SETUP REDUCTION TIME AT A BATCH MANUFACTURING PLANT

By

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EXECUTIVE SUMMARY

This project documents the efforts to reduce setup times at a batch manufacturing culture media production plant. The company is one of the leading producers in medical and laboratory supplies, including culture media. In the production of culture media, the production line requires to switch between solutions once or twice a day depending on the production schedule.

The report provides the production plant with a concrete analysis of their current changeover method, which tends to be lengthily and complicated, and suggest alternatives in short and long term periods of time to reduce setup time.

After analyzing the time studies of the current changeover method, the problems at production process fall into two categories: disorganization in the work area and disorganization in the work distribution. Solving these problems would give as a result a time efficient changeover process, saving time, resources and money. Several short term and long term ideas were proposed to compensate for these problems, but only 6 short term alternatives and 5 long term alternatives are examined and analyzed in this report.

The short term alternatives analyzed to solve the problems are: adding a cleaning supply station, increase the area for certain items, paint boxes, storage more Petri dishes, put markers on Conveyor Belt and the application of the SMED method. The long term alternatives analyzed to solve the problems are: Door Relocation, inclusion of a second reactor, a new communication system, UV Sanitation System

The implementation of these alternatives will reduce the variability and increase efficiency in the changeover process in the production of culture media at the plant.

INTRODUCTION

"One of the most noteworthy accomplishments in keeping the price of products low is the gradual shortening of the production cycle. The longer an article is in the process of manufacture and the more it is moved about, the greater is its ultimate cost." Henry Ford 1926

In today's global and competitive market, one of the most important aspects for companies is to be capable of producing a wide range of products for high demand. Customers with high demand, look for manufacturers that have the production capabilities to satisfy their needs. Companies with this production power are in constant struggle to compete for more customers. For companies of such caliber to be on top of the market, by producing quality products at competitive prices have become one of the highest challenges for production manufacturing processes.

More and more companies try to stay up to date with all the new manufacturing methods and processes to create a more efficient overall production. One of these methods, part of lean manufacturing, is setup reduction time. Set up time can be defined as the amount of time taken to change a machine from the last part of a production lot to the first good part of the next production lot. In high production systems, the amount of repetitive work accounts for a great part of the lead time of the product, the rest is usually set up time. Companies strive to minimize and, if possible completely eliminate setup time. Even though more companies are applying setup time reduction methods today, the reduction in setup time is not a new concept. Ford in 1926 was practicing lean manufacturing and just-in-time production and reducing set-up times at least 20 years before Toyota and other Japanese companies. What ultimately is

most surprising of all is that few American companies really have taken these lessons to heart, even 75 years after Ford introduced them.

THE COMPANY

The company is located in Santa Maria, California is one of the leading producers in medical and laboratory supplies, including clinical and industrial culture media, rapid test kits, stains, reagents, among others. The production line for these products requires a high diversity of solutions to be poured into small Petri dishes called surface samplings. The company has a wide range of culture media products, to be sold to clinics, hospitals and overall to the health care industry. With the company manufacturing over 3,200 different microbiology lab products and offering over 12,000 products to their customers, the changeover process from one product to the next must be as efficient as possible. Specifically, the entire changeover operation includes disassembly of tubes from the Petri dish holder, transport of reactors containing the liquid culture media, assembly of the new tubes from the Petri dish holder to the new reactor, cleaning, and paperwork among other smaller operations.

A major problem emerges in the production line when changing over other solutions, the set up time tends to be lengthy, complex and complicated, stopping production; therefore the company is wasting resources, production and money.

THE NECESSITY

The idea of this project spanned from IME 223 class. This class had the project of conveying the necessary time studies for the changeover process. The time studies are the principal tool in detecting waste times. The IME 223 Instructor saw the necessity and opportunity to expand the IME 223 projects and create a more complex and in-depth analysis of the problem. The analysis on this project consist in the implementation and knowledge from different Industrial and Manufacturing topics such as, ergonomics (IME 319), work study and measurement (IME 223), project management (IME 303), facilities planning (IME 443) quality engineering (IME 430).

After a complete and systematic implementation of Industrial and Manufacturing knowledge, and other techniques to solve or improve the current problem at the company's production clean room changeover process , the objectives of this project are:

- An overall reduction in setup time by at least 50 percent, increasing production and efficiency without affecting quality.
- The creation of an operational procedure for each operator, standardizing the changeover procedure.
- And an economical justification with savings and cost of implementation.

LIMITATIONS

This project will focus on the process of changing the different solutions into the production line and make it more efficient by reducing the set up time. Any other process not

involved directly with this would be out of scope. The proposed operating procedure for optimization will be design only for the Santa Maria factory and could work for similar facilities with similar set ups.

This report begins with a full analysis and background of the current clean room and its current setup methods. Several analytical times studies were performed in collaboration with IME 233 Work Measurement class, to determine the average amount of time dedicated to each different setup element. The techniques and methods used to perform time studies are explained, followed by a more in-depth analysis of the proposed recommendations.

THE APPROACH

This report would cover two different approaches, short and long term alternatives to reduce setup times at a batch manufacturing plant located in Santa Maria. Short term alternatives, would refer to small and inexpensive changes to the changeover that can have a great impact in the setup time. These changes can be achieved by modifying and adjusting how the changeover is done by creating a better work flow in the current layout and also by distributing all necessary responsibilities among operators. Long term alternatives refer to changes that would take longer to implement and have a more significant investment.

Short term and long term alternatives are explained followed by a comparison between the current Vs the New setup. Details of both methods are explained and discussed to more clearly illustrate the changes that were made.

BACKGROUND

The term Lean Manufacturing is not especially new, it derives from the Toyota Production System (TPS) or Just In Time Production (JIT), Henry ford and other predecessors. The implementation of similar procedures of Lean Manufacturing and Just in Time can be traced back to Eli Whitney in 1779 and the concept of interchangeable parts. After Whitney and for the next 100 years manufacturers primarily concerned themselves with individual technologies. Some of the most recognized would be Frederick W. Taylor and his advances in time study and standardized work, Frank Gilbreth with added motion studies and process charting, and finally but not less, Lillian Gilbreth, brought psychology into the mix by studying the motivation of workers and how attitudes affected the outcome of a process. This new knowledge changed the late 1890's and would change the work of the early Industrial Engineers.

In 1910, Ford developed the first comprehensive manufacturing strategy. The way Ford approached manufacturing was to look at all the element in a manufacturing system including machines, people, tooling information and products, and arranged them in a continuous system. He applied this very first method in the production of the very famous T Model. Because of this, Ford by many is considered the pioneer and first practitioner of Just In Time and Lean Manufacturing.

After WWII and with the allied victory, Japan was left with massive quantities of material, this caught the attention of Japanese Industrialist. They started by studying and

putting particular attention to Ford practices and quality control practices from Ishikawa, Deming and Juran. One of the Japanese companies that really put emphasis in to learn and developed a new manufacturing system was Toyota Motor Company. Taichii Ohno and Shigeo Shingo, began to incorporate Ford production and other techniques lean manufacturing techniques into an approach called Toyota Production System or Just In Time. One Key discovery was the product variety, the Ford system was built around a single, never changing product and this was one of its shortcomings. The Ford's system couldn't cope well with multiple or new products. It is here where the setup and changeover problem came to be. Shingo worked on this problem and came up with a method and technique for reducing setups to minutes and seconds, allowing smaller batches, more production flexibility and a more continuous flow like the original Ford concept. This method is better known as SMED, Single Minute Exchange of Dies.

LITERATURE REVIEW

"Reducing Machine Setup and Changeover Times." The paper examines in a very brief form the definition, uses, benefits and techniques of reducing set up time. This paper explains how to gain valuable manufacturing capacity in a very short time, applying creativity and common sense before capital. (Keberdle)

"Setup Reduction: At The Heart Of Lean Manufacturing." This article goes over set up reduction time and how it is one of the main elements in lean manufacturing. It gives examples of how companies used lean manufacturing to make their production more efficient. The article also explains a step by step process of doing setup reduction time and how can it be translated into lean manufacturing and a more efficient production. (Albert)

"Reducing Set-Up Times a Foundation for Lean Manufacturing." This article gives a brief explanation of the relation between set up time and the payback generated by its reduction. It also goes over several useful definitions and basic concepts. It gives suggestions on how a reduction in setup times can be achieved. (Kilpatrick)

"Set-Up Reduction As An Organization-Wide Problem." This paper describes why Set-up reduction is often considered a problem for those in production or manufacturing operations. But in actuality, other areas other areas other than manufacturing and production influence ad impact the improvement of setup times. In other words, if a reduction in setup time is desired, and a possibility is identified, it is a cross-functional responsibility, not only production. This

article also covers how different function affect setup times giving examples and applications. (D. V. Goubergen)

"Set-up reduction in pharmaceutical manufacturing: an action research study." This paper goes over how a reduction in setup time was applied at a pharmaceutical manufacturing plant. This article is a complete report explaining how a significant reduction in setup time was achieved, after a concise step by step process was applied to the company. The process follows tree different steps, one being research, the second one being onsite investigation and third and last being the setup time reduction itself. (Smith)

"Single machine scheduling with batch set-up times to minimize maximum lateness." This paper considers a problem of scheduling *N* jobs on a single machine to minimize the maximum lateness. A partitioning of the jobs into *F* families is given. A set-up time is required at the start of each batch, where a batch is a largest set of contiguously scheduled jobs from the same family. This article is important so I can come up with an algorithm trying to schedule the different operators and different solutions into the machine. If effective the result would be a reduction in setup time. (Hariri)

"Cambio rápido de herramientas y reducción en tiempos de preparación Nueva y más amplia versión del SMED." This webpage give a concise description of how the revolutionary system of production "Just In Time" by means of reducing setup time, cycle time etc made possible to reduce to its minimum expression the levels of inventory, returning more flexible the productive processes, reducing enormously the cost and increasing the levels of productivity. This article also covers the conditions and tools for the setup time reduction.

Some techniques are explained, going over time studies, statistical process charts and benchmarking among others. (Lefcovich)

"Phases of Setup Time Reduction." This article covers deeply the topic of setup reduction, explains why it is needed, how to reduce it and some of the results we can expect from the reduction. It also covers a four step plan to reduce setup time. The steps are: 1. Maintenance, Organization and Housekeeping 2. Internal Elements to External 3. Improve Elements 4. Eliminate Adjustments, the article describes each step, and explains how to apply them. (Strategics)

"Reducing Set-up Times of Manufacturing Lines." This article explains how a key for implementing Lean Manufacturing is having short set-up times. This means that the set-up reduction is a very important step towards a lean production system. The existing approaches for reducing set-up times, as published in other papers and books, focus merely on single machine situations where one person (or sometimes more) performs the set-up of an isolated workstation or machine. In practice, the situation gets more complicated when multiple machines and multiple persons are involved, as this is the case when performing a changeover of a whole machine line. In order to analyze and optimize this situation, the interaction between the different machines and between the different persons involved need to be considered. In this paper, they describe an appropriate methodology that can be used in these situations and the current state of this research. This overall approach was initially developed for improving existing set-ups of machine lines but it can also be used during in a design phase of new equipment. (D. V. Goubergen)

“Single Minute Exchange of Dies (SMED) / Quick Changeover.” This webpage cover different production systems and tools that can be used to create a more efficient manufacturing setup. This article explains how SMED is a tool used to reduce setup time in industry, exchange of Dies, cleaning, and for regular maintenance. It explains that these activities often take a big amount of manufacturing uptime. Setup works are often hard and are considered unproductive, why they are avoided as long as possible. Setup times are often regarded as something that we need to live with. Therefore, little effort is used to plan the work in advance, and to modify the equipment for quicker stops. It is normally possible to greatly reduce the set-up times. This article also covers the history of this methodology and talks about its pitfalls. Fantastic results are possible through better teamwork, good order, planning and simple modifications. This article also covers other production efficiency model like the 5s, TPM pillar and international TPM. (Olofsson)

"SMED Setup & Lead Time Reduction.” This is a very interesting and informational porwer point presentation, I goes over why sa setup time reduction is always needed in industry, covering the the organization strategy and priorities, material flow cycle looking towards a continues improvement. To reach this the presentation goes over some thechniqes and tools for setup reduction time. it gives a profound description of what tool or technique can be use when and where. Then I goes into the SMED methodlogy, and explains the goalsbenefits and implementation ofa reduction in setup time. (Subramaniam)

“Five techniques for reducing setup time: every tool in its place, a place for every tool.” This article makes reference to five simple different rules or tools, that when in place and

functional will develop a decrease in setup time. The tools explained in this article are, job documetation, tool setup, fisxture setup, process control and programm development. Each different too would have a different effect on the stup time, but to achieve a better result, the application of the five tools is graatly recommended. (Cengage)

"Set up time reduction." This book goes deeply into the setup time reduction matter. Explaining how manufacturing companies today are feeling intense pressure to increase their productivity and until now, had a proven guide to point them in the right direction. Set-Up Time Reduction lays out a simple method for increasing actual manufacturing time and bottom-line profits by reducing production set-up times by as much as 30 percent. Set-Up Time Reduction is an easy-to-read handbook for everyone involved in the manufacturing process from supervisors to frontline workers. It combines actual work experiences and applicable systems that are designed to help you initiate your effort by defining a vision, tapping the resources within by working in teams, supporting your employees through empowerment, and implementing problem-solving methods; calculate your return-on-investment benefits as a result of set-up time savings that can reach up to 90 percent; organize and store your set-up materials in the most efficient manner according to your company's specific needs; adopt a quality focus that results in complete customer satisfaction; a low cost product with correct counts and no defects, delivered on time; and reduce cycle time now and for years to come. (Claunch.)

"SMED: a set up time reduction project" This is a senior project from almost 20 years ago, with the same goal, reduce setup time. In this project the author explains how they used SMED methodology and how they applied it to a plant, to consequently reduce setup times.

This senior project is a good reference to see what has been done in the matter before and how can I get this knowledge and make it better. (O'Connor)

"Reducing Setup Time." This article explains briefly why setup time is needed, how it can be achieved and goes over some technique used in industry to achieve this. (Southworth)

"Just in Time Manufacturing: An Introduction." This book discusses in a clear, straightforward language, the implementation of JIT manufacturing. The objectives are twofold, first, to define JIT and to give all the necessary concepts and factors for its implementation and secondly, to reinforce the material with actual case studies. One of the tools for just in time manufacturing is setup time reduction, the book cover this topic in a more concise way. (T. C. Edwin Cheng)

"Introduction to Work Study." This book describes the basic techniques of work study as practiced in many parts of the world, has been widely recognized as the best available introduction to the subject for work study practitioners and industrial engineers. It provides training in method study and work measurement and covers not only "machine shops" but also process industries, the services sector and office work. Reference is made throughout to the use of information systems and computerization to solve work study problems. It also covers production management approaches and their relation to work study. Numerous illustrations and examples of work study practice are included as well. (Kanawaty)

SMED METHOD

Working in any kind of manufacturing environment one of the unfortunate characteristics is waste. Waste can extend from unused raw material to damaged products, and it can carry quite of a financial loss for the company if not treated in an efficient manner. In order to reduce waste, there are several number of methods and strategies that companies can use depending on the desired results. One of the most popular methods is Single Minute Exchange of Die or SMED.

A production line can have many different drawbacks, but one of the most recognizable is the setup time for a production run. What the SMED method implies is to reduce setup operations to in less than ten minutes, in other words, setup operations should be completed in a number of minutes that is representative by a single digit: one to nine minutes. Doing this, the production efficiency would increase by means of reducing waste and the time spent between each production runs. Introducing better changeover and setup practices, the production lots can be reduced and as well as the inventory because there is less waste, thus improving overall production flow.

The concept of SMED was originally adapted and used in Japan during the 1950's. The SMED method gained worldwide acceptance during the 1980's, after other countries wanted to imitate and get the same success of Japanese companies. The SMED method during its origins was adopted by Toyota, one of the reasons Toyota adopted SMED was because it needed additional space to store manufactured cars, because Japan is small and real estate is expensive. Toyota had to store their fleet of cars in high priced lots, reducing their profits. An

engineer named Shingo came about to solve this problem, he decided that if the changeover cost could be reduced, the company would gain higher profits. It took several years but Toyota managed to implement the SMED method by minimizing tools and steps in the manufacturing process. In addition to this, Toyota tried to maximize and standardized their components so that more cars shared the same components. With all the new changes to the production lane and minimizing waste, Toyota managed to cut back on costs and improve their profit.

To better explain the implementation of SMED method, the manufacturing process has deal with different changes. In a manufacturing process a changeover can be defined when the last item in a production run has been completed the equipment and machinery is shut down, cleaned, inspected and new tooling is either added or changed. This gets the equipment ready for the next run on a new item. Therefore the changeover can involve many different adjustments, resupplying all the raw materials, inspection and system checks for the next run. This setup time or changeover has a great cost to the company, mostly because no finished products are produced. In addition to this waste is being generated. All these can be reduced by applying SMED. For the SMED to take action, we need to separate setup processes into two categories: internal and external. External setup can be done while the machines are still running. Internal setup can only be done after the machines have been stopped for changeover.

There are different interpretations of the SMED method all aiming towards the same end, to reduce setup times. The implementation of SMED uses different steps to improve production and reduce waste. Some key steps taken from the website *World Class Manufacturing,* article by *Oskar Olofsson* are:

Step 1 – Apply 5S to the workplace

Step 2 - Analysis. Keenly observe the operations and processes. The present situation is analyzed using video-technique. The different moments are classified as being external or internal. All known disturbances are listed as well.

Step 3 - Separation between internal and external moments. The purpose is to secure that all external set-ups are performed when the machine is running. Resources are checklists, function controls and improved transports. For example collect necessary tools and consumables before the next operation starts up or sharp the tools before activity starts.

Step 4 - Elimination of waste. Measures are carried out to reduce all types of waste. This includes:

- *Elimination of all need for adjustments.*
- *Exchange of bolts for quick-fasteners.*
- *Standardization*
- *Increasing the number of equipments,*
- *Improved team-work.* (Olofsson)

The proper implementation of SMED method can have great implications for a company, the most common improvements come in reduction of downtime due to a decrease in changeover or setup time and the reduction of waste.

Additional benefits include:

- Machines have an increase in work rates.
- Productivity sees an increase.
- Fewer defects are produced.
- Level of safety is increased due to following proper change-up procedures.
- Less time spent cleaning up after production due to better organization.
- Overall costs of set-up are lower due to less time spent during change-over and less waste.
- Operation of equipment takes less skill and training due to simplified process.
- Lot size reduction
- Reduction in finished goods inventory
- Profits are increased without having to spend more money on more equipment.

5S METHODOLOGY

5S is a reference to a list of five Japanese words which all start with S. 5S is a philosophy and a way of organizing and managing the workspace by eliminating waste.

In the words of Hiroyuki Hirano, author of 5S: Five Pillars of the Visual Workplace: "A company that cannot successfully implement the 5 Ss cannot expect to effectively integrate JIT, re-engineering, or any other large-scale change. Good workplaces develop beginning with the 5S's. Bad workplaces fall apart beginning with the 5 Ss." (Das)

The key targets of 5S are workplace morale and efficiency. The assertion of 5S is that by assigning everything a location time is not wasted by looking for things. Additionally, it is quickly

obvious when something is missing from its designated location. 5S advocates believe that the benefits of this methodology come from deciding what should be kept, where it should be kept, and how it should be stored.

The 5S's are:

1. Seiri: tidiness, organization. Translated as **Sorting**. Refers to the practice of sorting through all the tools, materials, etc., in the work area and keeping only essential items. Everything else is stored or discarded. This leads to fewer hazards and less clutter to interfere with productive work.
2. Seiton: orderliness. Translated as **Straightening**. Focuses on the need for an orderly workplace. "Orderly" in this sense means arranging the tools and equipment in an order that promotes work flow. Tools and equipment should be kept where they will be used, and the process should be ordered in a manner that eliminates extra motion.
3. Seiso: systemized cleanliness. Translated as **Scrubbing**. Indicates the need to keep the workplace clean as well as neat. Cleaning in Japanese companies is a daily activity. At the end of each shift, the work area is cleaned up and everything is restored to its place. The key point is that maintaining cleanliness should be part of the daily work - not an occasional activity initiated when things get too messy.
4. Seiketsu : standards. Translated as **Standardize**. This refers to standardized work practices. It refers to more than standardized cleanliness (otherwise this would mean essentially the same as "systemized cleanliness"). This means operating in a consistent and standardized fashion. Everyone knows exactly what his or her responsibilities are.

5. Shitsuke : sustaining discipline. Translated as **Sustain**. Refers to maintaining standards. Once the previous 4S's have been established they become the new way to operate. Maintain the focus on this new way of operating, and do not allow a gradual decline back to the old ways of operating. (Cengage)

Benefits of the 5S System:

- Improved quality
- Achieve work standardization
- Decreased changeover time
- Improved safety
- Reduced storage costs
- Reduced cycle time
- Reduced machine down time
- Boost employee morale as well as work environment

DESCRIPTION OF PROCESS STUDIED

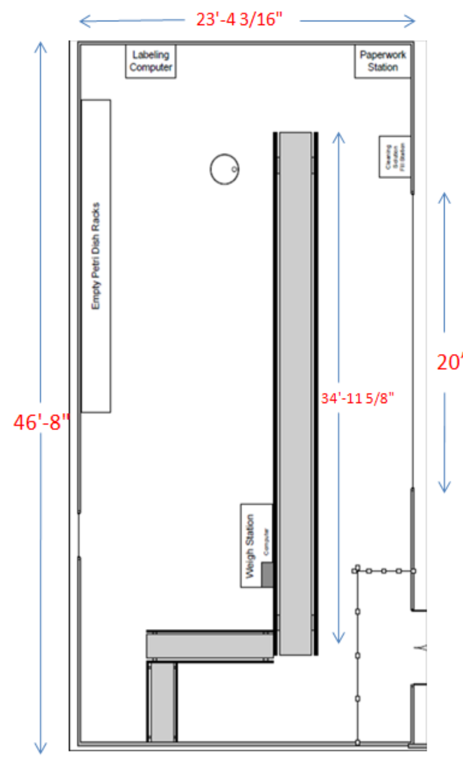
The focus of this project is in the changeover operation at culture media production process. The changeover process would occur when one production run was done, and the operators have to switch the production to another solution. During the changeover process, the workers are supposed to take the reactor from the previous product's production back to the kitchen to get cleaned and refilled and bring the reactor for the new product's production into the clean room. In addition to these tasks, workers are also supposed to clean the entire conveyor belt and stock new Petri dishes into the head of the line, among other tasks.

