Solving the Complexity of the Manufacturing Equipment Disposition Process Using Engineering Tools and Techniques

by

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ABSTRACT

The purpose of this thesis was to solve a complex problem in the manufacturing industry. The complex problem is the disposition and redeployment of specialized manufacturing equipment while accounting for import, export and supply chain security. The problem-solving approach is discussed in detail, focusing on lean and six sigma methodologies for a solution meeting both company internal and external requirements. This combination of lean and six sigma methodology has been validated by use in a pharmaceutical company.

The process flow to dispose equipment properly is presented in detail. The process details can be used as best practices by any company dealing with specialized manufacturing equipment, enabling them to develop a robust process tailored to their organizational structure, hierarchy and resource availability.

DEDICATION

To my wife Monica, children Jean-Pierre, Santiago and Sophia, who always gave me unconditional support and motivation to continue my education, to be resilient to adversity and to become a better husband, father and professional.

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Chapter 1

Introduction

The disposition of equipment is the disposal of equipment no longer needed or in non-working condition. In the manufacturing industry, disposition also embraces the sale and redeployment of equipment. Companies, large and small, have been disposing of equipment for decades. Equipment disposition was usually done by a capital engineering group with the knowledge and connections to “get rid” of equipment no longer needed. After World War II, a manufacturing company usually had one to two manufacturing sites. Very large companies like Ford had many different sites but they were the exception rather than the rule. Most companies advertised excess equipment locally and by personal contacts. Laws governing disposition of equipment were not strict and dealt more with safety than security. Defense contract and aerospace companies had a special set of stricter rules, but those industries are outside the scope of this thesis.

Things have changed drastically. Globalization has brought opportunity but with innumerable challenges. Outsourcing, third-party manufacturing, shared production, re-branding, etc, have spread manufacturing sites all over the globe. To be competitive, to have access to emerging markets and to pay fewer taxes, most corporations have operations abroad and own manufacturing equipment all over the world. When it is time to dispose of this equipment, the rules now are very different than in the past.

In the twenty-first century, with terrorist attacks, drug cartel violence and a world race for nuclear “energy,” laws governing the disposition of specialized equipment have multiplied. A good example is a nuclear reactor. There are non-power reactors, also known as research reactors, used primarily as a neutron source. They might be small and not “hot” enough to produce nuclear weapons, but they are still capable of “manufacturing harm.” When it is time to dispose of reactors, it is very important to know the final use of the equipment. As of 2010, there are sanctioned countries that cannot buy equipment from the United States. An example of current complexity is the disposition of tablet presses, which could be used by drug cartels for mass producing inappropriate pills. Some of these equipment issues are addressed by controlled export laws but other laws like sanctions, restricted party transactions and anti-boycott issues need to be followed appropriately.

Due to the complexity of the global market place and the creation of the Internet, equipment disposition faces an extra set of challenges. Electronic commerce, with its common global auction sites like eBay, has drastically reduced the opportunity to know the equipment buyer. What poses as a real business on the computer screen, could very well be an individual in his garage procuring tablet presses to be shipped to Canada. Those presses could then be disassembled, shipped by pieces to drug cartels in Mexico or Colombia, put back together and start mass producing banned drugs. If these “shippers” are careful enough, they may even include the original seller’s asset number, which would probably lead to legal action against the original company.

In order to cope with these new legal demands, many US-based companies have taken the safest path of only selling equipment within the United States of America. This is a less risky approach, but it also excludes buyers from foreign markets, reducing the potential monetary benefits of selling the equipment. Other companies have taken the approach of contracting a third party to dispose of assets. This path tries to transfer the liability to the third party, but this approach is not sufficient. Such third party vendors were contacted by the author and a team of subject area experts, and the vendor processes reviewed. It was quickly concluded such third party processes are flawed and liability still exists for the equipment owner.

In the course of this work, companies were contacted to benchmark and determine best practices of equipment disposition. An interesting discovery was made. Most companies did not understand the liability and risk they were assuming by hiring a third party, one focused on revenue rather than compliance. Companies do not usually have sufficient resources allocated to the disposition of equipment. Given that it is not a routine activity, it is not efficient to have dedicated resources for the task. But, whenever the need is there, a robust process needs to exist to make sure there are no compliance issues.

In order to benefit from being able to sell and redeploy equipment overseas, minimize the risk of using a third party and ensuring no compliance issues; the Fortune 500 company involved in this study decided to create a new process. The company's strategy was to leverage the knowledge of current employees experienced in an ad-hoc process with subject matter experts acting as consultants. This external and external knowledge was combined to make sure the resulting processes followed all local and international regulations. This approach had the goals of maximizing financial opportunity by selling equipment internationally within current regulations, and creating a robust process that minimized risk. The use of engineering tools, embodied in lean six sigma, to solve this complex problem, define best practices and create a robust overall process of equipment disposition was the subject of this thesis.

Chapter 2

Background Literature

Asset disposition or redeployment of information technology products has been thoroughly researched and published (Blazek, 1998), but little has been published for manufacturing equipment. When one mentions redeployment, the typical assets are human resources and military equipment. There are some papers and dissertations on military equipment redeployment (Brady, 2000; Frola, 1993), but nothing was found related to manufacturing equipment. The three largest service providers that deal with the disposition and redeployment of manufacturing equipment were contacted and their processes reviewed. It was quickly concluded that their processes were not robust enough to prevent legal failures and compliance issues for client companies. When asked about best practices in the industry, these contractors indicated that other companies do not really manage their manufacturing equipment at that level of detail and let the service provider do the imports and exports as necessary. However the original owner of the equipment is still responsible for any violations of regulatory compliance or inappropriate disposition of the equipment.

This situation was not satisfactory. Thus, the need to create a robust process was realized. Other manufacturing competitors in the industry were also and a similar response was received. This aspect of asset disposition has clearly been overlooked and non-compliance risks have not been properly addressed or contained.

There are many ways of solving a complex problem. Some are good, some are better, but all of them have something in common, structure. This commonality in structure increases the chances of success in a process-solving exercise. By using structure in problem solving, specific steps are taken to help the user understand the problem in detail and discover different solutions to solve the problem.

The lean techniques at the heart of the Toyota Production System have significantly impacted industry. The power of lean techniques has expanded from vehicle manufacturing to real estate (Chen, 2009). Most manufacturing companies use a variety of lean initiatives and there are many companies with very robust lean strategies driving their businesses.

Lean techniques have evolved over the years from being a “highly prescriptive tool-based approach” in the 1980s to “focusing on system level capabilities and integrated processes” in the new millennium (Boaden, 2005). “Lean” means “using less to do more” by “determining the value of any given process by distinguishing value-added steps from non-value added and eliminating waste so that ultimately every step adds value to the process” (Miller, 2005). Lean is a philosophy, not simply an exercise in eliminating waste. Thus, lean is much more than episodic Kaizen (rapid improvement) events; it is a continuous improvement approach. By asking the questions, “Why does this process exist at all? What is the value and the value stream?”, improvement is always occurring (Bevan, 2010).

Some books, (e.g., George, 2005) include the use of Six Sigma as a lean tool, but the Six Sigma methodology was created by Motorola in the 1980s as a method to eliminate defects and reduce variation in their processes. Six Sigma, in contrast to lean, starts with “How can we improve this process?,” but does not ask “Why does it exist at all? (Bevan, 2010).

The combination of Lean and Six Sigma is relatively new. There are a variety of books in which both methods are used to solve problems, but lately it is more common to see them combined as “Lean Six Sigma.” According to TBM Consulting Group (2010), the birth of the concatenated approach can be traced to 2010 when the use of this term was recognized by world class organizations such as Pfizer.

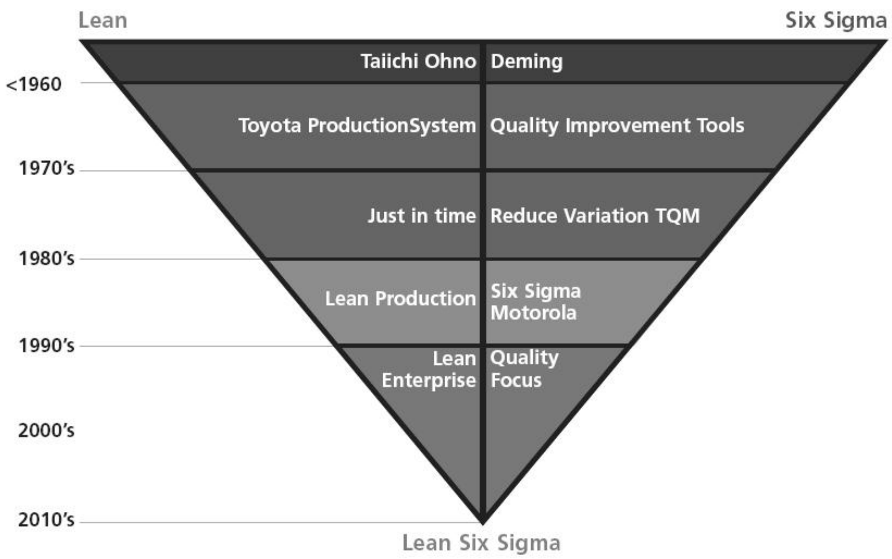

Figure 1. Evolution of Lean Six Sigma (TBM Consulting, 2010)

According to the Juran institute, the combination of both approaches can provide a philosophy and effective tools to solve problems and create rapid transformational improvement at lower cost (Bevan, 2010).

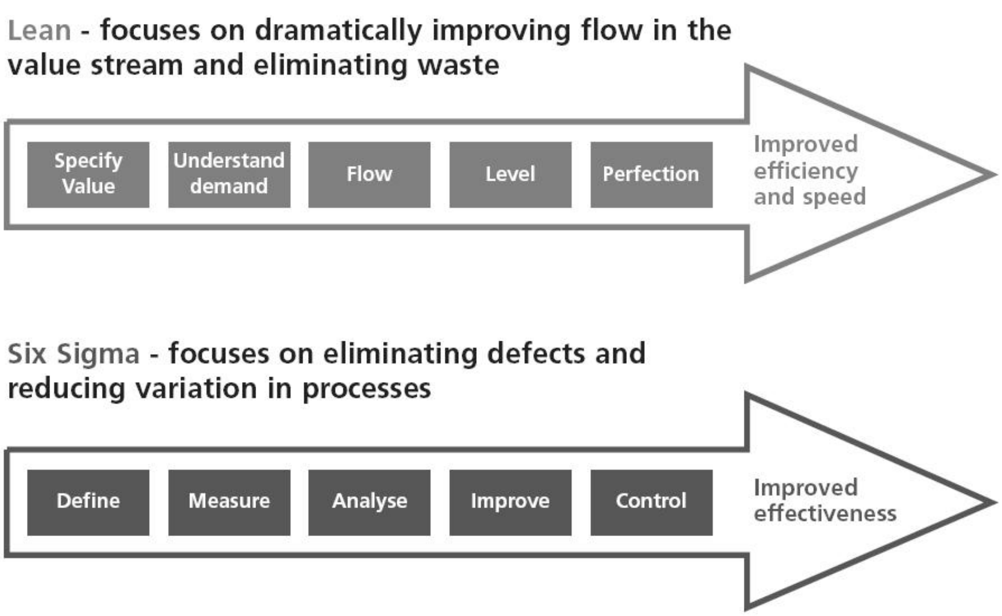

Figure 2. Process Flows for Lean and Six Sigma (Bevan, 2010)

Similarly, Nave (2002) has summarized the two approaches listing their differences in the table below.

