# Application of Lean Six Sigma to Improve Service in Healthcare Facilities Management: A Case Study

by

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ABSTRACT

The purpose of this paper is to present a case study on the application of the Lean Six Sigma (LSS) quality improvement methodology and tools to study the analysis and improvement of facilities management (FM) services at a healthcare organization. Research literature was reviewed concerning whether or not LSS has been applied in healthcare-based FM, but no such studies have been published. This paper aims to address the lack of an applicable methodology for LSS intervention within the context of healthcare-based FM. The Define, Measure, Analyze, Improve, and Control (DMAIC) framework was followed to test the hypothesis that LSS can improve the service provided by an FM department responsible for the maintenance and repair of furniture and finishes at a large healthcare organization in the southwest United States of America. Quality improvement curricula and resources offered by the case study organization equipped the FM department to apply LSS over the course of a five-month period. Qualitative data were gathered from pre- and post-intervention surveys while quantitative data were gathered with the Organization's computerized maintenance management system (CMMS) software. Overall, LSS application proved to be useful for the intended purpose. The author proposes that application of LSS by other FM departments to improve their services could also be successful, which is noteworthy and deserving of continued research.

# DEDICATION

This work is dedicated to the author's wife and children for their unconditional love and support.

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# CHAPTER 1

# INTRODUCTION

Healthcare organizations operate numerous facilities serving various purposes relating to inpatient care, outpatient care, specialty care, surgery, administrative services, education, research, laboratories, central utilities and engineering. Facilities management (FM) departments at healthcare organizations provide services ranging from facility planning and design to construction, renovation, operations and maintenance. FM is vital to maintaining aesthetically attractive, functionally efficient, safe, comfortable and recuperative healthcare facilities, but examining the quality of the services provided and taking steps to improve those services is easily overlooked.

Application of Lean Six Sigma (LSS) for deploying quality improvement (QI) has proliferated in the 21st century, and is becoming the de facto approach for business and industry (Timans, Antony, Ahaus, & van Solingen, 2012). LSS is a hybridized solution that integrates the philosophies and associated tools and techniques of Lean manufacturing and Six Sigma (Douglas, Douglas, & Ochieng, 2015; Timans, Antony, Ahaus, & van Solingen, 2012). Numerous research publications are available documenting the successful application of LSS in industries other than healthcare FM—predominantly in the service and manufacturing sectors (Gijo & Antony, 2014; Mohsen F. Mohamed Isa & Mumtaz Usmen, 2015; Roth & Franchetti, 2010; Saja Ahmed Albliwi, Jiju Antony, & Sarina Abdul halim Lim, 2015; Svensson, Antony, Ba-Essa, Bakhsh, & Albliwi, 2015). Generally speaking, LSS researchers tout the methodology's adaptability and encourage trial applications in new fields, inferring that success can likely to be found if LSS is applied carefully (Antony, 2014; Gijo & Antony, 2014).

# CHAPTER 2

## METHODOLOGY

In order to assess whether and how LSS methodology could be applied to FM services in a healthcare organization, a case study approach was deployed which (Assarlind et al., 2013) defined as “a research strategy which focuses on understanding the dynamics present within a single setting.” This case study focuses on application of LSS by a single FM department specializing in the maintenance and repair of furniture and finishes at a large healthcare organization in the southwest region of the United States of America.

First, the author performed a literature review of journal articles focused on the application of Lean Six Sigma in Healthcare FM or relatable sectors to gain understanding of “the breadth of research and the theoretical background” in the field of LSS and FM (Saja Ahmed Albliwi et al., 2015).

Secondly, the author took advantage of the host organization’s robust quality improvement curricula to develop the faculties deemed necessary by the Organization to lead a quality improvement project (QIP) based on LSS methodology and tools.

Following the literature review and preparatory studies at the Organization, the author formed an eight-person team and led them through a 20-week quality improvement project (QIP) while receiving coaching from a quality improvement expert at the Organization. The FM team deployed various LSS tools based on the phased Define, Measure, Analyze, Improve, and Control (DMAIC) framework. Qualitative data was obtained through interviews and a comprehensive survey, while quantitative data was extracted from the Organization’s computerized maintenance management system (CMMS) software.

In the Define phase, the FM team sought to define which specific gap in quality they would aim to improve with LSS. The FM team brainstormed opportunities for improvement, filled out a SIPOC+R diagram (Fig. 1), and solicited feedback from leadership and customers of the FM team through interviews and a comprehensive survey (Appendix E) in order to gauge customer satisfaction with existing services being provided by the FM team. With customer feedback, the FM team ultimately agreed on an aim to reduce their average response time on newly created facilities service requests (FSRs) for customers.

In the Measure phase, the FM team determined how to measure response time with the help of process mapping (Appendix F) and development of a data collection plan (Appendix G). Data logged by CMMS Software were transcribed into Microsoft Excel as well as Minitab 17 to generate summary reports of the quantitative data including descriptive statistics, hypothesis testing, and histograms.

In the Analyze phase, key factors causing longer average response time were identified following study of the baseline data, control charts, and root cause analysis.

In the Improve phase, brainstorming, improved process flow, affinity diagram, and impact/effort grid exercises were conducted by the FM team to decide upon feasible interventions that would improve the FM team's average response time to FSRs.

In the Control phase, a control plan and transition plan were developed to document how the FM team would maintain their improvements.

Results of the FM team's LSS application were documented in a run chart (Fig. 7) and through comparison of pre- and post-improvement data summaries (Appendix K) created in Minitab. The entire QIP was reviewed by the Organization's Quality Academy and graded based upon a Project Scoring Template (Appendix A) used in assessing the Organization's Silver and Gold-level projects.

# CHAPTER 3

# LITERATURE REVIEW

Lean and Six Sigma are perhaps the two most popular strategies for deploying continuous improvement in the industrial world (Saja Ahmed Albliwi et al., 2015). The term "Lean" is derived from the phrase "lean manufacturing" which was coined by Womack et al. (1990), who defined Lean as a "dynamic process of change, driven by a set of principles and best practices aimed at continuous improvement." Lean's roots are traceable back to the industrial revolution, Henry Ford, and Taiichi Ohno's Toyota Production System (TPS) (Assarlind et al., 2013; DeCarlo & Breakthrough Management Group, 2007; Womack, Jones, & Roos, 1990). Lean is a time-centric process improvement methodology that focuses on improving overall efficiency by eliminating non-value added activities and different types of waste (DeCarlo & Breakthrough Management Group, 2007; Saja Ahmed Albliwi et al., 2015).The eight wastes are generally considered to be: waiting, overproduction, rework, motion, transportation, processing, inventory, and intellect.

Psychogios et al (2012) describe Six Sigma as a collection of analytical and statistical tools and techniques. "While Lean is all about speed and efficiency, Six Sigma is about precision and accuracy: Lean ensures that the resources are working on the right activities, while Six Sigma ensures things are done right the first time" (Bhat, Gijo, & Jnanesh, 2016). In other words, Six Sigma aims to reduce variation and defects to bring about consistency in a process (Psychogios, Atanasovski, & Tsironis, 2012). In the 1922, Walter Shewhart introduced the term "sigma" in relation to quality "when he proposed a concept of three standard deviations along both sides of the mean, suggesting that outputs falling outside the three sigma range on both sides of middle of the normal curve, indicate a defect, requiring some process intervention" (Mohsen F. Mohamed Isa & Mumtaz Usmen, 2015). True Six Sigma-level performance means achieving less than 3.4 defects per million opportunities, however it is not always rational or cost-effective to target Six Sigma in certain processes. Regardless, the Six Sigma methodology is now a proven methodology for improving process performance.

The first integration of Lean and Six Sigma was in the USA by the George group in 1986 (Svensson et al., 2015). Since then, LSS has increased in popularity and deployment, especially in large organizations such as Motorola, Honeywell, and General Electric (Psychogios, Atanasovski, & Tsironis, 2012; Saja Ahmed Albliwi et al., 2015). Author Neil DeCarlo describes LSS as a "hybridized solution...meaning it is applied in companies that formerly would have applied each of its core elements (Lean and Six Sigma) separately" (DeCarlo & Breakthrough Management Group, 2007). The combination of Lean's concepts and principles with Six Sigma's DMAIC framework to bring about process improvements is the essence of LSS (Mohsen F. Mohamed Isa & Mumtaz Usmen, 2015). Bhat et al (2016) state that LSS uses tools from both the Lean and Six Sigma toolboxes, in order to get the better of the two methodologies, increasing speed, while also increasing accuracy.

Benefits gained in the manufacturing sector have motivated organizations in other sectors such as service and public (e.g. Healthcare) to implement LSS as well with hopes of reaping similar rewards. Albliwi et al's (2015) analysis of the type of industry where the most LSS cases emerged, revealed there was no common industry, meaning that industry types vary and bolsters the argument that LSS can be successfully implemented in many industry types (Saja Ahmed Albliwi et al., 2015).

Literature review of LSS reveals that benefits, motivation factors, limitations, and impeding factors are primary themes (Saja Ahmed Albliwi et al., 2015). Commonly cited benefits include the following:

- Increased profits and financial savings;
- Increased customer satisfaction;
- Reduced cost;
- Reduced cycle time;

- Improved key performance metrics;
- Reduced defects;
- Reduction in machine breakdown time;
- Reduced inventory;
- Improved quality; and
- Increased production capacity.

Commonly observed limitations to LSS are (Saja Ahmed Albliwi et al., 2015):

- The absence of clear guidelines for LSS in early stages of implementation.
- Lack of LSS curricula.
- Lack of understanding of the usage of LSS tools and techniques.
- Lack of a roadmap to be followed—which strategy first?
- The limited number of practical applications of LSS integrated framework.

Isa and Usmen (2015) highlight the difficulty of assessing quality of service operations, which researchers have characterized as intangible and heterogeneous. Service of the highest quality has to be delivered correctly the first time, every time; where service is in alignment between the customers' expectations (e.g. response time, project/activity duration, and cost estimate) and their perception of the service received. Hearing the voice of the customer (VOC) is essential to identify customer needs and requirements, which can then be converted into quantifiable service quality standards (Mohsen F. Mohamed Isa & Mumtaz Usmen, 2015).

Training in LSS methodology and its tools is essential to its successful deployment in any organization (Bogart, 2007; Psychogios et al., 2012). The high cost of training is also one of the leading barriers preventing more widespread use (Psychogios et al., 2012; Saja Ahmed Albliwi et al., 2015).

Assarlind et al (2013) argue that "the benefits of Lean and Six Sigma can be achieved without a single, clear-cut, standardized approach towards an integrated Lean Six Sigma concept” (Assarlind et al., 2013). Both concepts can be used concurrently and integrated at the same time, but the level to which each is deployed, can vary.

# CHAPTER 4

# CASE STUDY

## 4.1 Details of the Organization

This case study focuses on application of LSS in a FM department specializing in the maintenance and repair of furniture and finishes at a large healthcare organization in the southwest United States of America, herein referred to as “the Organization.” The Organization is a nonprofit, worldwide leader in medical care, research and education with two other major campuses in the Midwest and Southeast regions of the US.

The Organization’s Southwest enterprise is comprised of two main campuses in the greater Phoenix (Arizona) metropolitan area. Total square footage of the Organization’s infrastructure exceeds 2,200,000 square feet according to the Organization’s department of planning & design. The Organization’s facilities are maintained by staff within the Organization’s FM division named Facilities & Campus Management. The FM division is comprised of multiple departments, all of which operate under the following purpose statement:

> “Facilities & Campus Management will function as a team-based, collaborative department, whose staff: 1) plan, design, construct, operate and maintain aesthetically attractive, functionally efficient, safe, comfortable and recuperative facilities and equipment, 2) take care of the well-being of the buildings' occupants and, 3) promote the distinctive and unique professional environment of the organization for all its patients, visitors, medical staff and allied health staff”.

Departments of the FM division at the Organization include Environmental Services, Facilities Engineering & Operations, Healthcare Technology Management, Landscaping, Project Management, Project Planning and Design, Security, Systems Engineering, and Building Services. In-house staff performs much of the work throughout in the FM division, while some activities, such as engineering and construction work, are subcontracted to outside vendors.

Building Services—herein referred to as “the FM team”—is the department of the Organization’s FM division that specializes in the maintenance and repair of furniture and finishes within the Organization’s facilities. The FM team is comprised of 13 staff members—two supervisors (one for each main campus), one coordinator, and 10 technicians divvied up across two main campuses. Daily operations primarily consist of activities in response to corrective maintenance-type facilities service requests (FSRs) submitted by employees of the Organization through a web portal on the Organization’s intranet. FSRs are received and stored by the Organization’s Computerized Maintenance Management System software, herein referred to as “CMMS”—a computer database of information about the Organization's maintenance operations. The FM team manages 115 active FSRs on a given day. Common FSRs entail the following tasks: wall repair, flooring repair, hanging of items such as art/dispensers/brackets, replacement of ceiling tiles, furniture installation and repair, signage installation and repair.

## 4.2 Preparation for LSS Application

Prior to the case study, the FM team had established a reputation for satisfactory customer service, but their reputation was loosely based on hearsay and occasional compliments from satisfied customers. Despite any major sense of customer displeasure with the FM team’s services, the FM team itself was curious to more closely analyze and improve their service. The author identified the situation as an opportunity to study the applicability of LSS methodology to improve their FM-based service.

