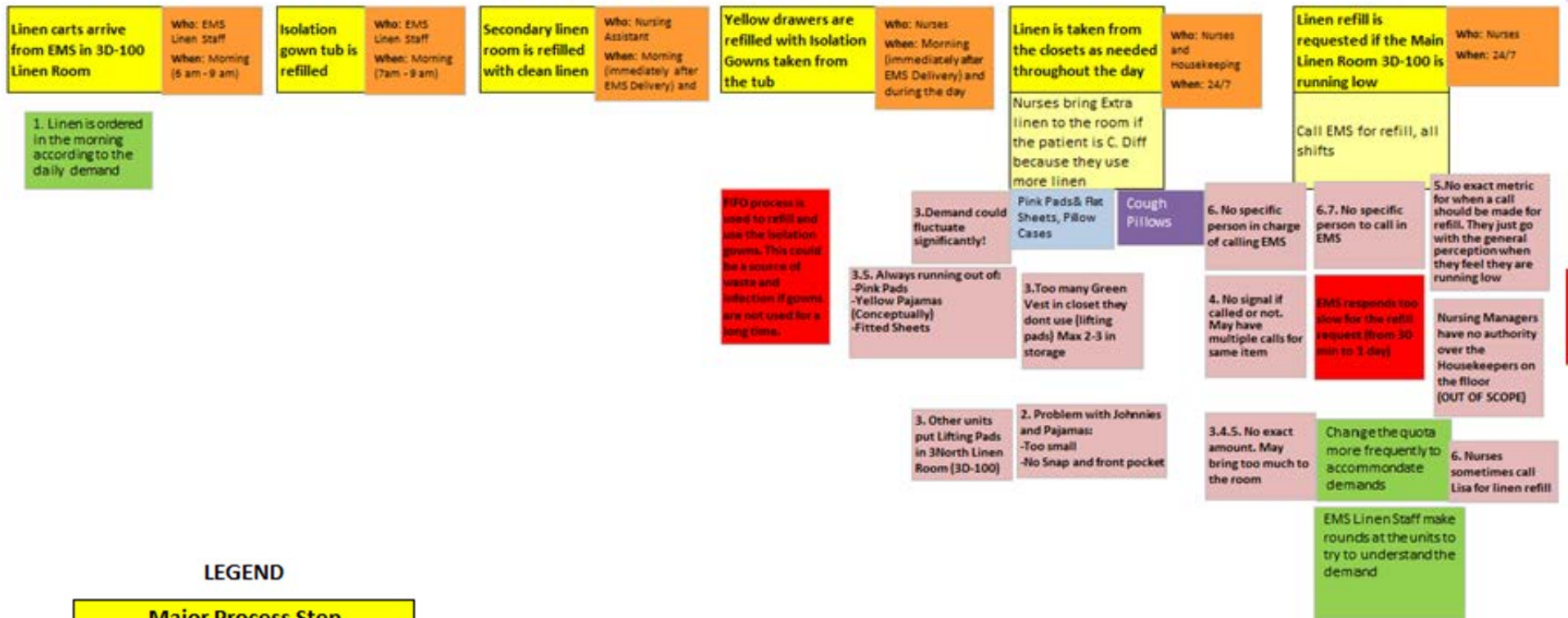


LEGEND

Major Process Step
Work Task or Document
Input to the Process or Task
Output of the Process
Undesirable Effects - 3rd degree
Undesirable Effects - 2nd level
Undesirable Effects - 1st degree
Who, What, Where, How
Action items & Suggestions

Current State VSM – 3 North

VA Linen Distribution Current State VSM--3 North



LEGEND

Major Process Step
Work Task or Document
Input to the Process or Task
Output of the Process
Undesirable Effects - 3rd degree
Undesirable Effects - 2nd level
Undesirable Effects - 1st degree
Who, What, Where, How
Action items & Suggestions

