INDUSTRIAL ENGINEERING CONSULTING

by

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A Senior Project submitted

in partial fulfillment

of the requirements for the degree of

Bachelor of Science in Industrial Engineering

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Graded By:_______________________ Submitted By:_______________________________

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Abstract

This paper documents the senior project of Blake Ahrold and Torrey Plana. This project was created to provide a solution to the problem of small to medium Sized enterprises (SMEs) being under represented by lean consulting companies. The project was at first intended to be a lean consulting startup and then pivoted to The Systems Optimization Club. A project charter, Gantt chart, and business model canvas were created for the startup and used as guidelines in the creation of the Systems Optimization club. The club is to be run like a lean consulting company. The club will provide teams of students for local SMEs to optimize their systems utilizing industrial engineering tools and methods, and those applicable from other majors, and in return students will receive industry experience and expand their professional network. The club worked with two manufacturers for projects, Hydrogen Junkie and Zodiac Aerospace's cabin Interiors division. Standard Times, spaghetti diagrams, and a facilities layout were created for Hydrogen Junkie. At Zodiac Aerospace, twenty two Systems Optimization Club members were split into 7 teams and worked on projects concerning standard times, ergonomics, 5S, workstation redesign, and value stream mapping. These projects will continue through the end of the year and into Fall 2015.

Introduction

Throughout tours or visits of manufacturing organizations and local business, it is not hard to spot areas of needed improvement, especially with an Industrial Engineering degree from Cal Poly. Cal Poly gives its Industrial Engineering students all the tools to improve a company, through applied skills, right upon graduation and entry into the job market. With so many enterprises that have poor process, it makes one wonder how a Cal Poly student can help by offering consulting services, during their degree progress. Many classes at Cal Poly require projects to be completed, applying current coursework to help processes within Cal Poly, or local companies. It is also apparent that the small to medium sized enterprises (SMEs) need more lean initiatives and applied industrial engineering efforts, but fail to get the help they need. What was observed was two different markets needing to be addressed; local SMEs could benefit from applied industrial engineering skills, and Cal Poly students could benefit from project experience with local enterprises.

The Systems Optimization Club (SOC) will address both of these markets. In order to be successful a few items need to be created to guarantee the success of the club; a Gantt Chart will need to be completed with important pivotal tasks outlined, a business model canvas filled out including customer segments and value propositions, the club structure needs to be defined and jobs assigned to board members, and a couple test projects with local SMEs need to be run to test the performance of the club and ability of the students to help selected SMEs. At the end of this project, the goal is to have a registered club with demonstrated success in at least 2 test run SME projects, and leadership in club set to run the 15-16’ school year.

The following report will be organized to follow a logical interpretation of how the tasks were addressed. First will be a Literature Review to gather background information on the consulting field and current services being offered by consulting companies, second will be the initial design of the Systems Optimization club and the two test projects, then will be the methods of how we tested our designs, followed by the results from these tests and projects, and finally the conclusion of our report.

Literature Review

An Industrial Engineering consulting company is not a groundbreaking thought. There are currently a wide number of IE consulting, Six Sigma consulting, and Lean consulting companies. However, most of these companies only cater to large enterprises or corporations. An entire market goes unaddressed: small to medium sized enterprises/manufacturers (SMEs). This is where the Systems Optimization Club plans to capitalize. These smaller companies are hindered in their growth in two ways; First, they have not been educated about the benefits of industrial engineering or consulting services. Second, they do not have the financial freedom to utilize these services. In this report we will establish the need for our services, outline how the Systems Optimization Club will work for SMEs, provide evidence through past successes, and identify the kind of services we can offer.

Market Validation

According to the 2011 U.S. bureau census data, there are 5.68 million employer firms in the U.S.. Firms with fewer than 500 workers accounted for 99.7 percent of those businesses, and businesses with less than 20 workers made up 89.8 percent. (SBE, 2011). Clearly most all of the businesses in America are small to medium sized. They also capture over half of the market in the U.S., making SMEs a valuable contribution to American sales. Small businesses in America account for 54% of all US sales and

provide 55% of all jobs (SBA). They deserve to have the same high level of operations as larger enterprises. Furthermore, the small business sector is growing rapidly. While corporate America has been "downsizing", the rate of small business "start-ups" has grown, and the rate for small business failures has declined. The number of small businesses in the United States has increased 49% since 1982. Since 1990, big businesses have eliminated 4 million jobs and small businesses have added 8 million new jobs (SBA). Due to the growing importance of supply chain management issues in the global market environment, large firms are heavily dependent on small to medium-sized enterprises for the provision of high quality products and/or services at a low cost. SMEs are the lifeblood of modern economies. The importance of SMEs to the economy of the UK and the industrialized world as a whole cannot be overemphasized (Jiju, 2005).

So why don’t SMEs already have IE/Lean/Six Sigma applications introduced into their own business? Turns out not only do they lack the knowledge/financial resources, but when they try to internally apply these applications they run into problems.

Problems in SMEs

During the birth of many SMEs, simple IE concepts that optimize a system are not considered. Then, after time and growth, these businesses that are built on poor processes fight to compete in their market then get strong-armed by companies built on

well-practiced IE concepts. Small companies are very good at finding reasons "why it cannot work here"? But a quality problem is a quality problem. Variation is variation. Waste is waste. An unhappy customer is an unhappy customer. The size of the company really does not change these facts (Jiju, 2008)

SMEs strengths	SMEs weaknesses
Flexible and hence changes can be introduced fairly quickly	Low degree of standardisation and formalisation
Flat with few layers of management and fewer departmental interfaces	Focus is on operational matters rather than planning
Top management highly visible and hence provide leadership by example	There are chances that management lay off employees when the work becomes superfluous. This makes SMEs work harder to retain a high calibre staff
Absence of bureaucracy in management teams	Limited investment in IT
Tend to have high employee loyalty	No incentive or reward programs in many cases due to budget and resources constraints
Managers and operatives are more likely to be directly involved with the customers	Lack of strategic planning and inspiring vision
Rapid execution and implementation of decisions	Responsible for many facets of the business and many decisions. Decisions are generally made for short-term profitability
Training likely to be focused	Lack of skills, time and resources; no specified training budget
Culture of learning and change rather than control	Incidence of "gut feeling" decisions more prevalent; often operate in a fire-fighting mode for survival
People oriented	Not systems oriented
More responsive to market needs and more innovative in their ability to meet customers' demand	Extent of training and staff development in SMEs is limited and informal
Likely to deploy improvements quickly and gain rapid benefits	Adamant and dictatorial nature of owner can damage new initiatives
Loose and informal working relationships and absence of standardisation	Formation of strategy process is intuitive rather than analytical

Figure 1: Strengths and Weaknesses of SMEs

Moreover, small companies do not have the slack to free up talented people to engage in training, followed by the execution of Six Sigma projects. These people are crucial to the day-to-day operations and problem solving within the company (Jiju 2008). As seen in Figure 1, there are many strengths and weaknesses of SMEs. Because of

the small size of these companies, improvements can be deployed quickly and benefits gained rapidly.

There are issues for SMEs such as: it is difficult to stay focused due to many distractions within the business; it is difficult to dedicate full time six sigma black belts to executing projects; employees perform many different functions unlike larger organizations; senior management leadership is important and can start by focusing on “low hanging fruits”(Jiju, 2008).