Twelve months before the formal LSS intervention began the author spent time independently researching LSS and exploring the Organization’s robust QI resources. The Organization focuses significant time and resources on the education of quality improvement. Individuals or teams at the Organization can learn ways to work together more effectively and efficiently, reduce waste or improve outcomes with resources organized by the Quality Academy—an internal department at the Organization that was established in the mid-2000’s to develop and deliver broad-based quality management curriculum for the Organization's staff. QI training at the Organization takes the form of "train-the-trainer;" that is, a QI expert trains QI project leaders, who can then train their teams.

First, the author participated in an "Introduction to Lean" course and developed the ability to:

- Identify key concepts of Lean
- Understand the benefits of a Lean process when compared to traditional processes
- Identify the various types of "waste"
- Understand how Lean is applied in healthcare settings

Next, the author learned that the Organization's management team and CEO endorse the recommendation that all leaders at the Organization including managers and supervisors obtain Bronze Certification in the Quality Academy's Quality Fellows Program (QFP). The QFP is available to all employees (physician, nurses, clinical and non-clinical allied health staff and students).

Participants can achieve three levels of QI certification at the Organization (Bronze, Silver, and Gold). A Diamond Lifetime Achievement Award has also been developed. As candidates progress to higher competency levels, the investment through sharing of expertise in and active advocacy for quality increases significantly, to include publications, committee work, presentations and representation at departmental, institutional and/or external meetings.

Bronze Certification requires completion of an online content module that takes about an hour to complete. Goals of the course are for staff to:

- Understand why quality is important to their daily work.
- Know their role in addressing quality gaps that affect their customer(s), and patients at the Organization.
- Recognize the elements of the Organization's Patient Safety program.
- Understand how Patient Experience is key to quality at the Organization.
- Recognize the Organization's tools and resources to improve quality.

Following completion of the Bronze certification, the author sought consultation from a QI expert within the organization—herein referred to as "the advisor"—and met to discuss the FM team's aim to apply LSS in FM.

First, the advisor recommended that the author pursue Silver Certification to help facilitate a formal application of LSS with the FM team. The Silver Certification had three requirements, which the author ultimately followed through with:

1) One eight-hour course titled "Silver Quality Essentials" instructed by the Organization's Quality Academy faculty. Learning objectives of the session are for participants to be able to:
    - Articulate the case for patient-centered QI in healthcare and why it is important to all staff
    - Identify, measure, and prioritize opportunities for improvement
    - Select and apply appropriate quality improvement methods and tools
    - Describe how to sustain long-term improvement
    - Prepare for a Silver Quality Essentials assessment and for meaningful participation in a Mayo Clinic Quality Improvement Project
2) Exam—The Silver Quality Essentials exam is comprised of 30 multiple-choice questions. Content of the exam is built from the concepts and tools within the Silver Quality Essentials class content.
3) Quality Improvement Project (QIP)—A formal QI intervention at the Organization, such as LSS, is referred to as a Quality Improvement Project (QIP). The results of completed QIPs are submitted for review by the Organization's Quality Review Board.

In addition to pursuing Silver Certification, the advisor also encouraged the author to apply to participate in a workshop designed to help teams execute Silver and Gold Level projects at the Organization. The workshop builds upon the knowledge provided in the Silver Quality Essentials course and takes the participants from learning concepts to actually applying the methodologies and tools to their own gap in quality. The workshop coaches leaders from the participating teams (2-4 participants) on how to navigate through a QIP and is closely aligned with the Project Scoring Template (Appendix A) used in assessing the Organization's Silver and Gold-level projects. Silver are divided over three half-day sessions with approximately 6–8 weeks between each session. Participating teams are expected to work on their QIPs between class dates and after the last class in order to complete their QIP and submit it to the Organization's Quality Academy for review. A fourth session another 6-8 weeks after the third workshop session provides an opportunity for the FM team and fellow participating teams to present their QIP results to their stakeholders at a shared venue.

The author formed an eight-person team herein referred to as "the FM team," and assigned roles to individual team members in preparation for the first workshop session and kicking off the formal QIP at the Organization. The FM team was comprised of four technicians, one coordinator, two supervisors, and one interior designer. The team was designed to include all of the FM team that was responsible for the sites that would be within scope of the QIP, plus the other campus' supervisor and coordinator were included to participate as fellow process owners who could offer insight during the QIP. An interior designer that frequently supports the FM team in daily operations was also invited to participate as a key stakeholder who could offer their own insights from a planning and design perspective. The FM team was granted permission to participate in the aforementioned workshop after submitting an abstract proposal (Appendix B) to improve a gap in quality relating to overall duration of the FM's teams' activities per FSR. The abstract proposal differs from the definitive aim statement of the QIP though that was developed by the whole FM team in the Define phase, which is described in .the following section.

### 4.3 Define Phase

DMAIC is a proven quality improvement framework whose roots are in Six Sigma, but is an applicable framework to follow in LSS interventions ("Making it better," 2014; Roth &

Franchetti, 2010; Saja Ahmed Albliwi et al., 2015; Svensson et al., 2015). There are five phases to DMAIC: 1) Define, 2) Measure, 3) Analyze, 4) Improve, and 5) Control. The Organization regularly promotes DMAIC for QIPs such as the case study LSS intervention.

DMAIC begins with the “Define” phase which aims to identify what the gap in process quality is. The FM team’s QIP was initiated to explore whether the FM team was focusing on the needs of their customers and to identify any gaps that might be present in that pursuit. The first workshop session helped the FM team’s leaders learn more about how to develop a S.M.A.R.T. (specific, measureable, agreed to, realistic, and time constrained) aim statement, conduct a Supplier Input Process Output Customer Requirement (SIPOC+R) exercise, and seek stakeholder input with various Voice of the Customer (VOC) tools.

Following the first workshop session, the FM team held weekly meetings and spent approximately six weeks exploring opportunities for improvement through brainstorming, FSR data analysis, and Voice of the Customer (VOC) exercises. A Critical-to (CT) Flow Down exercise (Appendix C) was conducted to brainstorm key factors and project ideas pertaining to the timeliness, price, and quality of their services.

A SIPOC+R diagram (Fig. 1) was prepared by the FM team to identify and document all relevant elements of the FM team’s FSR process. The SIPOC+R diagram created an ability to manage expectations and quickly identify and communicate:

- Who the FSR process serves (Customers)
- Required inputs to make the process successful (Inputs)
- Who provides the required inputs (Suppliers)
- Steps involved to complete the task (Process)
- The results that the process delivers (Outputs)
- What the customers expect (Requirements)

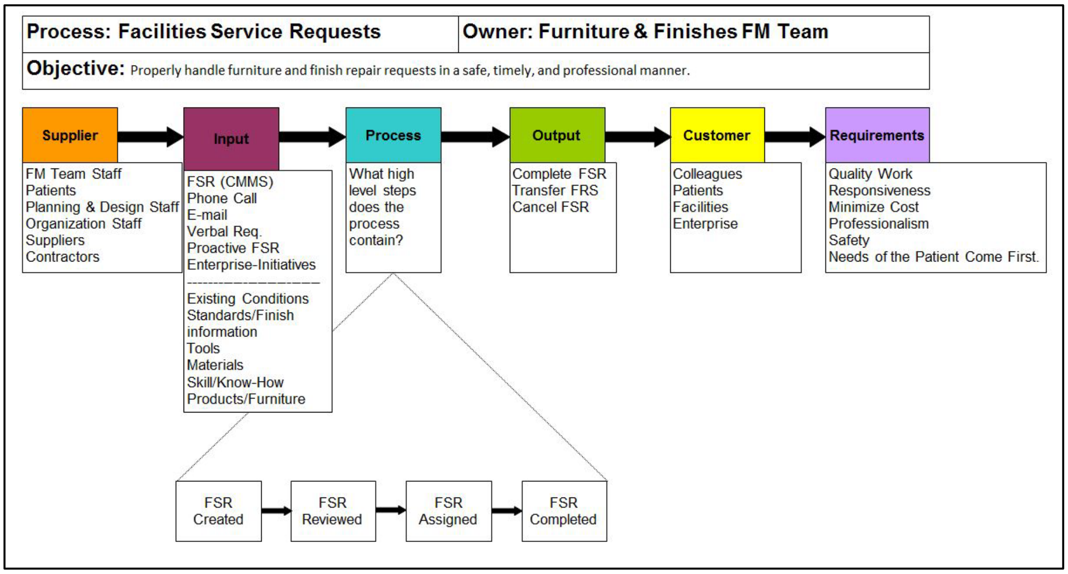



**Figure 1—SIPOC+R Diagram for the FM Team**

After creating the SIPOC+R, the FM team concentrated on the steps between “FSR Created” and “FSR Assigned” under “Process” as the focus of their LSS QIP intervention. A Swim Lane Process Map (Appendix E) was developed to show how the FSR process flowed and who was responsible for each step. After mapping the current state of the FSR process in the Measure phase, the FM would eventually circle back during the subsequent Improve phase to create a future state map to help identify process changes that would need to be implemented in order to improve the team’s timeliness (Appendix E).

The FM team was also eager to hear the Voice of the Customer (VOC). Past and present leaders of the FM team were interviewed; seeking comment on how they viewed the FM team was designed to serve the core mission and strategies of the Organization.

A customer satisfaction survey had yet to be conducted in the FM team’s existence. A 10-question customer service satisfaction survey was prepared by the FM team with a web-based application promoted for use by the Organization. The survey was distributed electronically to 379 customers of the FM team from the previous six months along with an open invitation for sharing the survey link with anyone else willing to contribute feedback. The first four questions in the survey asked customers to rate their satisfaction with the FM team's responsiveness to specific types of FSRs (i.e. repair/replace, install/uninstall, ergonomic furniture adjustments, and staff moves), based on a Likert-type rating scale of 1–5 as shown in Figure 2. Four additional questions asked customers to rate, in general, how satisfied they were with initial response time, communication, overall speed, and overall quality of service provided. An additional question asked if the customer agreed that the speed of response to and completion of FSRs should be the FM team's top priority. If answered "no," additional questions were asked to elicit suggested priorities (i.e. Cost, Quality, or other). The last question of the survey allowed for written comments, questions, or concerns.

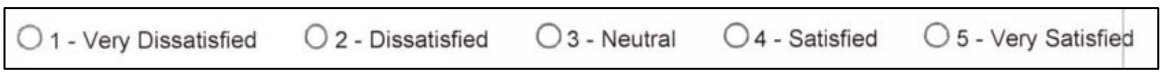


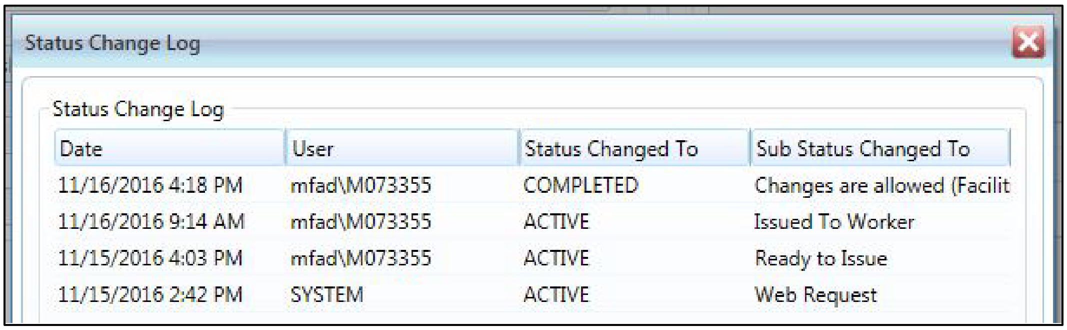

**Figure 2—Likert-type Scale used to rate Customer Service Satisfaction by the FM department (2016)**

Results from the survey are summarized in Appendix E, where the mean score and other descriptive statistics calculated by the Minitab software are included. In total, 177 responses (47% response rate) were received. The survey confirmed that customers were generally very satisfied with the FM team's service, where average customer satisfaction measured 4.77 out of 5.0. It was also confirmed that timeliness was most important to the FM team's customers and validated the team's intent to focus on improving the timeliness of their service.

### 4.4 Measure Phase

Entering the Measure phase of DMAIC, the FM team sought to assess their current performance. Before initial wait time became the focus of the QIP, the FM team analyzed completion info logged in the CMMS for FSRs completed the month prior to the QIP's kickoff.

Utilizing FSR data logged by the CMMS software, the FM team devised a way to calculate initial wait time through the reference of a sub-status field on FSRs in the CMMS software. A data collection plan was drafted (Appendix F) to document the data sourcing procedure. Staff agreed to change the sub status of an FSR from the default value (i.e. “Web Request”) to “Issued to Worker” in the moments after an FSR was being addressed to indicate that the customer had been made aware that their FSR was being addressed and by whom. A timestamp was automatically recorded in a Sub Status Log (Fig. 3) within each FSR in the CMMS software and could be referenced as a data point when calculating initial wait time.


Status Change Log

Status Change Log

| Date | User | Status Changed To | Sub Status Changed To |
|---|---|---|---|
| 11/16/2016 4:18 PM | mfad\M073355 | COMPLETED | Changes are allowed (Facilit |
| 11/16/2016 9:14 AM | mfad\M073355 | ACTIVE | Issued To Worker |
| 11/15/2016 4:03 PM | mfad\M073355 | ACTIVE | Ready to Issue |
| 11/15/2016 2:42 PM | SYSTEM | ACTIVE | Web Request |

**Figure 3—Sample Status Change Log Data from a Single FSR at the Organization**

The advisor encouraged the author to establish a baseline measure based on two full work weeks of FSR data. Each week of data—for the baseline period and for the duration of the QIP—began on a Tuesday and ended on the following Monday so that weekends would be included in the data.