The changeover process starts with each operator getting dressed in contamination-free coats; these coats don't leave the clean room at any time. Usually there are anywhere between two and five operators in the clean room at one time. At the time of the visit and the video footage there were three operators, one of them being the designated supervisor which leads and coordinates the changeover. The other two operators are responsible for cleaning, disassembling, preparing the Petri dishes, reactor and conveyor belt for the following filling process. Each operator works in a non-systematic way, randomly taking tasks to complete the changeover process, in other words they perform work as needed.

There is no apparent order or assigned responsibility among the operators to take over the tasks in the changeover process. Therefore the time studies show chunks of unproductive time wasted. Another setback for the changeover, is the poorly and unorganized location of necessary supplies.

Currently, this process is supposed to take approximately up to 30 minutes according to the managers at plant. However, during two of the three time studies that were analyzed, there were two unexpected problems occurring which caused the process to take much longer. The three changeovers analyzed ranged from 30 to 50 minutes in duration, they all had the same task to be performed. With this in mind, having no standard completion time for the changeover can dramatically impact the productivity and efficiency of the system and even more since the change over occurs at multiple times a day. This is the main reason why a reduction in setup time is highly needed in the process.

Main factors affecting the changeover operation refer to figure 1 for the Clean Room Current Layout, see Appendix A for Complete measurements and see Appendix G for 3D modeling of Current Layout:



- Only 3 operators
- Clean room
    - Location of cleaning supplies
    - Frequent changes of gloves, coats, and hair nets
    - Movement around the clean room
    - Clean room size
- Heavy reactors that must be moved every cycle over long distances
- Large conveyor belt

1 Clean Room Current Layout

MEASUREMENT AND PROCESS ACTIVITIES

The data in this report spanned from IME 223 class, this class was in charge of taking all the necessary measurement and record all process activities involved in the changeover process.

The data was collected as follows:

Student representatives were initially sent to the plant to record preliminary measurements so that a scaled floor plan could be created using a drafting program. A couple students used a measuring tape all around the clean production room to get the data. The measuring was focused on the outer walls and the conveyer belt because this is where the most of the changeover process takes place. Due to safety and regulatory reason 3 different changeover processes were videotaped.

The next step was to conduct all the necessary time studies on the operators who were performing the changeover. The time studies were done by timing the operators the instant the changeover process began. Every process that took place for each operator was timed and recorded. Even if an activity was a delay or if it was necessary for the changeover process was noted. The continuous time was used in order to make a more accurate data collection as possible. After all the times were recorded, the data was organized into flow process charts (see Appendix B-D) each one of them illustrates the changeover process per operator. With this information in hand, the whole changeover process was broken down into smaller pieces being able to come up with a precedence diagram to understand better the process (See Appendix E). In addition to this a multiple activities chart was created (see Appendix F).

After all the data was organized, a complete analysis was made to find out where the process needed improvement. One of the main problems that stood out immediately, it was the unproductive time in the beginning of the changeover. One of the operators didn't know where his cleaning supplies were, this caused a significant delay in the changeover competition.

Another aspect that stood out for improvement (see Appendix F), was that all of the operators finished the change over process at different times. For an efficient changeover process, all of the operators should have similar workloads so they end at the same time or close to the same time. This variability in times suggests that the workloads for the operators are uneven. If one operator does most of the work, it will lengthen the time it takes for the changeover to finish. It will also make it harder on this single operator who does a majority of the work.

To make the changeover process easier to assimilate it was broken down into 6 main categories. These categories are setup, cleaning, transport, breakdown and preparation (see Figure 2). Due to the above mentioned, the operators do not really have a standardize assignment from changeover to changeover. They are helping where needed, when needed without any direction. This increases confusion, variability, and time inconsistency. The solution to this problem would be one of the main focuses of this project.

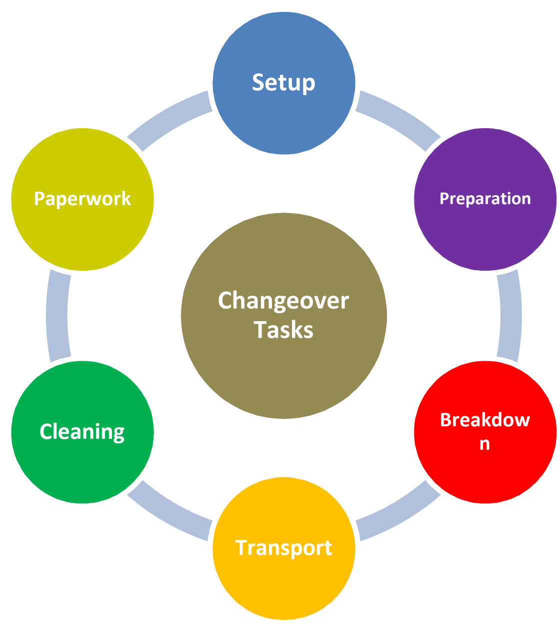


Figure 2 Changeover Tasks

ALTERNATIVES GENERATED

After a complete analysis of the changeover process at the plant using time studies, process flow, analysis of operation and multiple activity charts among others to evaluate the data gathered. Several waste elements were noticed right the way, these elements can be improved for a more efficient changeover process. The alternatives generated were broken down into two different categories, short and long term alternatives. Short term alternatives describe changes to the changeover process that can be done in a very short time with a minimum investment and can have immediate results. On the other hand, long term alternatives describe more complex changes to the system that imply a major capital investment and because of its complexity take longer to implement.

SHORT TERM IDEAS FOR IMPROVEMENT

The following short term ideas for improvement were generated:

1. Precedence and multiple activity charts
2. Clean gloves for each operator
3. More glove compartments
4. Using surface wipes
5. Using 5S methodology in current layout
6. Designate specific place for each of the cleaning tools
7. Using clipboards
8. Change of tubes assembly and disassembly
9. Storing more Petri dishes

10. Distribute all necessary responsibilities
11. Standardizing the sequence of operation
12. Markers on conveyor belt
13. Cleaning supply stations
14. Paint boxes
15. Stools
16. Straighten work environment
17. Standardizing jobs
18. More areas for certain items
19. SMED

LONG TERM IDEAS FOR IMPROVEMENT

The following long term ideas for improvement were generated:

1. Moving conveyer belt
2. Install communication system
3. UV sanitation
4. Add Computer system
5. Door relocation
6. Two reactors
7. Put Electric motor on the reactor
8. Have a 4th person do all the kitchen work
9. Add track or automated movement assistance

10. Install Cleaning system

11. Four operators working on changeover

12. Line balancing

EVALUATION AND SELECTION OF ALTERNATIVES

After generating the list of alternatives, seen in the above section, the setback in the changeover process can be synthesized into two main problems a disorganization in the work place and disorganization in the work distribution. Having this in mind, the alternatives were narrowed down to attack the core of these two problems. The following sections explain the problems in a more detailed way and give a solution using the proposed alternatives.

After short term alternatives have been put in place for a more consistent and efficient changeover process and the system has reached a plateau, long term alternatives can be place on top of the already placed short term alternatives and reach new efficiency and productivity heights. Long and short term alternatives will work in conjunction to create a better work environment, a better work flow and a more efficient changeover process. The difference between long term alternatives and short term alternatives is that long term alternatives are more complex, take a considerable investment and in most of the cases installation as well as training are needed.

STANDARDIZING WORK ENVIRONMENT

Problem: Disorganization in the Work Place

One of the most constant issues in the change over process that hinders the ability of the operators to complete their tasks effectively and efficiently on time can be blamed to the poor organization of the supplies and products around the clean room. Due to the lack of a standard location for the supplies (gloves, bottles and hand sanitizer) the operators are

required to spend time locating cleaning supplies within the clean room and also traveling to get additional supplies.

Drawbacks:

1. Operators missing items
2. Increase in traveling time by having to get items

RECOMMENDED SHORT TERM SOLUTION

Apply 5S Methodology

(Refer to Appendix U for time Improvements)

APPLICATION OF THE 5S METHODOLOGY

The first step into solving the disorganization in the workplace and increase efficiency in the changeover process was to implement the 5s methodology. The 5S stands for sort, straighten, sweep, standardize, and sustain. The 5s system is a proven tool when attempting to increase efficiency of a process. Next is a breakdown of the 5S methodology in terms of the needed application in the current changeover.

Sorting

Applying sorting in the cleaning room implies to go through all tools and material needed for the operation and changeover and only keep those that are essential for those operations. Everything else is stored or discarded.

Straightening

This step is very important at the production plant, there should be a place for everything and everything should be in its place. Every space should be clearly labeled and the items should always be located in the same location so that ht e workers don't have to be looking for missing items around the cleaning room. The most used items in the room should be kept at places that are easy to reach and have to improve workflow.

Sweeping

At the end of each shift or day, items should always be returned and restock to their original locations, therefore nothing will be misplaced or lost.

Standardizing

Every worker should know what his or hers responsibilities are around the clean room, making them more efficient by not overlapping doing the same operation twice. This step would be later described in the section Standardizing job Distribution.

Sustaining

The last step in the 5S methodology is to maintain and review the previous 4s's, if a new method or if a problem arises make changes as necessary.

SELECTION OF SHORT TERM ALTERNATIVES

Having the 5S methodology in mind, the following are some final alternatives to help improve the work flow and the standardization of the work environment at in the production room.

CLEANING SUPPLY STATION

After reviewing the change over and the problems that the cleaning supplies caused to the workers by not knowing where they left them, comes a recommendation to use a cart with all the cleaning supplies on them. The carts can also be used for other activities like cleaning, workers can put the clamps that are taken off the pumps, and also to put parts of the machine when this is disassembled to clean properly. The cart can be stored beneath the conveyor belt so it won't take more space.

MORE AREA FOR CERTAIN ITEMS

This alternative follows the same line of thinking than the alternative above mentioned. Adding more gloves, tables, cleaning supplies and hard surfaces will prevent operators from wasting time looking around for items and having to move to the closest flat surface to write. The inclusion of clipboards would be another viable solution to the problem of finding hard surfaces to write.

PAINT BOXES

One of the best ways to implement the Straightening step in the clean room is the idea of painting boxes at the bottom of all moving equipment. Paint boxes are drawn on the floor to straighten out where the larger boxes or tools should be stationed. By doing this, we can standardize where everything should be placed in the work area and also have the ability to quicken the cleaning process required at the end of the day or throughout the process of the day. Straightening out where all objects go cuts time off decision making through the work day

and standardizes the work place for all to cut excess time and movement in searching for particular tools.

PETRI DISHES

Another recommendation would be to bring as many racks of Petri dishes as they can fit in the clean room and align them against the wall before the first run of the line. This would help cutting current traveling time during the changeover avoiding the workers to pick up more Petri dishes while the changeover is in process.

MARKERS ON CONVEYOR BELT

A good way to standardize the cleaning would be the installation of markers along the conveyor belt. These markers can be numbered. Due to the fact that cleaning up the conveyor belt took a good chunk of the cleaning time, this addition would decrease the cleaning time. The problem was that during the cleaning of the conveyor belt there was no way for the worker to know where they were on the conveyor belt or how much of the conveyor belt had they cleaned. With this change the worker would be able to know where he started cleaning, go over the other markers and know where exactly to stop cleaning. This new system would create a more efficient cleaning system and would allow the workers to spend more time in other areas of the changeover.

RECOMMENDED LONG TERM SOLUTION

Aim for automation and improve work flow

(Refer to Appendix V for time improvements)

SELECTION OF LONG TERM ALTERNATIVES

After implementing short term alternatives the system can be further improved by automating, to minimize human error and increase production time. Automating would imply that operators will not need as many cleaning supplies as they normally use eliminating cluttering and cleaning supply stations. There won't be the necessity of having multiple operators at all time. The system can be also be improved by minimizing traveling time. The following are alternatives that aim to solve these problems and try to standardize the work environment even further.

DOOR RELOCATION

A major process improvement can be made by switching the location of the gowning room. The gowning room is currently in opposite corner from where the majority of the changeover process takes place. Moving the gowning area to a new location in the clean room will decrease the total distance moved by employees, as well as allow more convenient access to the kitchen. Fortunately, there is an emergency exit door already in the place of where a potential new door would be best added. For the remainder of the analysis the assumption that the door where the new gowning room should be is the emergency exit door, or EE door. Keep in mind that another door could be added adjacent to the EE door and it would still decrease the total amount of steps the employees would be walking throughout the changeover process. From first looking at the flow process diagrams, it is obvious that the employees go to the gowning room a handful of times. They go back and forth from the top of the conveyor belt to the gowning room multiple times, conducting a lot of different elements of the changeover

process. This gowning room is important because it is used to transport the new reactor through in order to replace the old reactor. It is also used as an entrance to the clean room from the kitchen. The employees must use this door every time they enter and leave the room. This is an extreme annoyance since it is away from where most of the changeover procedure is taken place.

The gowning room is a necessity, because it is used to keep the large room sanitary. Removing the gowning room completely is not an option; therefore, the most logical move would be keeping the gowning room, but just changing the location to better serve the changeover process. The location of the gowning room should indeed be moved the EE door, but it may not matter on which side of the door the gowning room is placed. From the video it is hard to tell if there is enough space to place the gowning room on the side of the EE door not in the clean room. It would be a tremendous possibility if it could be placed in the inside (not in the clean room) of the EE door. This would create a lot of extra space in the clean room and allow more possibility of movement for the employees. If the gowning area was placed on the inside, then all the sterilizing and gowning of the employees could be done outside of the clean room to allow for more space in the clean room and less distraction for the operators in the clean room. Of course, if there is not enough space behind the EE door then the company can disregard this idea completely. But, they should not disregard the fact that the EE door could be utilized as the new door for the gowning room. From watching the video, it is obvious that there is enough space for the gowning area to be placed in the clean room in front of the EE door. The company may have to move a few easily movable stations such as the cleaning station and glove station to make room for the new gowning area. Moving the gowning area

here will reduce the number of steps the employees will take during the changeover routine. This will be later explained by Work Measurement analysis.

For the remainder of the analysis, we will refer to the new gowning area as in front of the EE door, in the clean room.

This next section will now discuss the various methods of Time Study and Time Measurement to prove that switching the place of the gowning room to the area where the emergency door will be beneficial to the layout and flow of the workers in the clean room.

The first analysis was conducted on the distance walked by the employees. One way to increase productivity is to reduce the distance walked by employees to conduct certain elements of their job. Operator Phil's totals distance he walked during the changeover. The part of Phil's job that was studied began from the time when he started to clean equipment and ended when he goes to the process inspection area and does paperwork while waiting for the production line to start. From appendix I, the distance he walks to perform tasks 1-10. The focus is on tasks 1-10 to prove that changing the location of the gowning room would decrease the total distance he walks, therefore, saving time and money. Tasks 1-10 include starting to clear the equipment to get ready for the changeover until he reassembles the bottom parts of the reactor and cleans it. Using the measurements of the facility and approximate measurements, walks a total approximate distance of 150 feet during tasks 1-10 of the changeover before the gowning area change. A new diagram was created with the gowning area in the place of the emergency door. We assumed the distance of the emergency door to be 7.5 feet from the top wall. Using the assumed measurements of the room, the calculated

total distance walked by Phil with the adjustment of the new gowning area. In Appendix J the distance walked by Phil with the new gowning area is shown. The new distance came up to be 67.5 feet with the gowning room in front of the emergency room. The difference between the two distances is 82.5 feet. This distance is very significant and proves that by changing the location of the gowning area, Phil will decrease his total distance walked. Less distance means Phil will be able to minimize his steps to do the same amount of work as before the door change. The job he performs will be more efficient and more valuable.

All in all, decreasing distance traveled is a huge advantage in industry. It creates a more efficient production process and maximizes the operator's efficiency. An operator can accomplish more if he shortens his distance traveled, and he will be able to perform more tasks in a certain amount of time. Refer to Appendix V for the time improvement and Appendix W for the cost of this alternative.

TWO REACTORS

The reactor tanks contain the different substances filled into Petri dishes. The changeover process requires the switching of reactor tanks. First, Reactor tank 1's product is stopped and disconnected from filling the dishes and moved to the kitchen. Once reactor # 1 has cleared the clean room, the second reactor tank is moved into the clean room to be connected to the pumps where the first reactor tank was located. Once the reactor tanks stop filling Petri dishes, time and money is being lost because no product is being made. As seen from the first diagram, the changeover starts as soon as the process of filling the Petri dishes is stopped. The process is stopped because there is a need to fill the dishes with a different

product other than that Delete of what is in reactor one. There was also noticed that product is wasted by flushing out the tubes that carry the product to the Petri dishes. Rinsing of the tubes not only wastes product, but also costs manual labor. The switching of tanks and rinsing the tubes took a total of 54.1 minutes combine.

By installing a second pump station for the other reactor tank on the underside of the current bar pump attached the conveyor belt, it would: eliminate the need to clean each tube during the changeovers and allow the operators to switch back and forth, filling different products into the Petri dishes, or fill the bi-plates with each substance by turning on both sides (top and bottom) of the pumps. This system would improve productivity due to a decrease in the amount of time taken from switching reactor tanks in and out of the clean room.

Cleaning the tubes takes time. By determining an alternate method in the changeover, the tubes can remain connected to each of the pumps. The reason why the tubes need to be taken out of the bar pumps is because the company needs to produce a different kind of product for a selected consumer. If two reactor tanks were kept side by side in the clean room (refer to appendix: H) while one of them is filling the Petri dishes, then once that order is done, the operator just has to switch the pump button. This pump button would now switch to the other product to fill a different order through a different set of tubes. As noted during the visit and studying the different orders the company offers, bi-plates are a part of these orders. Filling the bi-plates following this new method to reduce changeover time would have a positive impact on the filling process. This will allow less down time that the conveyor belt isn't running with Petri dishes.

Understanding that reactor tanks do not carry an endless supply of product, one tank could be filling Petri dishes while the other is in the kitchen being prepped for the next order. Also, taking into consideration that the conveyor belt needs to be cleaned every so often to prevent contamination further along the assembly line, the pumps could be turned off while an operator wipes down the belt with the appropriate cleaning supplies.

The recommended set up is shown in appendix H giving a visual of how the floor layout would appear without interfering with the operators paths. After discussing alternate methods to cut down changeover time, this alternative would decrease the changeover time by not having to stop production between changeovers. The time improvements of this alternative are shown in Appendix V. Refer to Appendix W for the cost of this alternative.

COMMUNICATION SYSTEM

In any kind of work environment, communication between individuals is paramount to the success of the operation. This company is no exception. Observing the changeover process at the clean room, communication was not effective and its an area that can be improved drastically. These communication lapses that were observed only hindered the speed at which the changeover process was completed. The three main communication problems noticed were as follows: No communication between inside clean room and hallway, no communication between clean room and kitchen, and no communication between clean room and packaging room.

The interaction between the clean room and the hallway is very limited. To try and tell someone to do something in the clean room, one must use hand gestures through the window,

expect the person on the inside to read lips, or enter the clean room and risk exposing the product to foreign bacteria. On the other end of the spectrum, an individual inside the clean room trying to communicate with someone on the outside will also have to use nonverbal means through the window, or walk outside, requiring the individual to re-sterilize upon re-entering the clean room. Not only are these forms of communicating troublesome, but they are also quite inefficient. For example (1), during the changeover process, it was observed an employee leave the clean room to go look for cleaning supplies he or she may have misplaced or never possessed (see Appendix F). Either way, the time spent looking for these supplies could have been utilized to expedite the changeover process.

A large portion of the time to complete the changeover process is allocated to the removal and placement of old and new reactors, respectively. Example (2) When the kitchen is not in sync with the clean room, delays are almost certain to occur, as it was observed during our visit to the plant (changeover start time was delayed by approximately 25 minutes). Example (3) another large portion of the time spent to complete the changeover process is the recording of the data off of the reactor to the computer database. Although it is certainly necessary, there may be other ways to record the data needed onto the computer, which would make for a more efficient changeover process.

Delays in any manufacturing process can sometimes be unexpected. When a machine breaks down, no one is to blame, but the process gets delayed nonetheless. When a delay occurs because of human error, the process is delayed by an event that could have been avoided. Those responsible for the productivity of that manufacturing process need to examine

why this delay happened and find out ways to prevent it from happening again. In the changeover process, it was also observed a significant delay just before the actual manufacturing of the bi-plates was about to begin. The problem was that no one was in the packaging room, and the labels in the packaging had not been changed to match the new batch of plates about to be produced in the clean room Example (4). The process was delayed because of human error, which could have been avoided if there were efficient means to communicate between the clean room and the rest of the facility.