What is Lean Consulting

There is a very common misconception that Lean is ‘something new’ but actually it has existed in various forms for hundreds of years. Lean, itself, focuses on speed. It emphasizes reducing the amount of time between activities, events, and cycles. The shorter the cycle time, the more cycles you can complete in a given amount of time (Sherman). Common lean techniques and values have been spoken about by the world’s leaders since before the 20th century. Benjamin Franklin once said, "He that idly loses 5s (shillings) worth of time, loses 5s, and might as prudently throw 5s into the river....A penny saved is two pence clear. A pin a-day is a groat a-year. Save and have.” He speaks to the core values of lean manufacturing; The fact that eliminating waste and saving costs can be far more lucrative and have a higher rate of return than simply driving sales. Lean is structured common sense, nothing more and nothing less (Eaton).

Problem Statement

SMEs lack the knowledge and/or financial resources to become more efficient, effective businesses which would allow them to increase their capital and thus expand and develop. SMEs do not have the people to spare for training in optimization of processes or systems. The Systems Optimization Club would identify and eliminate an SME's waste, and improve their bottom line through the implementation of professional, yet low cost student projects.

The Consulting Provider / Client Relationship

When a relationship between a consulting service provider and a client is first established, the client usually reaches out to the consulting service, rather than the consulting service seeking out the client. Because of this, it is not uncommon for the consultants to be lost at first or not know what the client is intending to achieve from the relationship. This is because many professional clients use a complicated system for choosing different consulting services that can be based on cultural fit, pricing, past experience, referrals, and the consultants first impression.

After a close relationship has been established, it is important to set up a "form of infrastructure"(Bloetscher) for the project that the consultant is working on. Often times another consultant or worker has to be brought into a project in order to complete a

specific job. Documentation of the project, scope, and deliverables will help eliminate the time required to catch the additional worker up to speed. This sort of communication is vital for creating a timely and effective relationship.

There are many different experience levels of consulting. When clients look for a consultant, cost is usually not an issue for big companies. They want the best job done, that is why they are hiring in the first place. In tough times, it might not seem economically advantageous for either large or small companies to be implementing drastic changes, but tough times often bring the biggest challenges which “equate to excitement and change” (Lazerick). A smaller company might not be able to afford this option and is forced to go with a less experienced consultant. However, in the long run, the inexperienced consultant might end up costing the company more than the initially more expensive experienced one. This is because the experienced consultant does not need to take the time to learn or become familiar with the project. They can jump right in and get to work. Where as a consultant who has little to no experience may need to hire additional help, conduct research, learn more about the process at hand, or simply take more time to do the project. The best practice for an inexperienced consultant is to team up with an experienced one (Bloetscher).

A less than morally justified technique used by consultants is called “Gold plating” (Lewsauder). This is when a consultant adds on unimportant components to a project or increases its duration to boost their income. Since our services are free, we

will not have this problem. However, in order to help the client feel safer about doing business with you, it is important to add performance factors such as deadlines, budget constraints, benchmarks, and a justified scope (Lewsauder). These will help the client feel more content about the relationship and not become skeptical of your techniques or question whether or not a certain action within the project is necessary.

In conclusion, “client-consultant relationships are built on trust, honesty, the ability to listen and the ability to get work done”(Bloetscher). The consultant must demonstrate an ability to perform the work, a record of past experience, and communication and teamwork skills.

Methods and Applications

Methods that are used in Industrial engineering consulting include lean, JIT, Kaizen, Six Sigma, Lean Six Sigma, Theory of Constraints (TOC), and the Toyota Production System (TPS). There are many different methods for instating lean manufacturing and most consulting companies claim they use the method that is the best. In this section we will review some of the main lean tools and techniques.

Time Study

Arguably one of the most important work measurement techniques, a time study is a technique for recording the times to perform a certain job or its elements carried out

under specified conditions. It also includes analyzing the data so as to obtain the time necessary for an operator to carry it out at a defined rate of performance (Kanawaty). The end result of a time study is to develop a standard time for an average skilled worker, working at a normal pace, to complete the process/job being studied. It includes appropriate allowances for workers to recover from fatigue and allowances for elements to occur that may not have been observed during the study. This standard time for a job is extremely important for a variety of industrial engineering applications. It is required in workforce planning to calculate the time to process the existing work and in turn the number of workers required for a job. It is required in production leveling because the correct number of workstations for optimum workflow depends on the processing time, at each workstation. Material Requirement Planning systems cannot operate properly without accurate work standards. Simulation models cannot accurately simulate operation unless times for all operations are known. Work standards are necessary for determining not only the labor component of costs, but also the correct allocation of production costs to specific products (Kanawaty).

5S

5S is a simple and structured approach to create a better organized, tidier and more effective workplace. It is a strategy for businesses to create a cleaner, more orderly and safer working environment, irrespective of industry sectors and requires a disciplined

approach at all levels to maintain such an environment. This is fundamental for a well-run workplace in order to perform quality work productively and maintain a continuous flow. The 5S strategy defines how to affect change in the workplace and, even more challenging, maintain the new workplace and sustain the motivation. The term 5S comes from the Japanese terms Seiri, Seiton, Seiso, Seiketsu, Shitsuke, which translate in English to Sort, Set, Shine, Standardize, Sustain (5S and Lean). These are described below in Figure 2.

Figure 2: The 5S of Lean Systems

Quality Control Tools - Magnificent 7

The Magnificent 7 are basic statistical process control tools that help industrial engineers record, and present problems happening within a process. Total Quality

Management literature makes frequent mention of their uses, although no one tool is mandatory, any may be helpful depending on the circumstances. They represent data happening in a system, and make it easier for an industrial engineer to show the data to someone without a statistics background. Karou Ishikawa, a quality guru, found about 95% of quality related problems can be solved using these tools (Heras). This comes in handy when presenting material to upper management, or during consulting work where the customer can't relate to statistical numbers. Simply, the magnificent 7 make statistical analysis less complex. They are represented visually in Figure 3 below.