A control chart (Fig. 4) helped draw attention to both special cause and common cause variation. Upon closer review it was determined that 14 FSRs were created on Fridays and were not addressed until the following work week resulting in longer than average wait times. At the advice of the QIP advisor, 48 hours (representing time elapsed Saturday through Sunday) were credited to those 14 FSRs whose initial wait time measurement included weekend hours when the FM team staff are normally off duty.

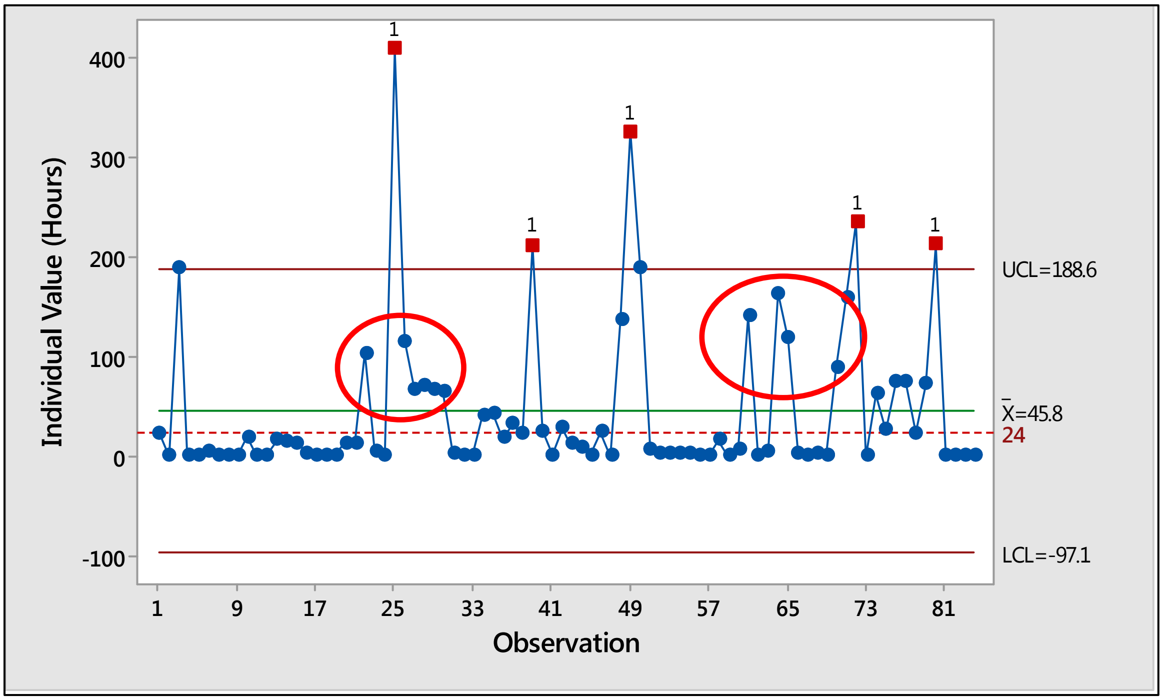



**Figure 4—Control Chart Revealing Common Cause Variation for Several FSRs Spanning Weekends**

The author reviewed the status change logs for each of 94 FSRs from a two-week span in September 2016 and typed the corresponding date values into an excel spreadsheet to calculate the initial wait time for each FSR.

The Minitab software was utilized to calculate and display descriptive statistics, a histogram, a box plot, and normality test information based on the baseline wait time data. The mean wait time was then inserted into the aim statement and used as the pre-LSS intervention baseline to measure against.

The 14-day average wait time was calculated to be 37.8 continuous hours—from the time of FSR submittal to the time that a BS staff member first addressed the FSR according to the status change log date value. Total FSRs analyzed in the baseline was 84 (Fig. 5) and constituted most of the population. Ten (10) FSRs did not include the appropriate sub status changes to be able to confidently calculate initial wait time and were not included in the baseline.

Figure 5 displays a summary report of the baseline data including descriptive statistics calculated by the MiniTab software. The mean of 37.75 hours is the average time customers waited for the FM team staff to address their new FSRs including overnight hours (4:30 PM–4:00 AM) when staff is not on duty, and accounting for the FM team's lack of weekend coverage as described earlier. The histogram portion of the summary report shows that a high percentage of FSRs were already being addressed promptly, with a median value of 10.55 hours. However, 25 out of the 84 FSRs (30%) measured in the baseline were more than 24 hours and skewed the data. A control chart helped the FM team identify which specific FSRs represented special cause variation, and studied those particular requests and discussed the reasons it took longer for the FM team to address them. Said discussions were crucial to understanding how the team could improve their timeliness. The high standard deviation value indicated extreme variability in wait time for BS customers, which was also validation that utilizing LSS methodology was appropriate since it could address both the timeliness and variability/efficiency issues that were of concern to the FM team.

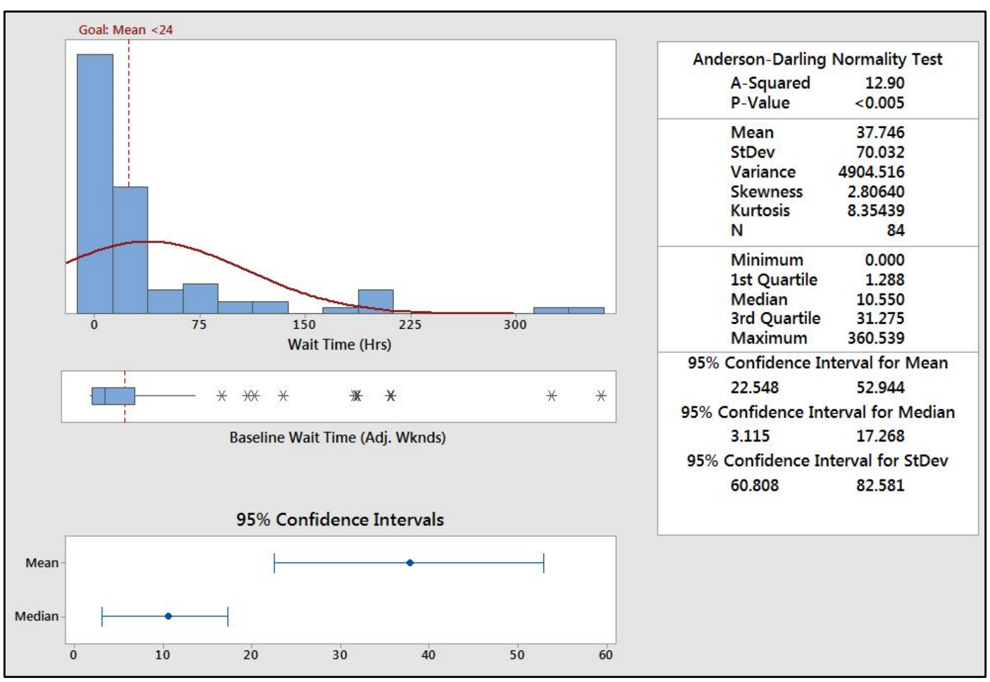



**Figure 5— Summary Report for Pre LSS Application (MiniTab)**

A run chart was used to monitor the behavior of the average initial wait time (per week) once the baseline was established (Fig. 8). The data collection plan (Appendix G) documents how the run chart data was gathered. The run chart became the most clear visual representation of the progress being made as the QIP progressed.

### 4.6 Analyze Phase

The Analyze phase of DMAIC focused on identifying the key factors that were causing longer initial wait time on the FM team's FSRs.

While the FM team was exploring various opportunities for improvement in the define phase, the opportunity to improve overall duration of FSRs was reviewed. The team analyzed duration data from 193 FSRs in the CMMS that were completed within the month prior to starting the QIP. A Pareto chart and histograms (Appendix H) were deployed using Minitab 17 to illustrate the underlying distribution of FSRs according to category. These analysis tools aided the FM team in identifying the more prominent types of FSRs from the month before. The FM continued exploring other opportunities for improvement though after deciding that the Pareto chart and histograms only illustrated that almost every category of FSR accounted for 80% of the FSRs received in a month's time.

Control Charts generated with the Minitab software using the Baseline data prompted study by the FM team of the FSRs constituting instances of special cause variation. The report summary from Minitab also included histograms that helped the FM team see a graphical representation of their continuous (time-based) data.

The FM team brainstormed root causes for longer initial wait times by preparing a Cause and Effect Diagram (Fig. 6). Once the key factors causing longer initial wait time were identified in the Analyze phase, the FM team entered the Improve phase of DMAIC.

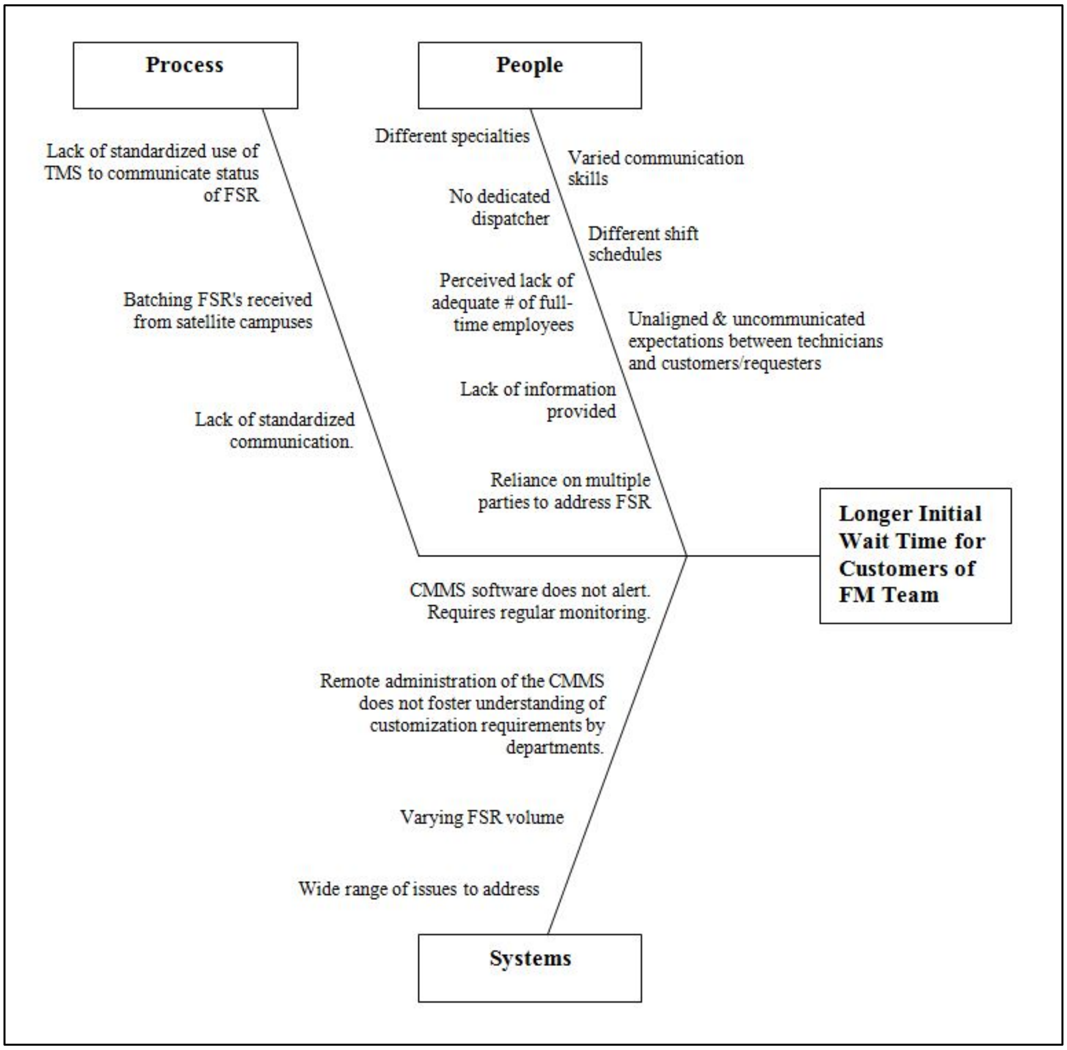



**Figure 6—Cause and effect diagram for longer initial wait time for customers of the FM team.**

4.7 Improve Phase

In the Improve phase, the FM team brainstormed potential solutions for the gap in quality (i.e. longer initial wait time) based on the key factors identified in the Analyze phase. An Affinity Diagram (Appendix I) was created by the FM team to organize their proposed solutions into natural groupings based on relationships between the ideas. Solutions were then numbered and plotted on an Impact/Effort Grid (Appendix J) to determine which solutions were feasible given the effort required to implement each one and the expected benefits.

The FM team implemented the following interventions to decrease average customer wait time for initial address by staff:

- Address FSRs—All staff check the CMMS software for new and/or unaddressed FSRs at least twice daily with the intent to address those FSRs with 24 hours of their creation, by communicating an anticipated response plan and schedule (i.e. establishing expectations for the customer) with the customer.
- Standardize use of CMMS fields—Staff standardized the use of and defined the meaning of the sub-status and assignment field values on FSRs to better communicate current status and responsibility of FSRs to each other, thereby also reducing redundant efforts in communication and physical activity (i.e. investigating an FSR that another team member has already begun to address).
- Use technology to expedite communication—Pertinent, reusable messages, also known as "canned responses," are deployed via features in both CMMS and Microsoft Outlook (i.e. Quick Parts) to aid staff in addressing FSRs promptly.