A simple way to correct these communication problems would be to implement a way for there to be communication not only from the clean room to the hallway, kitchen, and packaging room, but to the entire manufacturing facility. To fix these problems, one solution is to install a Communication System conformed of multiple intercoms located in the clean room, hallway, kitchen and packaging room with the opportunity to expand to a more complex Public Address Communication system to connect offices and trucks as well. This way, the delays due to communication problems (all those listed above) would have a viable solution.

Implementing Intercoms in different section of the plant will increase the efficiency in which workers communicate with each other, in turn increasing the efficiency of the overall manufacturing process. The three communication problems, between the clean room and hallway, between the clean room and kitchen, and between the clean room and the packaging room, can be corrected as soon as the intercoms or communication system is installed.

With the Intercoms, communication between the clean room and hallway would be effortless. Changing locations, wasting time, and risking contamination would no longer be necessary. Referring to Example (1), if the Intercoms were present, the worker would not have

had to leave the clean room and waste time looking for cleaning supplies. He or she could have simply used the Intercom to communicate with someone who had easier access to the cleaning supplies needed, thus reducing the wasted time of searching for the supplies.

In regards to the reactors being moved to and from the kitchen to the clean room, if the Intercoms were to be implemented, the reactors could be prepared to perfectly match the time when the other reactor is being wheeled out of the clean room. This way, any wasted time in Example (2) due to a discrepancy between one tank being ready and the other not being ready could be eliminated. Also, with the implementation of Intercoms, recording of data from the reactor to paper and then eventually to the computer database in the clean room could be eliminated Example (3). Using the new communication system, the workers in the kitchen could communicate with someone in the clean room what the values on the tank were. This way, before the reactor even reaches the clean room; one step that used to take approximately 4 minutes and 19 seconds could be eliminated.

Referring to example 4, the immediate benefits of the Intercoms are obvious. The worker inside the clean room could have used the new communication system to page the entire building to locate whoever was supposed to be working in the packaging room, or to get the worker actually inside the packaging room to start paying attention. Using the Intercoms in this instance may even prevent having to check the labels right before the new manufacturing process is to begin. If one of the workers communicates to the packaging room when the changeover process begins, that new labels need to be put on, then that eliminates the possibility of the packaging room delaying the start of the next manufacturing process. Refer to Appendix V for the time improvement and Appendix W for the cost of this alternative.

UV SANITATION

While examining the flow process, operation process, material flow, and multiple activities charts for the changeover, an area was identified that could be improved via complete atomization.

It is often the case that companies will continue a process a certain way due to uncertainties that could be created from changing that specific sub-process in any way. The processes concerning the sanitation of the conveyor belt during changeover, a viable solution is the implementation of an ultraviolet sanitizing light instead of the manual cleaning that is currently used (see Appendix H).

This small change will not only save a relatively large amount of time, because another operator is freed up for other tasks, but the tedious task of cleaning the conveyor belt will be made more efficient and thorough.

A relatively large amount of time will be saved. According to the various data collections that were taken, an atomization of sanitization would decrease the changeover by over 10 minutes. While conducting the time studies at on the location, it was found that an operator misplaced the cleaning supplies. This would be avoided with a permanent sanitation device (see appendix L).

The efficiency of the process would thereby increase drastically. For every product changeover, time would be saved, processes be made simpler, and efficiency increased. This would, in the long run save money for the company.

As the clean room where the changeover takes place is made to be bacteria free, the atomization of sanitizing would increase the thoroughness with which the conveyer belt is

sanitized. With human operators, there is always a degree of uncertainty in measurement and production. With the new introduction of the U.V. sanitizer, the company can be sure that in every changeover the conveyer belt would be 99% bacteria free, ready for the next batch.

The simple engagement and setup for such a device would save changeover time, increase efficiency, and save money for the company. Refer to Appendix V for the time improvement and Appendix W for the cost of this alternative.

STANDARDIZING JOB DISTRIBUTION

Problem: Disorganization in the Work Distribution

After revising the video and the time studies, one of the most recurring and hindering problems in the changeover was the complete disorganized arrangement of the worker's operations. At some points the operators would seem like they were doing their job randomly and as needed until the changeover was completed. Even though this is the simplest way to perform the changeover, not having a systematic and equally distributed amount of work for each of the operators has several drawbacks.

Drawbacks:

1. Without job standardization, workers are far more likely to forget a task, make a mistake or repeat tasks that other had already performed.
2. At times workers may be stranded waiting for other workers to assist in a task.
3. Unneeded delay time will be added to the changeover due to disorganization.

RECOMMENDED SHORT TERM SOLUTION

Apply SMED method and distribute all necessary responsibilities

(Refer to Appendix U for time improvements)

APPLICATION OF THE SMED METHODOLOGY

The SMED methodology plan to follow in the production process at the plant to reduce the changeover time is:

Study the setup process

Analyze and interpret all the data gathered from the visit including time analysis, multiple activity charts, video footage, process charts etc.

Classify setup operations

Waste operations are operations which do not add values to the setup. Internal Setups (IED) are operations that can only be performed while the machine is shut down, and finally, External Setups are operations that can be performed without shutting down the machine.

Eliminate the waste.

Eliminate all the operations that don't add value to the product and that take productive time.

Convert as many internal setups as possible to external setups.

The focus of the SMED method is to reduce down time for the machines so there is more production.

Improve internal and external setups

This step can be achieved following the 5S methodology and the standardization of the work environment mentioned in the above section.

Develop the standard operating procedure (SOP).

A set of instructions covering those features of operations which lend themselves to a definite or standardized procedure without loss of effectiveness. Refer to Appendices

RECOMMENDED LONG TERM SOLUTION

Assign a 4th person on all kitchen work

(Refer to Appendix V for time improvements, Refer to Appendix S for Proposed operating procedure)

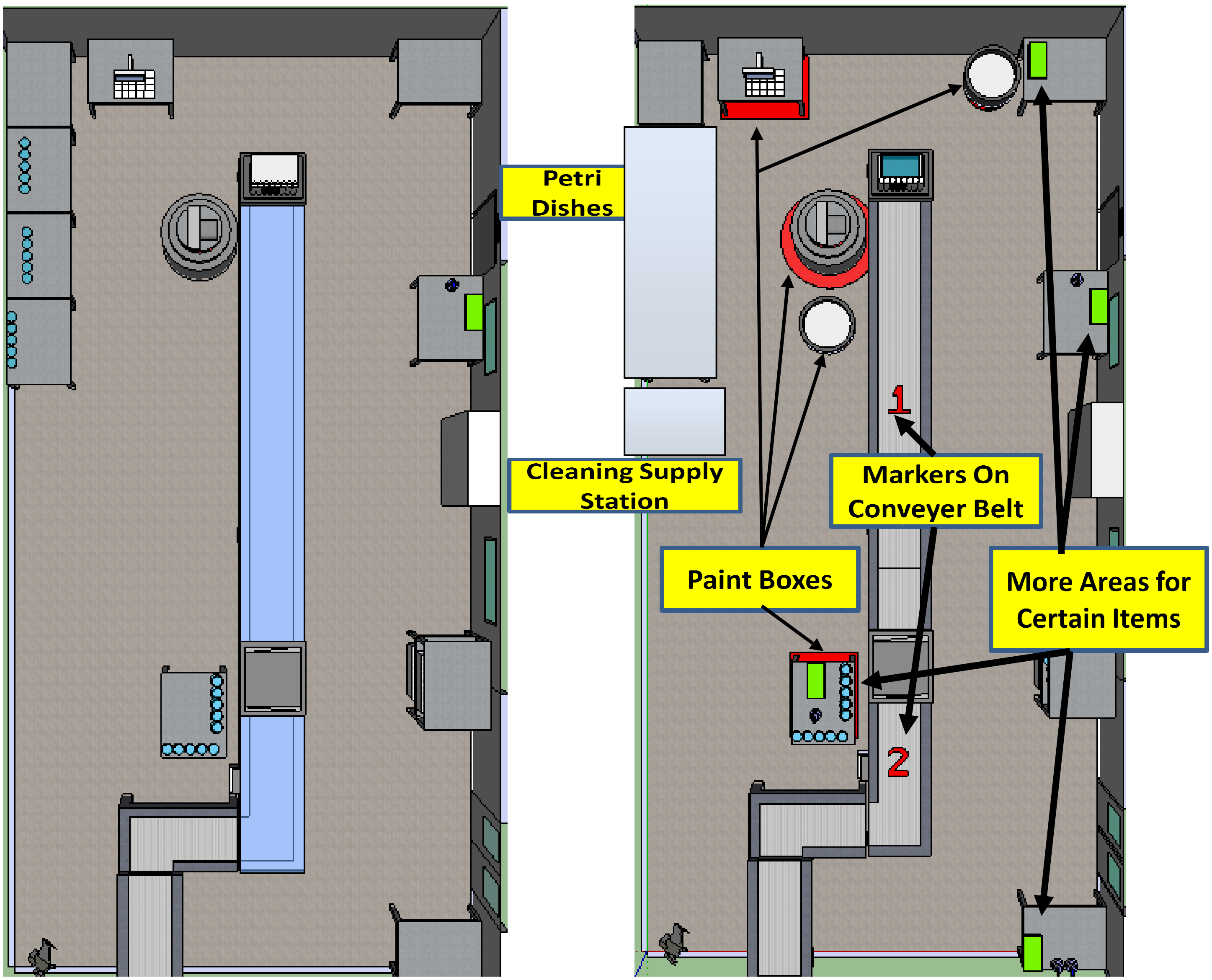
4TH PERSON ON KITCHEN WORK

The next alternative we designed was to have a fourth person do all the kitchen work and have all three operators work in the production room. We are not eliminating the work that has to be done to the reactor; we are simply assigning these responsibilities to an additional operator in the kitchen (See Appendix S for proposed tasks by kitchen operator). Since all three operators will be helping out in the production room, this alternative meets the thirty-minute changeover time requested by the company.

DESCRIPTION OF THE IMPROVEMENTS TO THE SYSTEM

SHORT TERM ALTERNATIVES

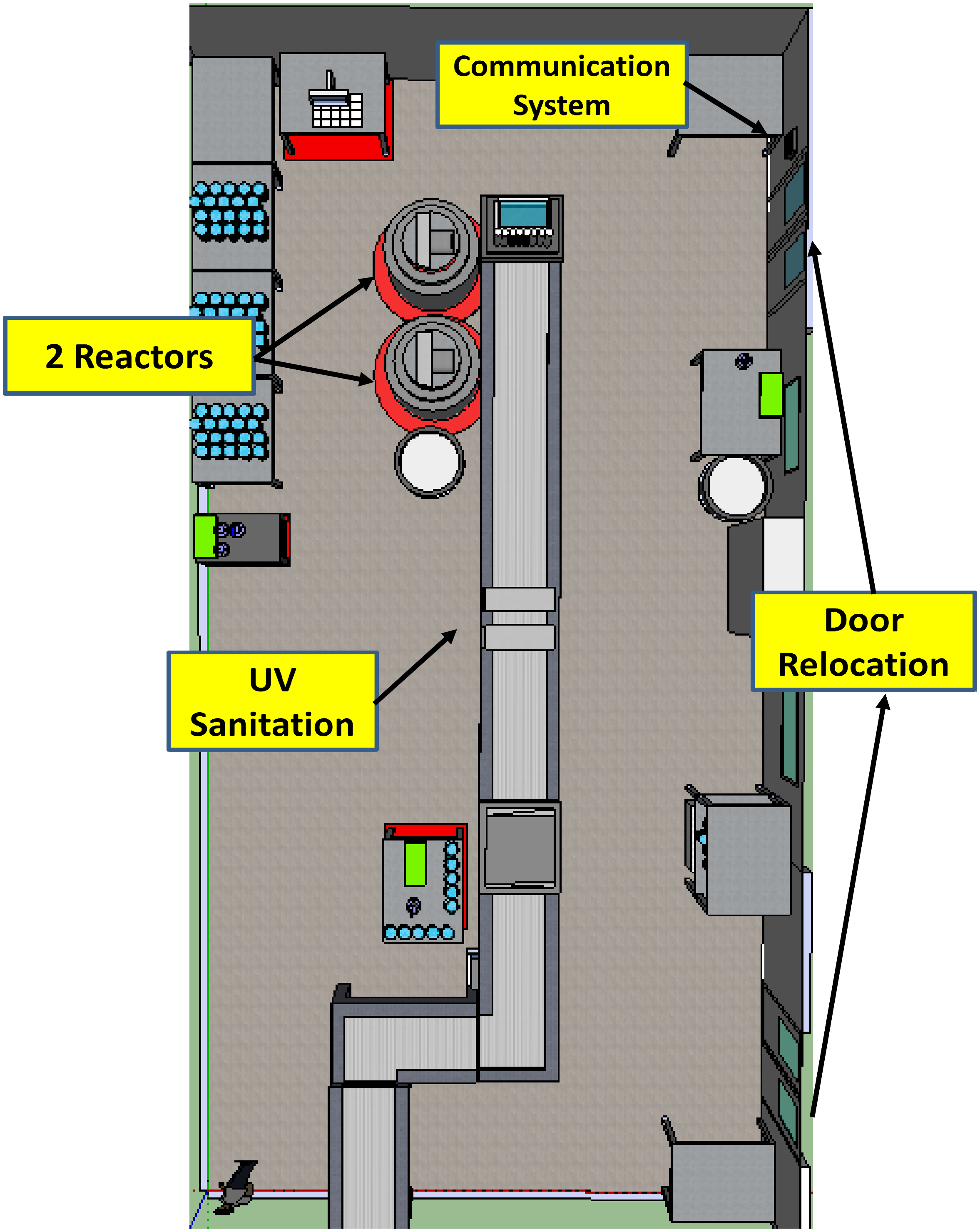
CURRENT VS PROPOSED LAYOUT



Term Changes Top View

LONG TERM ALTERNATIVES

NEW LAYOUT IN CURRENT ROOM



Layout with Long Term Changes Top View

RESULTING SYSTEM PERFORMANCE

SYSTEM PERFORMANCE WITH SHORT TERM ALTERNATIVES

After implementing all evaluated short term improvements, there is an expected improvement in the overall changeover time by approximately 27 percent. As seen in Appendices T and U, there is a reduction in the changeover time of about 14:30 minutes, going from a current changeover time of 52 minutes to 37:30 minutes. This reduction in time is mostly due to the application of the SMED method in combination with the 5s methodology. In other words, there is a better work flow due to the arrangement of the new layout and a better distribution of work. The cost of implementing these changes are minimum (under $100) mostly because the changes can be done very easily and can be done with instruments or items already in inventory.

Figure 6, Shows the before and after time improvement in each changeover category.

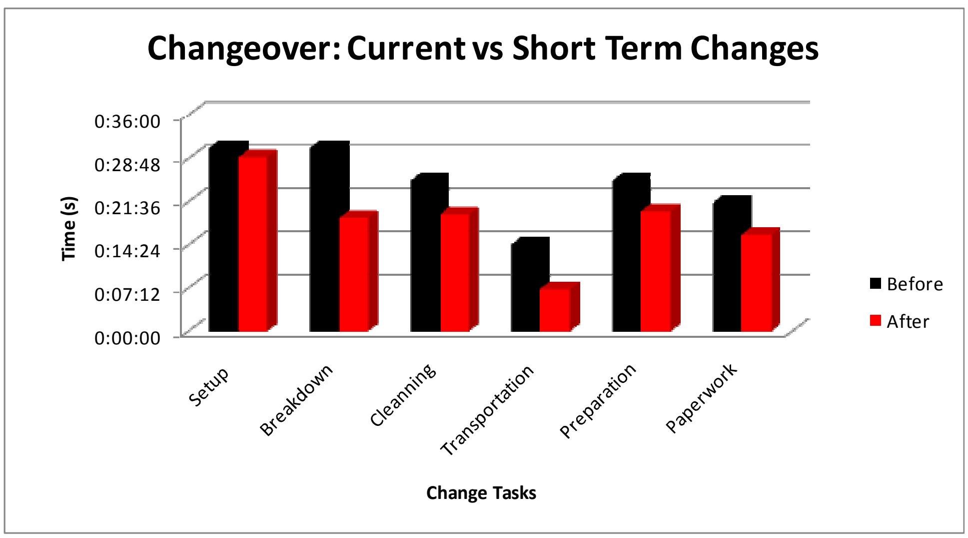


Figure 6 Changeover: Current Vs Short Term Changes

Task	Before	After	Improvement
Setup	0:30:30	0:29:00	4.92%
Breakdown	0:30:30	0:19:00	37.70%
Cleanning	0:25:00	0:19:30	22.00%
Transportation	0:14:30	0:07:00	51.72%
Preparation	0:25:00	0:20:00	20.00%
Paperwork	0:21:30	0:16:00	25.58%
Total Improvement			26.99%

Figure 7 Short Term Changes Improved Performance

From figure 7, the improvement in each of the different categories in the changeover process is shown. With a Total Improved Performance of 27 Percent, compared to the current changeover.

SYSTEM PERFORMANCE WITH LONG TERM ALTERNATIVES

After implementing the long term changes on top of the already improved short term changes, in the best case scenario there is an improvement of about 70.5 percent, from the current changeover time. This improvement in performance can be explained mostly by having another person working specifically on the kitchen duties, allowing the other operator to focus on the changeover operation. Also, in addition to that, the relocation of the door, the two reactors, the communication system and the UV Cleaning system add to this point and are a step forward to automating the plant. The time savings from using the long term changes is about 33 minutes better than the current changeover; this can be seen in Appendices T and V.

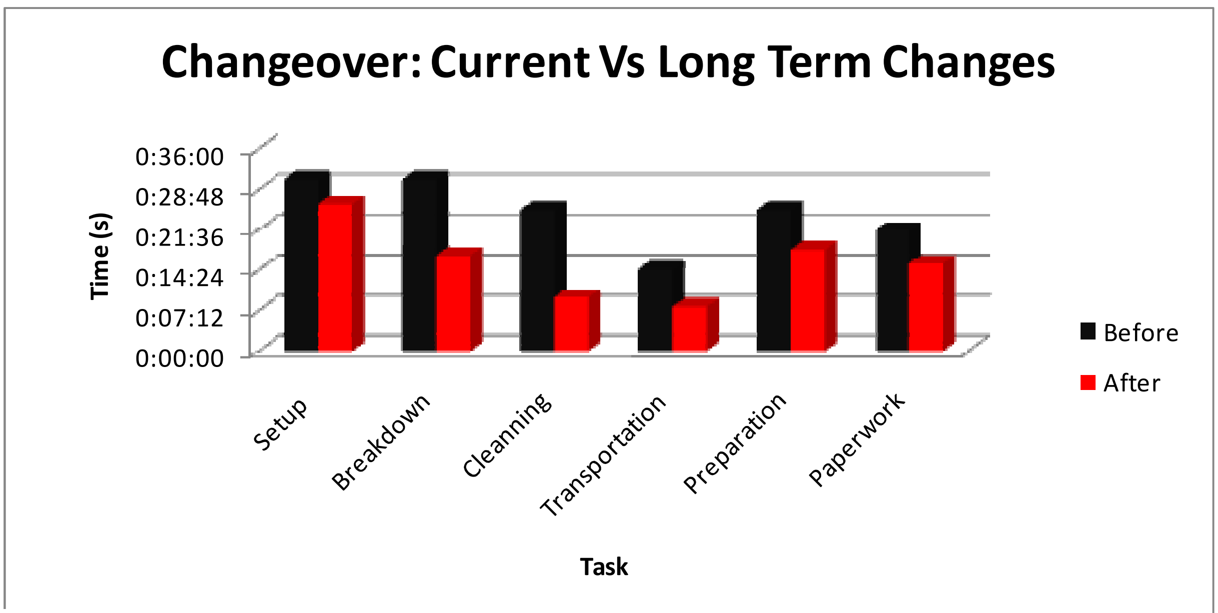


Figure 8 Changeover: Current Vs Long Term Changes

Figure 8, shows a comparison between the current changeover time and the improved Changeover time with Long Term changes, in each of the different categories of the changeover.

Task	Before	After	Improvement
Setup	0:30:30	0:26:00	85.25%
Breakdown	0:30:30	0:17:00	55.74%
Cleanning	0:25:00	0:09:30	38.00%
Transportation	0:14:30	0:07:49	53.91%
Preparation	0:25:00	0:18:00	72.00%
Paperwork	0:21:30	0:15:30	72.09%
Performance Improvement			70.50%

Figure 9 Long Term Changes: Improved Performance

Figure 9 shows the improvement in each of the different categories in the changeover process.

A total Improved Performance of 70.50 Percent, compared to the current changeover.

Appendix V, shows the Long Term Changes, break down into: the improved changeover time by adding a 4th operator and the improved time by adding the 4th operator plus the long term changes.

The cost justification is explained in terms of Return On Investment and Payback period.

Investment Cost Table shows the Investment cost breakdown.

The 4th Operator table shows the cost for training and salary of a new operator in the kitchen a year.