Table 1. Methodology Differences between Lean and Six Sigma

Methodology	Lean	Six Sigma
Theory	Reduce Waste	Reduce variation
Application guidelines	Identify Value Identify value stream Flow Pull Perfection	Define Measure Analyze Improve Control
Focus	Flow	Problem
Assumptions	Waste removal will improve performance. Many small improvements are better than systems analysis.	A problem exists Figures and numbers are valued. System output improves if variation in all processes is reduced
Primary effect	Reduced flow time	Uniform process output
Secondary effects	Less variation Uniform output Less inventory New accounting system Flow metrics Improved quality	Less waste Fast throughput Less inventory Variation metrics Improved quality
Criticisms	Statistical or systems analysis not valued	System interaction not considered Processes improved independently

General Electric, which is well known for their robust lean implementation, has plotted the relative strength of both approaches, shown on the graph below.

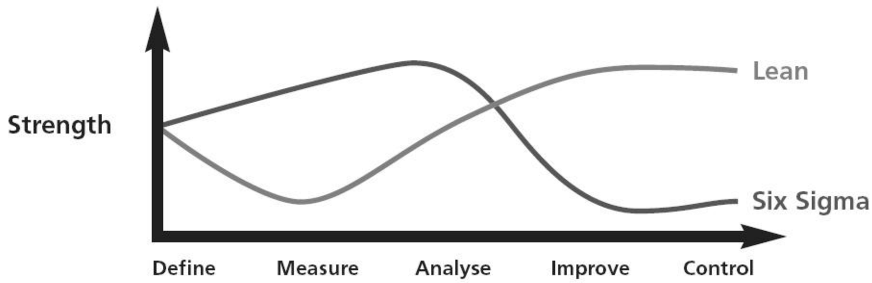

Figure 3. Relative Strengths of Lean and Six Sigma (Bevan, 2010)

It is clearly seen that the two methods complement each other, and where one method is weak the other is strong. Various studies and reviews indicate the use of both methods improves the results of process improvement effects. Thus, the Lean Six Sigma methodology was chosen for solving the asset disposition and redeployment problem. This combined method creates a robust methodology to continuously improve the process, reducing both waste and variation.

During the application of the Lean Six Sigma methodology for the asset disposition/redeployment project, some overlap of the tools and methodologies was identified. But, in such cases, both approaches created similar results.

Chapter 3

Methodology

The Lean Six Sigma approach borrows its structure from the Six Sigma methodology and encompasses the steps known as "DMAIC." DMAIC stands for Define, Measure, Analyze, Improve and Control. There are a variety of tools recommended to use in each step before moving to the next. Most of the tools were used in this thesis as they are applicable to both business and manufacturing processes. Other tools were not used as their application in a business process did not make much sense. Whenever a tool was not used, the reason was discussed in detail. The difference between a traditional Six Sigma and a "Lean Six Sigma" is the set of tools used in each DMAIC step. In order to utilize the power of the Lean Six Sigma combination, a set of tools and ideas from lean were inserted into the DMAIC steps to help the user better understand the problem and enable a better solution. The caveat is that, it is possible the overlap of tools may lead to lost time and decreased efficiency during process improvement by looking for the same answer via multiple ways.

Table 2. Define, Measure, Analyze, Improve, Control (DMAIC) Process and Tools Used

DMAIC	Tools
Define	Charter Suppliers, Inputs, Processes, Outputs, Customers (SIPOC) Tree Diagram Communication Plan Stakeholder Analysis
Measure	Process Mapping Data Collection Plan Pareto-like Charts
Analyze	Value Analysis Types of Waste Takt Time Risk Analysis
Improve	Benefit/Effort Matrix Responsible, Accountable, Consulted, Informed (RACI) / Decision maker, Advice Giver and Informed Stakeholder (DAI) Failure Mode Effect Analysis (FMEA) Push/Pull
Control	Control charts Standard Operating Procedure (SOP)

Define

This was the first step in the project. The problem statement, scope, stakeholders, timeline, key metrics, deliverables and required support were clearly defined. In this process, opportunities were identified to create a robust process by which performance improvement could be measured.

Project Charter.

The project charter shown below represents a summary of the project where the scope was clearly defined. This informative document sets clear expectations of different departments in regards to the project.

Table 3. Functional Charter – Asset Disposition and Redeployment

<table>
<tr><td>Product or Process Impacted</td><td>Globally, all manufacturing equipment that will be taken out of service in factories.</td><td colspan="3">Team Name</td><td colspan="2">Asset Disposition and Redeployment Team</td></tr>
<tr><td>Team Leader</td><td>Name – Manager</td><td colspan="3">Telephone Number</td><td colspan="2">Office phone number</td></tr>
<tr><td>Executive Sponsorship</td><td>Name – Director, Operations</td><td colspan="3">Business Unit & Division</td><td colspan="2">Operations</td></tr>
<tr><td>Start Date</td><td>November 15, 2010</td><td colspan="3">Target Project Completion Date</td><td colspan="2">December 31, 2010</td></tr>
<tr><td>Element</td><td>Description</td><td colspan="5">Team Charter</td></tr>
<tr><td>Problem Description:</td><td>Describe the Problem.</td><td colspan="5">No standard operating procedure (SOP) exists to adequately define a process for the disposition and redeployment of manufacturing equipment. Without such a process, the risk of not complying with local laws and legal regulations is high.</td></tr>
<tr><td>Process:</td><td>The process in which opportunity exists.</td><td colspan="5">Identify a robust process, avoid any non-compliance issues and leverage the opportunity to sell manufacturing equipment internationally. Develop performance metrics to allow continuous improvement of the process and determine areas of improvement opportunity.</td></tr>
<tr><td></td><td></td><td></td><td>Baseline (Today)</td><td>Goal (Future)</td><td></td><td>Units (Select)</td></tr>
<tr><td rowspan="3">Key Performance Metrics</td><td>Scorecard (level of satisfaction)</td><td></td><td>-0.5/10</td><td>8/10</td><td></td><td>Points</td></tr>
<tr><td>Avg. time to move through the process</td><td></td><td>30</td><td>15</td><td></td><td>Days</td></tr>
<tr><td>Appraise/Sold price ratio</td><td></td><td>63%</td><td>95%</td><td></td><td>Percentage</td></tr>
</table>

Team Members	Who are the team members?	Name – Manager Name – Process lead Name - Sites A single point of contact Name – Sites A engineering Name – Sites A finance Name – Sites A legal Name - Sites B single point of contact Name – Sites B engineering Name – Sites B finance Name – Sites B legal Name - Sites C single point of contact Name – Sites C engineering Name – Sites C finance Name – Sites C legal Name – Headquarters or local regulatory Name – Headquarters or local import/export
Benefit to Customers:	What benefits will external customers see and what are their most important requirements?	• A defined procedure to go about the disposition and redeployment of manufacturing equipment will streamline the current ad-hoc process and make it 100% compliant. The use of metrics will determine current state issues and opportunities. ○ A known process flow will create equal set of expectations for stakeholders at all levels. The clear set of directions will prevent compliance issues and the share of false information. ○ Improved quality resulting from the continuous improvement plan will increase the satisfaction level. ○ Security measures will allow the sale of manufacturing equipment overseas, increasing the monetary benefits.
Project Scope:	Which part of the process will be investigated?	The asset disposition and redeployment process will be used for all manufacturing equipment. It does not include equipment used to support manufacturing, such as furniture and information technology equipment.
Key Deliverables:	What are the key deliverables that will drive the anticipated results/benefits?	• Develop a standard operation procedure (SOP) for the disposition and redeployment process. • The process shall be applicable to all global sites and must meet local and international laws and regulations. • Each site will have a single point of contact in charge of executing the process and will be in constant communication with other single points of contact and the headquarters single point of contact.

Schedule: (key milestones/dates)	Executive approval of charter	August 31st, 2010	Charter gets signed.
	Kickoff meeting	September 15th, 2010	Communicate the scope, deliverables and timeline of the project. Executive sponsor to be present for initial meeting.
	DMAIC & SOP	October 15th, 2010	DMAIC process, output is the basis of the official SOP.
	Approval of SOP	November 15th, 2010	Get approval from all stakeholders.
	Process pilot run	December 15th, 2010	Pilot run of the process to determine any gaps.
9. Support Required:	Do you anticipate the need for any special capabilities, manpower, hardware, etc?	• Site support to detail current ad-hoc process. • Subject matter experts in the regulatory (DEA) department and customs department to help map the process. • Upper management support to get process signed and approved. • Service provider support to document best industry practices.	

Suppliers, inputs, processes, outputs and customers (SIPOC).

Immediately after finishing the project charter, a SIPOC exercise was performed to help identify key elements to be addressed. The information obtained was fundamental to building the process map for the project.

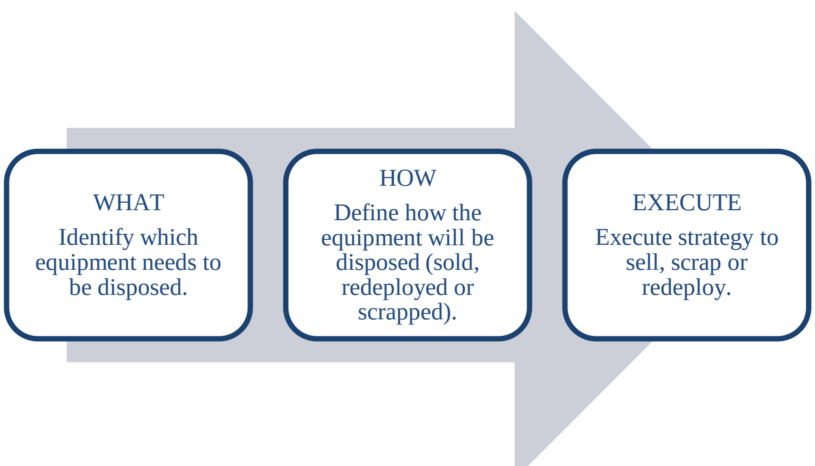

Figure 4. High Level Process Flow of Equipment Disposition

Once the process flow was determined, the identification of suppliers, their inputs, processes, outputs and the customers was done. Suppliers provide the inputs to be processed. The process output will then be delivered to the customers.

Table 4. Suppliers, Inputs, Processes, Outputs, Customers Identification (SIPOC)

Suppliers	Inputs	Process	Outputs	Customers
Capital Engineering	Equipment	Identify equipment to be sold	Equipment List	Site Single Point of Contact
Site Single Point of Contact	Equipment List	Define how it will be disposed	Procedure	Service Provider
Service Provider	Procedure	Execute (scrap, sell or redeploy)	Execution	Site Single Point of Contact

Note. The SIPOC table substantiated the voice of the customer (VOC) by identifying who the customers were for each function.

Voice of the customer (VOC).

The goal of obtaining the voice of the customer (VOC) was to obtain the necessary information to design processes so that they satisfy customer requirements. There are direct and indirect methods for obtaining the VOC. Two direct methods were used in this project since the internal customers were few, known by name and relatively easy to reach.

Method One - Interviews

Each customer was interviewed by phone and asked the following questions.

Are you the appropriate point of contact for redeployment activities at your site?

Are you familiar with the equipment redeployment process?

At a high level, how do you think it works?

Have you had any redeployment activity at your site?

How did it work? Were you satisfied how it was handled?

Do you plan to have redeployment of equipment soon?

Are you familiar with our current redeployment service provider?

Were you happy with their service?

How do you think it could be better?

Do you have plans to acquire equipment soon?