The above solutions were implemented by the FM team over the course of several weeks after the baseline was measured and the solutions were developed. A run chart shows the effect of the solutions over the span of the QIP. A graphical comparison of the pre- and post-improvement results is shared in Figure 6.

## 4.8 Control Phase

In order to control and sustain the improvements implemented during the QIP, the FM team agreed to measure their average response time based on a sampling of the population of FSR data, on a quarterly basis after the conclusion of the formal QIP, following the same procedure that was documented in the data collection plan during the Measure phase (Appendix G). If the mean response time of the sampled FSRs is calculated to be greater than 24 hours, further review and analysis of the sampled data will take place. Individual FSRs with response times measuring longer than 24 hours will be considered process failures and will be subject to a follow-up DMAIC process where the each letter of the acronym stands for:

- Determine—the specific failure(s)
- Measure—the impact of the failure
- Analyze—the cause of the failure
- Improve—the process to address the failure
- Control—Continue to control the “new and improved “process

# CHAPTER 5

# RESULTS

## 5.1 Summary

Re-measurement of average customer wait time for initial address was based on a 14-day, post-improvement study of 66 FSRs received between Nov. 8–21, 2016—a time span identical to the baseline period. The average wait time during the post-LSS application period measured 9.50 hours—a 75% improvement from the baseline mean. The standard deviation improved by 88% dropping from 70.03 hours down to just 8.42 hours. Figure 7 provides a graphical display of the results along with descriptive statistics calculated with the Minitab software. Appendix K provides a side-by-side comparison of the results, pre- and post-LSS Application.

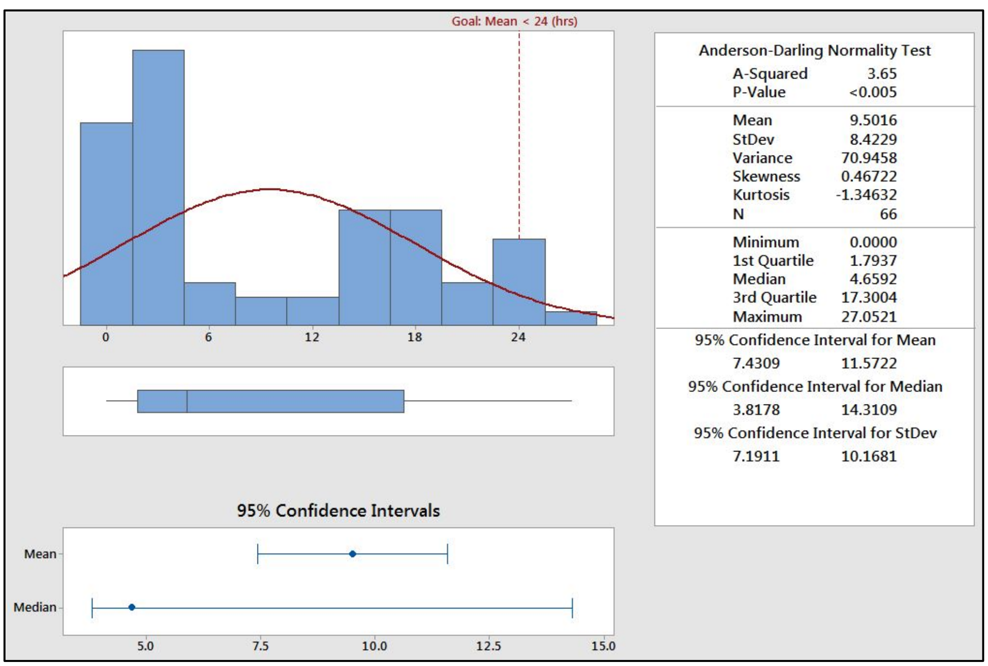



**Figure 7—Summary Report for Post-LSS Application**

A run chart (Fig. 8) was updated weekly throughout the QIP. The first two weeks (14 calendar days) correspond with the baseline period whose mean wait time was measured to be 37.75 hours. Over the following eight weeks, the run chart was updated with weekly averages and shows how the mean wait time trended well beyond the improvement goal of less than 24 hours as the FM team developed and deployed solutions. The last two weeks on the run chart represent the comparison period where the mean wait time was calculated to be 9.50 hours, which is a 75% improvement from the pre-LSS Application/baseline measure.

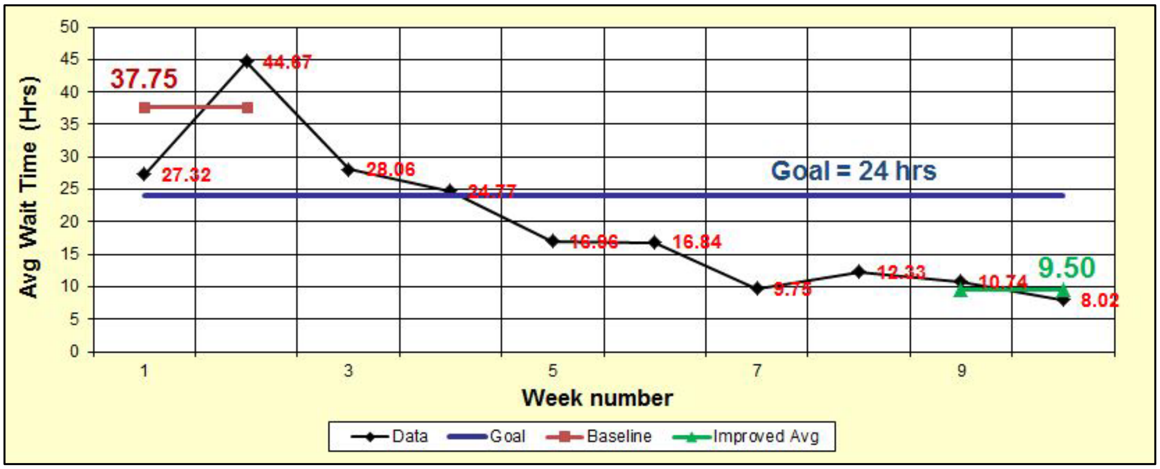



**Figure 8—Run Chart of Average Wait Time per FSR per Week During FM Team's QIP**

Minitab was used to calculate the statistical significance in the improvement. A two-sample T-test resulted in a P-Value = .001, meaning that the QIP interventions had a significant impact on the measured improvement.

Lastly, it is important to note that the FM also included a counterbalance exercise as part of the Organization's requirements for attaining a gold-rated QIP. The improvements implemented by the FM team forced the technicians, coordinator, and supervisors to adopt new practices and procedures in their daily activities. In doing so, the FM team did not want their improvement interventions to negatively impact team cooperation or trust. The pre-measure for the counterbalance came from the results to two relevant questions cited from an all-staff survey that had been distributed by the Organization several months prior to the FM team's QIP. The two questions were:

1. "There is a high level of trust among employees within my work unit."
2. "There is a spirit of cooperation and teamwork within my work unit."

The post-measure was a survey asking the same two questions of the FM team members to ensure that their improvement interventions did not negatively impact team cooperation and trust.

The premeasure for the first question—regarding level of trust amongst the team—was originally measured at 2.8 on a scale of 1-to-5, with 5 being "very favorable." The post-measure for the same question after the QIP concluded was measured to be 3.3 on the same scale. The sense of team trust improved by 29% according to the counterbalance measurements.

The premeasure for the second question—regarding spirit of cooperation and teamwork—was measured to be 3.3 on a scale of 1-to-5, with 5 being "very favorable." The post-measure for the same question was 3.7 on the same scale. The spirit of team cooperation and teamwork improved by 22% according to the counterbalance measurements. A graphical display of the FM team's counterbalance measurements pre- and post-LSS application is displayed in Figure 9.

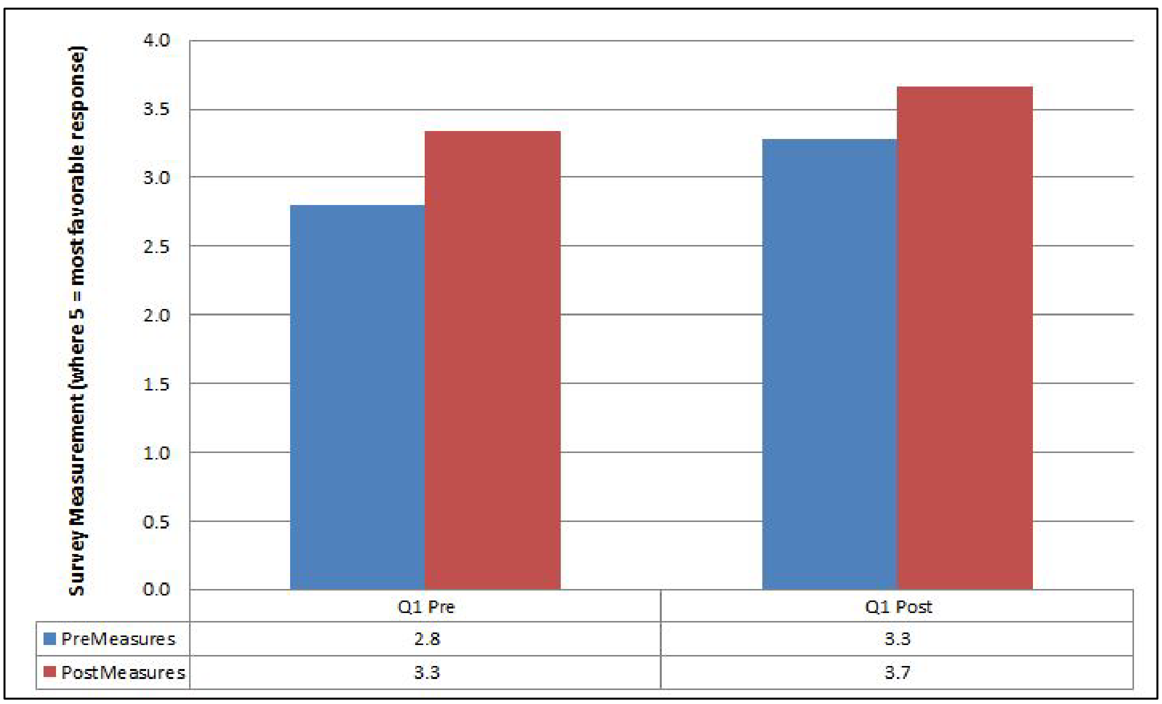



**Figure 9—FM Team Counterbalance Measurements Pre- and Post LSS Application**

## 5.2 Success Factors

The host organization's robust QI curriculum, quality academy, and QI experts were all key factors contributing to the success of this LSS application. It's notable that the Organization's culture and leadership encourages all staff to take time to learn how to lead quality improvement efforts regardless of their rank or role. It was also quite helpful to have an advisor available to coach the FM team throughout the QIP.

The CMMS software was also great resource for tracking and exporting quantitative data from both previously completed and presently active FSRs. The host Organization has long utilized CMMS software to track FSRs and hence provided a comprehensive archive of FSR information that the FM team could review and analyze. The CMMS was a key tool for measuring the response time of the FM team as well as for deploying canned responses to customers based on pre-defined criteria such as sub-status value.

## 5.3 Limitations

During the literature review, no journal articles were found focused on application of LSS in healthcare FM. The lack of precedent made it difficult for the author to know if he was leading the LSS application the right way.

The paper is based on a case study applied within a specialized, FM department at one campus of a healthcare organization; hence there is limitation in generalizing the results from the study.

This was the FM team's first-ever QIP. Only one of the FM team's members had ever previously participated in a QIP at the Organization. Given the lack of experience amongst the FM team members, the team often wished for better access to expertise (i.e. the Advisor) whose availability was limited at the organization due to a number of concurrent QIP team activities. The team would often wait days for advice or reassurance before feeling comfortable with a decision and making progress during the QIP.

The customer survey returned favorable results and did not offer any glaring recommendations for improvement which, while a high customer satisfaction rating is not a bad problem to have, the lack of clear direction left the FM team unsure of what aspect of their service they should improve for several weeks.

Another barrier to improvement was the lack of administrative rights necessary to make changes to the CMMS software that the FM team discussed as potential solutions to improve their ability to address FSRs and communicate with customers in a timelier manner. The Organization administers changes to the CMMS through a select group of individuals in another state that do not have a good understanding of how the FM team utilizes the CMMS software. Inviting a CMMS administrator to participate in the QIP with the FM team would have been helpful and may have resulted in additional improvements.

## 5.4 Future Research

There is a shortage of publications on LSS in healthcare FM. The author believes that additional case studies of other applications of LSS within healthcare FM should be conducted to develop additional knowledge and lessons learned. Future research is also recommended to assess how best to measure return on investment (ROI) when improving service in cost centers such as an FM department or division. Identification of key performance metrics for healthcare FM and how to measure them would also be important to research. Furthermore, there is a gap in literature relating to understanding of how to initiate LSS application in FM and healthcare FM (Albliwi, Antony, Abdul Halim Lim, & van der Wiele, 2014; Saja Ahmed Albliwi et al., 2015). Future research is recommended to address the current gaps in literature.