Current State VSM – PCU

VA Linen Distribution Current State VSM--PCU

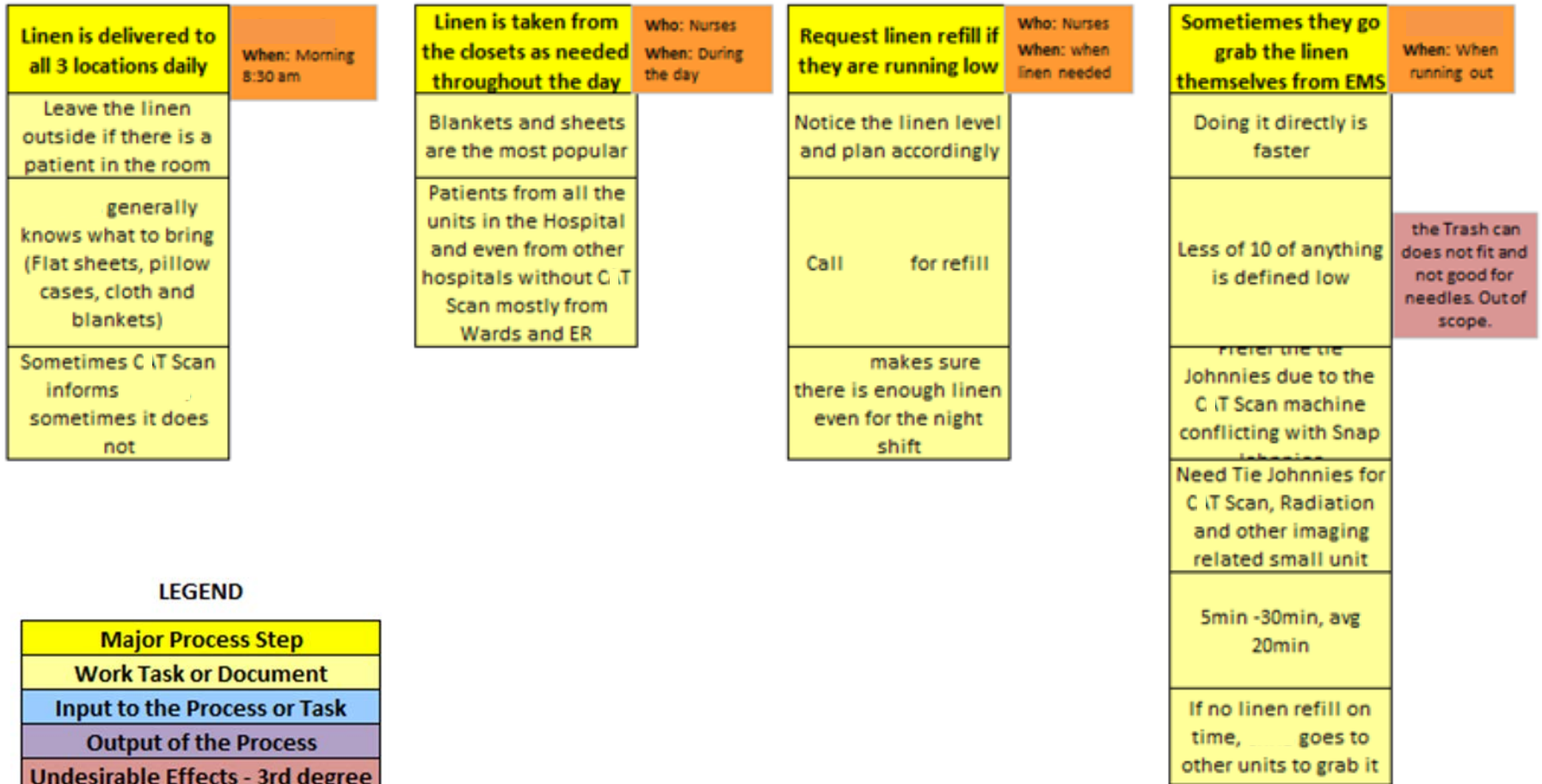


LEGEND

Major Process Step
Work Task or Document
Input to the Process or Task
Output of the Process
Undesirable Effects - 3rd degree
Undesirable Effects - 2nd level
Undesirable Effects - 1st degree
Who, What, Where, How
Action items & Suggestions