Long Term Improvement: Gains table, shows the money saved by the company depending on the price of the product ($25 or $40) and the number of changeovers a day (1, 2 or 3)

Investement Cost	
Door Relocation	$4,200.00
Two Reactors	$8,070.00
Communication System	$1,330.80
UV Sanitation	$2,340.00
4th Operator (training)	$800.00
Total	$15,940.80

4th Operator Cost			
	Time (hrs)	Hourly Rate	Total
Training	40	$25.00	$1,000.00
Yearly Cost	2080	$25.00	$52,000.00

Long Term Improvements: Gains	
Price	Price
$25.00	$40.00
$74,230.00	$118,768.00
$146,553.33	$234,485.33
$219,830.00	$351,728.00

ROI	7.67%	72.28%

Payback Period		
Cost fo the Project	68,940.80	68,940.80
Yearly Inflow	$74,230.00	$118,768.00
Payback (year)	0.93	0.58
Payback (Months)	11.14	6.97

Figure 10 Cost Justification

Using one changeover a day and price per piece of $25 dlls, ROI comes up to be 7.67%, Using one changeover a day and price per piece of $40 dlls, ROI comes up to be 72.28%. The return on investment is acceptable in both cases. Using the above amounts, the payback period of the project come up to be 11 months when the price is $25 dlls, and 7 months when the price of the product is 40 dlls. Both cases have a fast payback period, the investment is justified. To see the Cash Flow of both cases refer to Appendix

CONCLUSION

In conclusion, the problems in the changeover process at the plant can be break down into two main areas: the first one being the disorganization in the work area and the second one being the disorganization in the job distribution. The solutions to these problems are explained and evaluated in this project, giving short term solution and long term solution.

The short term solution to solve the disorganization of the workplace is given by having the 5S methodology in mind. Having a more organized work area improves the work flow. The alternatives implemented were: adding a cleaning supply station, create more are for certain items, paint boxes on the ground for standardization, have more Petri dishes ready and have markers on conveyor belt.

The short term solution for the job disorganization was in term of applying the SMED method (Single Minute Exchange of Die), a proven method to reduce changeover times to single a single minute digit.

The long term solution for the disorganization of the workplace was to aim for automation and improve the work flow. The alternatives to solve this problem were: door relocation, to reduce unnecessary traveling distances; having two reactors, to improve production rates and reducing the changeovers per day; having a communication system, to improve communication and work flow; UV sanitation system to improve time on cleaning.

The long term solution to solve the job disorganization was to add a 4^{th} operator, specifically in charge of the kitchen work. This change would give the other workers to focus

their attention to the changeover process, not having to worry about the transportation or the kitchen work.

With the application of the proposed solutions to the problems in the changeover process at the production plant, can either change in a short period of time or long period , the changeover time improved by at least 25%, a enhance workflow is achieved therefore increasing productivity.

BIBLIOGRAPHY

Albert, Mark. "Setup Reduction: At The Heart Of Lean Manufacturing." 2004. ModernMachineShop. 5 May 2010 <http://www.mmsonline.com/articles/setup-reduction-at-the-heart-of-lean-manufacturing>.

Cengage, Gale. Five techniques for reducing setup time: every tool in its place, a place for every tool. (Machining Centers). 2001. 5 May 2010 <http://www.thefreelibrary.com/Five+techniques+for+reducing+setup+time:+every+tool+in+its+place,+a...-a093212525>.

Claunch., Jerry W. Set-up time reduction. Chicago, Ill.: Irwin Professional Pub., 1996.

Das, Sujatha. Quest for Quality. 5 August 2007. 24 August 2010 <http://processandqualityimprovement.blogspot.com/2007/08/5s-methodology.html>.

Goubergen, Dirk Van and Hendrik Van Landeghemb. Reducing Set-up Times of Manufacturing Lines. Department of Industrial Management. Dresden, Germany: International Conference on Flexible Automation and Intelligent Manufacturing, 2002.

Goubergen, Dirk Van. "Set Up Time Reduciton as an Organization-Wide Problem." "Solutions 2000". Cleveland, Ohio (USA) May 22-24: Institute of Industrial Engineers, 2000.

Hariri, A.M.A. "Single machine scheduling with batch set-up times." Annals of Operations Research (1997): pp 75 – 92.

Kanawaty, George. Introduction to Work Study . Geneva: International Labour Office, 1992.

Keberdle, Charles L. Reducing Machine Setup and Changeover Times. Report. North Omsted, OH: Manuvis Corporation, 2008.

Kilpatrick, Jerry D. Reducing Set-Up Times a Foundation for Lean Manufacturing. Utah: MEP, 2003.

Lefcovich, Mauricio. "Cambio rápido de herramientas y reducción en tiempos de preparación Nueva y más amplia versión del SMED." 1998-2010. Ilustrados.com. 5 May 2010 <http://www.ilustrados.com/publicaciones/EEpAAypFukvcLryDbl.php>.

O'Connor, Kimberly A. SMED : a set up time reduction project. Senior Project. San Luis Obispo: California Polytechnic State University, 1991.

Olofsson, Oskar. "Single Minute Exchange of Dies (SMED) / Quick Changeover." 2009. World Class Manufacturing. 5 May 2010 <http://wcm.nu/smed.html>.

Smith, M. Gilmore and D.J. "Set-up reduction in pharmaceutical manufacturing: an action research study." International Journal of Operations & Production Management (1996): VOl 16, pp. 4-17.

Southworth, Tom. "Reducing setup time." 2007. 5 May 2010 <http://www.thefreelibrary.com/Reducing+setup+time-a0172339381>.

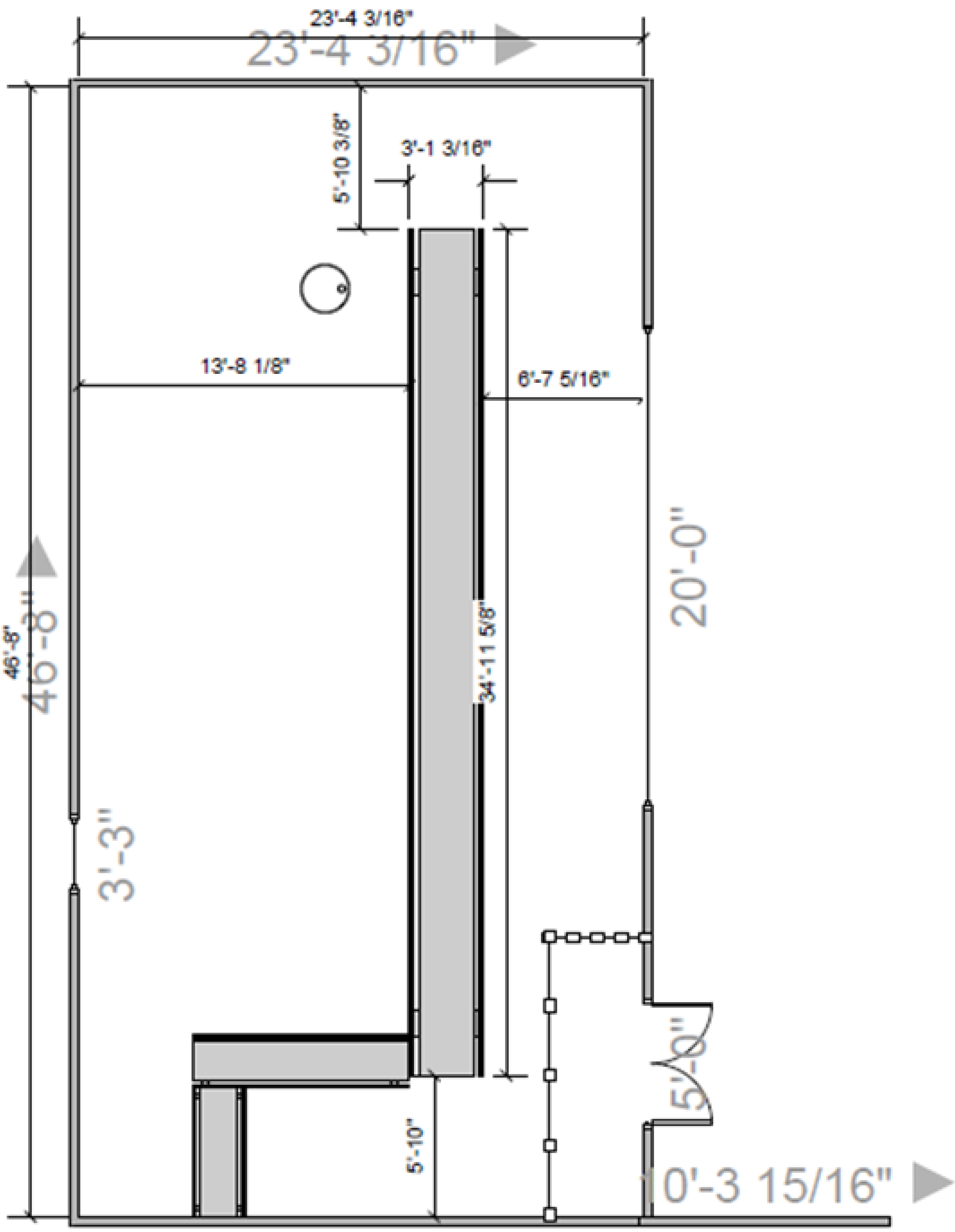
Strategics, Consultants Engineers. Phases of Setup Time Reduction. 2003. 5 May 2010 <http://www.strategosinc.com/setup_reduction2.htm>.

Subramaniam, Anand. "SMED Setup & Lead Time Reduction." 2010. Slide Share. 5 May 2010 <http://www.slideshare.net/anandsubramaniam/smed-setup-lead-time-reduction-2795055>.

T. C. Edwin Cheng, T. C. E. Cheng, Susan Podolsky, P. Jarvis. Just In Time Manufacturing: An Introduction. Chapmen and Hall, 1996.

APPENDICES

APPENDIX A: CLEAN ROOM MEASUREMENTS



APPENDIX B: CURRENT FLOW PROCESS CHART - ANTONIO

Flow Process Chart

Location: Santa Maria Production Room

Activity: Change-over

Date: 5/21/2010

Operator: Antonio

Circle Appropriate Method and Type

Method: Present Proposed

Type: Worker Material Machine

Remarks:

Summary

Event	Present	Proposed	Savings
Operations	20	20	
Transport	1	1	
Delay	3	3	
Inspection	3	3	
Storage	1	1	
Time (min)	35.16	27.09	
Distance (ft)	606.73	294.63	
Cost			

Event Description	Operation	Transport	Delay	Inspection	Storage	Time (min)	Dist (ft)	Notes/Method Recommendation
Paper work at weigh station	●					0.67	0.00	
Check packing				■		0.70	8.50	
Get cleaning bottle from C.S.	●					0.30	4.25	
Remove blood bag	●					1.50	27.63	
Retrieve new blood bag	●					0.60	1.00	
Hang new blood bag	●					0.90	8.50	
Reglove at cleaning station	●					0.80	12.75	
Clean the line (manually)	●					2.09	1.00	
Set and start UV lights	●					0.50	1.00	
Set up tubes	●					2.30	8.50	
Position reactor	●					1.20	1.00	
Hook tubes to reactor	●					1.30	1.00	
Reglove at cleaning station	●					0.50	4.25	
Retrieve batch record		➡				1.30	29.75	
Enter labels	●					0.80	63.75	
Check labels	●			■		1.23	1.00	
Send labels to autobasing	●					1.10	1.00	
Talk to bagging			◗			1.20	1.00	
Waiting to send lables			◗			0.50	1.00	
Talk to supervisor			◗			0.67	34.00	
Put away bi-plates	●				▼	1.50	8.50	
Paper work	●					1.30	29.75	
Retrieve monoplates	●					1.50	25.50	
Load monoplates into feeder	●					0.78	17.00	
Priming (test run)	●					0.45	1.00	
Quality check plates				■		0.60	1.00	
Prime hoses	●					0.80	1.00	
Total =						27.09	294.63	

APPENDIX C: CURRENT FLOW PROCESS CHART - PHIL

Flow Process Chart

Location: Santa Maria Production Room	**Summary**			
Activity: Change - Over	**Event**	**Present**	**Proposed**	**Savings**
Date: 05/21/10	Operations	12	12	
Operator: Phil	Transport	4	4	
Circle Appropriate Method and Type	Delay	2	2	
Method: Present Proposed	Inspection	3	3	
Type: Worker Material Machine	Storage	0	0	
Remarks:	Time (min)	45.25	41.94	
	Distance (ft)	376.6	378.6	
	Cost			

Event Description	Operation	Transport	Delay	Inspection	Storage	Time (min)	Dist (ft)	Notes/Method Recommendation
Clearing Equipment	●	⇨	D	□	▽	1.02	0.0	
Disconnect tubes	●	⇨	D	□	▽	1.85	1.0	
Move reactor 1 to door	○	➡	D	□	▽	0.77	17.0	
Retrieve petri rack	○	➡	D	□	▽	0.38	46.8	
Move 2nd reactor to door	○	➡	D	□	▽	0.43	63.8	
Load bottle/Clean prep	●	⇨	D	□	▽	0.5	63.8	
Disassemble/Clean top part	●	⇨	D	□	▽	7.39	8.5	
Reassemble/Clean top part	●	⇨	D	□	▽	2	1.0	
Diassemble/Clean bottom part	●	⇨	D	□	▽	3	2.0	
Reassemble/Clean bottom part	●	⇨	D	□	▽	2	2.0	
Reglove/hand sanitize	○	⇨	◗	□	▽	0.72	4.3	
Clean assembled parts	●	⇨	D	□	▽	0.95	4.3	
Pump/tube setup	●	⇨	D	□	▽	0.65	5.1	
Move Rreactor in	○	➡	D	□	▽	6	25.5	
Tube setup/input	●	⇨	D	□	▽	3.5	27.6	
Clean new reactor	●	⇨	D	□	▽	1.25	1.0	
Tube setup/attachment	●	⇨	D	□	▽	1.88	1.0	
Check box settings	○	⇨	◗	□	▽	1.62	10.6	
Check paperwork	○	⇨	D	■	▽	0.89	42.5	
Final setup/purge check	○	⇨	D	■	▽	3.83	25.5	
Goes to process inspection area	○	⇨	D	■	▽	1.31	25.5	
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
					Total =	41.94	378.6	

APPENDIX D: CURRENT FLOW PROCESS CHART - SUZANNA

Flow Process Chart

Location: Santa Maria Production Room
Activity: Change - Over
Date: 05/21/10
Operator: Suzanna

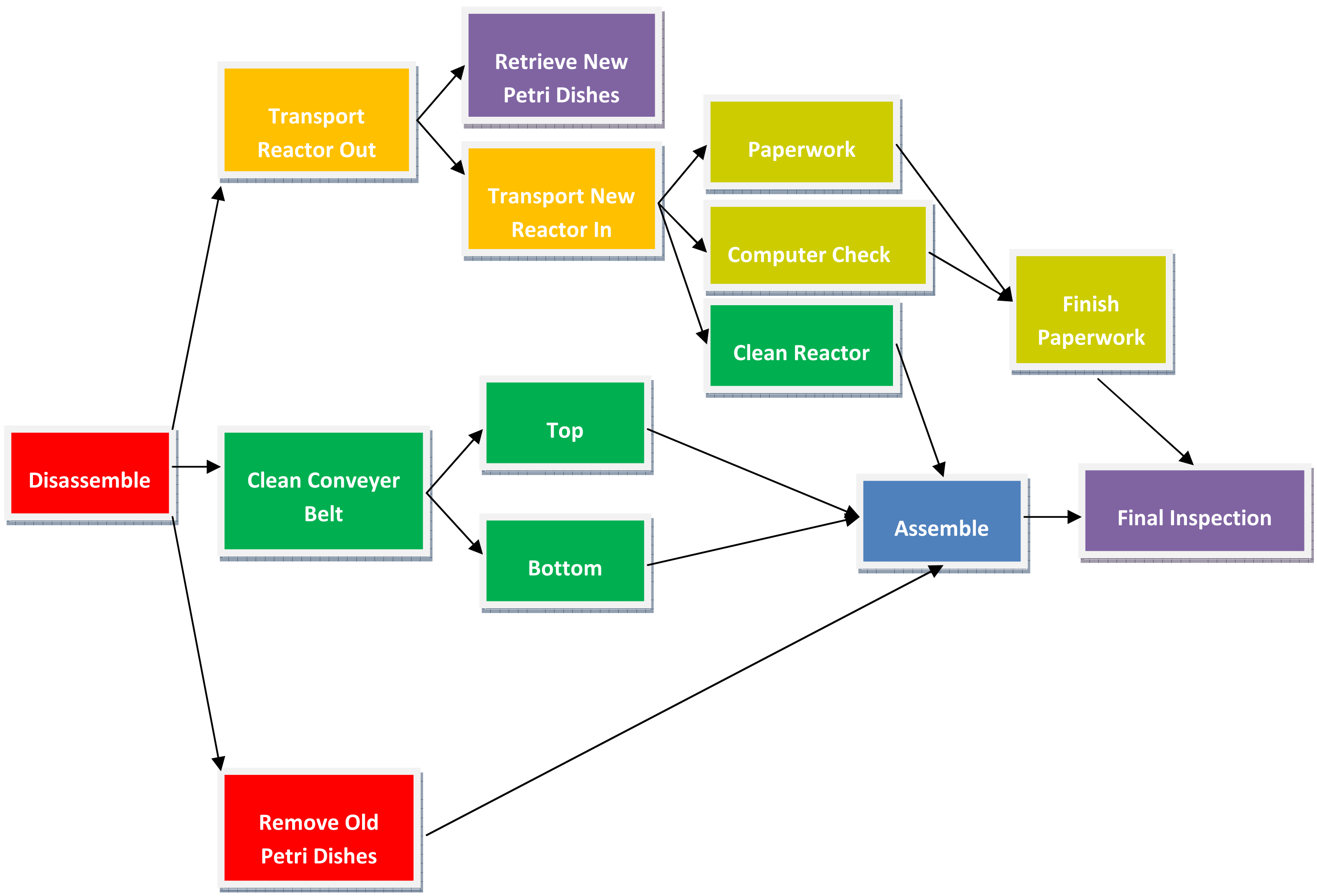
Circle Appropriate Method and Type
Method: Present Proposed
Type: Worker Material Machine
Remarks:

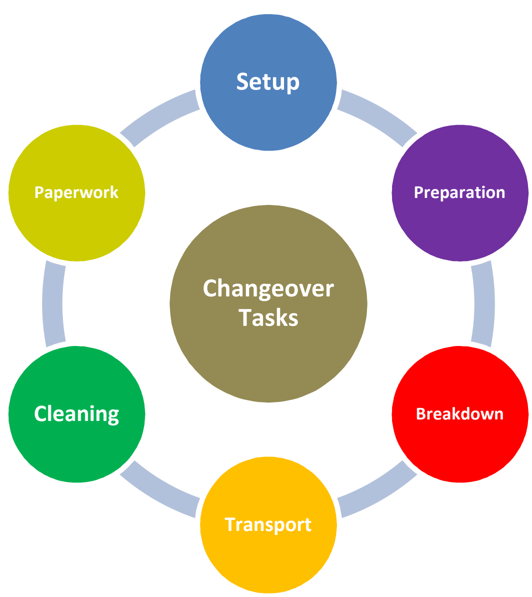
Summary

Event	Present	Proposed	Savings
Operations	20	20	
Transport	5	5	
Delay	0	0	
Inspection	0	0	
Storage	0	0	
Time (min)	54.1	43.90	
Distance (ft)	532.95	295.36	
Cost			

Event Description						Time (min)	Dist (ft)	Notes/Method Recommendation
Remove empy petri dishes	●	⇨	D	□	▽	3.08	0.0	
Remove reactor tubes	●	⇨	D	□	▽	0.07	0.0	
Disconnect pump heads	●	⇨	D	□	▽	1.00	0.0	
Wheel #1 to the clean room	○	➡	D	□	▽	1.4	38.3	#1 = Reactor 1
Walk back to production room	○	➡	D	□	▽	0.5	4.3	
Whell #2 to clean room	○	➡	D	□	▽	0.13	12.8	#2 = Reactor 2
Take #1 to kitchen	○	➡	D	□	▽	2.30	8.5	
Wash tubes first	●	⇨	D	□	▽	10.00	0.0	W/ Deionized H_2O
Remove nozzles	●	⇨	D	□	▽	1.3	0.0	
Drain #1 in kitchen	●	⇨	D	□	▽	2.5	0.0	
Clean pipettes in kitchen	●	⇨	D	□	▽	0.52	0.0	
Re-attach pipettes in reactor 2	●	⇨	D	□	▽	1.3	0.0	
Apply ethanol to pipettes	●	⇨	D	□	▽	1.09	0.0	
Rinse pipettes	●	⇨	D	□	▽	0.4	0.0	
Transition R7-A10 product	●	⇨	D	□	▽	1.05	0.0	
Walk back to clean room	○	➡	D	□	▽	0.55	12.7	
Remove foil from nozzle	●	⇨	D	□	▽	2.00	0.0	
Record blood/ Check temp.	●	⇨	D	□	▽	1.05	0.0	Serial # Connection
Monoplate deck/picklist	●	⇨	D	□	▽	2.00	0.0	
Reassemble reactor tubes	●	⇨	D	□	▽	1.50	78.6	
Verify label sent	●	⇨	D	□	▽	0.71	25.5	
Apply label to blood	●	⇨	D	□	▽	0.80	25.5	Formula # = Blood #
Finish checklist	●	⇨	D	□	▽	1.89	0.0	Color Check; Machine Flow
Check/prime machine	●	⇨	D	□	▽	1.54	42.5	
Weight dish sample	●	⇨	D	□	▽	1.85	38.3	8 Dishes
Check machine/ box product	●	⇨	D	□	▽	3.38	8.5	
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
Total =						43.90	295.36	