## 5.5 Conclusion

The goal of this study was to assess whether and how LSS methodology could be applied to FM services in a healthcare organization. It has been shown that careful application and implementation of LSS principles and tools can be used to reduce response time and thus improve services by an FM department at a healthcare organization. Be defining the problem, the FM team could measure their performance and analyze the data retrieved to develop an improvement and control plan. While only one process of a single FM department was studied in this paper, the LSS methodology deployed is applicable to other FM groups as well, with appropriate modifications and selection of relevant LSS tools.

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APPENDIX A

QUALITY IMPROVEMENT PROJECT SCORING TEMPLATE

| Project Title: | Project Reviewer: | Review Date: |
|---|---|---|
| **IOM Priority (Check all that apply)** | | |
| ☐ Patient-centered<br>☐ Safe | ☐ Effective<br>☐ Efficient | ☐ Equitable<br>☐ Timely |

| Unacceptable | | | | Exemplary |
|---|---|---|---|---|
| **DEFINE** | | | | |
| 1 ☐<br>Aim statement is not defined and/or does not include gap, target improvement, timeline | 2 ☐<br>Aim statement is defined and includes gap, target improvement and timeline | 3 ☐<br>Meets 2 and includes evidence of stakeholder input | 4 ☐<br>Meets 3 and potential impact is significant | 5 ☐<br>Meets 4 and potentially creates societal value |
| **Comments:** | | | | |
| **MEASURE** | | | | |
| 1 ☐<br>Data sources, baseline measures and/or sample size is not defined | 2 ☐<br>Data sources, baseline measures, and sample size are defined | 3 ☐<br>Meets 2 and includes a counterbalance measure before and after | 4 ☐<br>Meets 3 and includes an outcome measure | 5 ☐<br>Meets 4 and includes nationally recognized measure |
| **Comments:** | | | | |
| **ANALYZE** | | | | |
| 1 ☐<br>Factors contributing to gap are not defined | 2 ☐<br>Factors contributing to gap are defined | 3 ☐<br>Meets 2 and includes rationale for selecting intervention(s) | 4 ☐<br>Meets 3 and includes evidence of quality improvement method(s) | 5 ☐<br>Meets 4 and utilizes statistical analysis |
| **Comments:** | | | | |
| **IMPROVE** | | | | |
| 1 ☐<br>Intervention(s), re-measurement, graphical display, and/or comparison group are not defined | 2 ☐<br>Intervention(s), re-measurement, graphical display, and comparison group are defined | 3 ☐<br>Meets 2 and includes improvement in one process measure | 4 ☐<br>Meets 2 and includes improvement in one outcome measure | 5 ☐<br>Meets 3 or 4 and includes successful clinical or scholarly diffusion |
| **Comments:** | | | | |
| **CONTROL** | | | | |
| 1 ☐<br>Interventions are not implemented and/or lessons learned are not defined | 2 ☐<br>Interventions are implemented with lessons learned communicated to stakeholders | 3 ☐<br>Meets 2 and includes evidence of a transition plan | 4 ☐<br>Meets 3 and includes evidence of a control plan | 5 ☐<br>Meets 4 and includes evidence of sustained improvements for ≥ 1 year |
| **Comments:** | | | | |

APPENDIX B

QIP PROJECT CHARTER

| | |
|---|---|
| Location | The Organization |
| Project Name | FM Team QIP |
| Session Requested | Jun-Oct 2016 |
| Project Background | |
| | With a prerequisite of DMAIC being to understand what your customers want and then redesigning workflows to guarantee that those valued deliverables are provided in the most cost effective, timely and safe way possible, this project will demonstrate how a process improvement methodology can be adapted for use in facilities management (FM) activities (at the sub-departmental level of a healthcare organization) and analyze its impact according to its standards. |
| Project Value | Service |
| Gap in Quality | |
| | In 2015, the FM team had an average FSR duration of 7.625 days. 4.4 % of all the work orders are classifiable as special cause control points via control chart analysis. |
| Key Objectives | |
| | We want to reduce the percentage of special cause-type FSRs to 0%, thereby also decreasing the average duration of FSR activity. |
| Measure(s) of Success | |
| | A control chart should show 0% special cause over the period of implementation. The same data should also show a decreased average duration of FSR activity. |

Elements that are In Scope

FM team FSRs on the campuses they are responsible for.

Elements that are Out of Scope *

FSRs on the campuses they are not responsible for.

Known Risks

Achieving 0% Special Cause may not be achieved as a result of this project, but we will aim for it.

Known Barriers

Budget is not unlimited.

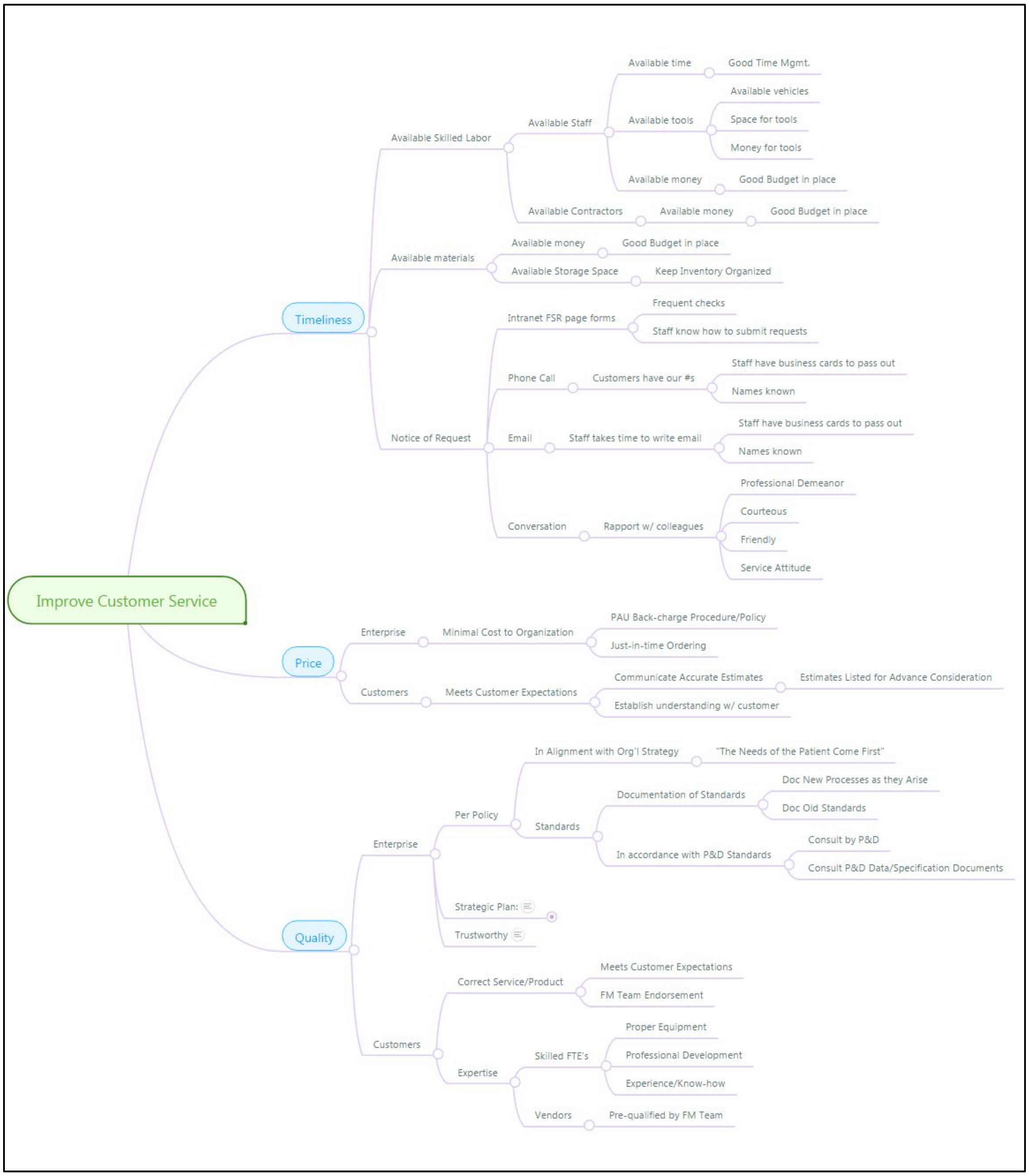
Support from stakeholders beyond the core team.

Additional Comments:

Thank you for considering this project.

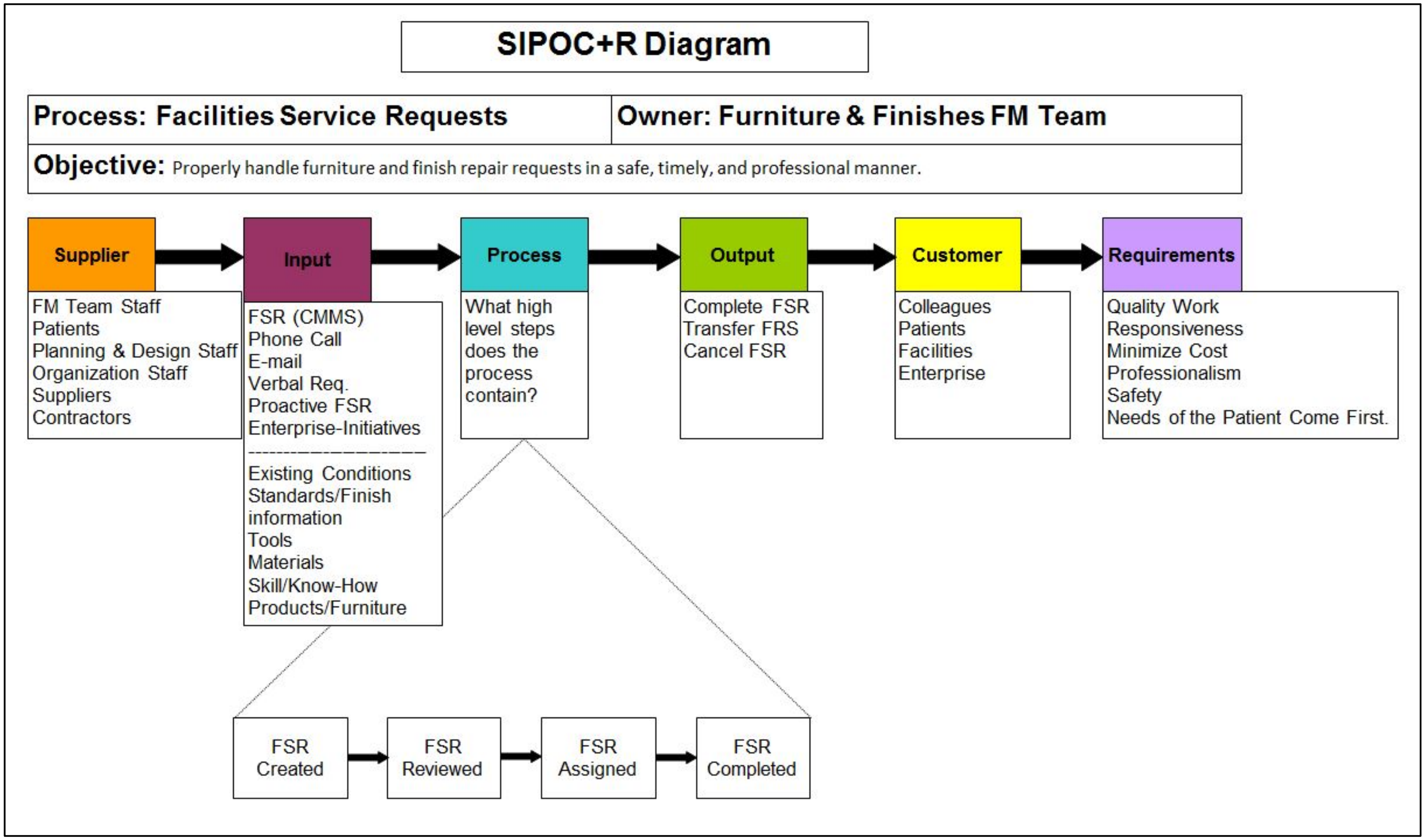
APPENDIX C

CRITICAL-TO FLOW DOWN DIAGRAM


Improve Customer Service
Timeliness
Available Skilled Labor
Available Staff
Available time
Good Time Mgmt.
Available tools
Available vehicles
Space for tools
Money for tools
Available money
Good Budget in place
Available Contractors
Available money
Good Budget in place
Available materials
Available money
Good Budget in place
Available Storage Space
Keep Inventory Organized
Notice of Request
Intranet FSR page forms
Frequent checks
Staff know how to submit requests
Phone Call
Customers have our #s
Staff have business cards to pass out
Names known
Email
Staff takes time to write email
Staff have business cards to pass out
Names known
Conversation
Rapport w/ colleagues
Professional Demeanor
Courteous
Friendly
Service Attitude
Price
Enterprise
Minimal Cost to Organization
PAU Back-charge Procedure/Policy
Just-in-time Ordering
Customers
Meets Customer Expectations
Communicate Accurate Estimates
Estimates Listed for Advance Consideration
Establish understanding w/ customer
Quality
Enterprise
Per Policy
In Alignment with Org'l Strategy
"The Needs of the Patient Come First"
Standards
Documentation of Standards
Doc New Processes as they Arise
Doc Old Standards
In accordance with P&D Standards
Consult by P&D
Consult P&D Data/Specification Documents
Strategic Plan:
Trustworthy
Customers
Correct Service/Product
Meets Customer Expectations
FM Team Endorsement
Expertise
Skilled FTE's
Proper Equipment
Professional Development
Experience/Know-how
Vendors
Pre-qualified by FM Team

APPENDIX D

SIPOC+R DIAGRAM


SIPOC+R Diagram
Process: Facilities Service Requests
Owner: Furniture & Finishes FM Team
Objective: Properly handle furniture and finish repair requests in a safe, timely, and professional manner.
Supplier
FM Team Staff
Patients
Planning & Design Staff
Organization Staff
Suppliers
Contractors
Input
FSR (CMMS)
Phone Call
E-mail
Verbal Req.
Proactive FSR
Enterprise-Initiatives
Existing Conditions
Standards/Finish
information
Tools
Materials
Skill/Know-How
Products/Furniture
Process
What high level steps does the process contain?
Output
Complete FSR
Transfer FRS
Cancel FSR
Customer
Colleagues
Patients
Facilities
Enterprise
Requirements
Quality Work
Responsiveness
Minimize Cost
Professionalism
Safety
Needs of the Patient Come First.
FSR Created
FSR Reviewed
FSR Assigned
FSR Completed

APPENDIX E

VOICE OF THE CUSTOMER SURVEY

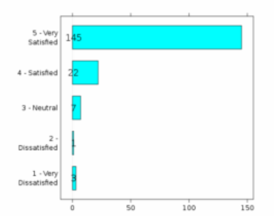
## Survey Results

- 379 initial recipients
  - 178 responses (47% Response Rate!)