Do you, or does someone at your organization, have a demand forecast for equipment?

What ideas and/or strategies do you think need to be included in an SOP for redeployment?

Do you have any suggestions on how to tie the redeployment process to your capital expenditure process?

The questions and answers were recorded for each customer participant and their responses were converted into customer requirements, as shown in table 5 below.

Table 5. Voice of the Customer Mapped as Customer Requirements

Customer Comments	Key Customer Issues	Customer Requirements
"We have equipment that hasn't been sold for five years"	It takes too long to sell some equipment	Equipment needs to be sold, scrapped or redeployed within 6 months
"Service provider haunts us when they need something and does not return calls when we need something from them"	Poor communication	Communication needs to be efficient from both sides
"Service provider send payment to my name"	Payment mistake	Payments need to be addressed to the company and need to be paid at the end of the 30 day cycle
"Service provider focuses on the equipment they make money and not on all the lot"	Lack of consistency	Service provider needs to provide equal level of service for all equipment
"Service provider has had multiple export compliance issues"	Export Compliance	Import and Export checks and balances need to be implemented
"Service provider shipped equipment to the wrong address"	Shipping mistake	Shipment address needs to be confirmed before shipment
"It takes too long to look online for available equipment"	Too much granularity of information	Needs a quicker way to view equipment

Method Two - Surveys

Surveys have been used for centuries and can obtain confidential and unbiased results from the customers. In *Fourth Generation Management* (1994), surveying is a requirement rather than an option. Surveys are not always easy, as a survey can potentially have leading and loaded questions, making the responses biased. The survey seen below has been carefully crafted to obtain unbiased information from the process customers. This survey was sent to the same interviewees contacted in method one. By using this confidential survey, it was believed that more accurate data was received as people usually are more forthcoming during anonymous input. A wide array of information on how to create unbiased surveys can be found on the Internet and psychology books. The results from the survey provided appropriate data allowing generation of a scorecard to be used as a baseline measurement for a continuous improvement initiative.

1. Are you the appropiate point of contact for manufacturing equipment disposition/redeployment activities at your site?*

   ○ Yes ○ No

2. Have you had any redeployments at your site?*

   ○ Yes ○ No

3. Have you had any disposition (sale or scrap) of equipment at your site? *

   ○ Yes ○ No

4. Did you use "service provider name" services for any of the above activities?*

   ○ Yes ○ No

5. Are you happy with their overall service?

   On a scale of 1 to 5 where 1 represents "Extremely dissatisfied" and 5 represents "Extremely Satisfied," how would you rate your level of overall satisfaction with Equipnet, Inc as a service provider?

	1	2	3	4	5
Level of Satisfaction	○	○	○	○	○

6. How satisfied are you with their services and processes?

   On a scale of 1 to 5 where 1 represents "Extremely dissatisfied" and 5 represents "Extremely Satisfied" Leave it blank if it does not apply or you don't have any information to share.

	1	2	3	4	5
Communication	○	○	○	○	○
Local Support	○	○	○	○	○
Sale Strategies	○	○	○	○	○
Regulatory/Export Expertise	○	○	○	○	○
Documentation/Paperwork	○	○	○	○	○
Rigging	○	○	○	○	○
Sale Price	○	○	○	○	○
Service Provider's Software	○	○	○	○	○
Payment/Transfer of Funds	○	○	○	○	○

7. Do you have any comments or improvement ideas? Please share as much as you can. The more we know about your needs, the better we will be able to serve you. Thank you very much for your time.

   Remaining Characters: 8000

Figure 5. Survey Sent to Site Single Point of Contacts

Results.

The results of the survey were very similar to the ones received in the interview process (Method One). The advantage of this type of survey is the ability to separate different categories (communication, local support, etc) and get clear measurements for each. There will always be survey error as it is hard to standardize what “satisfied” or “extremely satisfied” means to different people. Different perceptions are sure to exist.

Table 6. Survey Results (Number of Responses in Each Category)

Survey Number of responses	Extremely Dissatisfied	Dissatisfied	Neutral	Satisfied	Extremely Satisfied	Total Responses	% Pop.
Overall Satisfaction		1	3	1		5	100%
Communication	1	2	1	1		5	100%
Local Support		1	3	1		5	100%
Sale Strategies			2	3		5	100%
Regulatory/Export Expertise		3	2			5	100%
Documentation/Paperwork		3	2			5	100%
Rigging			2	3		5	100%
Sale Price			2	3		5	100%
Software		1	1	3		5	100%
Payment/Fund Transfer		3	2			5	100%
						50	

Tree Diagrams.

Tree diagrams were done based on the VOC to define the data collected and how to measure it. The tree diagrams columns start with the need, define the drivers and end with the critical customer requirements. This is a more challenging task than it looks, as selecting simple words to clearly describe a quality or measurement was difficult.

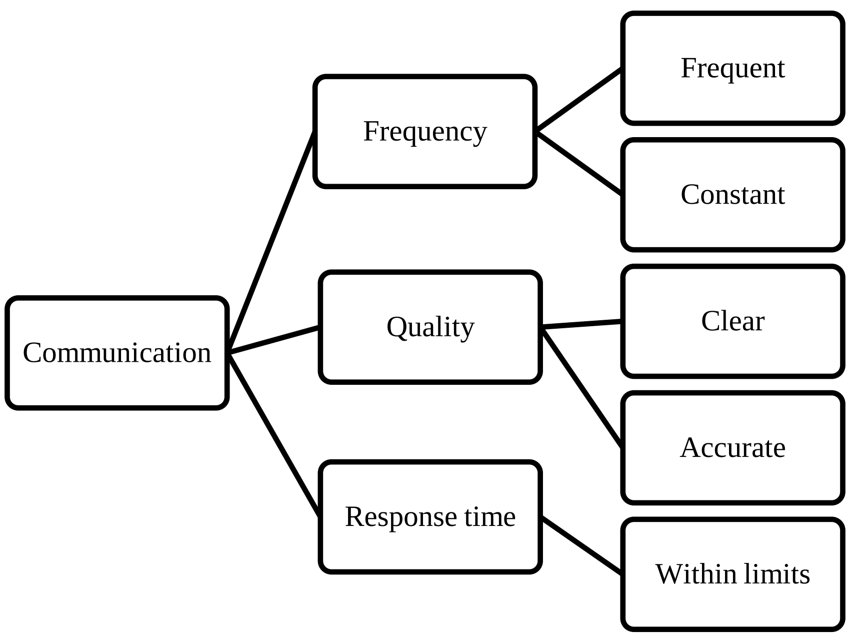

Figure 6. Tree Diagram for Communications

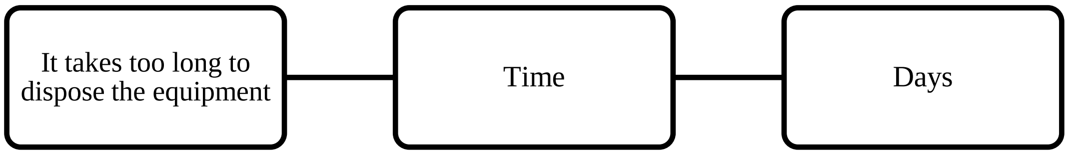

Figure 7. Tree Diagram for Process Time

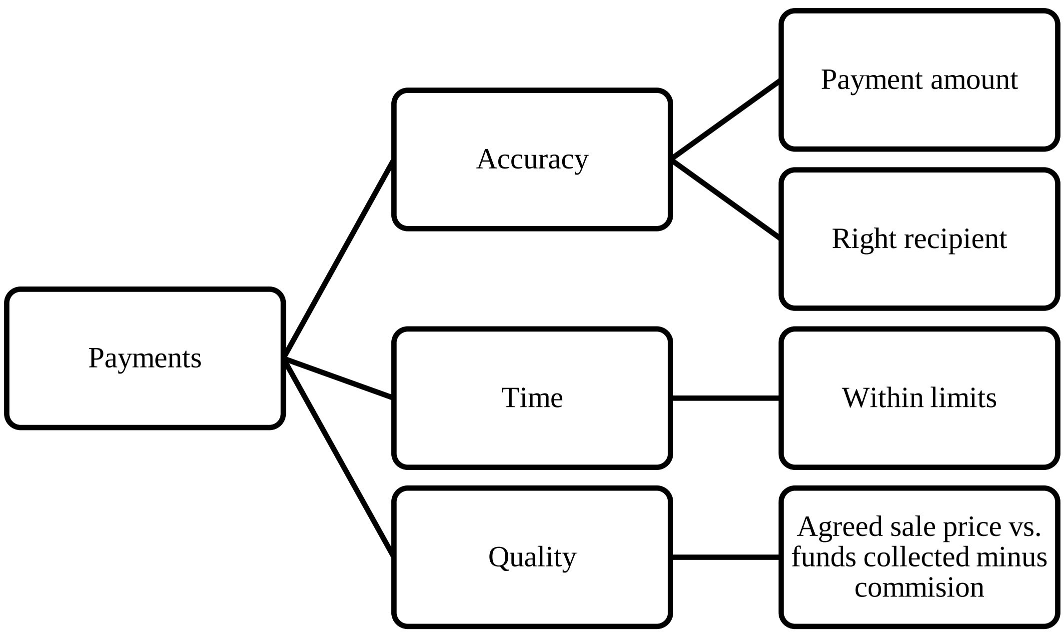

Figure 8. Tree Diagram for Payments

Figure 9. Tree Diagram for Service Level Determination

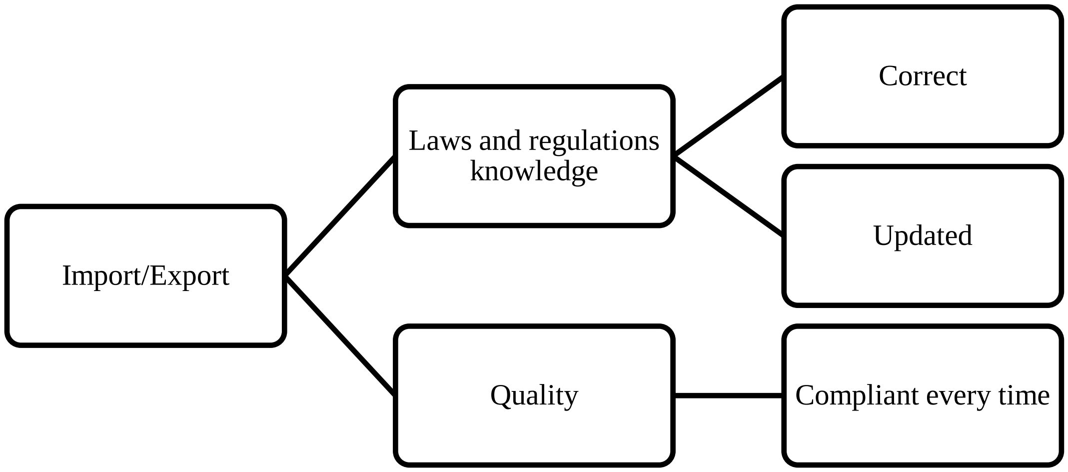

Figure 10. Tree Diagram for Import/Export Requirements

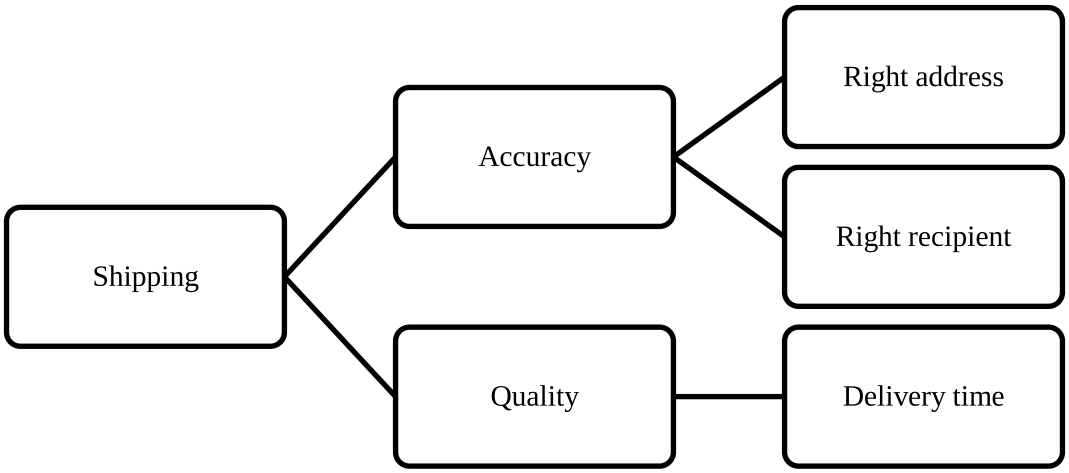

Figure 11. Tree Diagram for Shipping

As it can be seen above, the thought process behind these tree diagrams required converting qualitative needs into quantitative metrics. A complete measurement system could be implemented measuring all the current items and incorporates new measurements along the way. For example, how many times was the address right? How many times did the service provider know the answer to export questions and to regulatory questions? After measurement, resulting data can be statistically analyzed.