Current State VSM – CT Scan

VA Linen Distribution Current State VSM C T scan

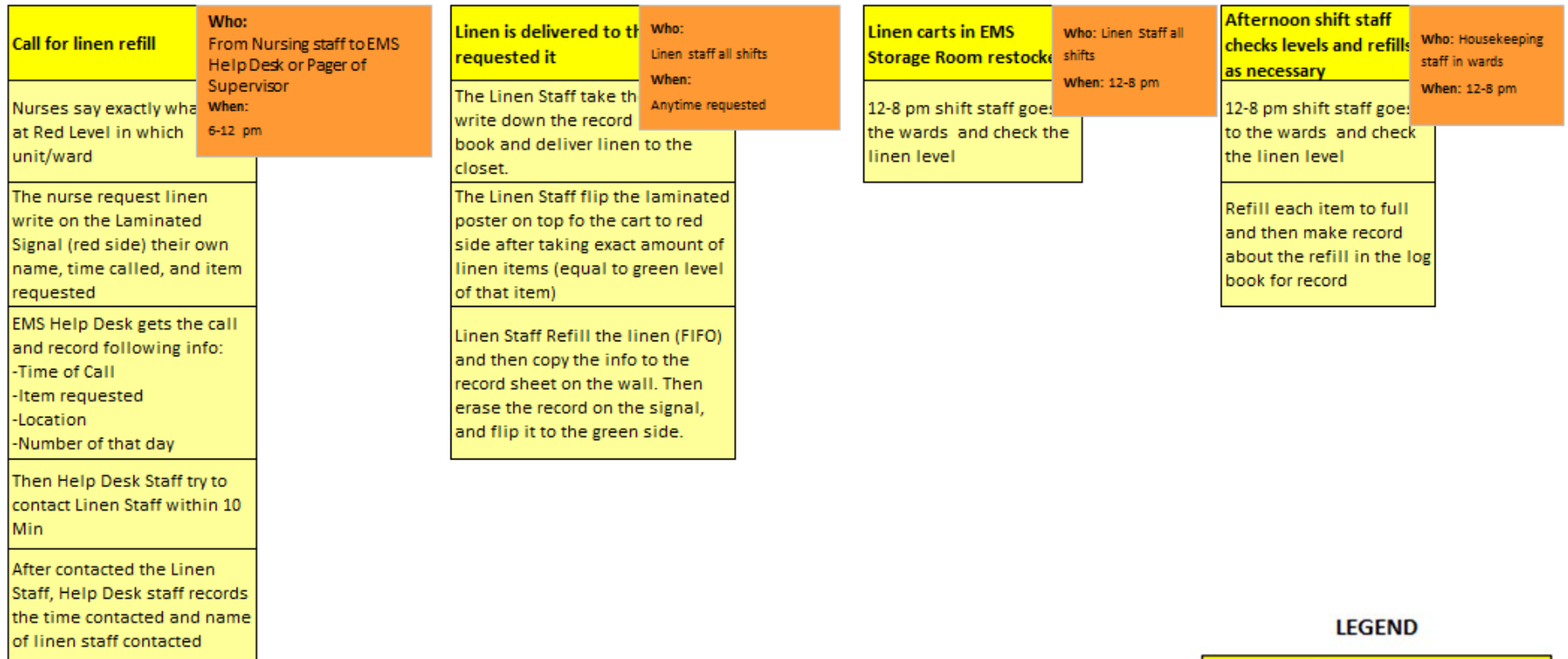


LEGEND

Major Process Step
Work Task or Document
Input to the Process or Task
Output of the Process
Undesirable Effects - 3rd degree
Undesirable Effects - 2nd level
Undesirable Effects - 1st degree
Who, What, Where, How
Action items & Suggestions

Future State VSM – Refill

VA Linen Distribution Future State VSM--Refill

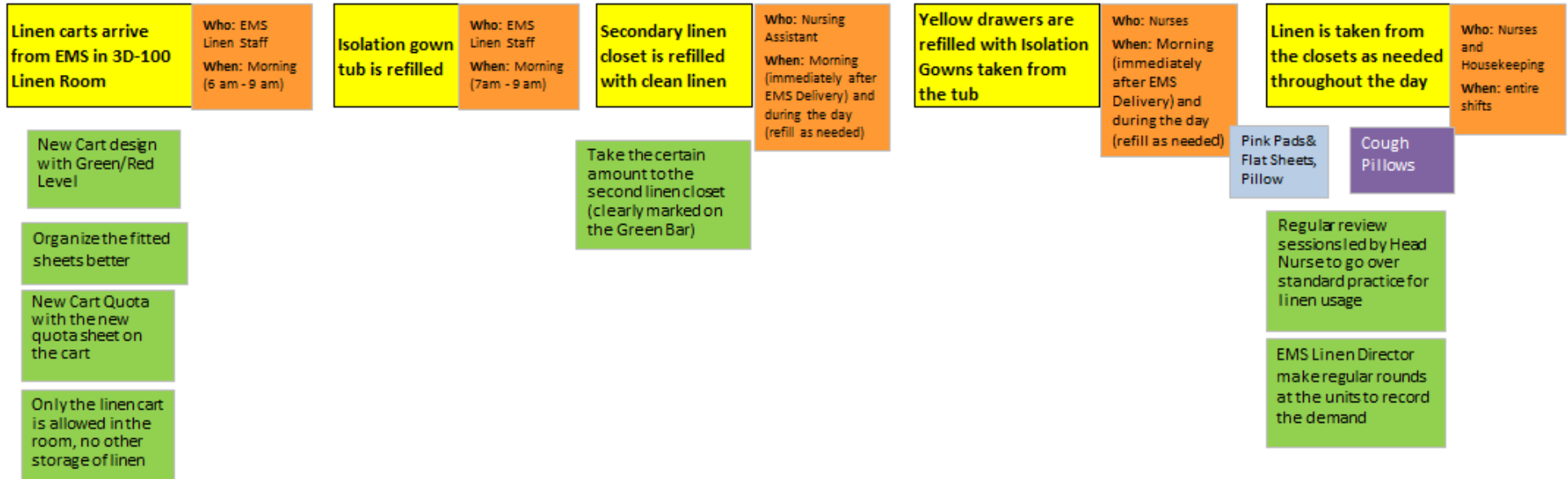


LEGEND

Major Process Step
Work Task or Document
Input to the Process or Task
Output of the Process
Undesirable Effects - 3rd degree
Undesirable Effects - 2nd level
Undesirable Effects - 1st degree
Who, What, Where, How
Action items & Suggestions

Future State VSM – 3 North

VA Linen Distribution Future State VSM--3North



LEGEND

Major Process Step
Work Task or Document
Input to the Process or Task
Output of the Process
Undesirable Effects - 3rd degree
Undesirable Effects - 2nd level
Undesirable Effects - 1st degree
Who, What, Where, How
Action items & Suggestions

VA Linen Distribution Future State VSM--PCU



LEGEND

Major Process Step
Work Task or Document
Input to the Process or Task
Output of the Process
Undesirable Effects - 3rd degree
Undesirable Effects - 2nd level
Undesirable Effects - 1st degree
Who, What, Where, How
Action items & Suggestions