APPENDIX E: PRECEDENCE DIAGRAM





APPENDIX F: CURRENT MULTIPLE ACTIVITY CHART

Time (30 sec)	Suzanna	Phil	Antonio
0:00:00	Remove Empty Petri dishes and Remove reactor Tubes		Paperwork
0:00:30			
0:01:00			
0:01:30			
0:02:00			
0:02:30			Check the packaging
0:03:00		Cleaning equipment	Find cleaning supplies
0:03:30			
0:04:00		Disconnect tubes	
0:04:30			
0:05:00	Disconnect Pump Heads		Take of bag
0:05:30			Undress
0:06:00			
0:06:30			
0:07:00	Wheel #1 to Clean Room	Wheel #1 to clean room	Find cleaning supplies
0:07:30	Walk back to Production Room	Retrieve Petri rack	
0:08:00	Wheel #2 to Clean Room	Wheel #2 to clean	
0:08:30	Take #1 to Kitchen	Load bottle/ Clean Prep	
0:09:00			
0:09:30		Disassembly of top parts	
0:10:00			Re-dress
0:10:30			
0:11:00	Wash Hoses		
0:11:30			Clean conveyor belt (Prep)
0:12:00			
0:12:30			
0:13:00			
0:13:30			Clean conveyor belt
0:14:00			
0:14:30			
0:15:00			Get bag
0:15:30			Re-glove
0:16:00			Handbags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Remove Nozzles Drain #1in Kitchen
Reattach Pipettes to reactor Apply ethanol/rinse pipettes Re-attach pipettes to reactor Walk back to clean room
Remove foil from nozzles
Re-assemble top parts
Disassembly of bottom parts
Reassemble bottom parts
New gloves/hand sanitation
Clean assembled parts
pump/tube setup
Move reactor in
Tube setup
Travel to reactor
Roll Reactor
Hook up reactor hose
Re-glove
Get Batch record
Enter/ check labels
Send labels to computer
Talk to bagging
Waiting to send labels on computer
Talk to supervisor
Put away bi-plates
Paperwork
Get mono-plates
Load plates
Priming
Quality check
Prime Hoses


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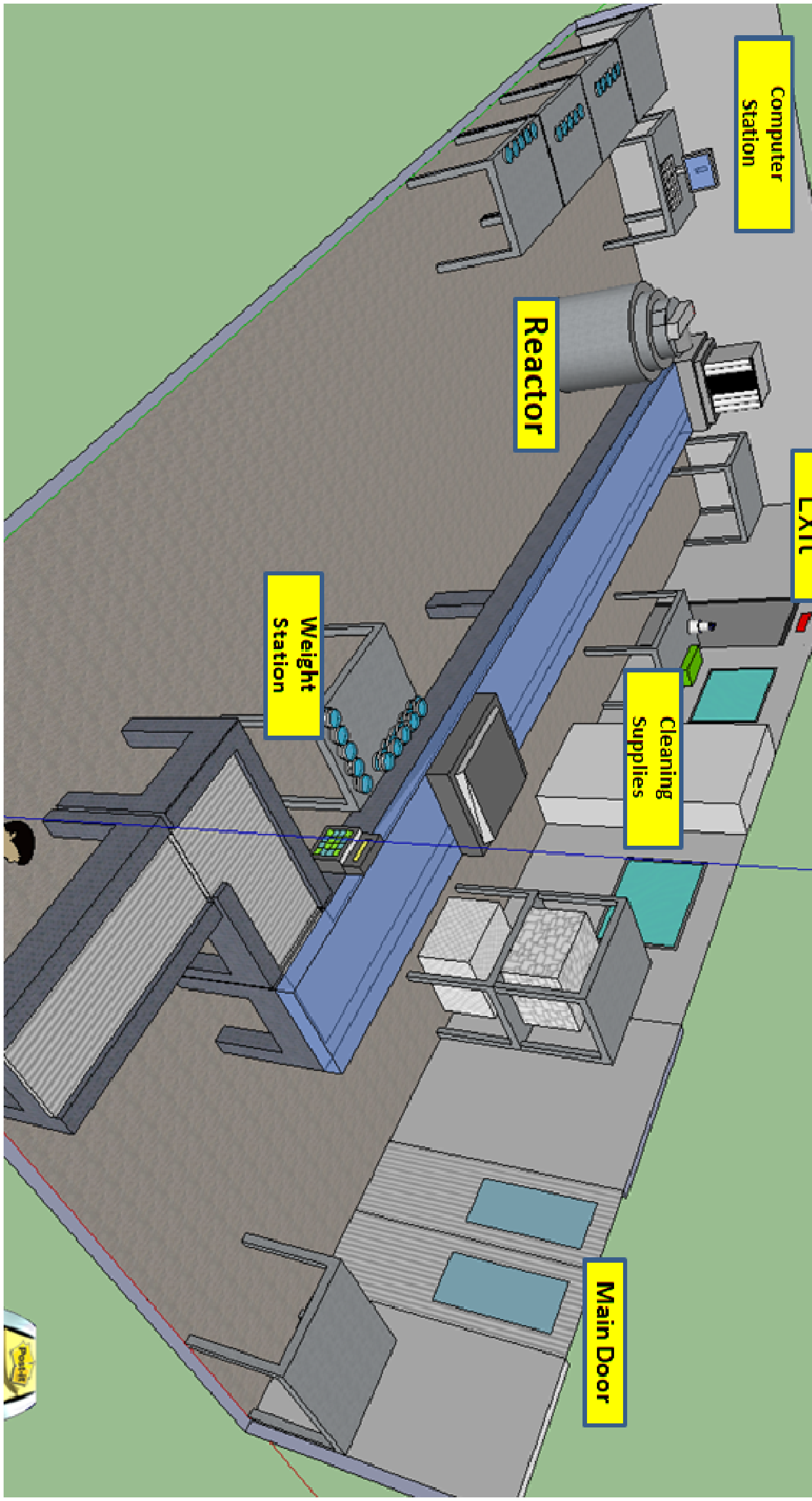
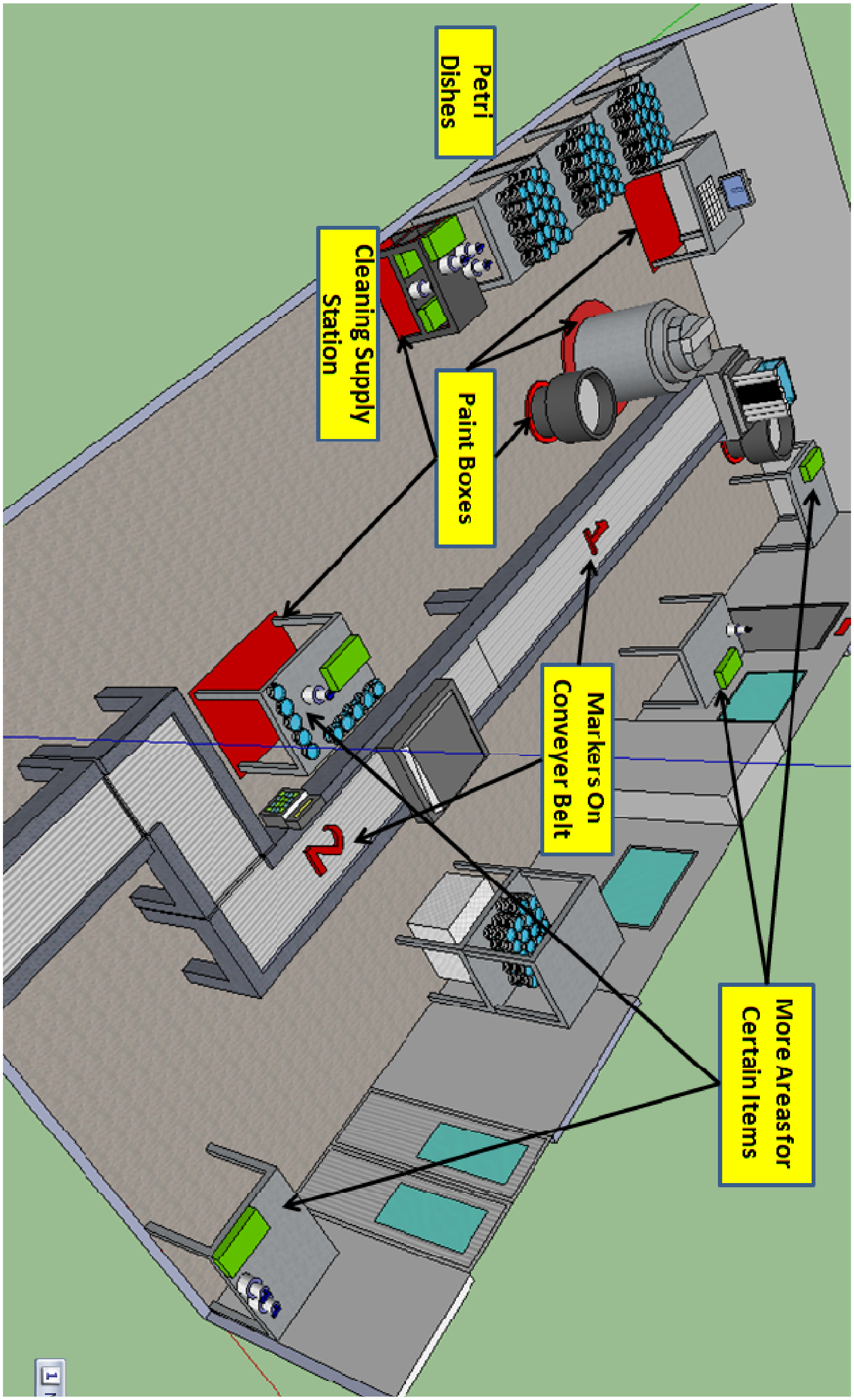
Record blood/ check temp Check mono-plate/ pick list
Reassemble reactor tubes
Verify label sent
Apply label to blood
Finish checklist Check prime machine weight dish sample
Check Packaging machine/box product
CHANGEOVER COMPLETE
Clean new reactor
Tube setup and attachment
Check pump setting
Final setup / purge check
Goes to process inspection area
CHANGEOVER COMPLETE
CHANGEOVER COMPLETE

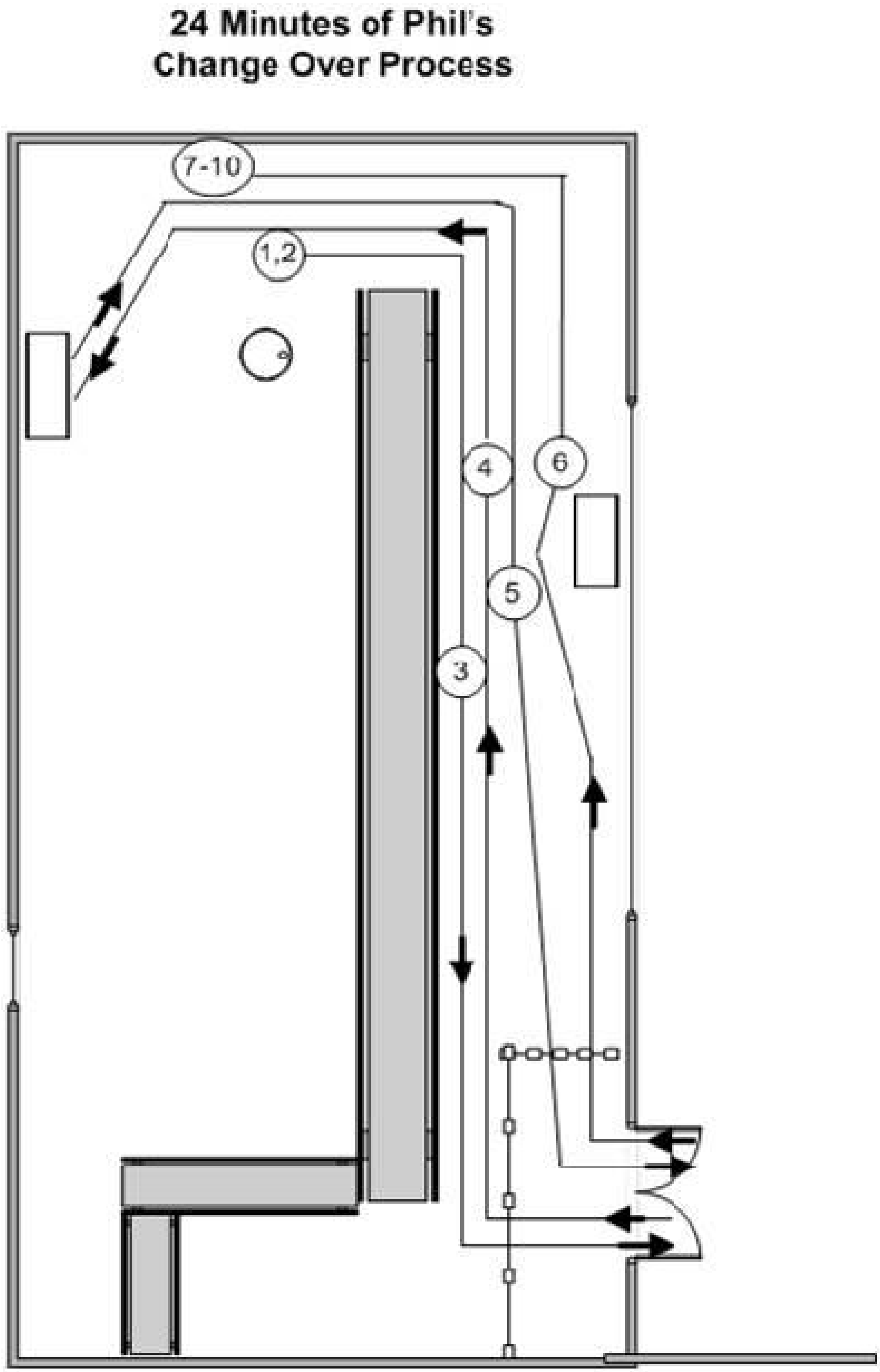
APPENDIX G: CURRENT LAYOUT 3D VIEW



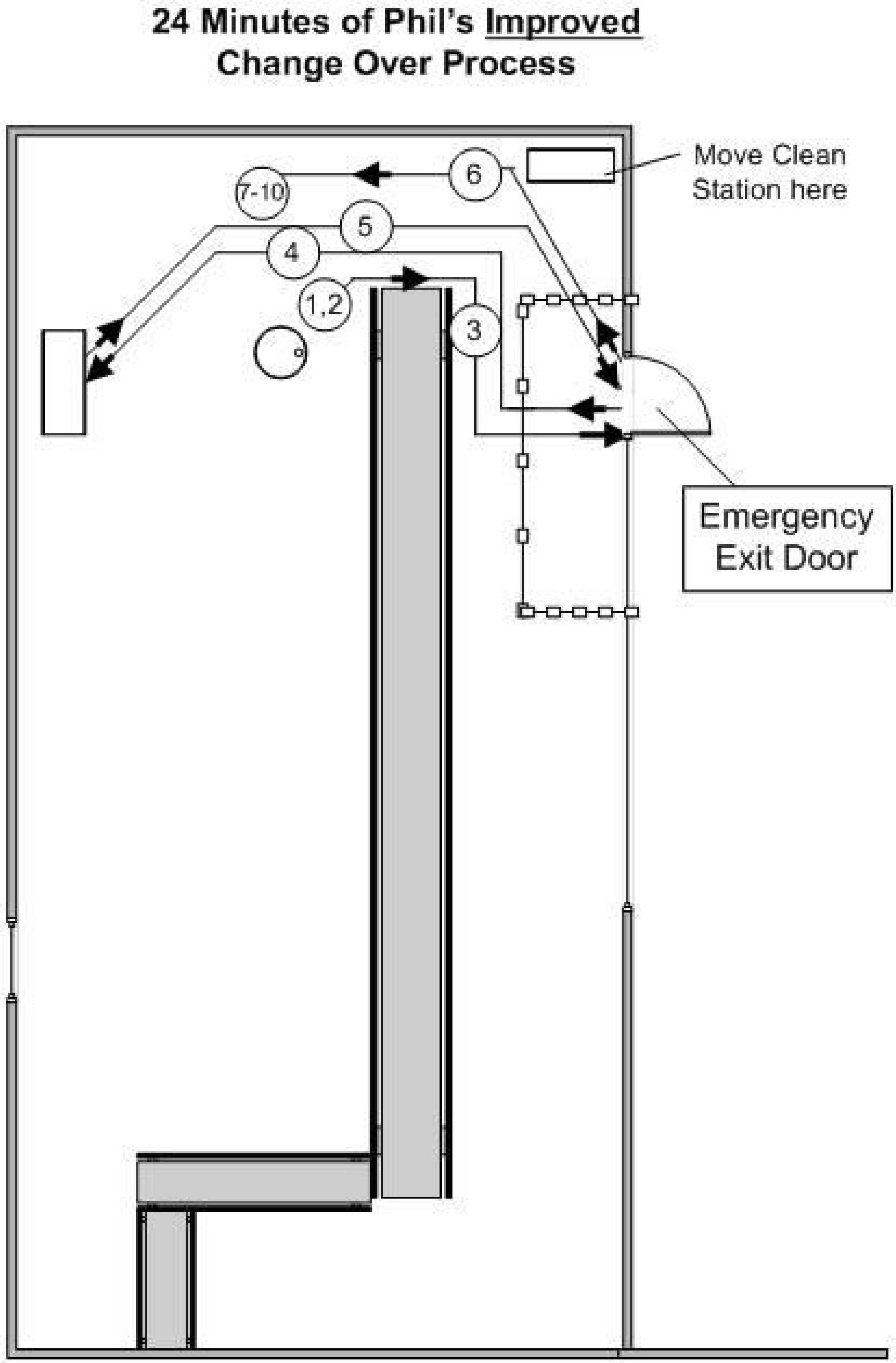
APPENDIX H: PROPOSED LAYOUT SHORT TERM ALTERNATIVES 3D VIEW



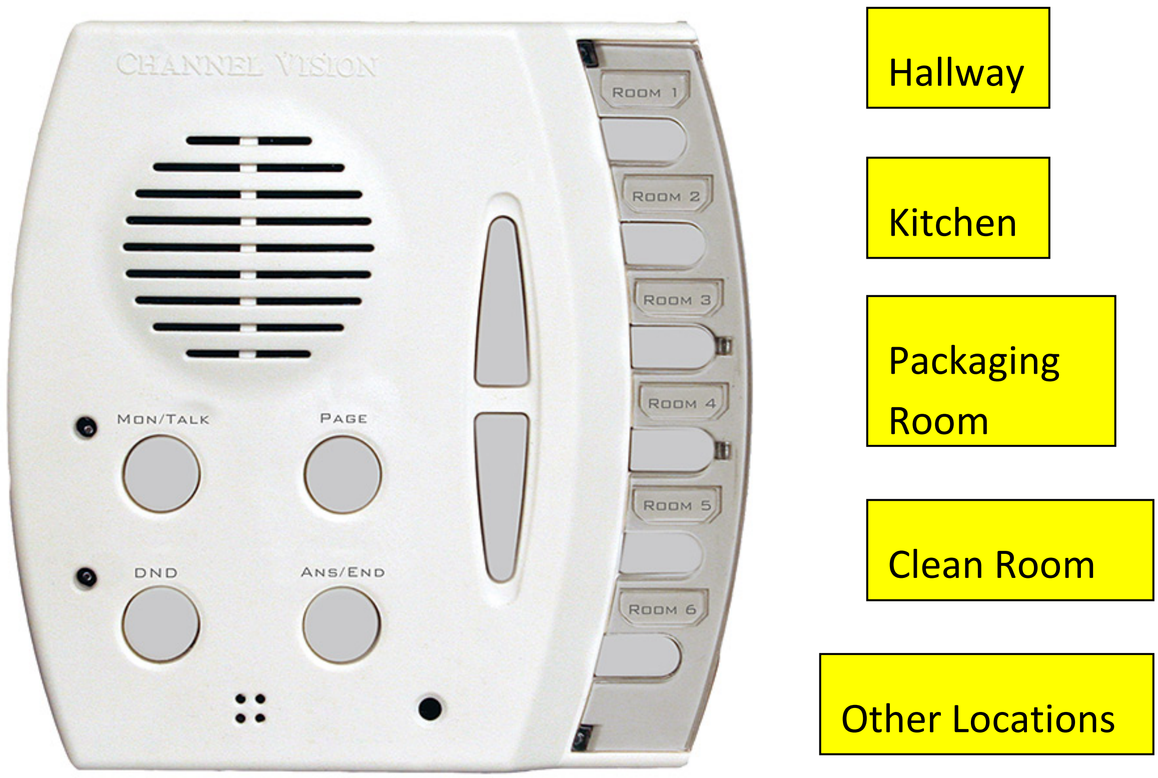
APPENDIX I: PHIL'S CHANGEOVER PROCESS – TRAVEL DISTANCE



APPENDIX J: PHIL'S CHANGEOVER PROCESS – IMPROVED TRAVEL DISTANCE



APPENDIX K: COMMUNICATION SYSTEM (INTERCOMS)



Channel Vision Cat. 5 Intercom Station Item# 50717
Price: Normally $108.99
Hot Deal $87.50