But who is going to do it? Does measurement add enough value relative to the time the analyst spends computing these data? Are there available resources to compute all these data points? The most common answer in a corporate environment is “no.” A pragmatic approach is to have enough metrics to measure process performance but avoid collecting unnecessary data. The definition of what is enough and what is too much is subjective and depends on many variables. In this case, there were three levels of information that will be recorded, and they are expected to give the process owner necessary information to identify improvement opportunities. More details about the information details collected and how they will be used, will be discussed in the following data collection and data analysis sections.

Communication Plan.

A communication plan was developed listing the interested audiences, media to be used, purpose of the communication, the topics of discussion, the owner of the process, frequency and the current status. The effective and structured communication helped build and maintain trust, prevent rumors and enlist the participation of employees. It was found to be an important factor in achieving common objectives.

Table 7. Communications Plan

Audience	Media	Purpose	Topics of Discussion Key Messages	Owner	Frequency	Notes/ Status
Site Single Point of Contact	live meeting	training	process flow expectations SOP	Name	Each document revision (~once/year)	TBD
Site Engineering	email	communicate	process flow expectations SOP	Name	Each document revision (~once/year)	TBD
Site Finance	email	communicate	process flow expectations SOP	Name	Each document revision (~once/year)	TBD
Site Regulatory	email	communicate	process flow expectations SOP	Name	Each document revision (~once/year)	TBD
Customs	one on one	training	process flow expectations SOP	Name	Each document revision (~once/year)	TBD
Service Provider	live meeting	training	process flow expectations SOP	Name	Each document revision (~once/year)	TBD

Stakeholder Analysis.

A stakeholder analysis was done to identify any stakeholders which might not support the project. The study enabled the creation of an influencing strategy to bring stakeholders closer to the needed buy-in.

Stakeholder Analysis & Response Plan									
Stakeholder	Strongly Against	Moderately Against	Neutral	Moderately Supportive	Strongly Supportive	Type Resistance	Example(s)	Influencing Strategy	Resp.
Site Single Point of Contact					O	No resistance			Name
Site Engineering		O →		X		Lack of knowledge	Don't attend meetings	Meet with them to review process	Name
Site Finance			O →	X		Lack of knowledge	Does not know much about the process	Meet with them to review process	Name
Site Regulatory				O →	X	Cautious		Include them on the meetings	Name
Import / Export				O →	X	Cautious		Include them on the meetings	Name
Service Provider					O	No resistance			
O - Baseline Support				X - Needed Support					

Figure 12. Stakeholder Analysis

Measure

Process Mapping.

The asset disposition and redeployment process was mapped using individual responses. These responses were collectively analyzed and process alignment determined. If there was an alignment issue, the root cause was determined and, using subject matter experts, the correct process was mapped to meet the laws and regulations applicable to that particular equipment or location. The updated process was continuously communicated with stakeholders to maintain their buy-in. The new process details were written in red so readers could see the information that had been updated and its impact on their functions. They had to revise and question as needed. It is important to note that processes were always referred as tentative processes, implying that no decisions would be made without the stakeholders' approval. This little, but important, detail kept the stakeholders engaged and aware that their input was important and necessary to finish the project.

The process mapping was the most time consuming part of the design process as it required review by all stakeholders thirteen times. Each time a stakeholder proposed a change, large or small, it had to be reviewed and approved by other stakeholders. Once it was determined that all stakeholders' requirements were aligned with the process, a general meeting was called to review the process map, its details and obtain everyone's approval.

The process evolution can be seen in the following figures. The figures below are intentionally very small and hard to read to protect the proprietary nature of the information. But it clearly can be seen how it started from a very simple process flow and became to a more complex flow reflecting the actual complexity of the process. The company SOP (not shown in this thesis) has only the latest process map. But since it will be revised on a yearly basis, it is expected that the process will continuously improve and adapt to changing market conditions or regulatory requirements.

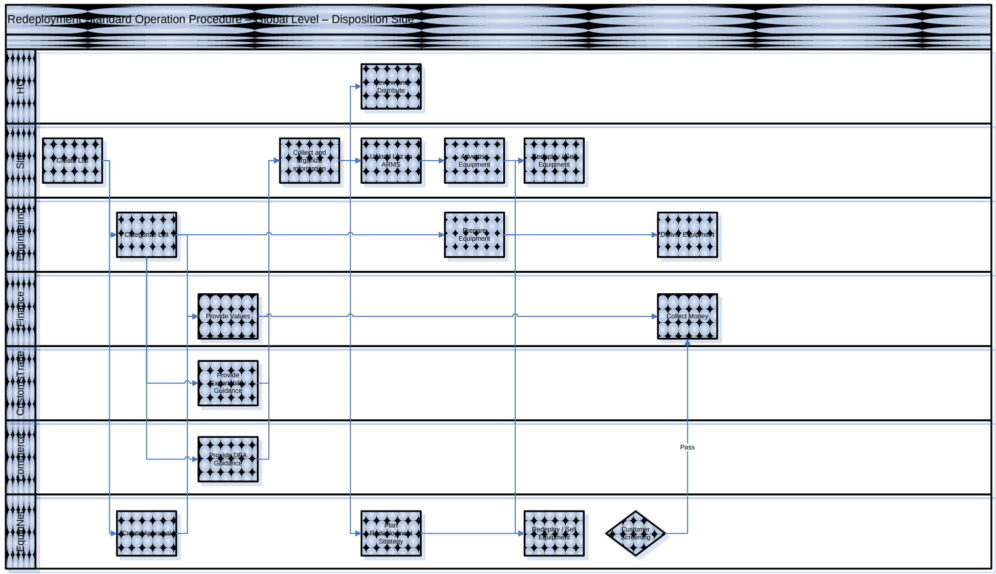

Figure 13. Version One of the Process Map

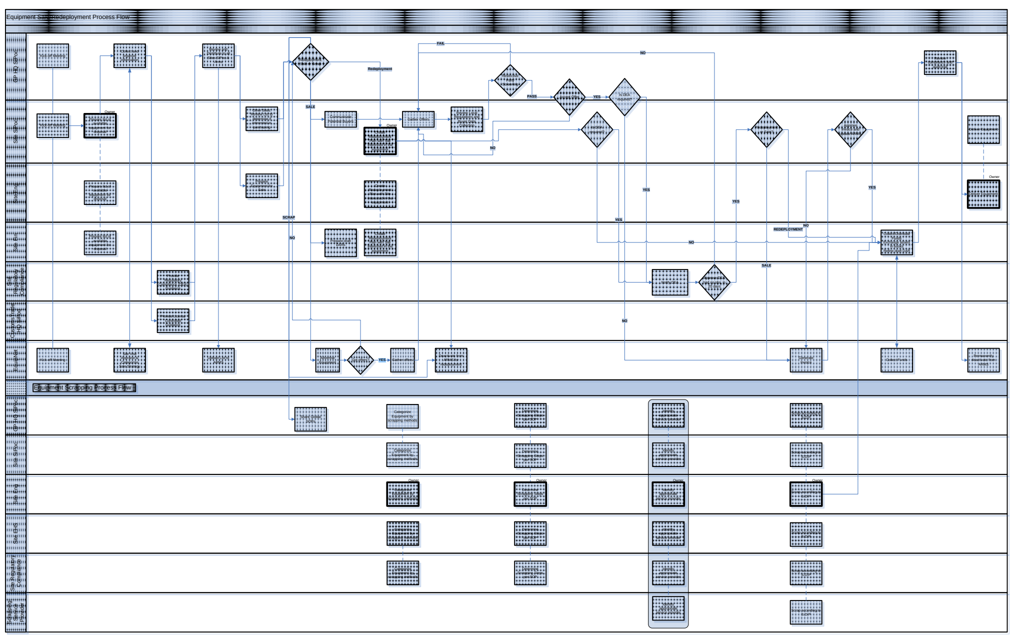

Figure 14. Version Thirteen of the Process Map (Post Design)

Building this process map was where the best practices were designed to be a hundred percent compliant. To be compliant, there were checks and balances needed to make sure appropriate subject matter experts are making the decisions on equipment categorization.

Data Collection Plan including operational definitions.

Performance Measure/Metric	Units	Operational Definition	Sample Size	Source & Location	Collection Method	Who Will Collect Data	When Will Data be Collected
Appraise to Upload	days	Time it takes to upload the equipment on the software from when the appraisal is received	100%	E-mails Software	Manual / Software	Name	Every transaction
Upload to Sold	days	Time it takes to sell the equipment from the day it was uploaded on the software	100%	E-mails Software	Manual / Software	Name	Every transaction
Sold to Payment Received	days	Time it takes to receive the payment from the day the equipment was sold	100%	E-mails Software	Manual / Software	Name	Every transaction
Service Provider							
Overall Satisfaction	score	How satisfied the customer is with the overall service	100%	Survey	Manual	Name	Every 6 months
Communication	score	How satisfied the customer is with the communication	100%	Survey	Manual	Name	Every 6 months
Local Support	score	How satisfied the customer is with the local support	100%	Survey	Manual	Name	Every 6 months
Sale Strategies	score	How satisfied the customer is with the sale strategies	100%	Survey	Manual	Name	Every 6 months
Regulatory / Export Expertise	score	How satisfied the customer is with the expertise in regulatory and export issues	100%	Survey	Manual	Name	Every 6 months
Documentation/Paperwork	score	How satisfied the customer is with the handling of documentation/paperwork	100%	Survey	Manual	Name	Every 6 months
Rigging	score	How satisfied the customer is with the rigging or removal of the equipment	100%	Survey	Manual	Name	Every 6 months
Sale Price	score	How satisfied the customer is with the price they are getting for their equipment	100%	Survey	Manual	Name	Every 6 months
Software	score	How satisfied the customer is with the software where the equipment is uploaded	100%	Survey	Manual	Name	Every 6 months
Payment / Fund Transfer	score	How satisfied the customer is with the payments or fund transfers	100%	Survey	Manual	Name	Every 6 months
Sale price vs appraised price	percentage	The difference between their appraisal and the amount the equipment actually was sold for	100%	Software	Manual	Name	Every transaction

Figure 15. Data Collection Table.