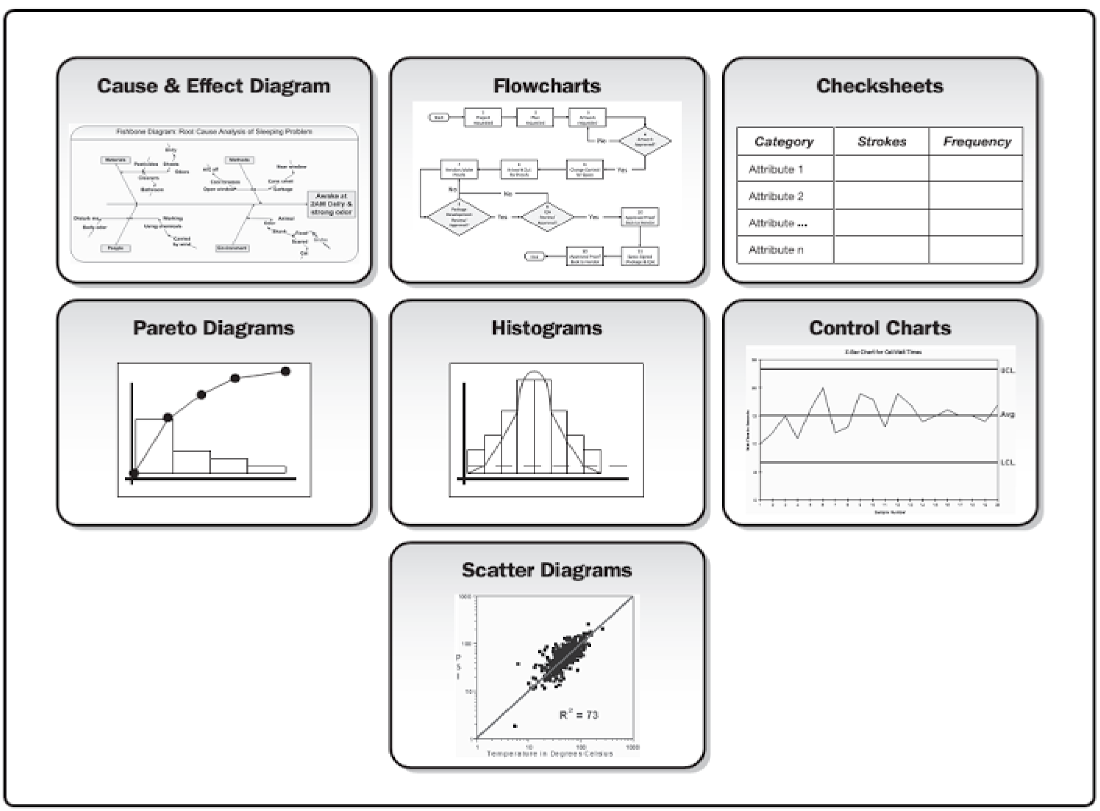

Figure 3: Conceptual Example of each of the Magnificent 7

Control Chart

Control charts are the most complicated of the seven basic tools of TQM, but are based on simple principles. The charts are made by plotting in sequence the measured values of samples taken from a process. For example, the mean length of a sample of rods from a production line, the number of defects in a sample of a product, the miles per gallon of automobiles tested sequentially in a model year, etc. These measurements are expected to vary randomly about some mean with a known variance. From the mean and variance, control limits can be established. Samples recorded inside these control limits are said to be normal, and do not raise any alarms in the process. A sample measurement outside the control limits indicates that the process is no longer stable, and is usually reason for corrective action. Other causes for corrective action are non-random behavior of the measurements within the control limits. Non-random behavior is defined by a set of rules (i.e. six or more points continually increasing). Control limits are established by statistical methods depending on whether the measurements are of a parameter, attribute or rate (Heras). When the rules of a control chart are violated, usually the worker follows a defined standard operating procedure (SOP) to bring the process back into control.

Flow Chart

A flow chart shows the steps in a process i.e., actions which transform an input to an output for the next step. This is a significant help in analyzing a process but it must reflect the actual process used rather than what the process owner thinks it is or wants it to be. The differences between the actual and the intended process are often surprising and provide many ideas for improvements (Heras).

Check Sheet

The check sheet is a simple and useful tool that is often used in the early stages of a quality control program. It provides a uniform and consistent means for data collection and analysis. Like many of the traditional tools, the check sheet is defect oriented and is used to classify the types of defects frequently found for a product or service. It is used to spot problem areas by identifying defect types that frequently occur. As a result, a check sheet is often used as the input to the next tool, called the Pareto chart (Salvendy).

Pareto Chart

Alfredo Pareto was an economist who noted that a few people controlled most of a nation's wealth. "Pareto's Law" has also been applied to many other areas, including defects, where a few causes are responsible for most of the problems. Separating the

"vital few" from the "trivial many" can be done using a diagram known as a Pareto chart (Heras). In the context of quality or the observance of defects, time has proved over and over that there are usually a disproportionately small number of defect types that cause a majority of the problems. As a general rule of thumb, it is commonly observed that around 20% of the defect types can cause around 80% of the problems. Pareto analysis and the resulting Pareto chart are used to identify what is commonly known as the ‘‘vital few and the trivial many.’’ Most quality professionals agree that the Pareto chart is one of the best tools, if not the best tool, within the Magnificent Seven (Salvendy). The Pareto chart will help us identify underlying problems in an enterprise, and address only the problem that causes most damage. It is a great way to quickly identify what needs to be worked on.

Fishbone Diagram

They are called fishbone charts, after their appearance, or cause and effect diagrams after their function (also Ishikawa Diagrams after their creator, Kaoru Ishikawa). Their function is to identify the factors that are causing an undesired effect (e.g., defects) for improvement action, or to identify the factors needed to bring about a desired result (e.g., a winning proposal). The factors are identified by people familiar with the process involved. Once factors are identified, it is easier for an individual or team to stay on track with a project by visually addressing what needs to be worked on. As a starting point,

major factors could be designated using the "four M's": Method, Manpower, Material, and Machinery; or the "four P's": Policies, Procedures, People, and Plant (Heras). Factors can be subdivided, if useful, and the identification of significant factors is often a prelude to the statistical design of experiments.

Histogram

The histogram is a graphical tool that presents the relative frequency (in number or percentage) of observations within predefined cells. In other words, the histogram provides a graphical representation of a population or process under examination. The natural spread or distribution, the central tendency, and the variation of the process are readily observable in the histogram. Since the data supporting the histogram are defined by individual observations, the comparison of the process variation to the allowable spread, as defined by specifications, is easily demonstrated by plotting the specifications on the histogram. The histogram is a simple tool that provides a wealth of information regarding the natural tendencies of a product or process under study. From a probability perspective, the histogram provides an empirical estimate of the probability density function defining the product or process (Salvendy).

Scatter Diagram

Scatter grams are a graphical, rather than statistical, means of examining whether or not two parameters are related to each other. It is simply the plotting of each point of data on a chart with one parameter as the x-axis and the other as the y-axis. If the points form a narrow "cloud" the parameters are closely related and one may be used as a predictor of the other. A wide "cloud" indicates poor correlation (Heras).

Industrial Engineering Consulting Today

Enterprises today are adopting more and more lean principles. It is hard for a company to change, but as business gets more competitive in the growing market, companies have to sacrifice their current inefficient principles to become more lean. Ultimately, lean needs to be witnessed as a business philosophy, the more you believe in its doctrine, the easier it is to transform the business and reap the benefits (Bhasin). Getting a business to adopt lean principles is an achievement in itself. Too many companies make the mistake of hiring consultants based on the promised return on investment. I read a proposal that said, “I will, in this year; it will cost a million dollars, and I’m going to generate $10 million in cost savings. Here is how I am going to do it, and here is my road map, and my job for the year is to get the $10 million. It’s not to teach and coach.” (Liker). A consultant must teach and coach someone in the organization and allow them

to learn lean principles, perhaps through a project. Once the student gets the training and can apply the knowledge, they will continue to spread lean throughout the organization in future projects, without the consultant. It becomes contagious, multiplies to the next level of employees, and continuous improvement will start to develop. Consultants today have to be the catalyst for change in an organization, but not the means of continuing that change throughout the lifecycle of the corporation. It takes a good teacher, a good coach, to hand off the knowledge and training to an employee who will continue to apply lean practices in an organization.

Design

There are a lot of unknowns when creating a consulting business. The first is simply where to start. There were many alternatives to choose from when creating a set standard for structuring the consulting company, acquiring cliental, running the business, and completing the projects.

For the design of the company, there were many different business models to choose from. It could utilize a freemium, subscription, donation, free trial, or a service level based model. The business needed to provide a service to these local companies at an affordable rate. Low cost is one of the most important characteristics in creating a solution for the problem statement so it was very important to choose the right company structure that would support this characteristic. A free trial model for the company was decided upon because of the significant advantages it would have in securing and keeping clients. There was a hidden benefit to this model that was not seen till later on in the design process. The company decided to employ current Cal Poly Industrial Engineering students for these consulting services that we will be offering SMEs. It added an extra incentive for the students to do well in the projects because if they did a good job, then these companies would be more inclined to continue the relationship through implementing another project, which would guarantee that the students receive payment in one form or another for the new project, depending on the terms of the agreement.