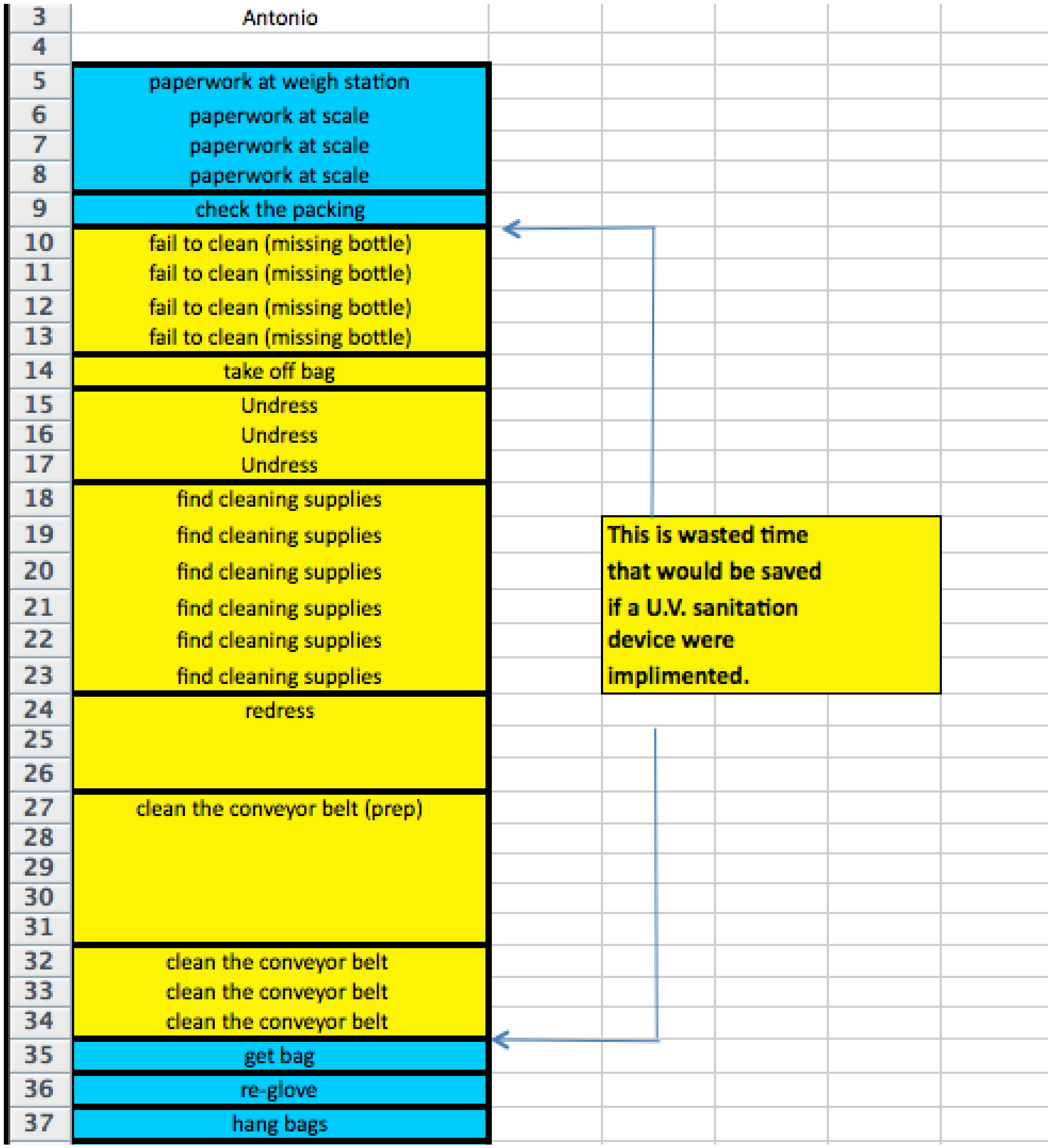
Overview

- Allows for direct and broadcast room to room communication with six other stations
- Communication expandable up to 24 rooms
- Can be used with a door strike
- 2 built-in doorbell chimes

Essential Info

The Channel Vision Cat5 Intercom Station is an excellent add on piece that integrates with a Channel Vision Cat. 5 Whole-House Intercom System. Each intercom station is a master unit providing direct room-to-room communication, as well as broadcast communication to other intercom stations or front door intercoms. Using Cat. 5 wiring technology, the intercom allows for convenient installation and reliable communication at an affordable price. One intercom station allows you to communicate via a whole house broadcast or directly to six rooms and two door stations; you can even grant access to visitors with the addition of a door strike module. The direct contact number is expandable up to 24 rooms by using Channel Vision Intercom Six Station Expanders, making it adaptable to virtually any size home.

APPENDIX L: MULTIPLE ACTIVITY CHART – UV SANITATION IMPLEMENTATION



APPENDIX M: UV SANITATION DETAILS

RK-97505-35
UV germicidal lamp; 60 watts, 152µW/cm2 intensity, 230 VAC/50 Hz
(each)

Qty: 1
Add to Cart

$350.00 / each (USD) Usually ships in 35 days.

Product Rating (0 Ratings) Write a Review

- **A low-cost choice for destroying bacteria, molds, yeast, and viruses**

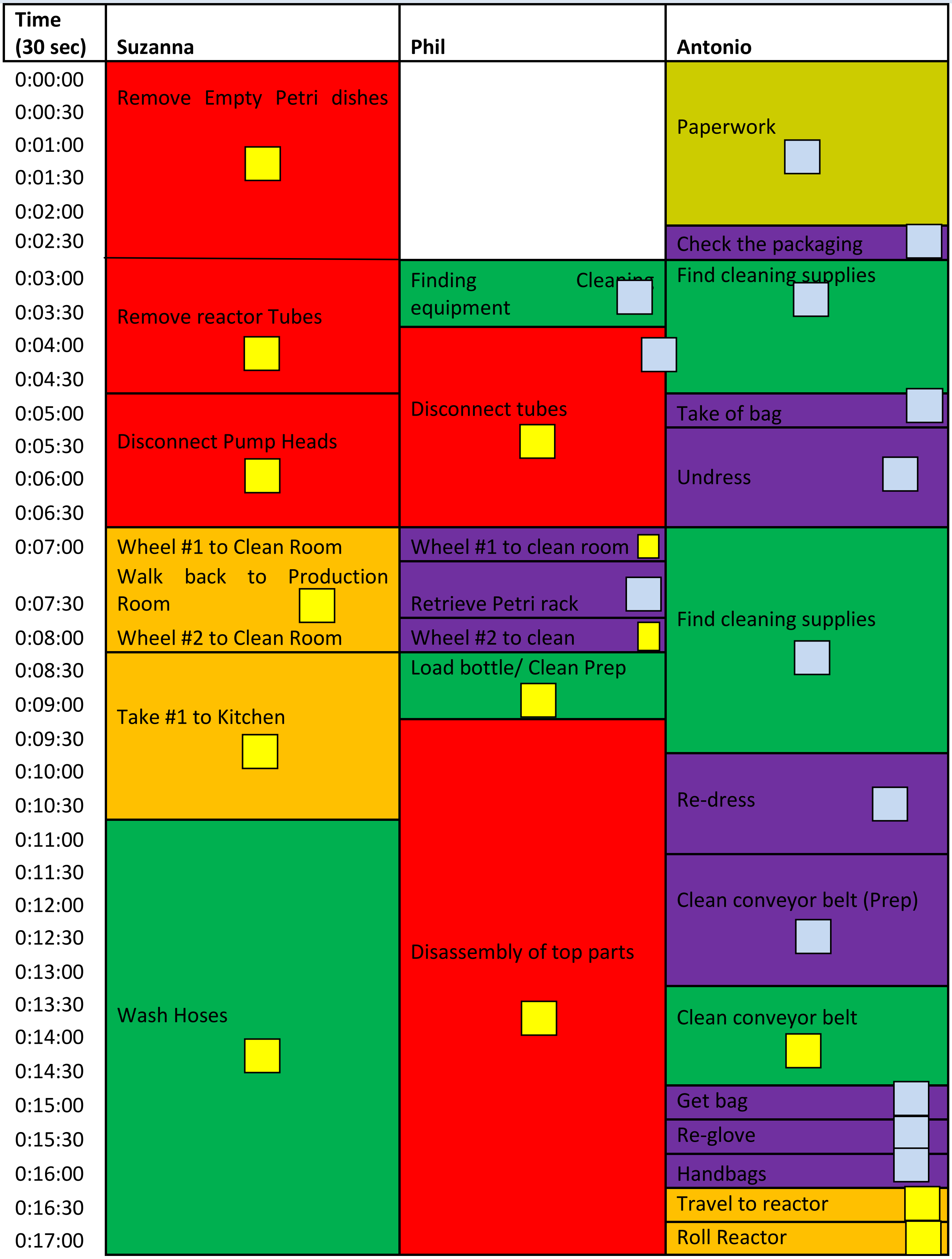
Help prevent contamination in your research laboratories, food factories, and white rooms with these germicidal lamps. They emit 254 nm UV light that is efficient in the destruction of bacteria, molds, yeast, and viruses. Tube life is approximately 2000 hours. Replace starter every time you replace tubes.
Choose from models with intensities from 31 to 152 µW/cm², in either 115 or 220 VAC versions. The 115 VAC models include a 6-ft cord and three-prong plug. Lamps measure 25-7/8"L x 5-1/2"W x 4-1/4"H.

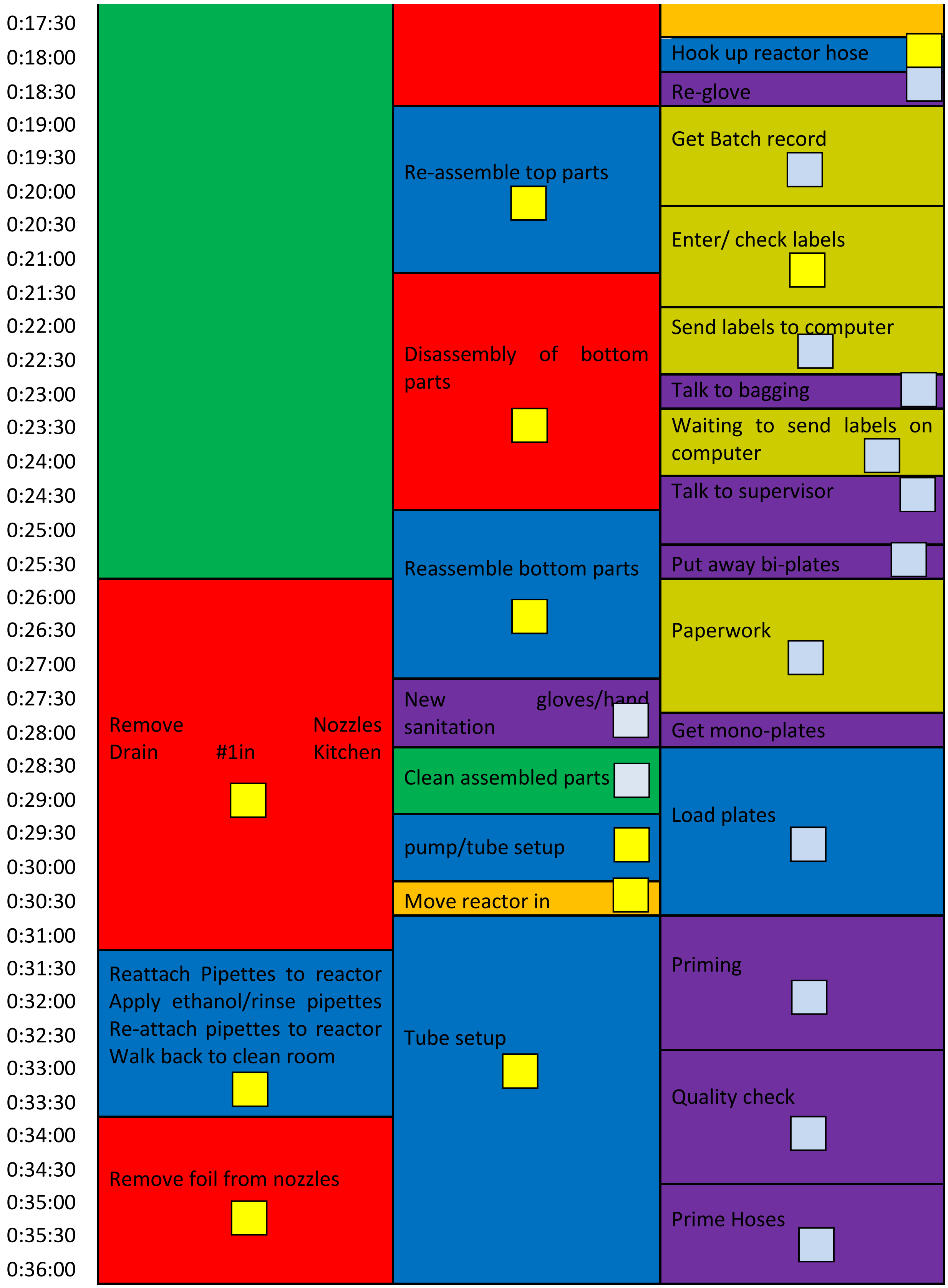
Specifications

Wavelength	254 nm
Intensity	152 µW/cm²
Power	220 VAC, 50 Hz
Watts	60
Dimensions	38"L x 5-1/2"W x 4-1/4"H
Model	VL-230G-220V
Manufacturer number	VL-230G-220V

Technical Appendix

APPENDIX N: MULTIPLE ACTIVITIES CHART – INTERNAL VS. EXTERNAL TASKS

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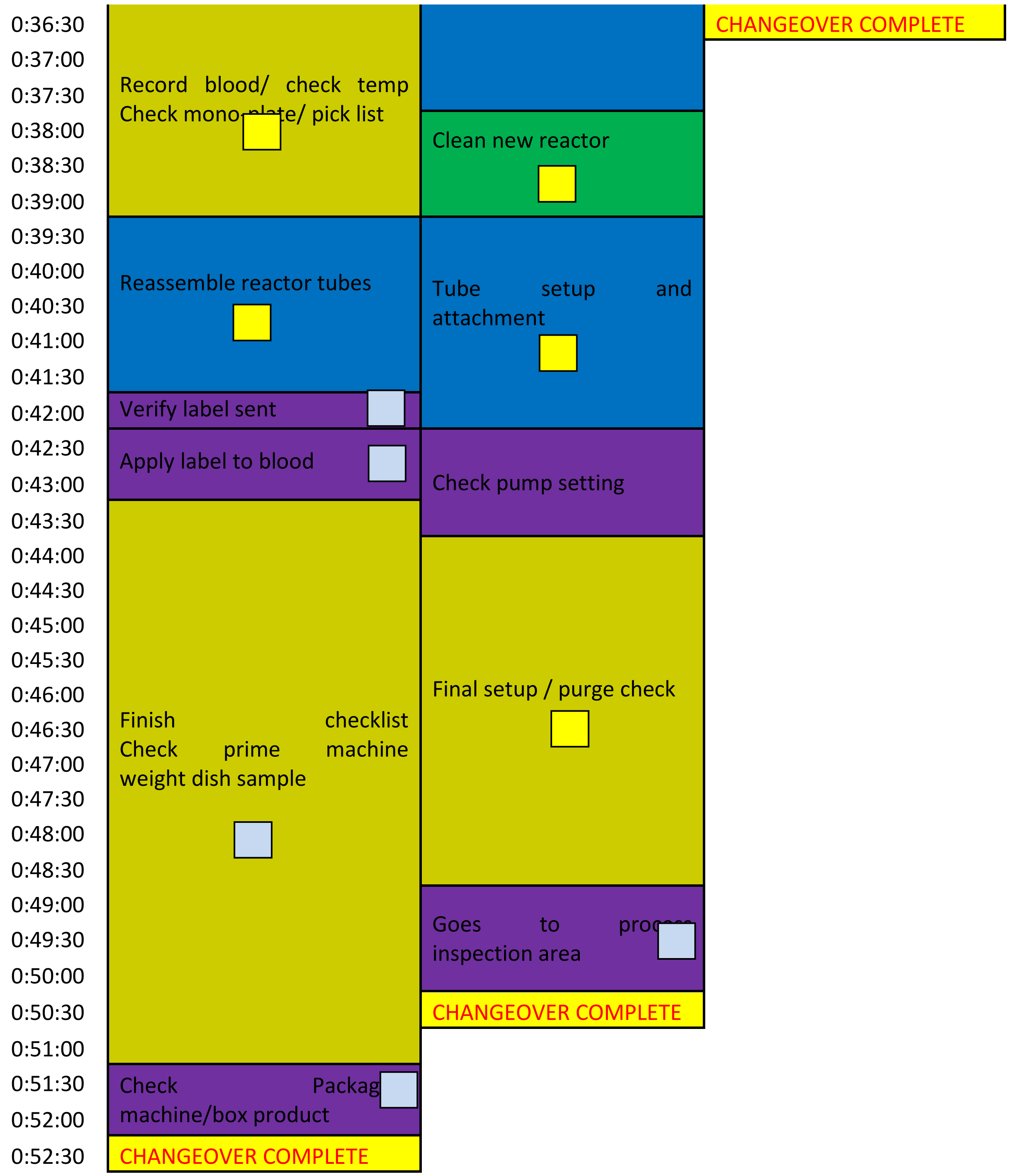
Remove Nozzles Drain #1in Kitchen
Reattach Pipettes to reactor Apply ethanol/rinse pipettes Re-attach pipettes to reactor Walk back to clean room
Remove foil from nozzles
Re-assemble top parts
Disassembly of bottom parts
Reassemble bottom parts
New gloves/hand sanitation
Clean assembled parts
pump/tube setup
Move reactor in
Tube setup
Hook up reactor hose
Re-glove
Get Batch record
Enter/ check labels
Send labels to computer
Talk to bagging
Waiting to send labels on computer
Talk to supervisor
Put away bi-plates
Paperwork
Get mono-plates
Load plates
Priming
Quality check
Prime Hoses