## Survey Results: Q1

*How satisfied are you with Building Services' responsiveness to the following types of requests...*

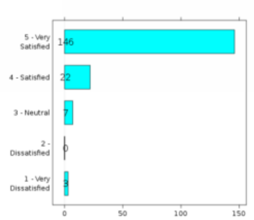
**REPAIR / REPLACE** requests involving painting, wallpaper, flooring, ceiling tiles, malfunctioning furniture, etc.
The current average is < 8 days, including weekends, for follow-up, scheduling and completion.:
Refresh Plot | missing values (0%)




## Survey Results: Q2

*How satisfied are you with Building Services' responsiveness to the following types of requests...*

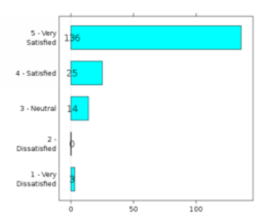
**INSTALL / UNINSTALL** requests including hanging art, mounting equipment, custom fabrication, workstation accessories, etc.
The current average is < 5 days, including weekends, for follow-up, scheduling and completion.:
Refresh Plot | missing values (0%)




## Survey Results: Q3

*How satisfied are you with Building Services' responsiveness to the following types of requests...*

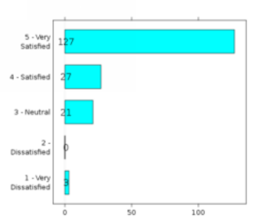
**ERGONOMIC** requests involving work surface height adjustments, replacing chairs, adding keyboard trays, etc.
The current average wait time is < 10 days, including weekends, for follow-up, scheduling and completion.: Refresh Plot | missing values (0%)




## Survey Results: Q4

*How satisfied are you with Building Services' responsiveness to the following types of requests...*

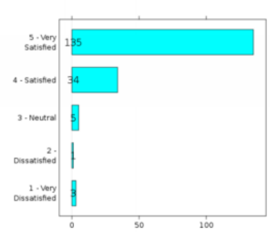
**MOVE** requests involving the supply of boxes for packing (aka E-Crates), helping staff move between offices, relocate existing furniture, etc.
The current average is < 5 days, including weekends, for follow-up, scheduling and completion.:
Refresh Plot | missing values (0%)




## Survey Results: Q5

*Now, in general, how satisfied are you...*

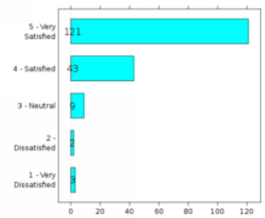
...with the average time it takes Building Services staff to **FIRST** followup on requests—be it in person, by phone, or via e-mail?: Refresh Plot | missing values (0%)



## Survey Results: Q6

*Now, in general, how satisfied are you…*

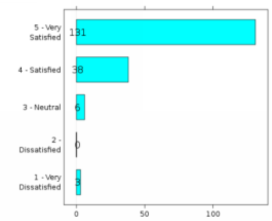
**…with the number of status updates that Building Services staff provide while requests are being reviewed and completed?:** Refresh Plot | missing values (0%)




## Survey Results: Q7

*Now, in general, how satisfied are you…*

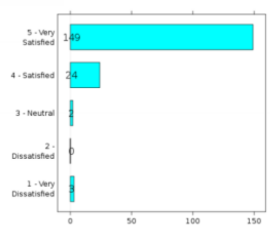
**…with the overall speed in which Building Services complete requests?:** Refresh Plot | missing values (0%)




## Survey Results: Q8

*Now, in general, how satisfied are you…*

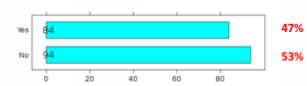
**…with the overall quality of service Building Services provides?:** Refresh Plot | missing values (0%)




## Survey Results: Q9a & 9b

*Do you agree with the following statement?*

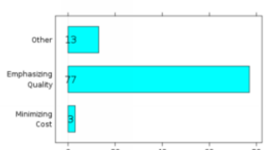
**The speed in which Building Services staff respond to and complete requests should be their TOP priority—more so than minimizing cost or emphasizing quality.:** Refresh Plot | missing values (0%)



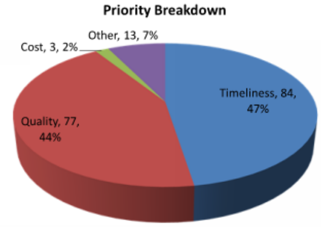

## Survey Results: Q9b

- 53% of respondents said “No” to Q9a…

**If you answered "No" the previous question (#9)…What then, should be Building Services TOP priority?:** Refresh Plot | missing values (47.8%)




## Survey Results: Q9b



# Survey Results:

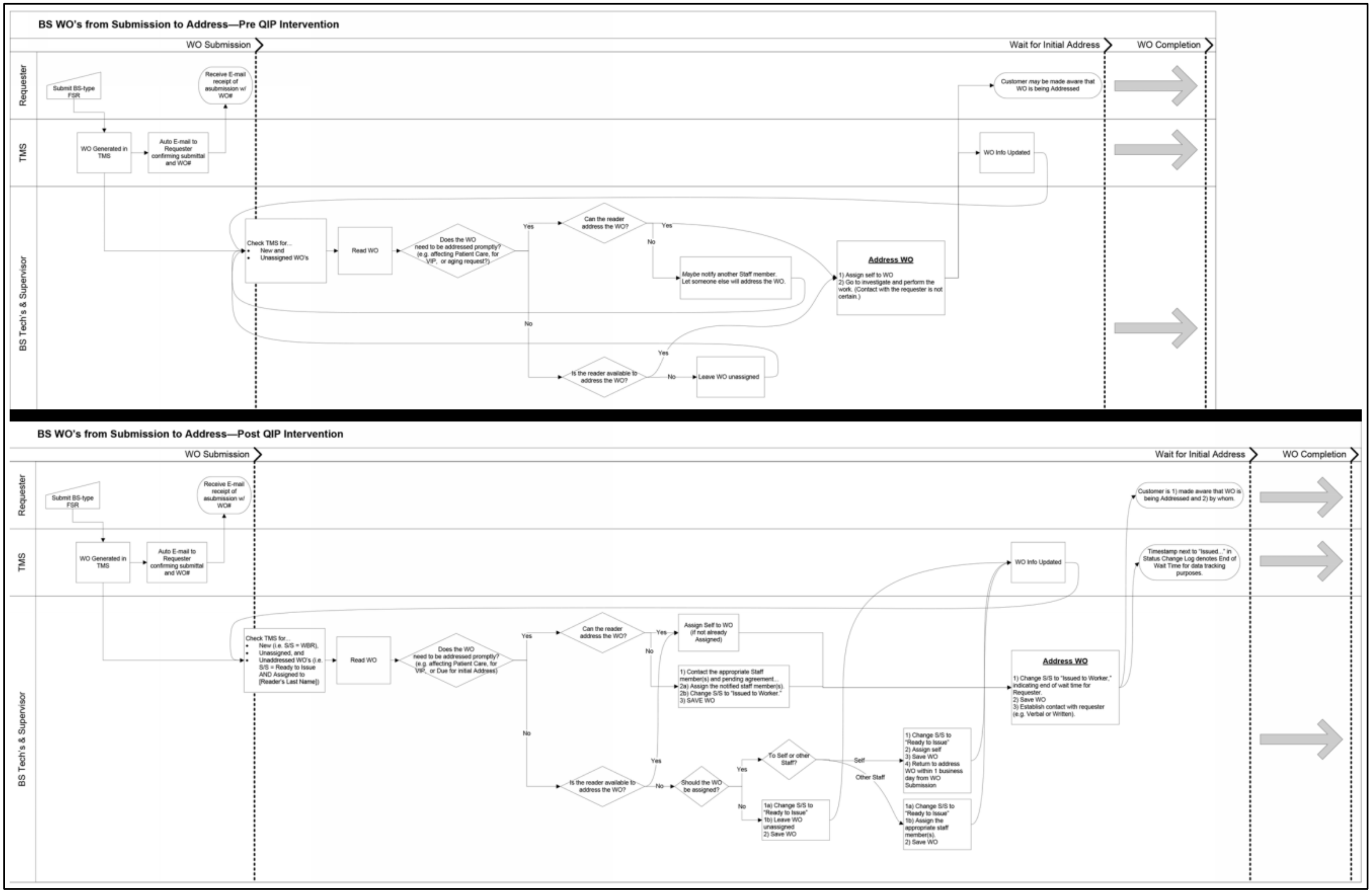
**Descriptive Statistics: Recoded 1_Re, Recoded 2_In, Recoded 3_Er, Recoded 4_Mo, ...**

| Variable | Total Count | N | N* | Percent | Mean | SE Mean | StDev | Minimum | Q1 |
|---|---|---|---|---|---|---|---|---|---|
| Recoded 1_RepairReplace | 177 | 177 | 0 | 100 | 4.7119 | 0.0544 | 0.7242 | 1.0000 | 5.0000 |
| Recoded 2_InstallUninsta | 177 | 177 | 0 | 100 | 4.7288 | 0.0522 | 0.6949 | 1.0000 | 5.0000 |
| Recoded 3_Ergonomic | 177 | 177 | 0 | 100 | 4.6328 | 0.0581 | 0.7729 | 1.0000 | 5.0000 |
| Recoded 4_Move | 177 | 177 | 0 | 100 | 4.5424 | 0.0626 | 0.8323 | 1.0000 | 4.0000 |
| Recoded 5_FirstRespond | 177 | 177 | 0 | 100 | 4.6667 | 0.0541 | 0.7204 | 1.0000 | 5.0000 |
| Recoded 6_Communication | 177 | 177 | 0 | 100 | 4.5537 | 0.0594 | 0.7896 | 1.0000 | 4.0000 |
| Recoded 7_SpeedOverall | 177 | 177 | 0 | 100 | 4.6497 | 0.0532 | 0.7082 | 1.0000 | 4.0000 |
| Recoded 8_QualityOverall | 177 | 177 | 0 | 100 | 4.7740 | 0.0477 | 0.6350 | 1.0000 | 5.0000 |
| Recoded 9_PrioiritySpeed | 177 | 177 | 0 | 100 | 1.4746 | 0.0376 | 0.5008 | 1.0000 | 1.0000 |

| Variable | Median | Q3 | Maximum | IQR |
|---|---|---|---|---|
| Recoded 1_RepairReplace | 5.0000 | 5.0000 | 5.0000 | 0.0000 |
| Recoded 2_InstallUninsta | 5.0000 | 5.0000 | 5.0000 | 0.0000 |
| Recoded 3_Ergonomic | 5.0000 | 5.0000 | 5.0000 | 0.0000 |
| Recoded 4_Move | 5.0000 | 5.0000 | 5.0000 | 1.0000 |
| Recoded 5_FirstRespond | 5.0000 | 5.0000 | 5.0000 | 0.0000 |
| Recoded 6_Communication | 5.0000 | 5.0000 | 5.0000 | 1.0000 |
| Recoded 7_SpeedOverall | 5.0000 | 5.0000 | 5.0000 | 1.0000 |
| Recoded 8_QualityOverall | 5.0000 | 5.0000 | 5.0000 | 0.0000 |

APPENDIX F

SWIM LANE PROCESS MAP


BS WO's from Submission to Address—Pre QIP Intervention
WO Submission
Wait for Initial Address
WO Completion
Requester
TMS
BS Tech's & Supervisor
Submit BS-type FSR
Receive E-mail receipt of asubmission w/ WO#
WO Generated in TMS
Auto E-mail to Requester confirming submittal and WO#
Check TMS for...
• New and
• Unassigned WO's
Read WO
Does the WO need to be addressed promptly? (e.g. affecting Patient Care, for VIP, or aging request?)
Yes
No
Can the reader address the WO?
Maybe notify another Staff member. Let someone else will address the WO.
Is the reader available to address the WO?
Leave WO unassigned
Address WO
1) Assign self to WO
2) Go to investigate and perform the work. (Contact with the requester is not certain.)
WO Info Updated
Customer may be made aware that WO is being Addressed
BS WO's from Submission to Address—Post QIP Intervention
WO Submission
Wait for Initial Address
WO Completion
Requester
TMS
BS Tech's & Supervisor
Submit BS-type FSR
Receive E-mail receipt of asubmission w/ WO#
WO Generated in TMS
Auto E-mail to Requester confirming submittal and WO#
Check TMS for...
• New (i.e. S/S = WBR),
• Unassigned, and
• Unaddressed WO's (i.e. S/S = Ready to Issue AND Assigned to [Reader's Last Name])
Read WO
Does the WO need to be addressed promptly? (e.g. affecting Patient Care, for VIP, or Due for initial Address)
Yes
No
Can the reader address the WO?
Assign Self to WO (if not already Assigned)
1) Contact the appropriate Staff member(s) and pending agreement...
2a) Assign the notified staff member(s).
2b) Change S/S to "Issued to Worker."
3) SAVE WO
Is the reader available to address the WO?
Should the WO be assigned?
To Self or other Staff?
Self
Other Staff
1) Change S/S to "Ready to Issue"
2) Assign self
3) Save WO
4) Return to address WO within 1 business day from WO Submission
1a) Change S/S to "Ready to Issue"
1b) Assign the appropriate staff member(s).
2) Save WO
1a) Change S/S to "Ready to Issue"
1b) Leave WO unassigned
2) Save WO
WO Info Updated
Address WO
1) Change S/S to "Issued to Worker," indicating end of wait time for Requester.
2) Save WO
3) Establish contact with requester (e.g. Verbal or Written).
Customer is 1) made aware that WO is being Addressed and 2) by whom.
Timestamp next to "Issued..." in Status Change Log denotes End of Wait Time for data tracking purposes.