Ledermann Satisfaction Index Chart

Pareto charts are useful to separate the critical problems from the trivial. They take into account the frequency of responses and are graphed from highest to lowest frequency. For this thesis, a custom chart was created that also takes into consideration the scores of each category. Since it was not known by the author or the thesis committee if this type of chart has been used before, it was named “Ledermann Satisfaction Index Chart.” It takes into consideration, as does the Pareto chart, the frequency of responses, but also multiplies them by the score of each category. The sum of these manipulations represented a satisfaction index, as shown in Figure 16. The results were graphed from lowest to highest score, showing the areas that need attention. The data used for the calculations came from a scorecard created for this process. A score was assigned to each satisfaction level from the VOC data. “Extremely Dissatisfied” was given a negative one point and “Extremely Satisfied” received a positive one point. A neutral response earned zero points. Thus, the frequency of responses shown in Table 6 was multiplied by the number assigned to each satisfaction level. An example will be done for “Communication” to illustrate the calculation steps.

Communication (frequency of responses from Table 6, shown again below for convenience):

1: “Extremely Dissatisfied” (ED)

2: “Dissatisfied” (D)

1: “Neutral” (N)

1: “Satisfied” (S)

These were multiplied by the value of each different response category from Table 8:

1 (ED) x (-1) = -1

2 (D) x (-0.5) = -1

1 (N) x (0) = 0

1 (S) x (0.5) = 0.5

The results were then added (-1 + (-1) + 0 + 0.5), resulting in a satisfaction index of -1.5. The satisfaction index was then graphed and shown in Figure 16 from lowest to highest score to determine which categories need more attention.

Table 6. Survey Results (Number of responses in each category)

Survey Number of responses	Extremely Dissatisfied	Dissatisfied	Neutral	Satisfied	Extremely Satisfied	Total Responses	% Pop.
Overall Satisfaction		1	3	1		5	100%
Communication	1	2	1	1		5	100%
Local Support		1	3	1		5	100%
Sale Strategies			2	3		5	100%
Regulatory/Export Expertise		3	2			5	100%
Documentation/Paperwork		3	2			5	100%
Rigging			2	3		5	100%
Sale Price			2	3		5	100%
Software		1	1	3		5	100%
Payment/Fund Transfer		3	2			5	100%
						50	

Table 8. Scorecard

Scorecard	Extremely Dissatisfied	Dissatisfied	Neutral	Satisfied	Extremely Satisfied	Satisfaction Index
Value per response	-1	-0.5	0	0.5	1	
Overall Satisfaction	0	-0.5	0	0.5	0	0
Communication	-1.0	-1.0	0	0.5	0	-1.5
Local Support	0	-0.5	0	0.5	0	0
Sale Strategies	0	0	0	1.5	0	1.5
Regulatory/Export Expertise	0	-1.5	0	0.0	0	-1.5
Documentation/Paperwork	0	-1.5	0	0.0	0	-1.5
Rigging	0	0	0	1.5	0	1.5
Sale Price	0	0	0	1.5	0	1.5
Software	0	-0.5	0	1.5	0	1.0
Payment/Fund Transfer	0	-1.5	0	0.0	0	-1.5
					Total Score	-0.5
					Total Possible	10.0
					Range	20.0

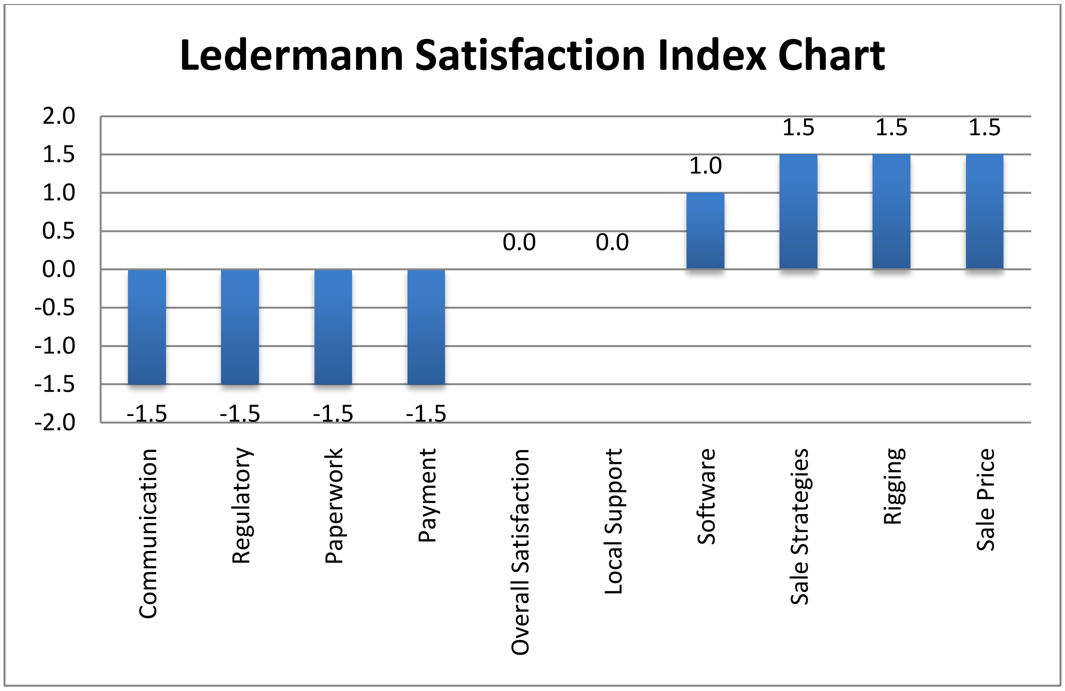

Figure 16. Scorecard Plot

As it can be seen in the figure above, the four categories needing the most attention are communication, regulatory expertise, paperwork and payment. It is a coincidence that all of them had the same scores, but all were considered priority areas for improvement.

Analyze

Value Analysis

Value analysis is one of the most fundamental tools in Lean Six Sigma. The categorization of all processes into customer-value add (CVA), non-value add (NVA) and business-value add (BVA) gives the user a clear understanding on what processes add value and thus are needed. The equipment disposition process flow was analyzed and each process categorized. The results are shown on the figure below.

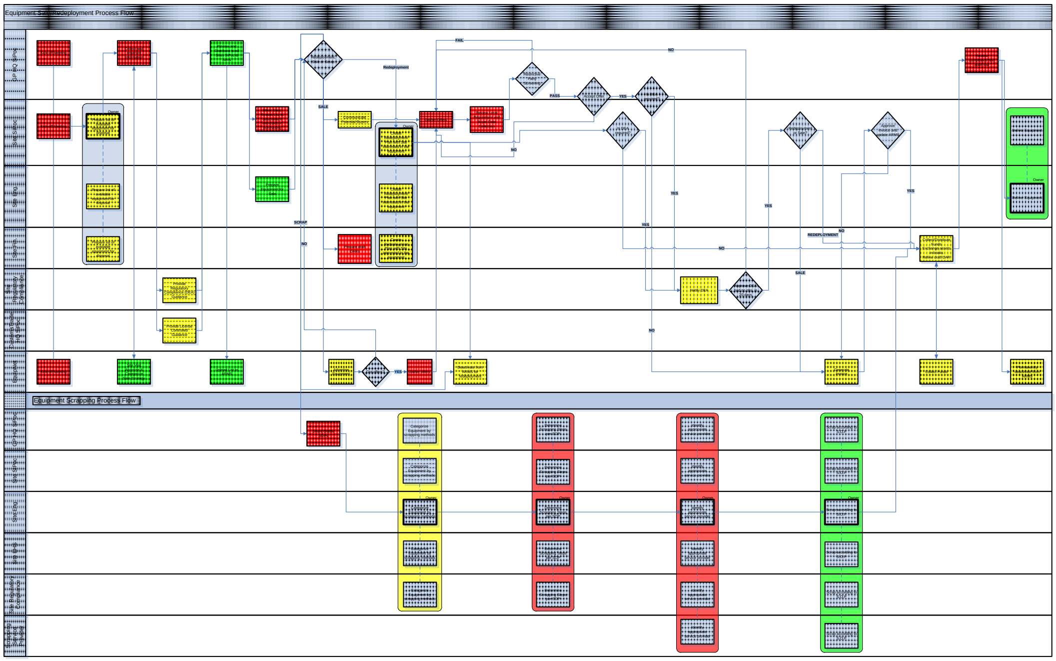

Figure 17. Value Analysis Mapping

As seen above, the number of CVA processes (medium shading) were low compared to the number of BVA (light shading) and NVA (dark shading). This process was not as lean as possible but the risk inherent to the process also needed to be taken into consideration. Ideally from a lean perspective, the process may have BVA activities needed to run the business but most activities would be CVAs. From a compliance perspective, necessary checks and balances increased the NVAs activities. However, value analysis depends on who does the categorization. In this case, the number of NVA activities was high and the number of CVA activities was very low. If someone from a legal or compliance department had done the exercise, different results would have been obtained. For those departments, checks and balance activities would have been considered CVA. It is important to understand the perspective used to categorize the processes. In a business process, the customer might not be the final consumer, but rather internal customers who are not interested in how fast the process flow but rather how efficient it is. In a manufacturing environment, the efficiency is very important but the speed is also considered important when calculating the productivity. A good analogy of fast versus efficient is a car. A fast car does not necessarily mean it is an efficient car.

Process Cycle Efficiency = Value Add Time/Total Cycle Time

It would be ideal to measure the time it takes each process to be completed and use the results to calculate the process cycle efficiency. In this case, measurements of each process was not feasible given the limited amount of resources available (lack of workforce dedicated to this process).

Types of waste

When doing a value analysis, it is important to understand the types of wastes. Types of waste could be categorized into the following: transportation, inventory, motion, waiting, over-production, over-processing, defects/rework and intellect (MCS Media, 2003). When categorizing NVA processes or activities, the type of waste should be identified in each NVA to determine the opportunity for improvement. In this case, all NVA activities were over-processing, also called bureaucracy. Bureaucracy is inherent in large corporations and it is usually created by the employees. In the equipment disposition process, over-processing has been created to make sure each transaction is 100% compliant. If company personnel or the service provider could be held accountable for non-compliance, this mandate could be relaxed. But, the reality is that if there is non-compliance of any sort, the government penalties will impact the corporation and not necessarily the individual or service provider that made the mistake. The reputation, the legal difficulty and resulting compliance issues that a mistake might cause, are much more expensive than any efficiency lost in over-processing. This fact works against the lean initiative but improvements are still possible, even with the compliance mandate.

Takt Time.

A Takt time measurement is usually considered the base calculation in all lean projects. It can be found differently depending on the process.

Takt Time = Production Time Available / Number of Units to Produce.

Takt Rate = Units to Produce / Production Time Available

The Takt rate calculation is used to find constraints or bottlenecks in a process. The processes or operations below the Takt Rate are identified as constraints and remediation plans need to be envisioned.

In a business process, it is observed by the author that the formula names should be changed to reflect a business process in a more accurate way:

Takt Time = Process Time Available / Number of Processes to Run.

Takt Rate = Number of Processes to Run / Process Time Available.

Unfortunately, the number of processes necessary in equipment disposition will change constantly depending on specific site requirements. The process time available results from the stakeholders' available process time. The time available depends on each stakeholder and there are so many site dependent drivers, it was not pragmatic to quantify. If performance is strongly related to the available resources to run the equipment disposition process, then the increase of capacity or resources will make a difference on the end result.