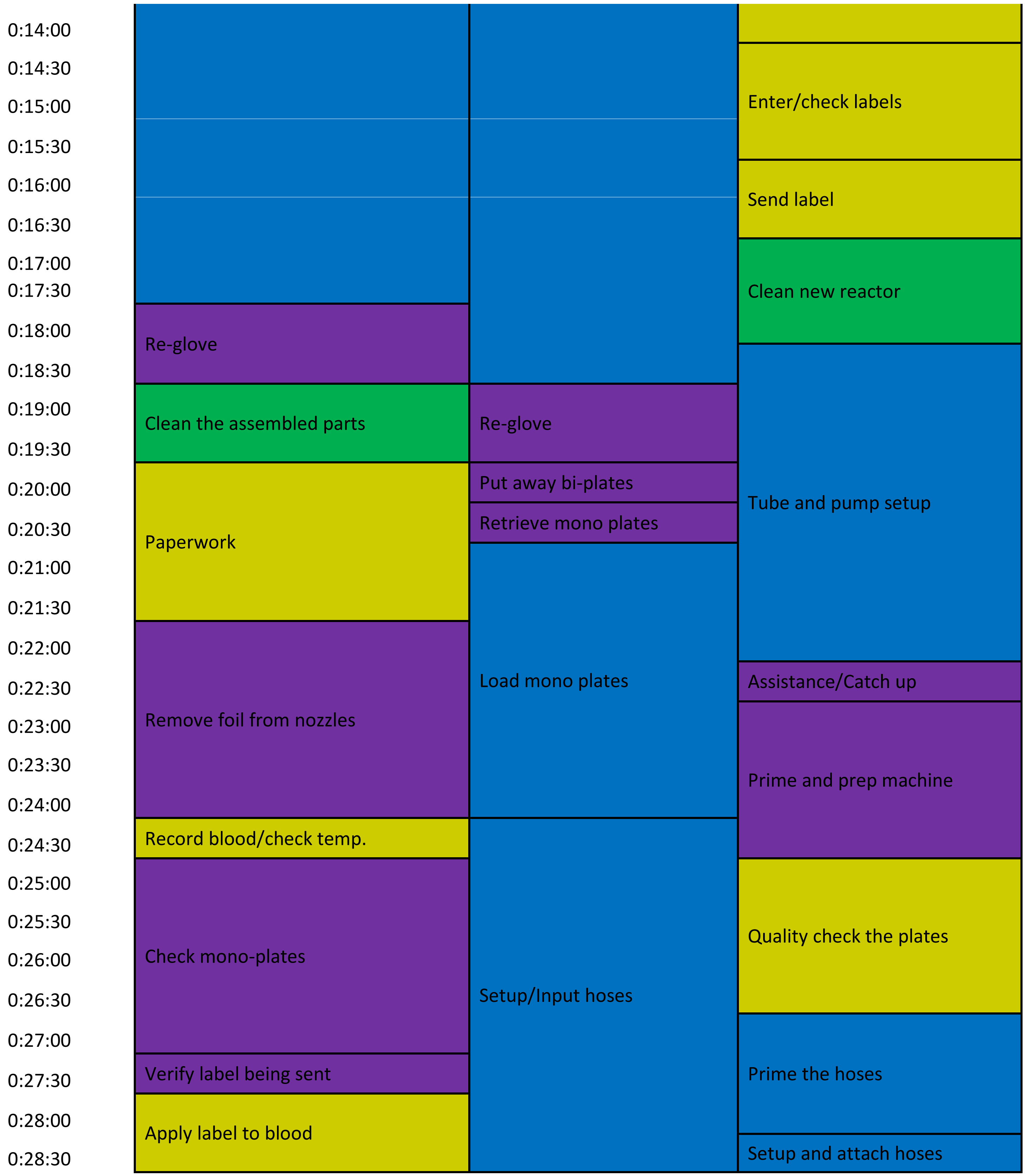
Labeling

External Process

Internal Process

APPENDIX O: PROPOSED MULTIPLE ACTIVITIES CHART AFTER SMED METHOD

Time (30 sec)	Suzanna	Phil	Antonio
0:00:00	Remove reactor tubes	Load Bottle/Clean	Paperwork at weigh station
0:00:30		Disconnect Tubes/Clean	
0:01:00			
0:01:30			
0:02:00			Check the packing
0:02:30			Remove empty petri dishes
0:03:00			
0:03:30			
0:04:00	Disconnect pump heads		
0:04:30		Wheel #1 Reactor to clean rm	
0:05:00			
0:05:30	Wheel #1 reactor to clean rm.	Walk back to prod. rm	Remove blood bag
0:06:00		Wheel #2 to clean rm.	Clean conveyor belt
0:06:30	Walk back to prod rm.	Walk back to prod. rm	
0:07:00	Wheel #2 reactor to clean rm.	Work on top parts	
0:07:30	Take #1 to kitchen		
0:08:00			
0:08:30			
0:09:00			
0:09:30			
0:10:00	Walk back to production rm.		Get new blood bag
0:10:30			Re-glove
0:11:00			Hang blood bag
0:11:30			Walk to clean rm.
0:12:00			Roll new reactor to station
0:12:30	Work on bottom parts		
0:13:00			Attach reactor hoses
0:13:30			Get batch record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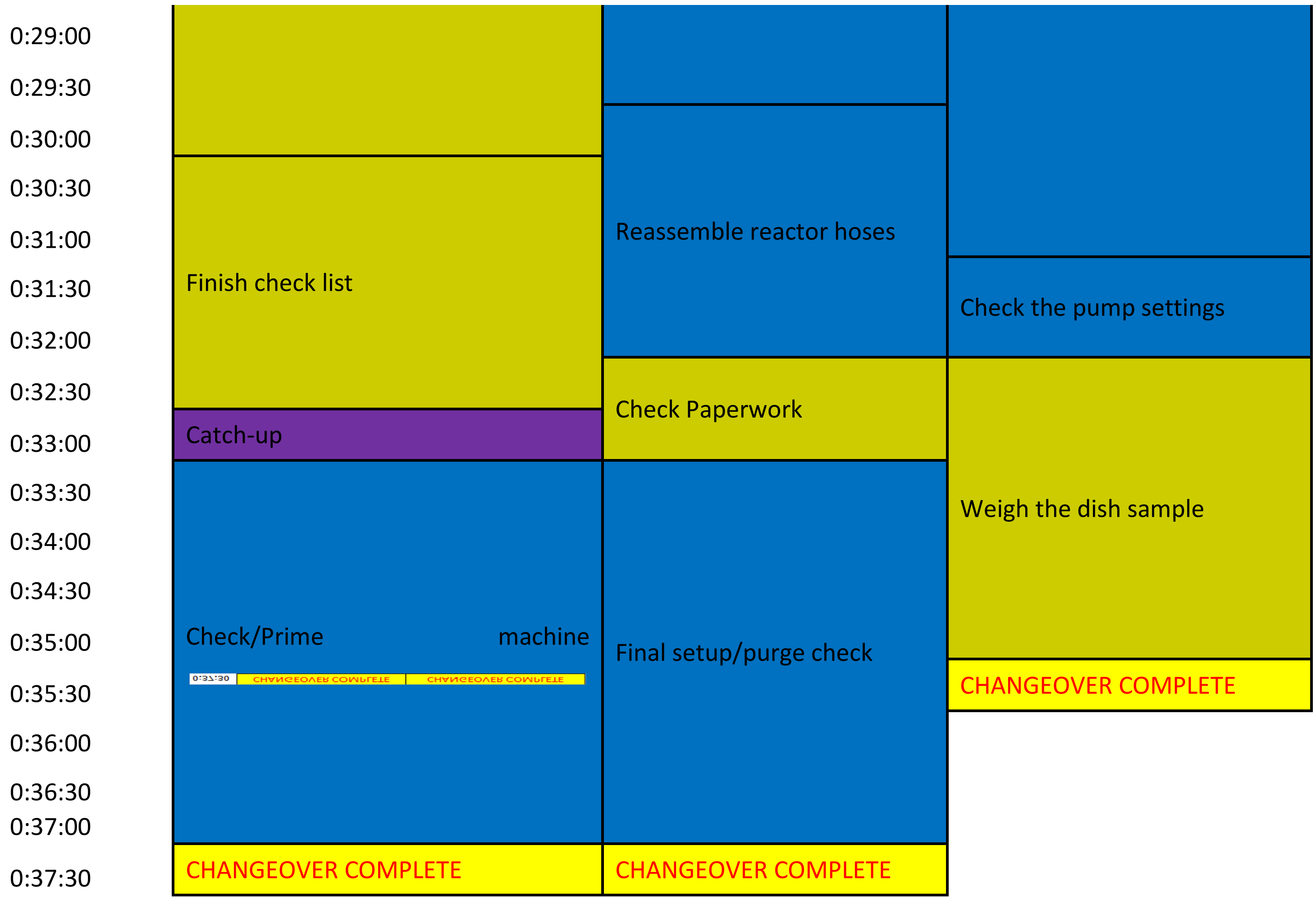
0:28:30
Re-glove
Clean the assembled parts
Paperwork
Remove foil from nozzles
Record blood/check temp.
Check mono-plates
Verify label being sent
Apply label to blood
Re-glove
Put away bi-plates
Retrieve mono plates
Load mono plates
Setup/Input hoses
Enter/check labels
Send label
Clean new reactor
Tube and pump setup
Assistance/Catch up
Prime and prep machine
Quality check the plates
Prime the hoses
Setup and attach hoses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0:33:00
0:33:30
0:34:00
0:34:30
0:35:00
0:35:30
0:36:00
0:36:30
0:37:00
0:37:30
Finish check list
Catch-up
Check/Prime machine
CHANGEOVER COMPLETE
Reassemble reactor hoses
Check Paperwork
Final setup/purge check
CHANGEOVER COMPLETE
Check the pump settings
Weigh the dish sample
CHANGEOVER COMPLETE

APPENDIX P: PROPOSED FLOW PROCESS CHART - SUZANNA

		Summary			
Location: Santa Maria Production Room					
Activity: Changeover Process		**Event**	**Present**	**Proposed**	**Savings**
Date: 5/18/2010		Operations		8	
Operator: Suzanna		Transport		5	
Circle Appropriate Method and Type		Delay		2	
Method: Present ~~Proposed~~ (Proposed circled)		Inspection		4	
Type: Worker (circled) Material Machine		Storage		0	
Remarks:		Time (min)		36:50	
		Distance (ft)			
		Cost			

Event Description	○ Operation	⇨ Transport	D Delay	□ Inspection	▽ Storage	Time (min)	Dist (ft)	Notes/Method Recommendation
1. Remove reactor tubes	●					3:30		
2. Disconnect pump heads	●					1:50		
3. Wheel #1 reactor to clean rm.		●				0:50		
4. Walk back to prod rm.		●				0:20		
5. Wheel #2 reactor to clean rm.		●				0:30		
6. Take #1 to kitchen		●				2:30		
7. Walk back to production rm.		●				2:20		
8. Work on bottom parts	●					5:30		
9. Re-glove	●					0:50		
10. Clean the assembled parts	●					1:00		
11. Paperwork				●		2:00		
12. Remove foil from nozzles	●					2:40		
13. Record blood/check temp.				●		0:30		
14. Check monoplates				●		2:30		
15. Verify label being sent			●			0:30		
16. Apply label to blood	●					2:30		
17. Finish check list				●		2:30		
18. Catch-up			●			0:30		
19. Check/Prime machine	●					4:00		
					Total =	36:50		

APPENDIX Q: PROPOSED FLOW PROCESS CHART - PHIL

		Summary			
Location: Santa Maria Production Room					
Activity: Changeover Process		Event	Present	Proposed	Savings
Date: 5/18/2010		Operations		10	
Operator: Phil		Transport		4	
Circle Appropriate Method and Type		Delay		0	
Method: Present ~~(Proposed)~~		Inspection		1	
Type: (Worker) Material Machine		Storage		0	
Remarks:		Time (min)		36:20	
		Distance (ft)			
		Cost			

Method circled: Proposed. Type circled: Worker.

Event Description	Operation	Transport	Delay	Inspection	Storage	Time	Dist (ft)	Notes/Method Recommendation
1. Load Bottle/Clean	●					0:50		
2. Disconnect Tubes/Clean	●					3:50		
3. Wheel #1 Reactor to clean rm		●				0:50		
4. Walk back to prod. rm		●				0:20		
5. Wheel #2 to clean rm.		●				0:30		
6. Walk back to prod. rm		●				0:20		
7. Work on top parts	●					11:50		
8. Re-glove	●					0:50		
9. Put away bi-plates	●					0:30		
10. Retrieve mono plates	●					0:30		
11. Load mono plates	●					3:20		
12. Setup/Input hoses	●					5:30		
13. Reassemble reactor hoses	●					2:20		
14. Check Paperwork				●		1:00		
15. Final setup/purge check	●					3:50		
					Total =	36:20		

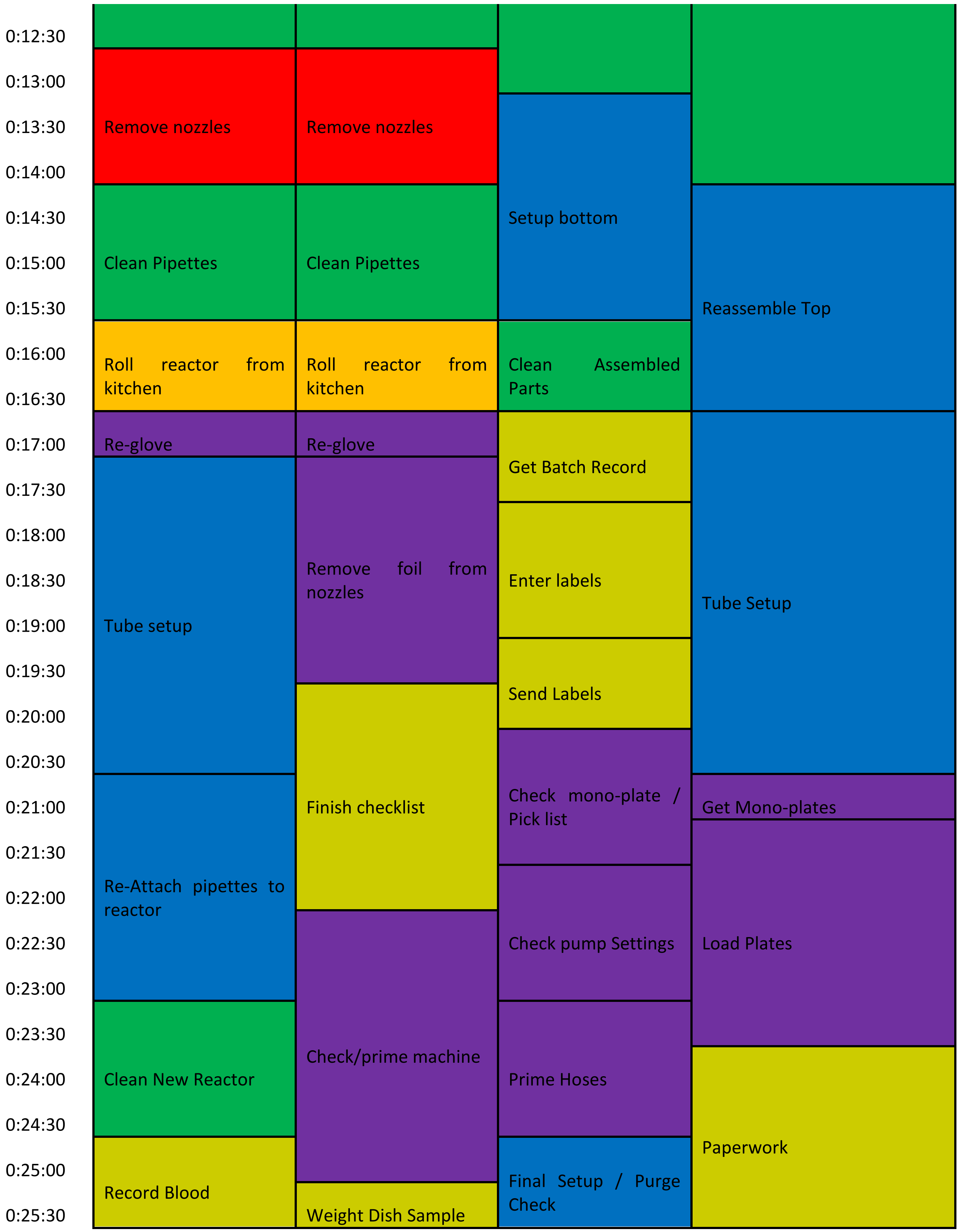
APPENDIX R: PROPOSED FLOW PROCESS CHART - ANTONIO

Location: Santa Maria Production Room		Summary			
Activity: Changeover Process		Event	Present	Proposed	Savings
Date: 5/18/2010		Operations		15	
Operator: Antonio		Transport		2	
Circle Appropriate Method and Type		Delay		1	
Method: Present Proposed		Inspection		5	
Type: Worker Material Machine		Storage		0	
Remarks:		Time (min)		34:10	
		Distance (ft)			
		Cost			

Event Description	Operation	Transport	Delay	Inspection	Storage	Time (min)	Dist (ft)	Notes/Method Recommendation
1. Paperwork at weigh station				■		2:00		
2. Check the packing				■		0:30		
3. Remove empty petri dishes	●					3:00		
4. Remove blood bag	●					0:30		
5. Clean conveyor belt	●					4:00		
6. Get new blood bag	●					0:30		
7. Re-glove	●					0:50		
8. Hang blood bag	●					0:20		
9. Walk to clean rm.		➡				0:20		
10. Roll new reactor to station		➡				0:50		
11. Attach reactor hoses	●					0:30		
12. Get batch record				■		0:50		
13. Enter/check labels	●					1:20		
14. Send label	●					1:00		
15. Clean new ractor	●					1:20		
16. Tube and pump setup	●					4:00		
17. Assistance/Catch up			◗			0:30		
18. Prime and prep machine	●					1:50		
19. Quality check the plates				■		2:00		
20. Prime the hoses	●					1:20		
21. Setup and attach hoses	●					2:50		
22. Check the pump settings				■		1:30		
23. Weigh the dish sample	●					2:20		
					Total =	34:10		

APPENDIX S: PROPOSED MULTIPLE ACTIVITIES CHART 4TH

Time (30 sec)	Suzanna	Phil	Antonio	4th Operator (kitchen)
0:00:00	Remove Reactor Tubes	Remove reactors Tubes	Paperwork at weight station	Check Packaging
0:00:30				Disconnect Pumps
0:01:00				
0:01:30				
0:02:00			Remove empty Petri dishes	
0:02:30				Retrieve Petri Rack
0:03:00	Take hoses and reactor to kitchen #1	Take hoses and reactor to kitchen #2		Wheel Reactor #1 to rm
0:03:30			Cleaning Equipment	Wheel Reactor #1 to rm
0:04:00				Clean Prep
0:04:30				
0:05:00			Clean Conveyor belt	
0:05:30	Wash Hoses	Wash Hoses		Disassembly Top
0:06:00				
0:06:30				
0:07:00				
0:07:30				
0:08:00				
0:08:30			Get blood bag	
0:09:00			Re-glove	
0:09:30			Hang blood bags	
0:10:00			Work on Bottom Parts	
0:10:30				Clean Top
0:11:00				
0:11:30				
0:12:00			Clean Bottom	


0:12:30
0:13:00
0:13:30
0:14:00
0:14:30
0:15:00
0:15:30
0:16:00
0:16:30
0:17:00
0:17:30
0:18:00
0:18:30
0:19:00
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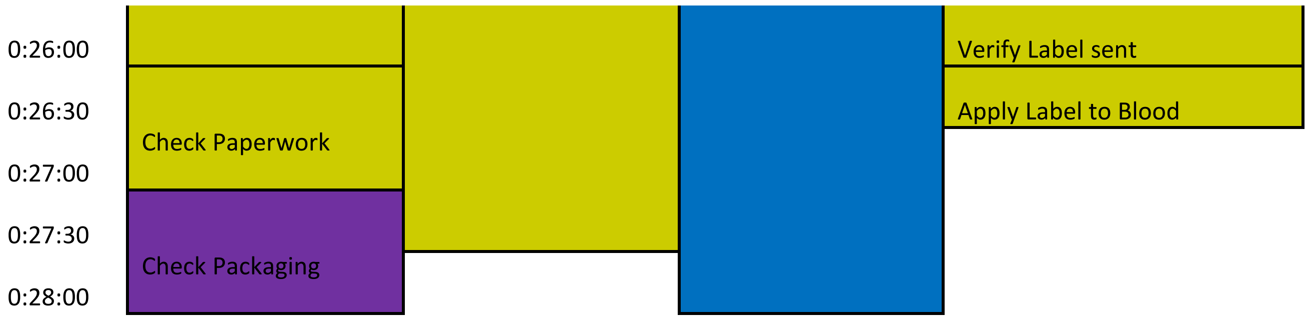
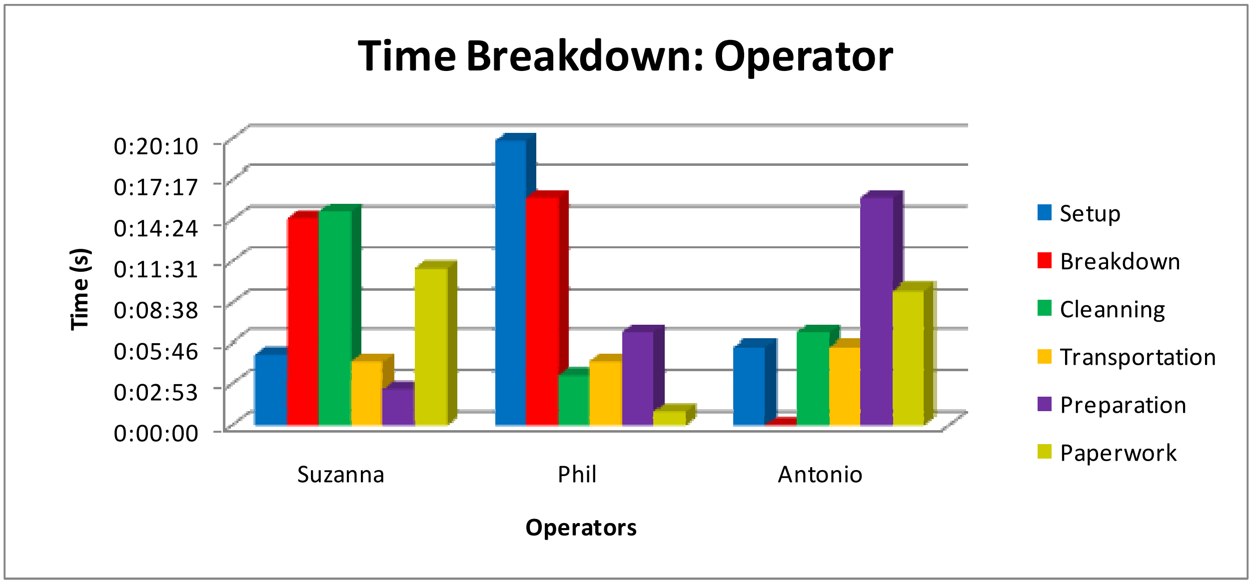
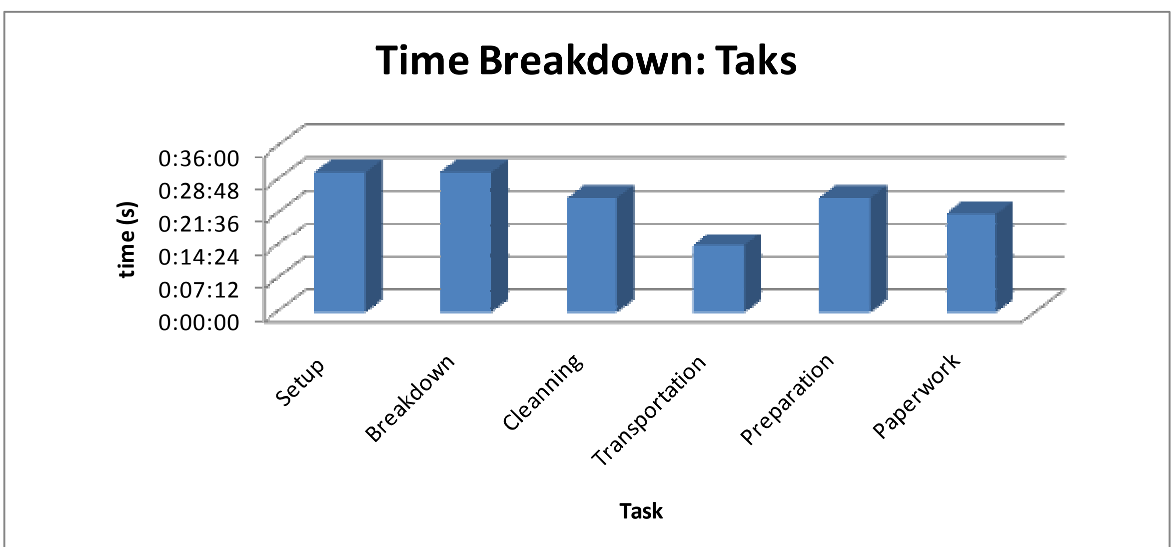
0:21:00
0:21:30
0:22:00
0:22:30
0:23:00
0:23:30
0:24:00
0:24:30
0:25:00
0:25:30
Remove nozzles
Clean Pipettes
Roll reactor from kitchen
Re-glove
Tube setup
Re-Attach pipettes to reactor
Clean New Reactor
Record Blood
Remove nozzles
Clean Pipettes
Roll reactor from kitchen
Re-glove
Remove foil from nozzles
Finish checklist
Check/prime machine
Weight Dish Sample
Setup bottom
Clean Assembled Parts
Get Batch Record
Enter labels
Send Labels
Check mono-plate / Pick list
Check pump Settings
Prime Hoses
Final Setup / Purge Check
Reassemble Top
Tube Setup
Get Mono-plates
Load Plates
Paperwork


0:26:00
0:26:30
0:27:00
0:27:30
0:28:00
Check Paperwork
Check Packaging
Verify Label sent
Apply Label to Blood