APPENDIX G

DATA COLLECTION PLAN

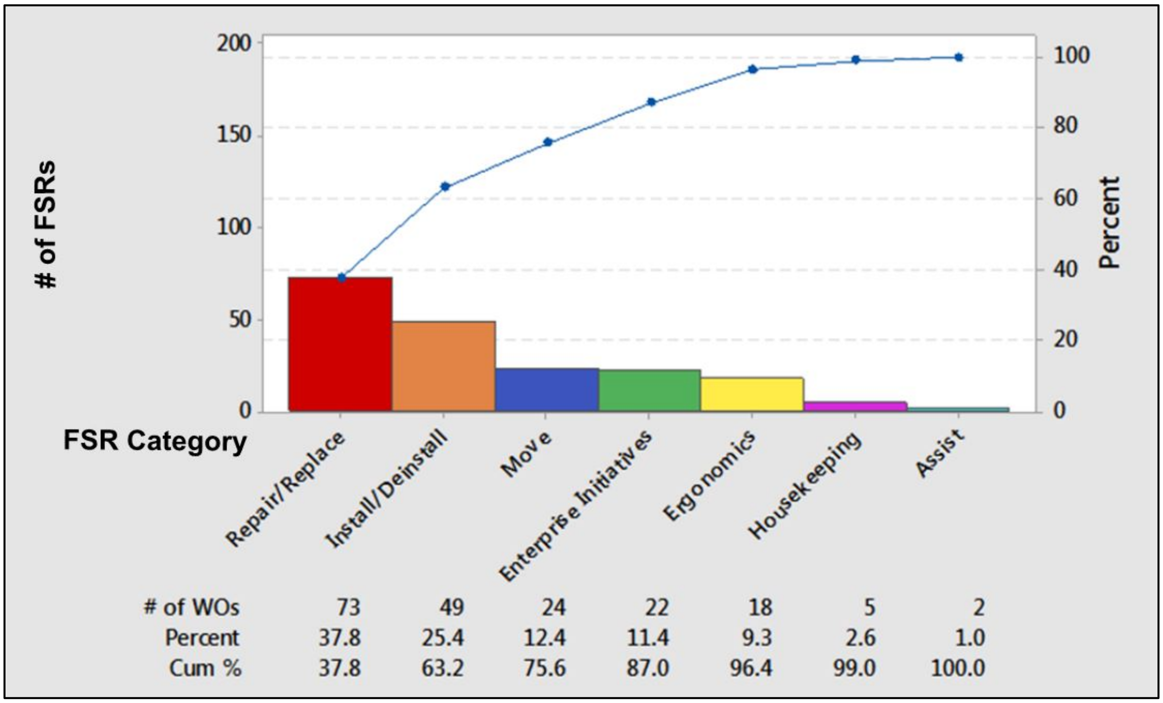
Process: FM Team FSR Wait Time for Initial Response

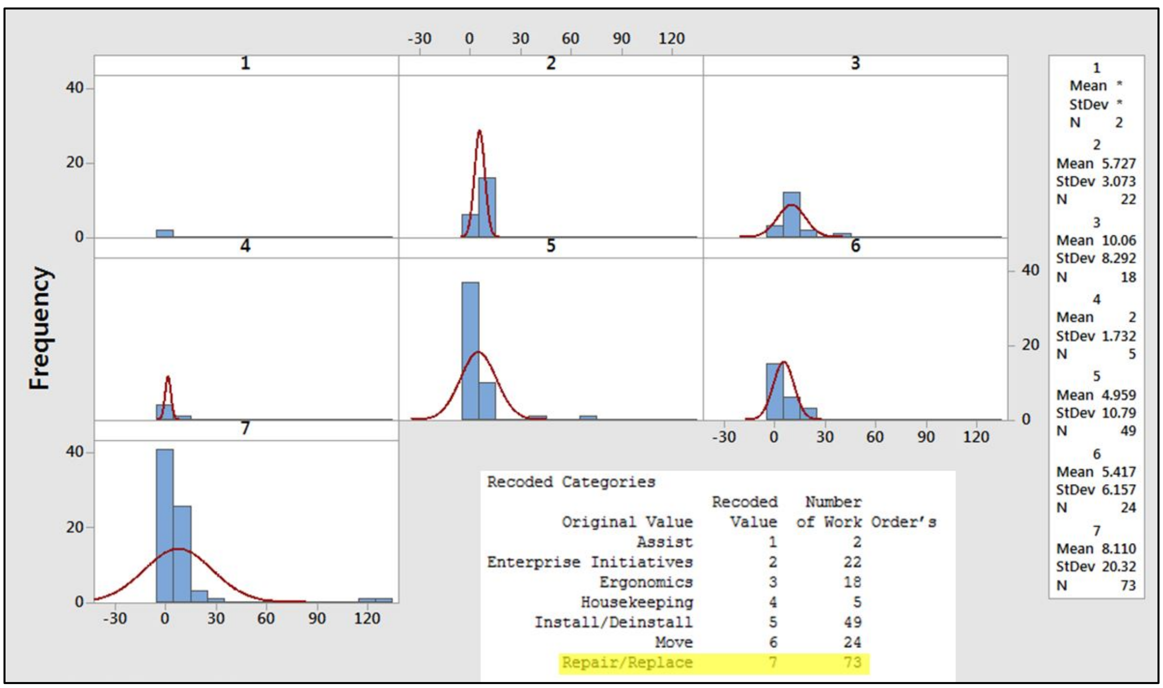
Data Collection Plan

| Indicator | Indicator Type (input, process, outcome, structure, perception) | Operational Definition | Data Source | Person responsible for collecting the data | When and where to collect the data (incl. frequency) | Sampling info (sample size, conf level, allowable error, sampling method) | Data entry plan | Data analysis plan | Communication/ Dissemination Plan |
|---|---|---|---|---|---|---|---|---|---|
| Response time—Baseline (Mean) | Outcome | For the facilities the FM team are responsible for, response time is the total elapsed time (measured in hours) from the point that an FSR is created in the CMMS software to the time that an FM team member changes the sub status field on the FSR from the default value (i.e. "Web Request") to another value, indicating that they have personally communicated with the FSR's requester and/or the work itself, thereby establishing clear expectations with and a point of contact for the customer. | CMMS Software | FM Team Project Manager | 14 Days after start of Baseline Period at a computer with access to the CMMS software. | 100% (sampling not used). Disregard any FSRs that do not have sufficient/appropriate sub-status changes logged in CMMS. FSRs created on Fridays and left unaddressed until the following week will be credited 48 hours to account for lack of weekend coverage (common cause variation). | FM Team PM will transcribe the CMMS Sub Status Change Log date values into Excel and then calculate response time. Minitab will be used to calculate and display descriptive statistics and charts for further analysis. | FM Team PM will confer with FM Team and QIP Advisor during scheduled meetings to analyze & determine appropriate actions. | FM Team PM will distribute the summary data & charts in the next FM Team meeting. |
| Response time—Runchart & Control Phase procedure (Mean) | Outcome | For the facilities the FM team are responsible for, response time is the total elapsed time (measured in hours) from the point that an FSR is created in the CMMS software to the time that an FM team member changes the sub status field on the FSR from the default value (i.e. "Web Request") to another value, indicating that they have personally communicated with the FSR's requester and/or the work itself, thereby establishing clear expectations with and a point of contact for the customer. | CMMS Software | FM Team Project Manager | Weekly, after the baseline is established, (Quarterly after QIP concludes) at a computer with access to the CMMS software. | Sample size calculated using a sample size calculator (https://www.surveymonkey.com/mp/sample-size-calculator/) and then a random number generator (https://www.random.org/sequences/) to select which observations from the population to include. Disregard any FSRs that do not have sufficient/appropriate sub-status changes logged in CMMS. FSRs created on Fridays and left unaddressed until the following week will be credited 48 hours to account for lack of weekend coverage (common cause variation). | FM Team PM will transcribe the CMMS Sub Status Change Log date values into Excel and then calculate response time. Weekly average will be added to a run chart created in Excel. | FM Team PM will confer with FM Team and QIP Advisor during scheduled meetings to analyze & determine appropriate actions. | FM Team PM will distribute the summary data & charts in the next FM Team meeting. |
| Response time—Post Intervention (Mean) | Outcome | For the facilities the FM team are responsible for, response time is the total elapsed time (measured in hours) from the point that an FSR is created in the CMMS software to the time that an FM team member changes the sub status field on the FSR from the default value (i.e. "Web Request") to another value, indicating that they have personally communicated with the FSR's requester and/or the work itself, thereby establishing clear expectations with and a point of contact for the customer. | CMMS Software | FM Team Project Manager | Final 14 Days of the QIP at a computer with access to the CMMS software. | 100% (sampling not used). Disregard any FSRs that do not have sufficient/appropriate sub-status changes logged in CMMS. FSRs created on Fridays and left unaddressed until the following week will be credited 48 hours to account for lack of weekend coverage (common cause variation). | FM Team PM will transcribe the CMMS Sub Status Change Log date values into Excel and then calculate response time. Minitab will be used to calculate and display descriptive statistics and charts for further analysis. | FM Team PM will confer with FM Team and QIP Advisor during scheduled meetings to analyze & determine appropriate actions. | FM Team PM will distribute the summary data & charts in the next FM Team meeting. |

APPENDIX H

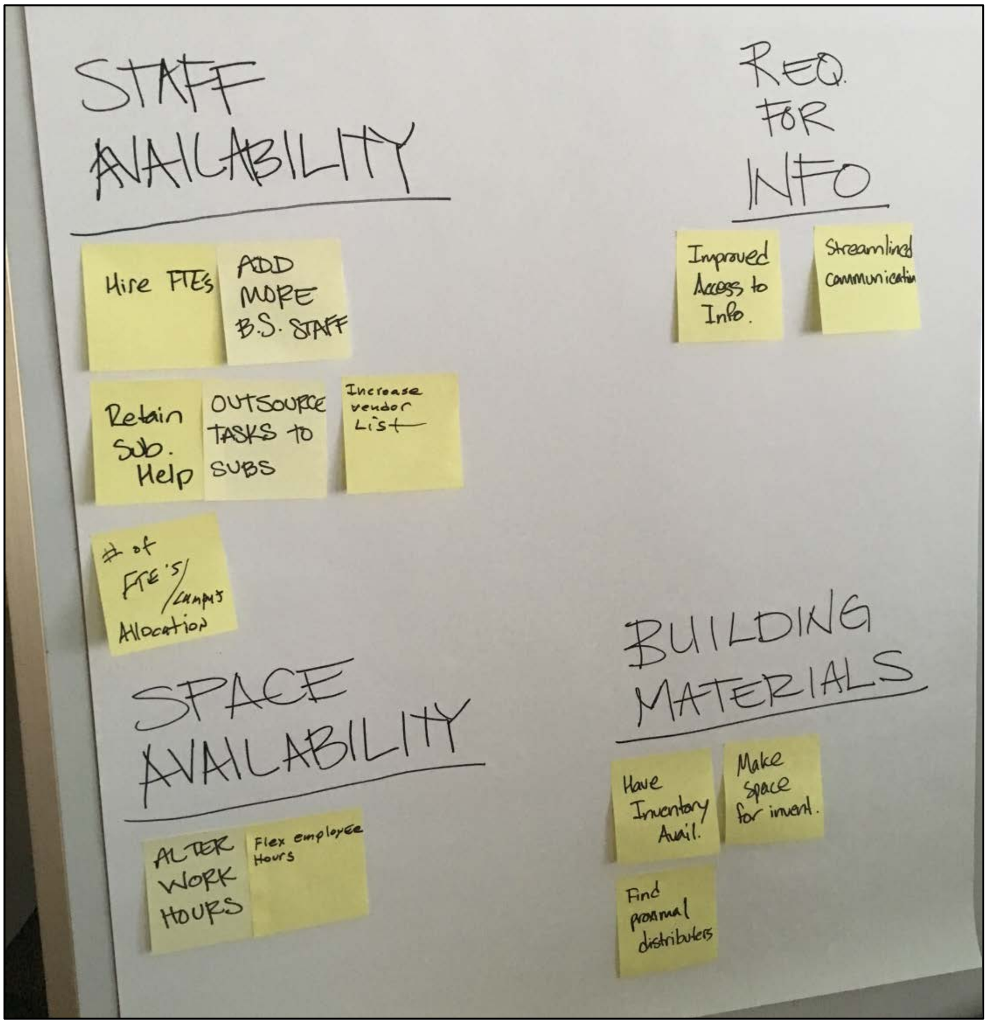
PARETO CHART & HISTOGRAMS (WITH NORMAL CURVE)