During the design phase of the senior project a necessary pivot occurred that could expand the life-span of the consulting company indefinitely. After this year, there would be no one left to run the consulting business, due to graduation, and the relationships and projects the team had built would be dissolved. The choice was made

to replicate the business model into a recognized Cal Poly club, called the Systems Optimization Club. Not only would this allow the business to be run year after year, but it would also keep a steady inflow of new students willing and eager to learn what it is like to work in their industry. It would also have a lasting impression on local economy as well.

In finding cliental, the first thing we tried was speaking to faculty about potential businesses that have expressed interest in working with students on company projects. We were able to find a couple companies but communication breaks with these companies hindered our progress. We then tried using our current professional networks, which proved to be fruitful, however the companies we were connected with were located too far away and hence the travel time would have greatly lengthened the duration of the projects, beyond our ideal timeline. We then attempted to find clients through alumni of the Industrial Engineering department at Cal Poly, and by simply googling local manufacturers in San Luis Obispo. By gathering contact information from local companies we developed a list of potential clients. We began cold calling SMEs within the central coast to offer our consulting services. However, we immediately ran into roadblocks when doing so, We found that the SMEs were unaware of how they could utilize our services and we were unsure of how we could help them. Because of this it left a large amount of skepticism and hesitation on the table. We had to change our approach. The final and most effective alternative we found was contacting local manufacturers and offering them a very specific service; standard times. We found that if we contacted manufacturers and only offered them one service, creating standard times for their industrial processes, and told them how that would help them develop as

a company and grow their business, we received immediate positive feedback from these prospective clients. After calling each client and explaining the value the SOC can add to their company, we will be able to establish which local SMEs are suitably aligned with our value proposition (from Figure A): To lower costs, while increasing productivity, efficiency, and effectiveness of the system, at an affordable price.

The next step is finding students who are interested in SOC's value proposition (from Figure A): provide projects that pertain to students current classes, allowing real world experience, and helping make better career choices in the future. Our first attempt to gain interested students was by an email blast to the whole Industrial Engineering Manufacturing department about a club meeting, which turned out to be very successful. The first SOC meeting had a large turnout, plenty enough to generate teams for initial project formulation.

Then it was important to create a project charter (Figure B) and list of tasks needing to be completed to guarantee the success of our value propositions. The project charter would help us reference the purpose of the project, define key milestones of success, outline constraints/assumptions, develop deliverables, and scope of project. We developed a Gantt Chart (Figure C) to follow, making sure that all important tasks had a deadline and person responsible for completion. This allowed us to manage our project and keep the scope feasible.

Design of Systems Optimization Club

To guarantee the success of the Club, board positions need to be elected and jobs assigned, so elected officials can maintain the student-company relationship in an organized manner. Initial formulation of club structure is given by the following Figure D.

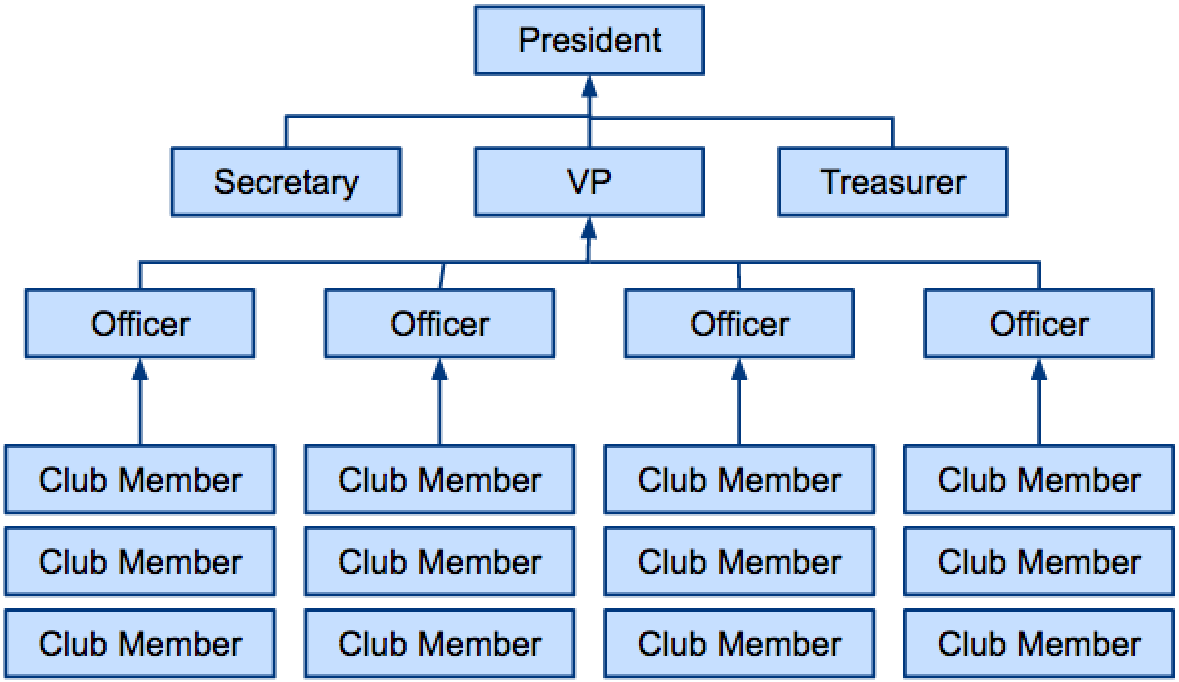

Figure D: Initial Club Structure

Club members are grouped together into project teams (of about 3-4 students depending on the scope of the project), with one member as the officer, in charge of communication with the rest of SOC and the specified SME for their project. The officer needs to have prior experience in their assigned projects, whether from the classroom or previous project. Teams need to be balanced between experienced members and inexperienced members, so no single member feel overwhelmed and weight of the project falls on all project participants. SOC will hold review sessions of topics for selected projects. For example, a local SME hires SOC to find standard times of a product line, then SOC will hold a review session of standard times and time studies.

The club officers will report to the Vice President. The VP is in charge of making sure every team has a defined scope and deliverables for their project, and guiding them on a path to success for their project. The VP reports to the President, who will also help guide the teams if necessary, or if the VP needs help. The President also

conducts club meetings and contacts new SMEs for future projects (with help of VP). The Secretary will hold the minutes for SOC meetings, bring food, and hold necessary documents that are needed for SOC. Treasurer will be in charge of financials for the club. This includes collect club dues ($20/year), and money for events.

Since in the Systems Optimization Club we will be reaching out to our clients and not the other way around, it is very important that we get our foot in the door by offering a service that we are skilled in, that can produce tangible results, and help demonstrate our knowledge and commitment to our client. This service will be the implementation of standard times. Since every company needs standard times for their operations, and this information will help them reduce their bottom-line, this initial project will help build trust and an enduring relationship with our clients.

Methods

SOC Structure

The future of the Systems Optimization Club is as much the responsibility of the current members as the authors of this report. Therefore we found the best way to validate the board positions was to inquire the rest of the club in a general meeting. In this meeting the club structure in Figure D was presented, and recommendations with explanations were collected. New positions were proposed and voted on, and well as duties for those positions. The resulting club structure will be presented in the following Results section of the report.

In a separate meeting we elect the new SOC board members. This is going to be done by vote of the hands of all club members. The candidate with the most votes wins that position.