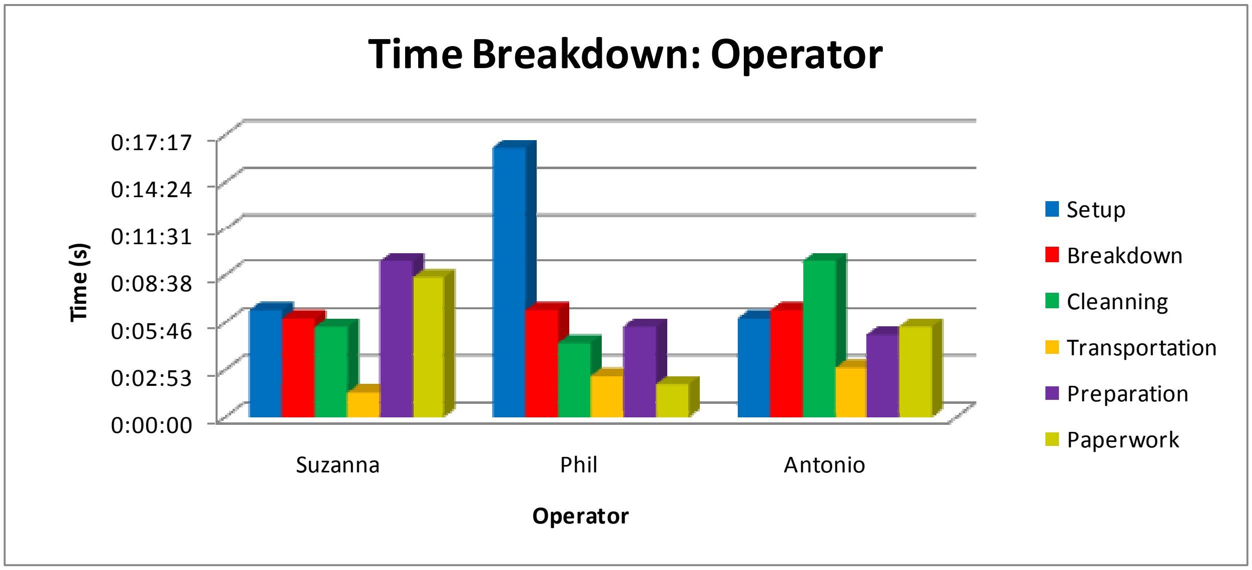
APPENDIX T: CURRENT CHANGEOVER- TIME BREAKDOWN



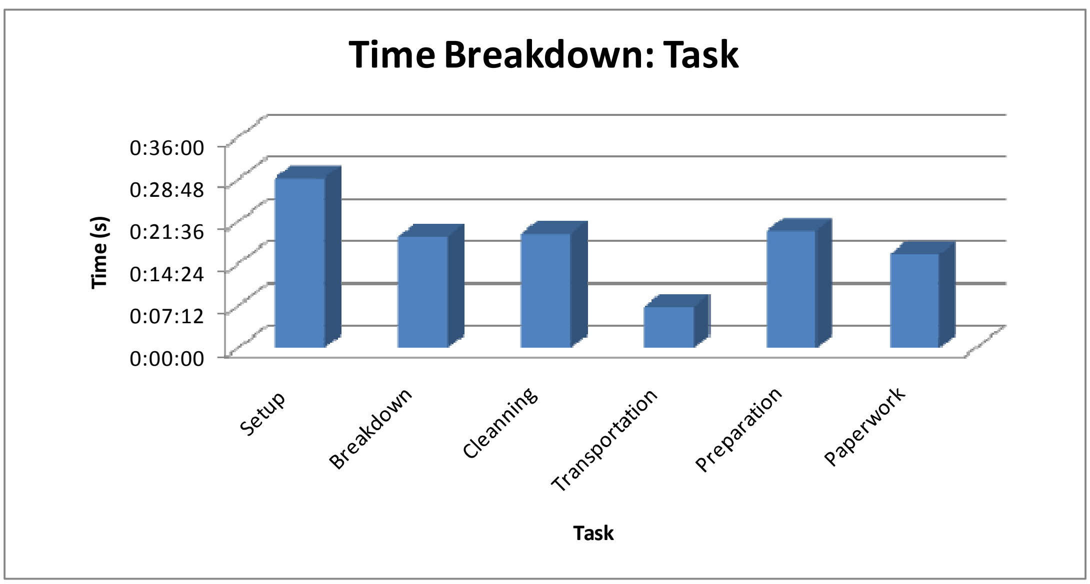
Task	Suzanna	Phil	Antonio	Total
Setup	0:05:00	0:20:00	0:05:30	0:30:30
Breakdown	0:14:30	0:16:00	0:00:00	0:30:30
Cleanning	0:15:00	0:03:30	0:06:30	0:25:00
Transportation	0:04:30	0:04:30	0:05:30	0:14:30
Preparation	0:02:30	0:06:30	0:16:00	0:25:00
Paperwork	0:11:00	0:01:00	0:09:30	0:21:30
Total	0:52:00	0:47:30	0:37:00	2:27:00



APPENDIX U: SHORT TERM CHANGES- TIME BREAKDOWN

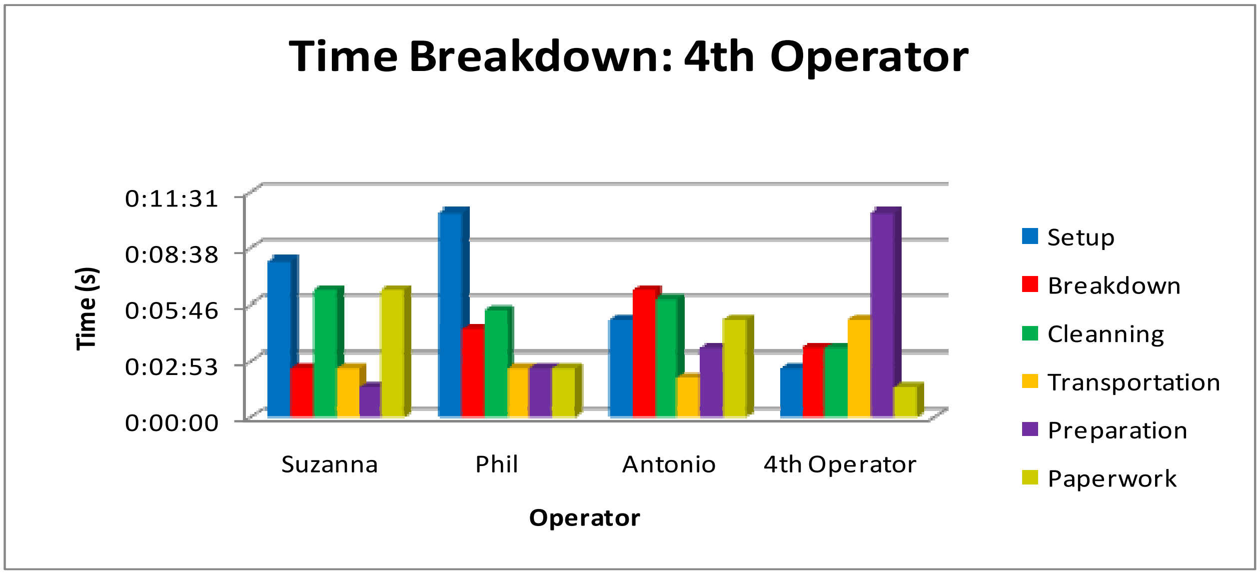


SMED				
Task	**Suzanna**	**Phil**	**Antonio**	**Total**
Setup	0:06:30	0:16:30	0:06:00	0:29:00
Breakdown	0:06:00	0:06:30	0:06:30	0:19:00
Cleanning	0:05:30	0:04:30	0:09:30	0:19:30
Transportation	0:01:30	0:02:30	0:03:00	0:07:00
Preparation	0:09:30	0:05:30	0:05:00	0:20:00
Paperwork	0:08:30	0:02:00	0:05:30	0:16:00
Total	0:37:30	0:37:30	0:35:30	1:50:30

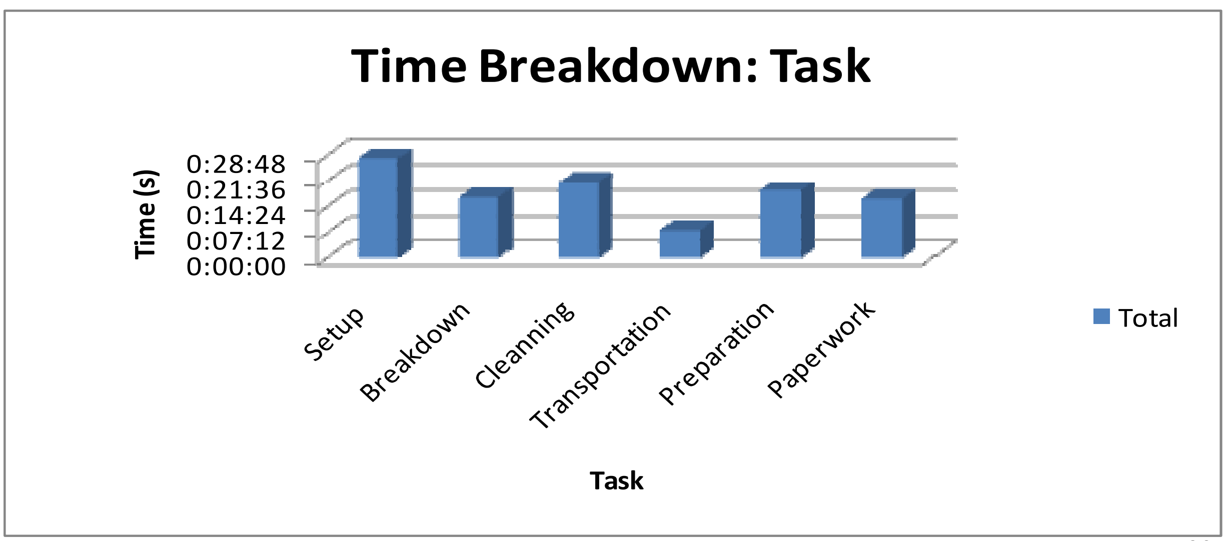


APPENDIX V: LONG TERM CHANGES- TIME BREAKDOW

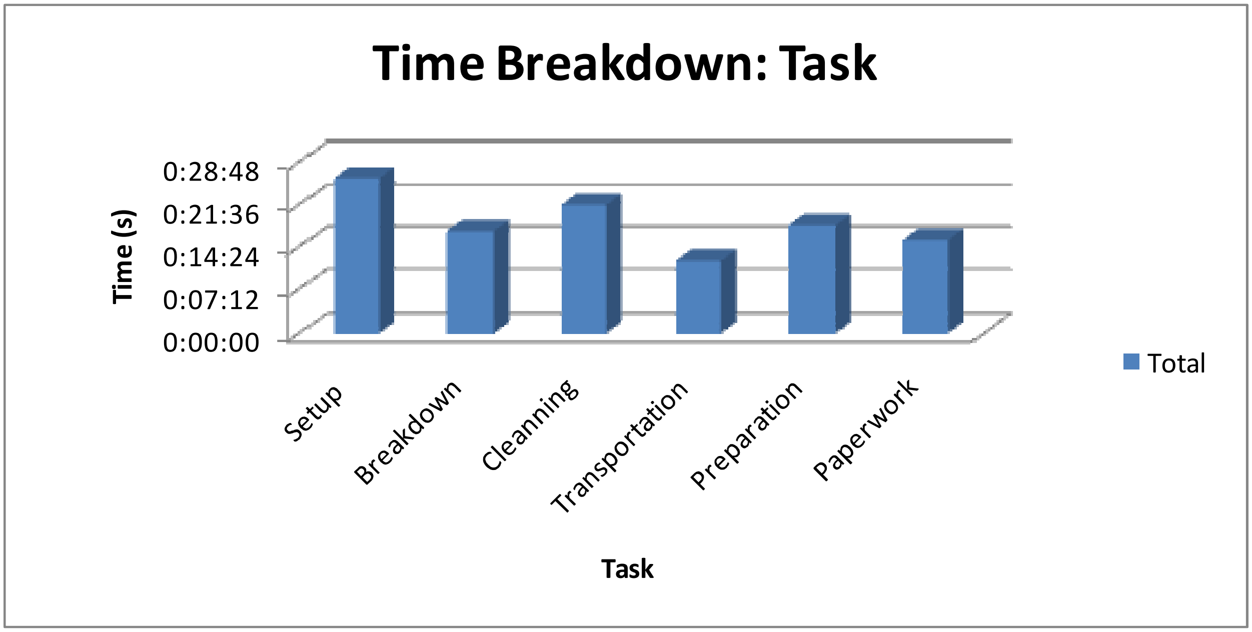
4TH OPERATOR TIME BREAKDOWN



4th Operator					
Task	**Suzanna**	**Phil**	**Antonio**	**4th Operator**	**Total**
Setup	0:08:00	0:10:30	0:05:00	0:02:30	0:26:00
Breakdown	0:02:30	0:04:30	0:06:30	0:03:30	0:17:00
Cleanning	0:06:30	0:05:30	0:06:00	0:03:30	0:21:30
Transportation	0:02:30	0:02:30	0:02:00	0:05:00	0:12:00
Preparation	0:01:30	0:02:30	0:03:30	0:10:30	0:18:00
Paperwork	0:06:30	0:02:30	0:05:00	0:01:30	0:15:30
Total	0:27:30	0:28:00	0:28:00	0:26:30	1:50:00



4^{TH} OPERATOR PLUS LONG TIME ALTERNATIVES



Long Term Alternatives			
Task	Total	Improvement	Improved Time
Setup	0:26:00	0:00:00	0:26:00
Breakdown	0:17:00	0:00:00	0:17:00
Cleanning	0:21:30	0:12:00	0:09:30
Transportation	0:12:00	0:04:11	0:07:49
Preparation	0:18:00	0:00:00	0:18:00
Paperwork	0:15:30	0:00:00	0:15:30
Total	1:50:00	0:16:11	1:33:49

LONG TERM ALTERNATIVES TIME IMPROVEMENT

Door Relocation

	Ft		
	To door	to Kitchen	Total
Old Distance	65	75	140
New Distance	15	75	90
Improvement			35.71%

	mi/hr	Ft/s
Speed	3	4.40
time (S)	time(min)	2 ways
0.03	1.89	3.77
0.05	2.93	5.87

		One way	One trip
Time saved		2.10	4.19
		2.1666667	4.316667
		0:02:06	0:04:11

UV Sanitation System

	Time Range	
Cleaning	0:25:00	0:25:00
Time Saved	0:12:00	0:10:00
Improved Time	0:13:00	0:15:00
% improved	48.00%	40.00%

Communication System

	Time Range	
Current Transportation	0:14:30	0:14:30
One way vs one trip to the kitchen	1	2
Time Saved	0:02:06	0:04:11
Improved Time	0:12:24	0:10:19
% Improved	14.48%	28.85%

Two Reactors

	Time
Current Transportation	0:14:30
Cleaning/ setup tubes	0:04:00
Total	0:18:30
Time Saved	0:04:11
Improved Time	0:10:19
% Improved	28.85%

APPENDIX W: COST JUSTIFICATION

INVESTMENT

Long Term Alternatives	Amount	Unit cost	Total Cost
Door Relocation			
Doors and hollow metal jams and casing	1	$450.0	$450.0
Door knobs, lock, dead bolt	**3**	$100.0	$300.0
Framing material	1	$150.0	$150.0
Labor	**3**	$400.0	$1,200.0
To hang sheet rock	**1**	$600.0	$600.0
Threshold (covers up floor, metal to cover 6 foot):	**4**	$50.0	$200.0
Painting	**1**	$500.0	$500.0
Move light switch	**1**	$100.0	$100.0
Total			$3,500.0
Overhead			$700.0
Total cost			$4,200.0
Two Reactors			
Bellco Glass BCS Vessel Bioreactor System	1	$6,569.0	$6,569.0
Filling tubes	8	$19.5	$156.0
Total			$6,725.0
Overhead			$1,345.0
Total Cost			$8,070.0
Communication System			
Intercom Station	5	$110.0	$550.0
Cad 5 Cable 1000ft	1	$159.0	$159.0
Labor	1	$400.0	$400.0
Total			$1,109.0
Overhead			$221.8
Total Cost			$1,330.8
UV Sanitation			
UV lamp	4	$350.0	$1,400.0
Labor	1	$500.0	$500.0
Electric cable	1	$50.0	$50.0
Total			$1,950.0
Overhead			$390.0
Total Cost			$2,340.0
Grand Total			$15,940.8

4th Worker on Kitchen Work				
		Time (hrs)	Hourly Rate	Total
Training		40	$15.00	$600.00
Yearly Cost		2080	$15.00	$31,200.00
		Time (hrs)	Hourly Rate	Total
Training		40	$20.00	$800.00
Yearly Cost		2080	$20.00	$41,600.00

Current VS Improved Changeover: Short Term Alternatives	
	Time
Current Changeover	0:52:00
Short Term Alternatives	0:37:30
Time Saved	0:14:30
% Improved	27.88%

Current Changeover			Improved Changeover: Short Term Altern			Savings	Improved Production	Saving $	
Changeover(s) a Day	Time	Hrs a Year	geover(s) a	Time	Hrs a Year	Hrs a Year		$25.00	$40.00
1	0:52:00	225:20:00	1	0:37:30	162:30:00	62:50:00	1508.00	$37,700.00	$60,320.00
2	1:44:00	450:40:00	2	1:15:00	325:00:00	125:40:00	3016.00	$75,400.00	$120,640.00
3	2:36:00	676:00:00	3	1:52:30	487:30:00	188:30:00	4524.00	$113,100.00	$180,960.00

Current VS Improved Changeover: 4th Operator	
	Time
Current Changeover	0:52:00
Short Term Alternatives	0:28:00
Time Saved	0:24:00
% Improved	46.15%

Current Changeover			proved Changeover: Short Term Alternativ			Savings	Improved Production	Saving $	
Changeover(s) a Day	Time	Hrs a Year	geover(s) a	Time	Hrs a Year	Hrs a Year		$25.00	$40.00
1	0:52:00	225:20:00	1	0:28:00	121:20:00	104:00:00	2496.00	$62,400.00	$99,840.00
2	1:44:00	450:40:00	2	0:56:00	242:40:00	208:00:00	4992.00	$124,800.00	$199,680.00
3	2:36:00	676:00:00	3	1:24:00	364:00:00	312:00:00	7488.00	$187,200.00	$299,520.00

Current VS Improved Changeover: Long Term Alternatives	
	Time
Current Changeover	0:52:00
Long Term Alternatives	0:23:27
Time Saved	0:28:33
% Improved	54.90%

Current Changeover			proved Changeover: Short Term Alternativ			Savings	Improved Production	Saving $	
Changeover(s) a Day	Time	Hrs a Year	geover(s) a	Time	Hrs a Year	Hrs a Year		$25.00	$40.00
1	0:52:00	225:20:00	1	0:23:27	101:37:00	123:43:00	2969.20	$74,230.00	$118,768.00
2	1:44:00	450:40:00	2	0:47:38	206:24:40	244:15:20	5862.13	$146,553.33	$234,485.33
3	2:36:00	676:00:00	3	1:11:27	309:37:00	366:23:00	8793.20	$219,830.00	$351,728.00

Investement Cost	
Door Relocation	$4,200.00
Two Reactors	$8,070.00
Communication System	$1,330.80
UV Sanitation	$2,340.00
4th Operator (training)	$800.00
Total	$15,940.80

4th Operator Cost			
	Time (hrs)	Hourly Rate	Total
Training	40	$25.00	$1,000.00
Yearly Cost	2080	$25.00	$52,000.00

Long Term Improvements: Gains	
Price	Price
$25.00	$40.00
$74,230.00	$118,768.00
$146,553.33	$234,485.33
$219,830.00	$351,728.00

ROI	7.67%	72.28%

Payback Period		
Cost fo the Project	68,940.80	68,940.80
Yearly Inflow	$74,230.00	$118,768.00
Payback (year)	0.93	0.58
Payback (Months)	11.14	6.97

CASH FLOWS

EOY	Investment	Savings	Recurring Cost	BTCF	Payback
0	$ (16,940.80)			$ (16,940.80)	$ (16,940.80)
1		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 289.20
2		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 17,519.20
3		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 34,749.20
4		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 51,979.20
5		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 69,209.20
6		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 86,439.20
7		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 103,669.20
8		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 120,899.20
9		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 138,129.20
10		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 155,359.20
11		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 172,589.20
12		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 189,819.20
13		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 207,049.20
14		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 224,279.20
15		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 241,509.20
16		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 258,739.20
17		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 275,969.20
18		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 293,199.20
19		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 310,429.20
20		$ 74,230.00	$ (57,000.00)	$ 17,230.00	$ 327,659.20

	Project Cost	4th Operator Training	Total
Investment	15940.8	1000	16940.8
	4th Operator Salary	Maintainace	
Recurring cost	52000	5000	57000

EOY	Investment	Savings	Recurring Cost	BTCF	Payback
0	$ (16,940.80)			$ (16,940.80)	$ (16,940.80)
1		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 44,827.20
2		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 106,595.20
3		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 168,363.20
4		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 230,131.20
5		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 291,899.20
6		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 353,667.20
7		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 415,435.20
8		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 477,203.20
9		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 538,971.20
10		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 600,739.20
11		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 662,507.20
12		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 724,275.20
13		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 786,043.20
14		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 847,811.20
15		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 909,579.20
16		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 971,347.20
17		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 1,033,115.20
18		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 1,094,883.20
19		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 1,156,651.20
20		$ 118,768.00	$ (57,000.00)	$ 61,768.00	$ 1,218,419.20