# of FSRs
Percent
FSR Category
Repair/Replace
Install/Deinstall
Move
Enterprise Initiatives
Ergonomics
Housekeeping
Assist
# of WOs 73 49 24 22 18 5 2
Percent 37.8 25.4 12.4 11.4 9.3 2.6 1.0
Cum % 37.8 63.2 75.6 87.0 96.4 99.0 100.0


Frequency
1
Mean *
StDev *
N 2
2
Mean 5.727
StDev 3.073
N 22
3
Mean 10.06
StDev 8.292
N 18
4
Mean 2
StDev 1.732
N 5
5
Mean 4.959
StDev 10.79
N 49
6
Mean 5.417
StDev 6.157
N 24
7
Mean 8.110
StDev 20.32
N 73
Recoded Categories
Original Value | Recoded Value | Number of Work Order's
Assist 1 2
Enterprise Initiatives 2 22
Ergonomics 3 18
Housekeeping 4 5
Install/Deinstall 5 49
Move 6 24
Repair/Replace 7 73

APPENDIX I

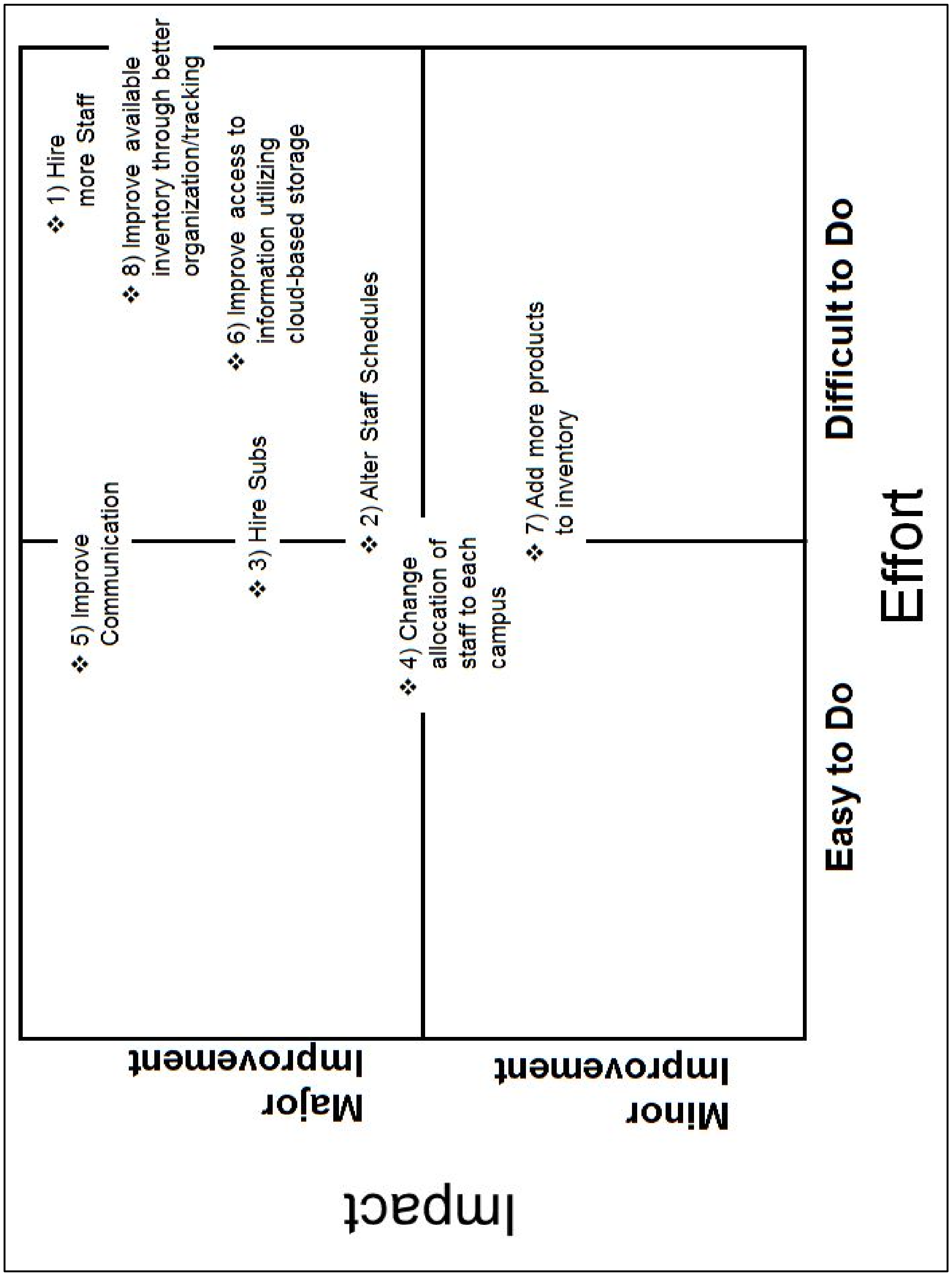
AFFINITY DIAGRAM (PHOTO)



STAFF AVAILABILITY
Hire FTE's
ADD MORE B.S. STAFF
Retain Sub. Help
OUTSOURCE TASKS TO SUBS
Increase vendor List
# of FTE'S/campus Allocation
REQ. FOR INFO
Improved Access to Info.
Streamlined communication
SPACE AVAILABILITY
ALTER WORK HOURS
Flex employee Hours
BUILDING MATERIALS
Have Inventory Avail.
Make space for invent.
Find proximal distributors

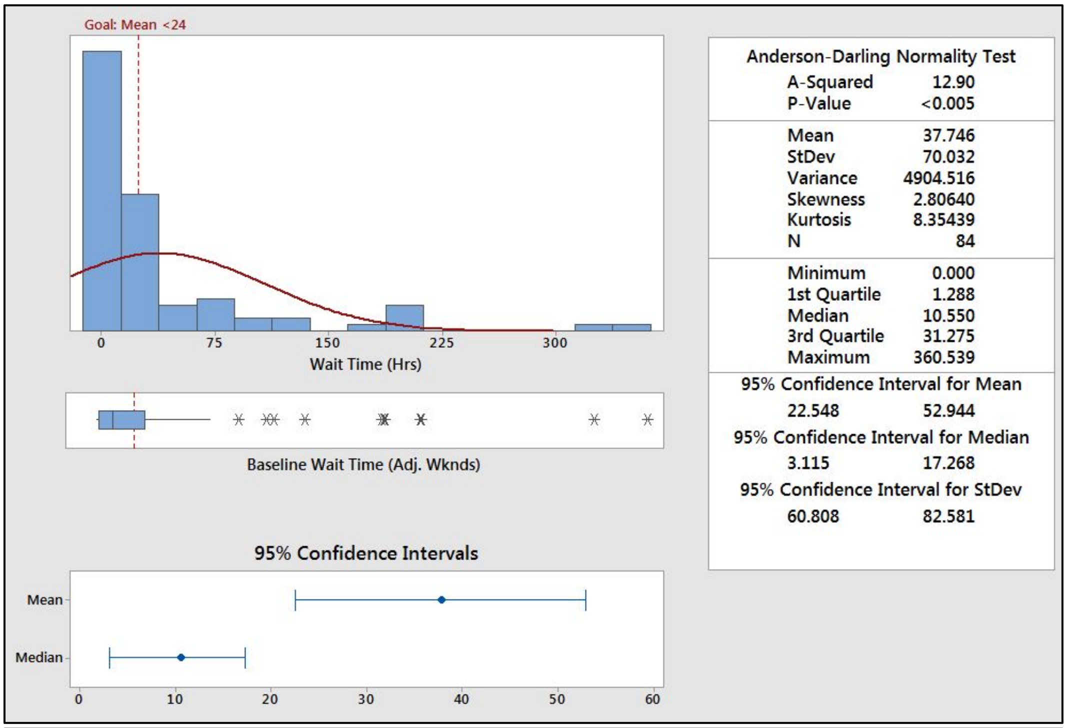
APPENDIX J

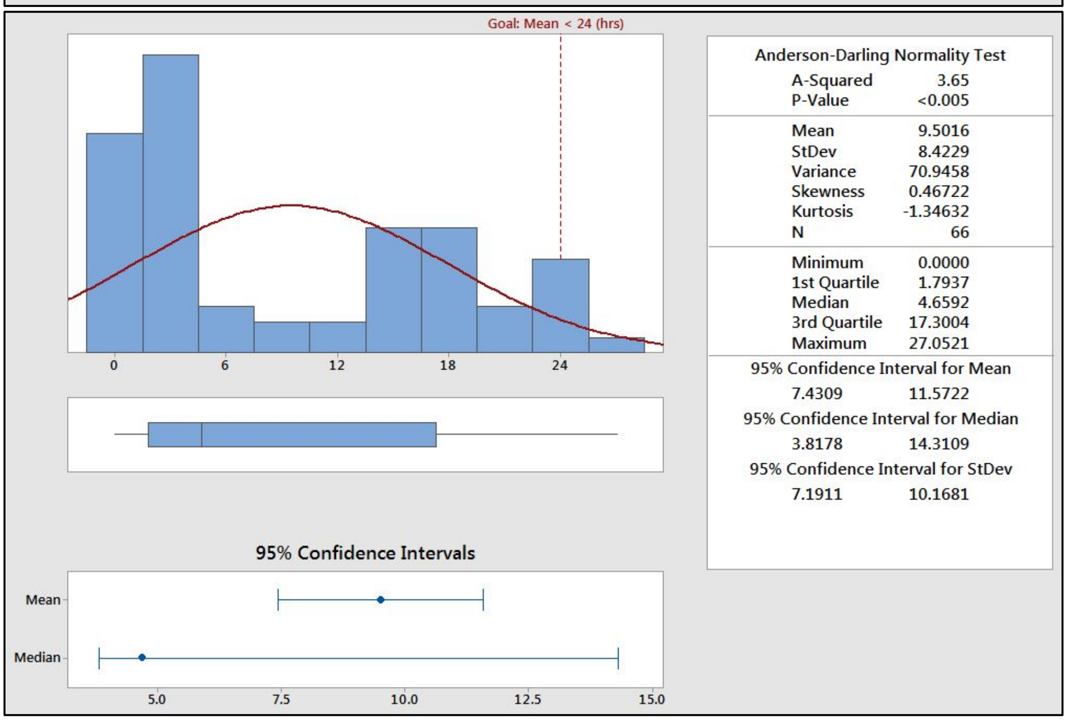
IMPACT EFFORT GRID


Impact
Major Improvement
Minor Improvement
Effort
Easy to Do
Difficult to Do
1) Hire more Staff
8) Improve available inventory through better organization/tracking
6) Improve access to information utilizing cloud-based storage
2) Alter Staff Schedules
5) Improve Communication
3) Hire Subs
4) Change allocation of staff to each campus
7) Add more products to inventory

APPENDIX K

WAIT TIME—PRE- AND POST-IMPROVEMENTS


Goal: Mean <24
0
75
150
225
300
Wait Time (Hrs)
Baseline Wait Time (Adj. Wknds)
Anderson-Darling Normality Test
A-Squared 12.90
P-Value <0.005
Mean 37.746
StDev 70.032
Variance 4904.516
Skewness 2.80640
Kurtosis 8.35439
N 84
Minimum 0.000
1st Quartile 1.288
Median 10.550
3rd Quartile 31.275
Maximum 360.539
95% Confidence Interval for Mean
22.548 52.944
95% Confidence Interval for Median
3.115 17.268
95% Confidence Interval for StDev
60.808 82.581
95% Confidence Intervals
Mean
Median
0
10
20
30
40
50
60


Goal: Mean < 24 (hrs)
0
6
12
18
24
Anderson-Darling Normality Test
A-Squared 3.65
P-Value <0.005
Mean 9.5016
StDev 8.4229
Variance 70.9458
Skewness 0.46722
Kurtosis -1.34632
N 66
Minimum 0.0000
1st Quartile 1.7937
Median 4.6592
3rd Quartile 17.3004
Maximum 27.0521
95% Confidence Interval for Mean
7.4309 11.5722
95% Confidence Interval for Median
3.8178 14.3109
95% Confidence Interval for StDev
7.1911 10.1681
95% Confidence Intervals
Mean
Median
5.0
7.5
10.0
12.5
15.0