Hydrogen Junkie

By calling local manufacturers found on the internet, we were able to make a few contacts for potential projects. One of which was Jerome Law, who runs Hydrogen Junkie. He is a paraplegic, and uses a wheelchair for all movement, while conducting his one man operation building hydrogen fuel cells, out of his garage. Jerome took quickly to our cause of helping local manufacturers better their process, aiming to make them more efficient and increase their bottom line. Rather than delegate this project to club members, what better way to judge the potential of SOC than to take on a project ourselves.

A quick tour resulted in a lot of potential improvements we believed we could implement for Jerome. His facility was located in his extremely cluttered garage (Figure E), and Jerome seemed to have no standard process that he followed. There was a sequence of tasks he knew in his head, but nothing concrete or outlined. Jerome often spoke of moving his facility from his garage to a standard storage container, where he would be less distracted by all the items in his garage, and be able to focus on work. We decided to focus on developing a standard procedure for him, and designing a new facility in a shipping container.

Zodiac Aerospace

We obtained multiple projects with Zodiac Aerospace through a Cal Poly alumni contact working for Zodiac. Zodiac provided as many projects as SOC could handle,

which meant as many club members that wanted a project. After a tour of the Zodiac facility and a description of the projects, we came back to the club with a list of projects and asked members to email which projects they would like to be involved in. Using this information, along with each members past project/class experience, we designed 7 teams to take on 7 different projects with Zodiac (Figure F below).

Zodiac Aerospace Cabin Interiors Department		
Our Contact:	Pat Brennan	
Leaders:	Blake Ahrold	
	Torrey Plana	
Green = team project manager		**Initial Visit**
Team 1A	Wicky Woo	Thur May 7, 5-6pm
Value Stream Mapping, Workstation Redesign	Wade Bedinger	
	Alyssa Leventis	
Team 1B	Melisa Esquivias	Fri May 8, 4-5pm
Value Stream Mapping	Jamie Kusumoto	
	Chris Luong	
Team 2A	Fernando Calderon	Mon May 4th, 1-2pm
Standard Times	Hayden Rahman	
	Ashwin Ramanathan	
Team 2B	Pierre Abdel-Malek	Thur May 7th, 1pm
Standard Times	Harry Chaw	
Team 2C	Charlie kesecker	Fri May 8th, 9-11am
Standard Times	Becca Farr	
Team 3	Anthony Vasquez	Thur April 30, 9am
5S Shipping	James Losack	
	Teja	
Team 4	Danielle Bierman	Fri May 8th, 10:45am
Ergo Workstation and Redesign	Angela Mariani	

	Jenny Caudillo	

Figure F: Zodiac Aerospace teams with project topics and initial Zodiac visits

These teams all started their projects by touring the facility and taking a close look at the area where there project would be. Zodiac required each student to sign an NDA, which prohibits the discussion of their methods and results in this report. We will briefly touch on their progress but not go into detail about what work was done.

Results

Systems Optimization Club Structure

The resulting club structure in Figure F below, was formulated from an SOC meeting.

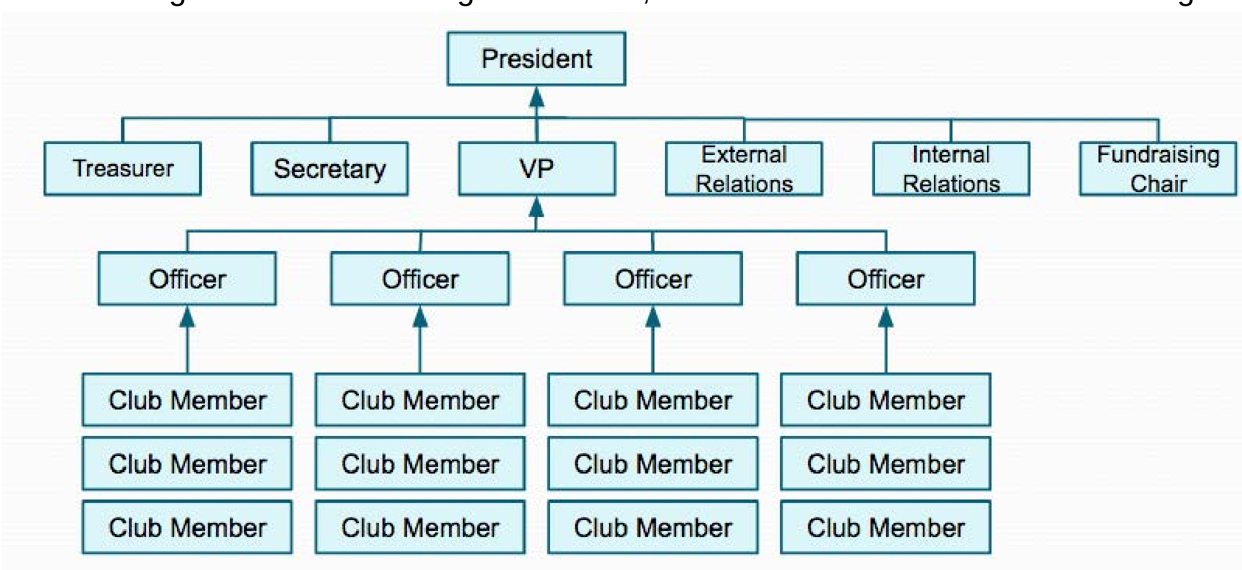

Figure F: Final Club Structure

The basic structure is the same, however, new positions were added, and responsibilities defined more clearly. The responsibilities of each elected official are listed below in Table 1. Any responsibilities not defined but needed, will be voted on by the new board members , when encountered during the 2015-16 school year.

President	Vice President	Treasurer	Secretary
Hold general meetings, works with E.R. to secure new projects, absorbs many club duties when needed, formulates teams for projects	Keep reports to show club validity to potential SMEs, facilitates review sessions for project topics	Collects dues, financial responsibilities with ASI	Register events/meetings with ASI, hold meeting minutes, bring food to meetings, in charge of Google Drive where all Club documents and reports are held.
Internal Relations	**External Relations**	**Fundraising Chair**	**Officers (new each project)**
Facilitate creation of new SOC website, settles disputes between club members	Effort to contact companies to secure new projects	Attain sponsors for SOC	Facilitate communication with SME and team, report to VP

Table 1: Club Positions and Responsibilities

Elections for new board positions were held successfully, and every position was filled ready to begin work during the new school year.

Hydrogen Junkie

In order to better understand Jerome's process and find a metric to justify changes, we wanted to perform a time study and find the standard time for Jerome to build one hydrogen fuel cell. From this time study we would be able to generate a standard process for Hydrogen Junkie.

In order to design a new facility, Visio, a designing software, needs to be used to generate an ideal setup for our designed standard process. The time study can be used to generate a new standard time if we moved his facility into this container.

The standard time to build one hydrogen fuel cell was found to be about 160 minutes. This was the process in Jerome's garage, with a lot of unnecessary

overlapping movement. A spaghetti diagram (Figure G) shows the repetitiveness of his movement, especially when he forgot tools from different workstations, or moved to the next step before he was finished with the last. The workstations are also spaced very far apart, which increases the transport time far beyond what it should be. After creating a facility inside a shipping container (Figure H), and designing a standardized process around workstations strategically placed inside that container (Figure I), we estimated a new standard time of about 90 minutes. This is a reduction of 70 minutes, which would allow him to build almost two hydrogen fuel cells in the time it took him to build one. A spaghetti diagram was created to model his ideal movement in the new container (Figure J). This diagram shows a much more ideal movement pattern between stations, and workstations are much closer together, reducing transport time.