Risk Analysis.

A risk analysis was done to identify potential threats and opportunities in the process. The identification of these issues prevents surprises and crisis in the future. The process is composed of four steps.

Risk Identification.

In order to do the risk identification, the Strength, Weakness, Opportunity, Threat (SWOT) methodology was used. The results are shown below and were prioritized by using the risk grid previously discussed.

Table 9. Strength, Weakness, Opportunity, Threat Table (SWOT)

Strength	Weakness
Willingness of the team to do things right	Categorize equipment correctly
Ability to have SME (Subject Matter Experts) on exports and regulations	Knowledge on local laws regarding drug enforcement
Future availability of a SOP to guide users to avoid any mistakes	Knowledge of local laws regarding exportability requirements
Future robust process that will allow international sales	Lack of visibility of actual buyers
	Lack of use of customer screening
	Sending payments to the wrong person
Opportunity	**Threat**
Motivation	Export compliance issues
Resources	Regulatory compliance issues
Guidance	Service Provider issues
SOP	

Risk Prioritization.

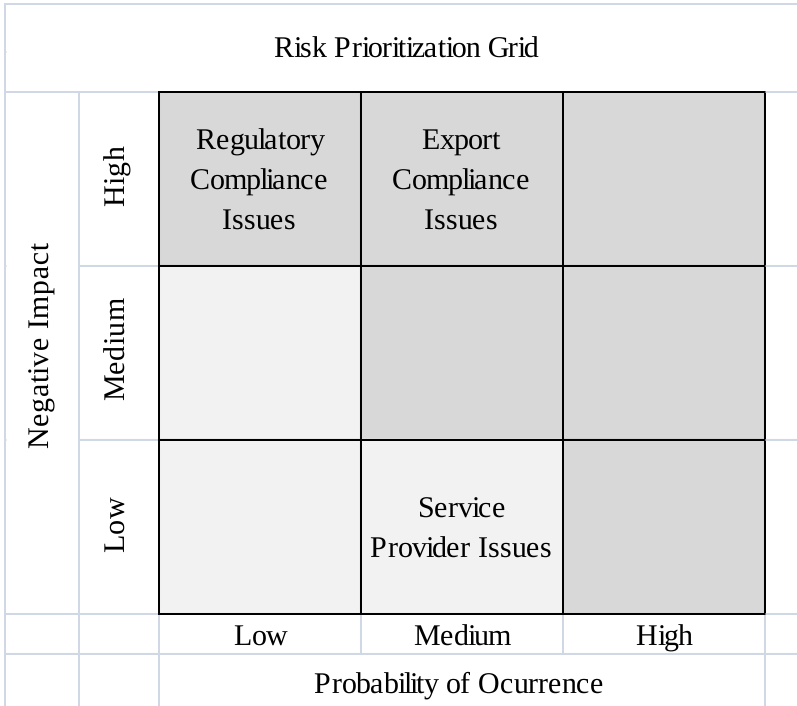

Figure 18. Risk Prioritization Grid

Risk Response Development.

Only the two threats fell into the high impact area and are discussed. The risk response development was based on four actions.

Avoidance.

Avoidance meant that no equipment would be sold / redeployed outside the US, reducing drastically the potential benefits of higher bids offered by international buyers.

Transference.

Transference was the most common approach. When equipment was being sold, the ownership of the assets would be transferred to the service provider, transferring any liability to them. As explained in the previous sections, these third party companies were contacted and their processes were not yet up to par with the requirements in this company.

Mitigation.

Mitigation of compliance issues was hard to define. Mitigation depends on the level and kind of the issue needing mitigation. Once a problem occurs, the first step is to determine how it can be corrected. If the event has been already processed by legal authorities, then the company has to approach them to determine the next step. If the event has been processed and a fine issued, then the company's legal department will need to be consulted to determine best practices. Most likely, the company will have to pay the fine, which could be up to three million dollars for reactors sold to the wrong country and possible jail time for responsible parties. That is why it is so important to have the necessary checks and balances to avoid this situation. The checks and balances do add waste to the process, in productivity terms, but could be tagged as business critical.

Acceptance.

Acceptance of risk has been the typical response to high risk threats. The company accepts the consequences and will do everything to avoid the occurrence. In the meantime, the transference of liability option needs to be analyzed in the future to determine opportunities.

Risk Response Control.

Risk response control involves the continuous re-evaluation and re-quantification of risks and results. All findings and new strategies need to be documented for future reference. This is the job of the process owner.

Improve

Benefit/Effort(B&E) Matrix.

A B&E matrix was developed to better understand the effort required for those improvement ideas put forward brought by stakeholders during the interviews and surveys. The list of improvements is the same as the one shown on the VOC section previously discussed.

Table 10. Benefit and Effort Matrix

Item	X	Y	Title
A	70	70	Time to sell equipment
B	10	95	Poor communication
C	20	80	Payment mistakes
D	40	40	Lack of consistency
E	35	80	Export compliance
F	20	90	Shipping mistakes
G	85	35	Too much information

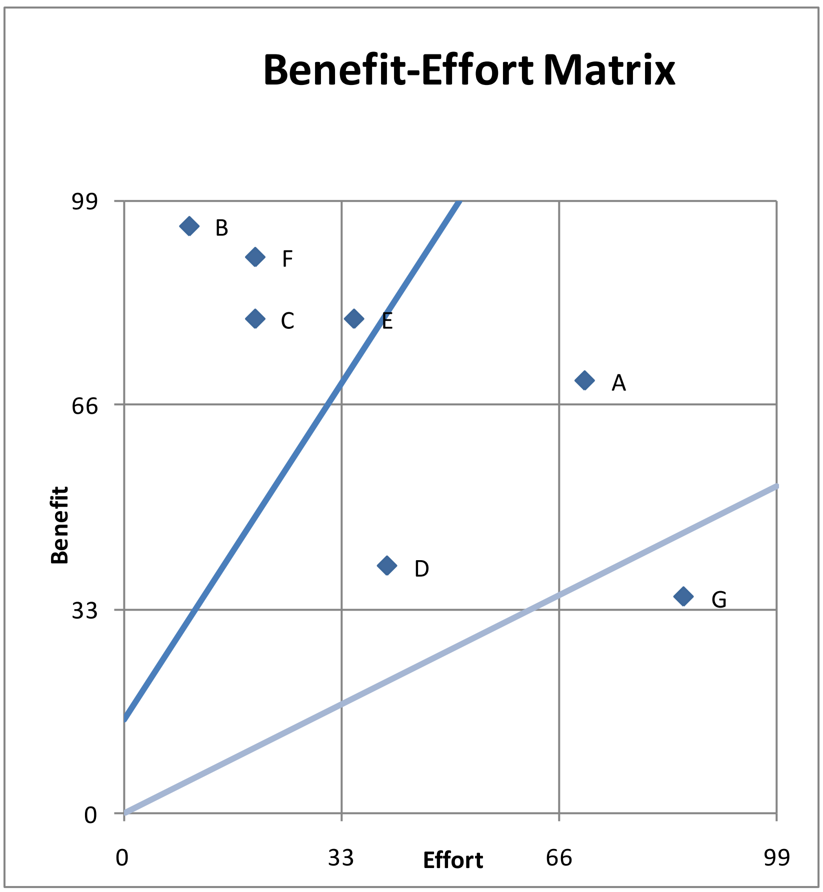

Figure 19. Benefit and Effort Matrix

It can be seen on the matrix that there are many opportunities above the top line. The items in the upper left corner create a lot of benefit and do not require much effort. Tasks B, F, C and E were chosen as improvement opportunities worth the effort. From Table 10, it can be seen that those opportunities are: communications, shipping mistakes, payment mistakes and export compliance. The results of these efforts are shown in Chapter 4.

Decision Maker, Advice Giver, Informed Stakeholder (DAI).

The decision role clarity model was used to clarify the role and responsibility of each stakeholder in the decision-making process. Every sub-process was analyzed to determine these three variants of individual roles.

As seen in the process flow below, the swimlanes determine the stakeholders of each process. If the process has more than one stakeholder, then the owner is clearly shown. The other stakeholders become advise givers and the headquarters single point of contact will be the informed stakeholder when the process flow comes to his/her swimlane. The chart below is very small and hard to read intentionally to protect the proprietary nature of company information. Typical swimlanes (stakeholders) involved in this type of process are: headquarters, site capital engineering, site regulatory, site import/export, legal, site finance, service providers.

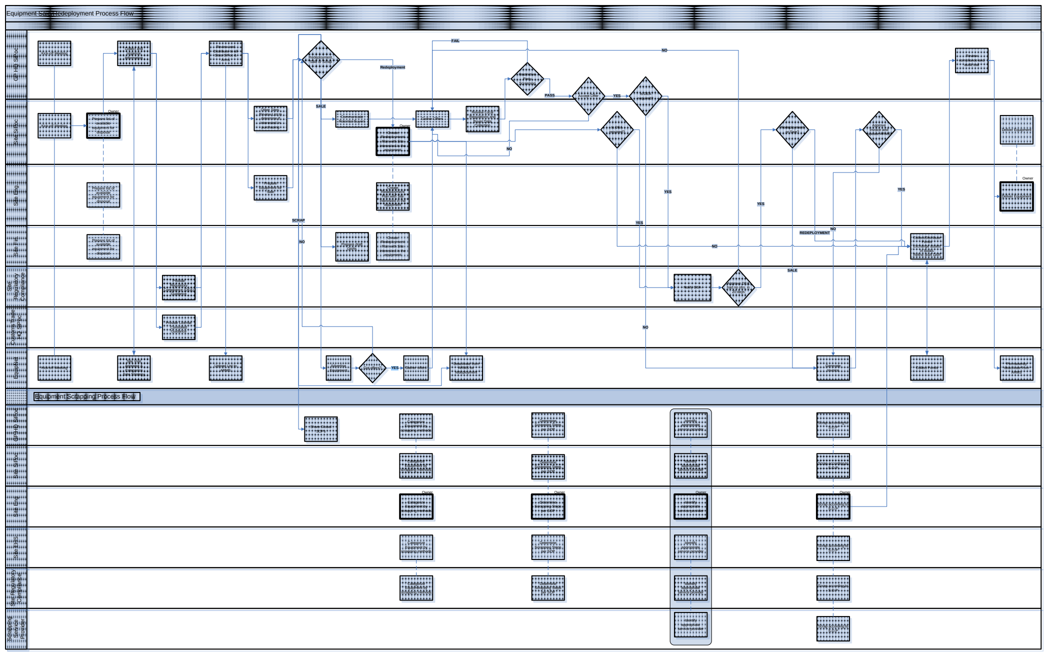

Figure 19. Process Flow

The responsible, accountable, consulted, informed (RACI) model is very similar to the DAI models. The difference is that RACI has a responsible individual identified to do the work and a different accountable person, in most cases, the manager of the responsible person. This was a good example of overlapping techniques where two similar methods have the same results. There was no value in this work to do both. Given that the equipment disposition process deals with the managers directly, the DAI method was preferred over the RACI.

Failure Mode and Effect Analysis (F MEA).

The failure mode and effect analysis method was reviewed to determine if its use was necessary. This method is commonly used to prioritize process activities that could fail or have a high risk factor. The identification of high-risk processes and their prioritization was previously completed with the risk prioritization grid. Given this overlap, it was decided that the FMEA was not necessary for this project.

Push/Pull.