To decrease the standard time for building of one hydrogen fuel cell even further, we explored the option of outsourcing some of Jerome's work to his suppliers. We found most of the drilling could be outsourced at an additional price. Although we were not able to gather pricing information, we were able to calculate the standard time with these outsource options included. It would take Jerome about 50 minutes to build a hydrogen fuel cell if he outsourced his drilling process to his plate supplier.

Adopting this standardized process in a new shipping container would allow Jerome to spend more time either building different facets of his business, gaining new clients to sell to, build more hydrogen fuel cells, or spend more time with his family.

Conclusion

The problem for this senior project was that SMEs were missing out on the key advantages of lean consulting services because of their lack of financial resources and/or knowledge of such services. The objective was to provide these companies with a credible and low cost consulting service. The Systems optimization club solved this problem by providing a resource for SMEs to utilize that helps both them and Cal Poly students.

Conclusions

- Everyone doubted us at the start but we persevered.
- When contacting manufacturers about consulting services, offer something specific and tell them why it will help; i.e. Standard Times.
- Communication with clients, especially over email, can take weeks.
- Both projects were a success, club has platform to succeed
- Underclassman can now receive industry experience in a professional setting, outside of the classroom.
- More SMEs now have the knowledge of how industrial engineers can help them, and have access to their services.
- The Systems Optimization Club now has a proven track record with 2 enterprises giving them credibility in the industry.
- THE S.O.C. Executive board members have been chosen and are driven to take the club to the next level for the following year.

- Deliverables: Project Charter, Gantt Chart, Business Model Canvas, Hydrogen Junkie Standard Times, work log, Spaghetti Diagram, new facilities layout.

Our most important result was the official swearing in of next year's executive board members for the Systems Optimization Club. Without this result, there would be no guarantee of the club's continuation and success. But luckily, a highly performing and dedicated board has been chosen and they are ready to put in all of their effort into growing and establishing the club as a premier leader on campus and in industry.

We reached many road blocks and obstacles throughout this project and learned a lot from them. We learned that when contacting manufacturers, it is not enough to simply say, "we want to do consulting work for you". Like many consumers, many of them do not know what they want. It is far more efficient to offer a service and to tell them how such a service will help them, like conducting standard times, than it is to just generally ask. Once we switched over to this method, we started instantly receiving interest from local companies. We also learned that communicating with contacts at companies over email is very time consuming. It can be weeks before you get a response so it is very necessary to plan accordingly.

The biggest learning experience we gained from this project was the process of pivoting. At the beginning of our project, we were getting discouraged with our business model and not gaining any traction with local companies. We were doubted and we doubted ourselves. It was hard to make that choice, because it felt like we were no longer a real company. But once we pivoted from a startup to a club on campus, everything changed. As much as we wanted to have our own company, a real startup, it was better for the clients, Cal Poly, and us. Switching to a club like platform meant that

our consulting company would have a constant influx of new students and would be able to establish a reputation as a part of Cal Poly. If we were to redo this project, we would have wanted to pivot sooner so that we could have more time to oversee the projects and make sure that the club can run smoothly on its own.

We are much prouder to have built this club than what we would have been building our own company. The social impact on the local industry and Cal Poly students is extremely positive. We have had our club members email us and thank us and have had students come up to us and shake our hands in appreciation. They are grateful because now although they might have little to no experience or their GPA might be suffering, they can still learn more about their chosen field while receiving real industry experience with local manufacturers and expanding their professional networks. It will not be uncommon for freshman industrial engineers to obtain internships because of this club. The impact on local SMEs is also positively correlated. Not only do they receive industrial engineering consulting work at a very lows cost, that is going to help them improve the efficiency of their systems and lower their bottom line, but they also get to develop a mutually beneficial relationship with both Cal Poly and its students.

Appendix

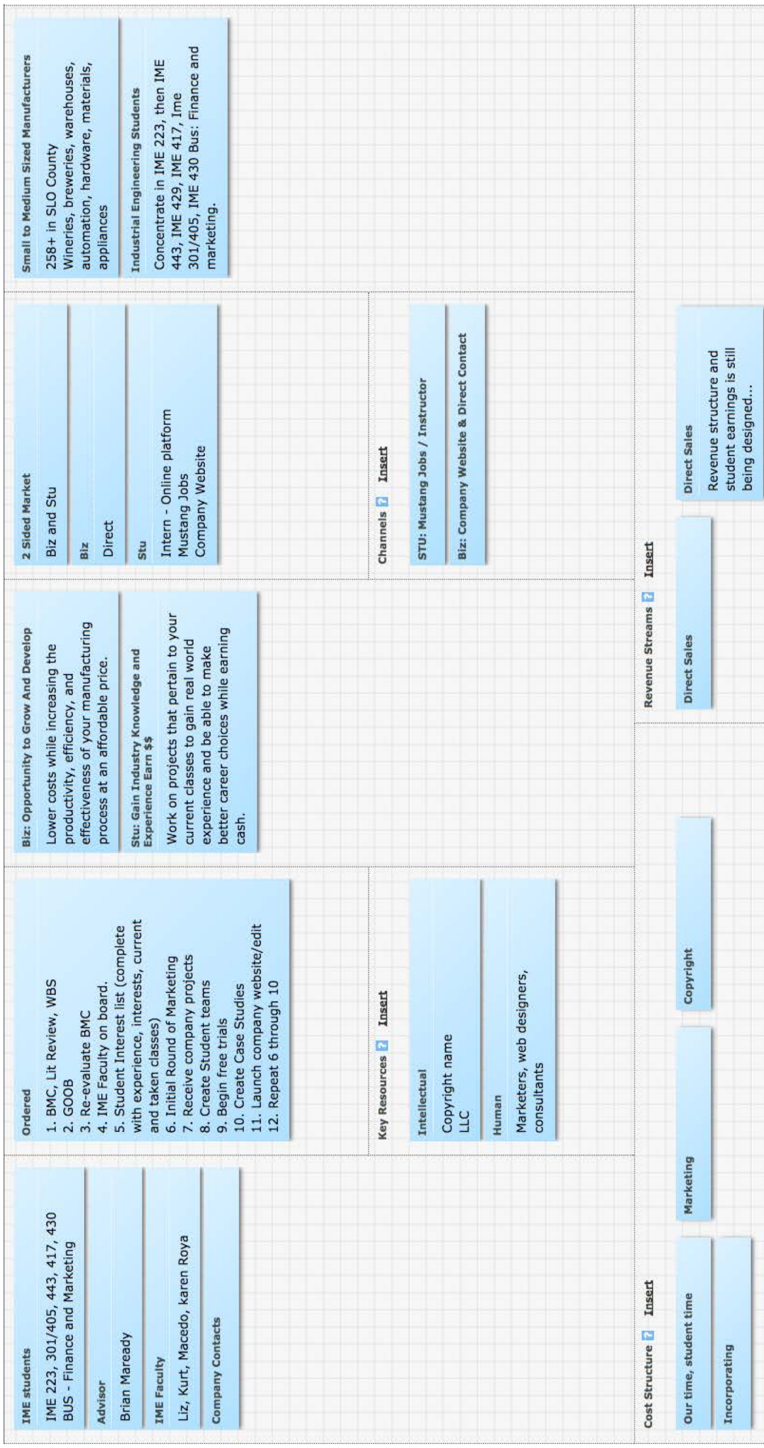

Figure A: Business Model Canvas

PROJECT CHARTER

Project Name: Ahrold Plana Consulting	**Names:** Blake Ahrold
Date: 12/3/14	Torrey Plana

1. PROJECT PURPOSE

Small to Medium sized enterprises/manufacturers (SMEs) lack the knowledge and funds to hire Industrial Engineering Consultants. Ahrold-Plana Consulting has the affordable lean solutions for theses companies, which will implement long-term solutions to cut wasteful habits, and above all, reduce the bottom line. Ahrold Plana utilizes a two-sided market; students and manufacturers are our customers. Students will be hand picked on staff for the advancement of their education (resume builder), and manufacturers will benefit from our services.

2. DELIVERABLES

Fall: Business Model Canvas- illustrate the companies structure (revise throughout)
Fall: Gantt Chart/WBS- Time line of project, work breakdown structure (revise throughout)
Week 1 Winter: Literature Review- review on research done in this field, showing the need for this company
Winter-Spring: Data on test run
Spring: Test Run Analysis- Report out on test run

3. SCOPE DEFINITION

The project will include:
Literature Review
Business platform of how Ahrold Plana Consulting will do business
Research on current IE consulting firms
Trial run, simulation of being hired and consulting an SME

The project will not include:
Precise breakdown of Cost Structure
Precise breakdown of Revenue Structure
Actual Creation of Business (won't obtain permits for small business)

Figure B: Club Charter Pg. 1/2

4. PROJECT MILESTONES

Week 1 Winter- Completion of Literature Review
Start Winter- Contact Test Run Manufacturer
End Winter- Finish Test Run
End Spring- Report out

5. ASSUMPTIONS, CONSTRAINTS & DEPENDENCIES

Ahrold Plana is assuming students at Cal Poly want project experience with local SMEs. Also assuming that the projects Ahrold Plana undertakes will take only 10 weeks (1 quarter), so student can use as project for class, and keep our senior project on schedule.

We are constrained by time due to other Cal Poly courses we take, and time invested in finding a full time job after June 2015. Blake's Involvement in Cal Poly Athletics will also require key time management.

Due to our limited experience of school projects and internships, Ahrold Plana might find constraints in difficulty being accepted as Consultants.

Ahrold Plana is dependent on the students of Cal Poly to want project/internship experience. Also dependent on SMEs interest in improving their current state of business and reducing their bottom-line.

6. RELATED DOCUMENTS

Gantt Chart

Figure B: Club Charter pg. 2/2

		Task	Task Name	Duration	Start	Finish	Predecessors	Resource Names	Notes
1			Research Current Companies / books	10 days	Wed 10/15/14	Tue 10/28/14			Fall
2			Project Charter	5 days	Wed 10/29/14	Tue 11/4/14	1		
3			Create Intitial Business Model Canvas for IE Consulting	5 days	Wed 11/5/14	Tue 11/11/14	2		
4			Lit. Review Prep	15 days	Wed 11/12/14	Tue 12/2/14	3		
5			Literature Review	16 days	Mon 12/15/14	Mon 1/5/15	4		Break
6			Find An Advisor: Brian Maready (Lean Built)	2 days	Mon 12/15/14	Tue 12/16/14	4		Break
7			Schedule Meetings with Manufacturers (For 1/6 thru 1/16)	16 days	Mon 12/15/14	Mon 1/5/15	4		Break
8			GOOB (Develop Customer Segments)	4 days	Tue 1/6/15	Fri 1/9/15	7		Winter
9			Speak to 1 Manufacturer	2 days	Mon 1/12/15	Tue 1/13/15	8	Blake	
10			Speak to 1 Manufacturer	2 days	Mon 1/12/15	Tue 1/13/15	8	Torrey	
11			Speak to 2 diff. Small Biz	2 days	Wed 1/14/15	Thu 1/15/15	9,10		
12			Edit BMC Customer Segments	2 days	Fri 1/16/15	Mon 1/19/15	11	Torrey	
13			Edit BMC Value Proposition	2 days	Fri 1/16/15	Mon 1/19/15	11	Blake	
14			Consult with Advisor	2 days	Tue 1/20/15	Wed 1/21/15	13		
15			Create Brochure: list of Consulting Services	10 days	Thu 1/22/15	Wed 2/4/15	14		
16			First round of Marketing: Direct/Social	20 days	Thu 2/5/15	Wed 3/4/15	15		
17			Teacher/Student Interest	5 days	Thu 3/5/15	Wed 3/11/15	16		
18			Visit manufacturing Sites	3 days	Thu 3/12/15	Mon 3/16/15	17		
19			Create Project Instructions/scope/guide	7 days	Tue 3/17/15	Wed 3/25/15	18		
20			Select Students for Project	5 days	Mon 3/30/15	Fri 4/3/15	19		Spring
21			Provide Project Oversight	30 days	Mon 4/6/15	Fri 5/15/15	20		
22			Report Out	2 days	Mon 5/18/15	Tue 5/19/15	21		
23			Create Senior Project Presentation	10 days	Wed 5/20/15	Tue 6/2/15	22		
24			Present Senior Project	1 day	Wed 6/3/15	Wed 6/3/15	23		