The push/pull concept emphasizes the importance of having a pull system from the customer rather than pushing product from the factory. If this concept is applied in this situation, the customers will pull equipment disposition data as needed instead of the data being pushed to them.

Control

Control Charts.

Control charts show how a process is behaving over time. There are upper and lower control limits to determine when the process is going out of control. In this case, control charts might be useful in the future, when more process data are available. At this point, there was only one measurement of current state. If the process is measured every six months, then every six months a new point will be created. A control chart will give the process owner a quick overview of the process status and if it is getting close to the target specified on the process improvement charter.

Standard Operation Procedure (SOP).

A standard operating procedure was created at the end of the project to document and publish the best practices learned. The proper use of this document will control process execution, variability and adherence to a standard. A short sample of the document can be seen in the Appendix, with limited data due to confidentiality.

Chapter 4

Results

Results were categorized as company specific or a basic contribution of knowledge. Company specific includes the individual results gathered by the different lean six sigma methods utilized in the process development. With the help of these various methods and the expertise of the employees, the company-specific process flow was defined. This process flow was used as the basis for writing the standard operating procedure used to reduce process variability, allow international equipment disposition and have the necessary checks and balances to be compliant.

Contribution of knowledge refers to the generic process flow made available by this thesis to the general public, allowing the creation of their own equipment disposition process tailored to their organization structure, hierarchy and requirements.

Company Specific.

The company-specific results were:

- Data push
- Risk identification, prioritization and response development
- Process improvement
- Metrics
- Process flow
- Standard operating procedure
- Deliverables
- Tool scores

Data Push.

In theory, it could be presumed that employees would be pro-active and constantly look for redeployment opportunities at other sites. However other tasks usually are a priority for employees, thus delegating the equipment redeployment activity to as-needed basis. For site single point of contacts to benefit from the redeployment opportunities at other sites, these data should be pushed to them. The "List of Available Equipment" will be shared by the site single point of contact with the site engineering single point of contact and site finance to determine current or future needs for equipment. The occurrence of this data push will be driven by any creation of a new list of available equipment. Once each site single point of contact reviews the list with his/her team, they communicate with headquarters' single point of contact if they are interested in any piece of equipment. If no one is interested in the equipment, then that item will be sold or scrapped, following the new equipment disposition process.

It is definitely against lean principles to push data instead of pulling, but given the lack of resources and willingness to pull the data, it was considered necessary to push data to reduce the lost opportunities resulting from a pull system.

Risks Identification, Prioritization and Response Development.

The SWOT tool in Table 9 was used to identify the risks in the process. The summary of results can be seen in the table below.

Table 11. Identified Risks

Opportunity	Threat (Risk)
Motivation	Export compliance issues
Resources	Regulatory compliance issues
Guidance	Service Provider issues
SOP	

The three risks were prioritized using the risk prioritization grid on Figure 18. Only two of the three threats fell into the high impact area for which a risk response was developed. The four actions defined for these risks were avoidance, transference, mitigation and acceptance. More details can be found in the methodology section.

Process Improvement.

The improvement ideas gathered from the customers were analyzed using the benefit/effort analysis on Table 10 and Figure 9. It was concluded that only four out of the seven improvement opportunities provided large benefits with little effort to correct. These opportunities were: communication, shipping mistakes, payment mistakes and export compliance.

Communication.

The communication between the site single point of contacts and the service provider was easily improved by making sure the expectations of all parties were divulged and standardized. Some participants may think that replying to an e-mail within the week is prompt communication. Others might think that an e-mail should be replied to within twenty-four hours. The stakeholders were asked their perspectives of good communication with the following companywide results:

Reply an e-mail, voicemail or letter within a determined time.

Make sure the service provider has information readily available at all times in case it is needed.

Make sure the service provider does not call homes or mobile phones to get information after hours or during the weekends.

Two business days was a reasonable time to reply to an e-mail, voicemail or letter. It is important to note that everyone expects a letter to take up to five business days to arrive at its destination.

The service provider agreed to keep information current so it could be analyzed by the company. Such information will only be provided by the single point of contact at the service provider and can only be requested by the company headquarters single point of contact.

The service provider agreed that only work contact information will be used. In case of an emergency, the company headquarters single point of contact will be contacted after hours at his/her mobile number.

Shipping Mistakes.

The shipping mistakes caused by the service provider resulted from the address on file not being the right one for specific equipment. The service provider agreed that they will call the site single point of contact to double-check the shipping address. This effort might be a non-value added activity but given the high cost of shipping manufacturing equipment, it was decided that making sure the right address is used every in shipment that has value. Given that the shipping address changes constantly, it is not feasible to have it pulled from a standard list.

Payment Mistakes.

Previous payment mistakes resulted from the service provider not knowing who the responsible party was to receive the check. It was decided to create a list of payees at each site so it is known where the payments should to go and to whom they should be addressed.

Export Compliance.

The export compliance issues were attributed to a lack of expertise. It was decided that all categorized lists done by the service provider will be reviewed by the company regulatory and customs departments to make sure each piece of equipment is correctly categorized.

Metrics.

The current state was also measured in three different areas providing a baseline for the continuous improvement initiative. The results are shown in Table 12 below.

Table 12. Metrics

Metrics	Baseline (Today)	Goal (Future)	Units
Overall Scorecard (satisfaction level)	-0.5/10	8/10	Points
Average time to move through the disposition process	30	15	Days
Appraisal / Sold price ratio	63%	95%	Percentage

Process Flow.

As stated before, the process flow contains confidential information that cannot be published. For this reason a generic process flow was created. This is the main primary contribution of knowledge by this thesis and encompasses the best practices learned in this project. The equipment disposition generic process flow is found in the contribution of knowledge section in this chapter.

Standard Operating Procedure.

An SOP controls the execution and adherence to a process standard, thus reducing variability. Once signed by upper management and implemented, then all employees need to follow the SOP process to be compliant with the company, and thus the laws and regulations governing the equipment disposition process. A short sample of how the document can be seen in the Appendix, with limited data due to confidentiality. Each process and sub-process in the equipment disposition process flow was explained in full in this document.

Deliverables.

The table below shows the deliverables stated on the project charter and their completion state.

Table 13. Deliverables

Deliverables	Completed
Develop a standard operation procedure (SOP) for the disposition and redeployment process.	YES
The process shall be applicable to all sites globally and must meet local and international laws and regulations.	YES
Each site will have a single point of contact in charge of executing the process and will be in constant communication with other single points of contact and the headquarters' single point of contact.	YES

Tool Scores.

Different tools under Lean Six Sigma are shown in the table below and their usefulness graded by the author.

Table 14. Tool Scores

DMAIC	Tools	A waste of time	Not useful	Neutral	Useful	Necessary
Define	Charter					X
	SIPOC				X	
	Tree Diagram				X	
	Communication Plan			X		
	Stakeholder Analysis				X	
Measure	Process Mapping					X
	Data Collection Plan				X	
	Pareto Charts				X	
Analyze	Value Analysis				X	
	Types of Waste			X		
	Takt Time			X		
	Risk Analysis					X
Improve	Benefit/Effort Matrix					X
	RACI/DAI				X	
	FMEA			X		
	Push/Pull			X		
Control	Control charts				X	
	SOP					X

As it can be seen on the table above, there are a few tools that did not provide any value to this process. Again, it is not that they are not useful at all, but in this type of project, with very limited resources, they were not appropriate, e.g., non-value added.

Contribution of Knowledge.

To make the best practices learned by the company, without sharing confidential information, process flows were created to show the minimum steps needed to have a compliant process.

The first equipment disposition process flow deals with equipment categorization and the second with the checks and balances needed to be compliant. These basic process flows can be used to create process flow tailored to a particular organization. It is important to note that this information is for specialized manufacturing equipment and United States laws and regulations only. There are similar laws and regulations in each country that vary by equipment type. It is fundamental to adhere to those laws and regulations if the equipment is shipped from the United States.

The first step in deciding how to dispose of equipment is its categorization. It does not matter which department makes the categorization as long as they have the right skills and knowledge pertinent to manufacturing equipment. It is typical for a large company to use the following departments: site capital engineering, site regulatory, site import/export, site legal, site finance and local/global service provider. In the process flow below, it can be seen how specific departments or subject area experts can be used to have the appropriate checks and balances before initializing the paperwork with local and international authorities.

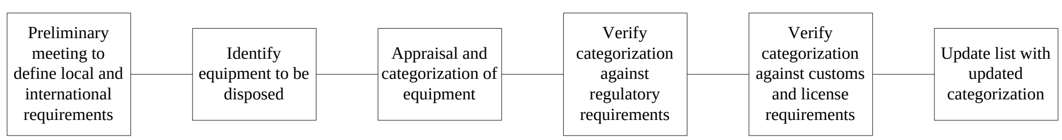

Figure 20. Equipment Categorization Verification.

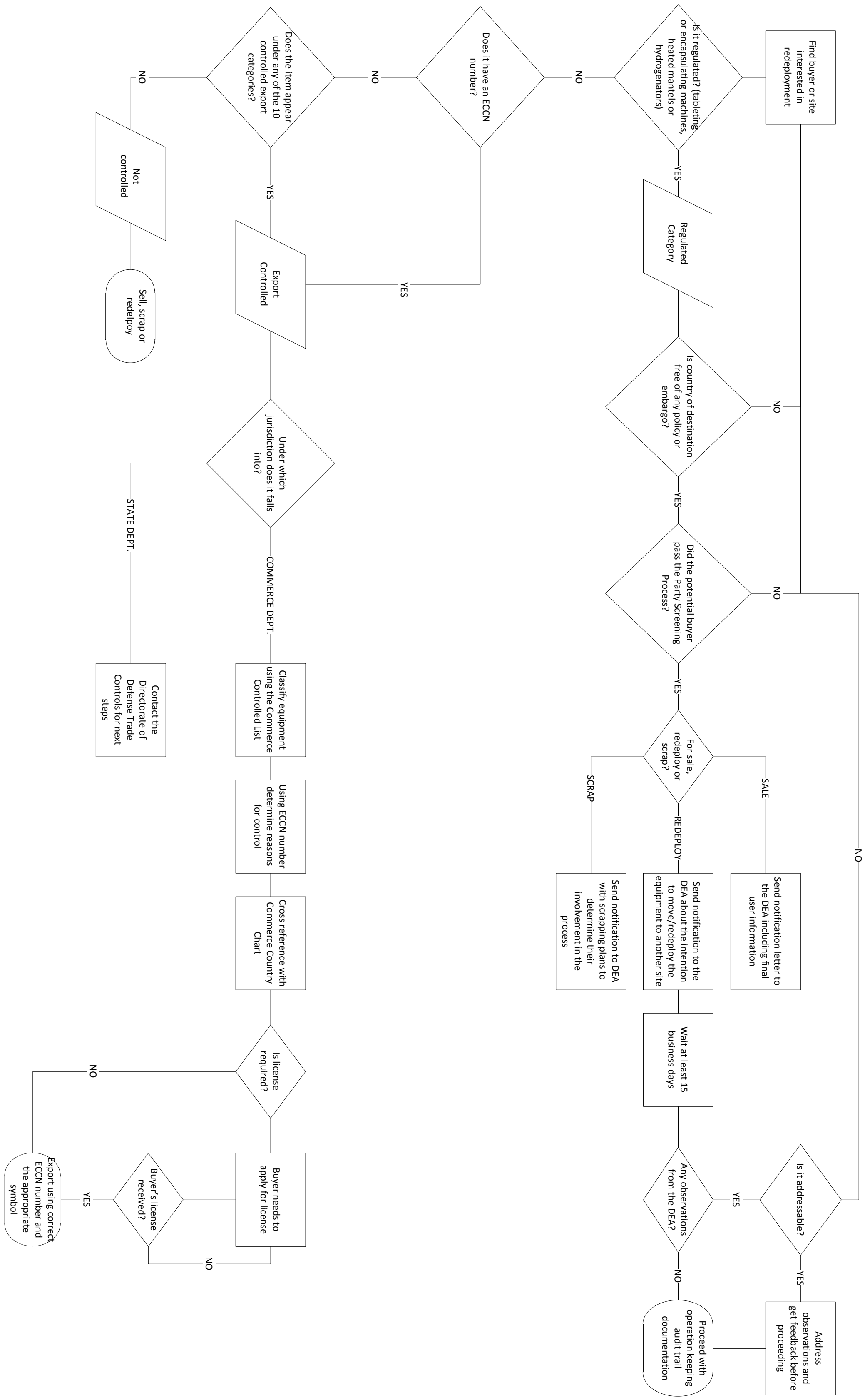

Figure 21. Basic Process Flow to be Compliant.