Figure C: Gantt Chart

Figure E: Storage section, part of Hydrogen Junkie facility

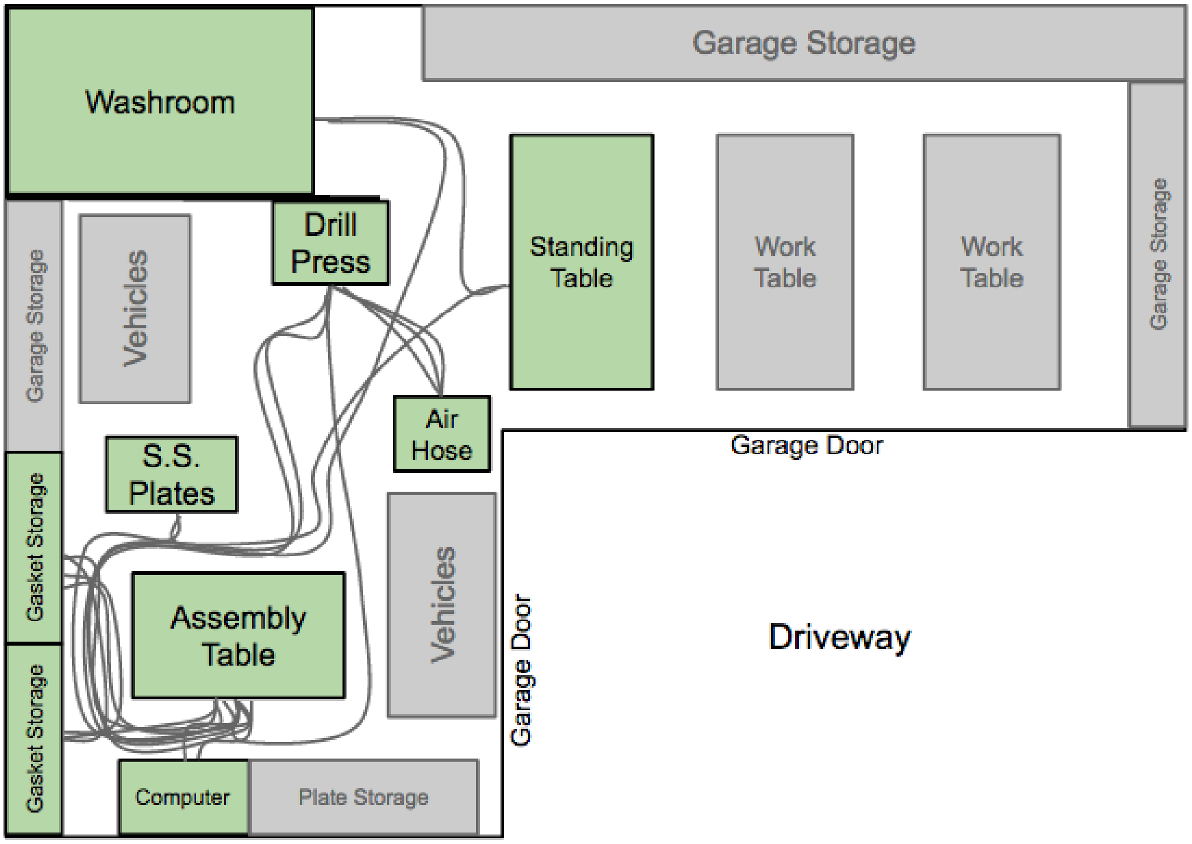

Figure G: Hydrogen Junkie Spaghetti Diagram, current process and facility

Figure H: Proposed Shipping Container for new Hydrogen Junkie Facility

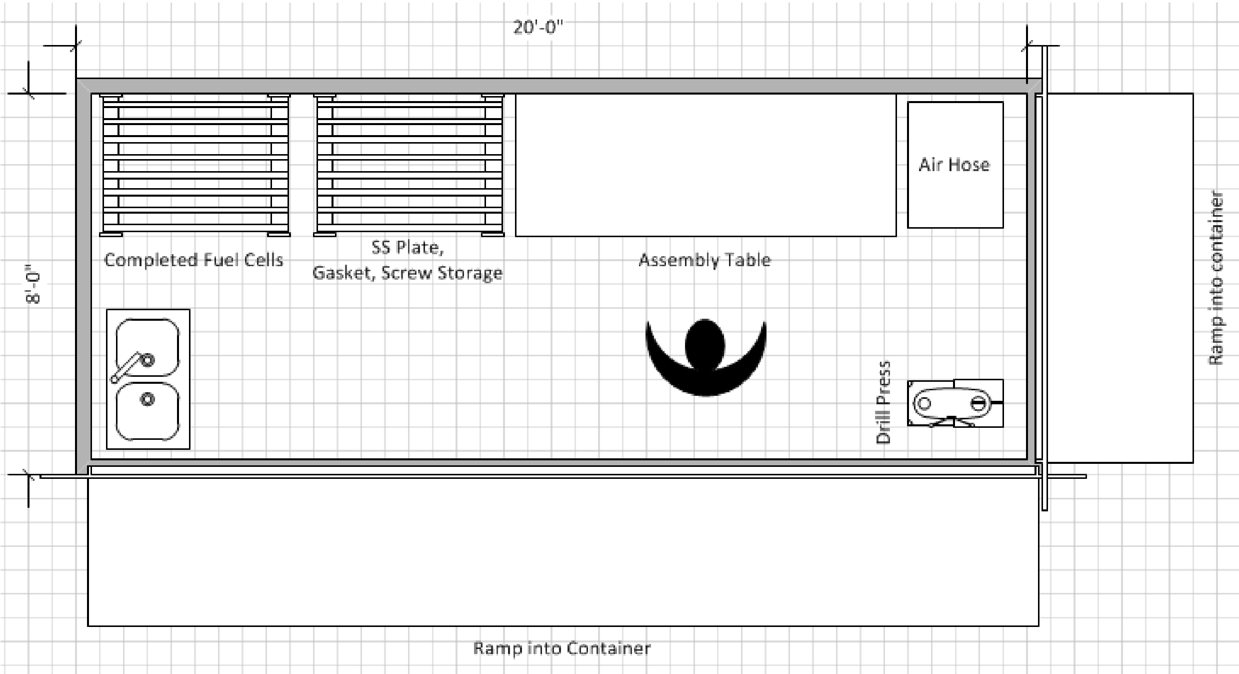

Figure I: Design of Proposed Shipping container for new HJ Facility

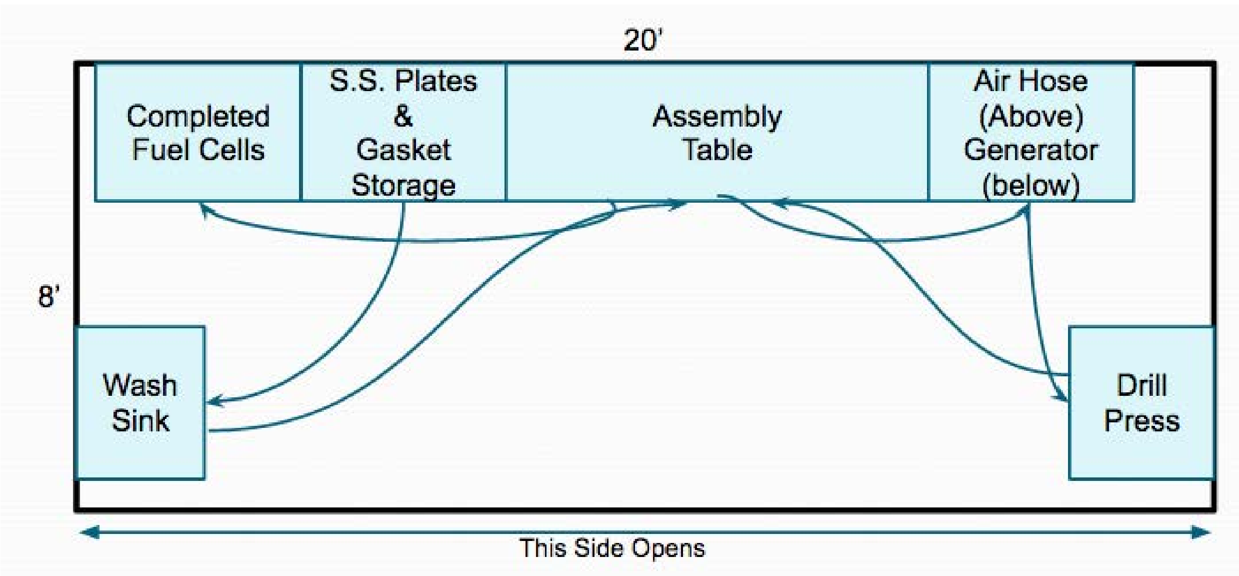

Figure J: Spaghetti Diagram of proposed HJ facility

Date	Duration (hrs)	Task	Name	Notes			
11/11/2014	1	Create work log / Lit Review Prep	C	Done.			T = Torrey
11/11/2014	1	Fidning Scholarly Articles (lit Rev)	T				B = Blake
11/13/2014	1	Finding Scholarly Articles (LitRev)	B				C = Both
11/15/2014	3.5	Literature Review	C				
11/18/2014	1	Summarizing L.R. Articles	B				
12/1/2014	1	Summarizing LR Articles	T				
12/1/2014	6	Presentation Prep.	C				
12/20/2014	1	Literature Review	T	Six Sigma VS. Lean			
3/20/2015	1	ASI meeting validate club	B	President and Treasurer Training			
3/25/2015	1	ASI paperwork	B				
4/2/2015	1	Emails with Manufacturers	B	Zodiac, RED			
4/15/2015	2	S.O.C. Meeting and Prep work	T				
4/16/2015	4	Zodiac Aerospace Tour	T				
4/20/2015	3	Email, responding to students, connecting with Zodiac	T				
4/21/2015	3	IME 482. Creating Teams	C				
4/21/2015	1.5	More Email responses, creating teams, Standard Times, itinerary	T				
4/21/2015	2	Lit Review Methods	B	Time Study, 5S,			
4/24/2015	0.5	Conference Call- Zodaic: Pat/Chad	T				

Figure K: Work Log for Senior Project

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