There are essentially three categories of equipment for disposal purposes. The first category is composed of all equipment types requiring regulatory involvement. In this company's situation, the Drug Enforcement Administration (DEA) was involved with regulated equipment. The DEA ensures narcotics traffickers do not acquire equipment for manufacturing illegal drugs. Pharmaceutical equipment falling into this category are tableting and encapsulating machines, twenty-two liter heating mantels and hydrogenators. The DEA needs to be notified of the movement of such equipment fifteen business days before it occurs. The seller is expected to have screened the potential buyer beforehand. This screening process is a restrictive party screening. The restrictive party screening consists of the seller screening the potential customer against restrictive party lists published by the United States Government and involved countries. These restrictive party lists can be found on the U.S. Bureau of Industry and Security website, a part of the U.S. Department of Commerce. If the potential customer is not on the list, a second search should be done online to make sure there are no additional sanctions or online complaints against the company, organization or individual. When scrapping equipment, DEA agents need to be present for the destruction of the equipment. It is also suggested that an employee of the disposing organization travels to the scrapping location with the equipment and takes detailed pictures of the entire process for audit purposes. If the equipment is being sold or redeployed, then the DEA has fifteen days to raise concerns. If no communication is received, the user can proceed with the transaction while making sure everything is documented and properly filed for future audits. No response from the DEA does not necessarily imply the equipment is free of all potential issues, but it does imply the liability of the seller is minimized by giving the agency proper notification. It is recommended to wait twenty business days instead of fifteen to take into consideration the transit time of mailed documentation.

The second category, “controlled exports,” is the most complex and extensively regulated. All equipment in the controlled export category should be treated differently due to compliance policies. Adherence to these policies is critical in ensuring the organization retains the privileges of importing and/or exporting into and from the countries in which business is conducted. As in the previous category, this thesis will publish details needed to be compliant in the Unites States but not the ones specific for countries abroad. The controlled exports are processed by two different agencies: the U.S. Bureau of Industry and Security (BIS), which is in the U.S. Department of Commerce, and the Directorate of Defense Trade Controls (DDTC), within the U.S. Department of State. This dual agency ownership creates complexity in the process, but there is an export control reform initiative currently underway. For the export of pharmaceutical equipment, the DDTC is seldom involved as it deals more with defense equipment. BIS is the primary licensing agency for dual-use exports, while the DDTC licenses defense articles and services. If the equipment falls into both categories, a Commodity Jurisdiction should be requested by the DDTC. The correct export licensing jurisdiction of an item will be determined at this time. The BIS uses a list that contains ten different commerce controlled categories. Each category has multiple items. The items under these categories usually have an export control classification number (ECCN) that describes the types of controls placed on that particular item. If the equipment does not have an ECCN number, and it is listed under the ten BIS categories, the Bureau of Industry and Security needs to be contacted to determine next steps. A rule of thumb is that any manufacturing equipment shipped, or needing to be shipped, from the United States may fall into this category. The actual equipment might not be on the list, but certain components of the machine might be export controlled. That is why it is important to have good working knowledge of the machines being disposed. Any controlled export might also need licensing. The license is not transferrable and the end-user needs to apply for his/her license before the equipment transfers. Once the equipment is found to be controlled, the reason for control needs to be defined. The reasons will be defined by the ECCN number and will tell the exporter if a license is required. The reason for export control needs to be cross-referenced with the commerce country chart. This chart, also supplied by the Department of Commerce, has a listing of all controlled countries and the types of reasons for controls. If the country where the equipment is to be exported is not listed in the chart with an X, then a license is not needed. After that check, the final user needs to be screened the same way as in the regulatory case. There is an entity list, a designated nationals and blocked person list, an unverified list and a denied persons list. This screening entails the exporter looking for the potential buyer on these lists. If the company or individual is not found, then the potential buyer should be safe. But it is also recommended to do some additional checks on the potential buyer (Size of company, final use of equipment, references, etc). It is not normal for an individual to buy manufacturing equipment for personal use, so the final use needs to be investigated. Once the party screening is concluded, the equipment needs to be properly categorized in terms of export controls. These categories include no license required (NLR), license exception and license.

The third and last category refers to any equipment that is not regulated by the Drug Enforcement Administration or export controlled by the Bureau of Industry and Security or the Directorate of Defense Trade Controls. The process flow below shows the minimum necessary steps to be compliant when selling and redeploying equipment. The scrapping process detail is not included given that it is most likely done locally and not exported. If the equipment falls under the export controlled category and it is being scrapped, then the owner is responsible for documenting the scrapping process and cancelling any current license.

It is important to note that on November 9, 2010, the President of the United of States of America, Barack Obama, issued an executive order to create the Export Enforcement Coordination Center. "The purpose of this initiative is to coordinate and strengthen our enforcement efforts – and eliminate gaps and duplication – across all relevant departments and agencies" (Obama, 2010). It may be in the near future, the process flow above, with all its checks and balances, might be modified.

If the above flow charts are compared to version thirteen in Figure 14, noticeable complexity differences can be clearly seen. The differences are due to the environment in which the tailored equipment disposition process was designed. As explained at the beginning of this thesis, the process developed for the organization was very specific. The Lean Six Sigma process approach is recommended to build a process with adequate checks and balances to have a robust process. This process mapping was the most important and time consuming step taken to define the steps, the stakeholders and accountability.

Chapter 5

Conclusions And Recommendations

Conclusions.

The adoption by a major company of the equipment disposition process created by this work is a measure of its importance and success. The methodology developed met rigorous internal and external requirements, yet provided the capability to source and dispose equipment globally.

An executive order from the President of the United States of America for an export control reform on November 9, 2010 is a clear indication of the complexity of the equipment disposition process. The difficulty in categorizing the equipment appropriately and knowing which jurisdiction it belong to, makes the equipment disposition process very difficult to control and be compliant.

The development in this thesis of a generic process as a contribution of knowledge creates the opportunity for individuals and organizations with similar characteristics to develop their own processes. Given the new export control reform under way, it is very important to be aware of any new law or regulation that could affect any current process flow. However, such reform could be a lengthy process and companies need a working process today.

The application of Lean Six Sigma to manage the solution of a complex problem is a testament of its compatibility in non-traditional applications. While a complex problem, equipment disposition became a manageable process and as lean as possible in a regulatory environment. The capability of having metrics to continuously improve the process makes the application of Lean Six Sigma valued.

Recommendations.

Besides a control chart and the standard operating procedure, there are other types of control methods, like the very common 5S (sort, set, shine, standardize and sustain), visual tools and mistake proofing. The 5S tool could be used to have all the documentation well organized and audit ready. The use of this method should be investigated further to determine if the benefit/effort ratio makes it feasible. Mistake proofing could also be applied in case there is a mistake with repetitive paperwork. A template could be created to make sure all necessary information is included to prevent mistakes. The use of templates should be decided at a later stage when the process matures and commonality in mistakes is found.

Communication could greatly improve if regular meetings were scheduled. A meeting every two to four weeks with the different stakeholders would ensure everyone is on the same page in the current process, and aware of new developments, challenges and opportunities. The ability to plan versus react might decrease the “fire fighting” mentality common in corporate environments.

Cross-training personnel would benefit the process and the company overall. At this point there is only one process owner and it would be safer to have someone else involved to make sure he or she can take over the process if needed.

It is the job of the process owner and the company to develop supplier capabilities to get better service, reducing the amount of resources needed to run the process at the company.

It could also be very beneficial to find a solution that transfers the liability to the service provider and let them run the process.

REFERENCES

Nave, D (2002). *How to compare Six Sigma, Lean and Theory of Constraints*, Quality Progress.

Miller (2005). *Going Lean in Healthcare*, IHI White Paper.

Dan Jones and Jim Womack (2000). *Seeing the Whole – Mapping the Extended Value Stream*, The Lean Enterprise Institute

Peter S. Pande, Robert P. Neuman, and Roland R. Cavanagh (2000). *The Six Sigma Way: How GE, Motorola, and Other Top Companies are Honing Their Performance*. McGraw-Hill

Ruth Boaden (2005). *Lean Six Sigma in the NHS*, Manchester Business School.

Helen Bevan (2010). *Lean Six Sigma* - *Some basic concepts* NHS Institute for Innovation and Improvement (Warwick, UK)

Mike Rother and John Shook (2003). *Value Stream Mapping to create value and eliminate Muda*. The Lean Enterprise Institute

Michael L George (2005). *The lean six sigma pocket toolbook*. McGraw-Hill

Running Lean (2003) *The lean pocket guide*. MCS Media

TBM Consulting Group (2010). *Evolution of the LeanSigma Philosophy*. http://www.tbmcg.com/about-tbm/leansigma.html

Obama, Barack (2010) *Video Remarks by The President to the Department of Commerce Annual Export Controls Update Conference.* Office of the Press Secretary. The White House

Frola, F. R. et al. (1993). *The Shrinking U. S. Military. What To Do with the Excess Equipment.* Logistics Management Institute. Bethesda, MD

Brady, Roger A (2000). *Building and Commanding Expeditionary Units: Lessons from Kosovo.* Air University. Maxwell AFB, AL

Blazek, M. et al. (1998). *Life cycle management of personal computers in a service company.* Electronics and the Environment.

Chen, Li-wen et all.(2009). *Research on Integrated Development of Real Estate Based on Lean Supply Chain Management.* School of Management, Hebei University of Technology, Tianjin 300130, China

APPENDIX A

STANDARD OPERATING PROCEDURE SAMPLE

Standard Operating Procedure Short Example

Purpose

The purpose of this SOP is to ensure a consistent process for: selling, scrapping and redeploying manufacturing equipment; defining roles and responsibilities associated to these procedures; and establishing a standard practice for compliance and control with local and international laws and regulations.

Scope

This standard operating procedure applies to all employees who are required to sell, dispose or redeploy manufacturing equipment at any site. In terms of equipment, it applies to all equipment used for manufacturing functions. It does not include equipment used to support manufacturing functions, e.g., office furniture, computers and consumables.

General Requirements

The equipment disposition and redeployment procedure will be followed to sell, scrap or redeploy equipment from any manufacturing site in the world. It is important to note that the process does not take into consideration the local laws and regulations of each country. These local laws and regulations need to be followed accordingly for each type of equipment.

Procedures

1. Preliminary meeting
    - i) Review specific project requirements
    - ii) Review rules for compliance for specific site
2. Prepare list of available equipment for disposal containing the following information
    - i. Listing number and so on.