Facilities Planning for an Aerospace Manufacturing Company

By

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Abstract

Absolute Technologies Inc. (ATI) has been growing for years, and is running out of space at their current manufacturing facility in Yorba Linda, CA. ATI will be moving to a much larger facility this winter. They are looking for an efficient way to utilize this space. The machine positions were taken as fixed, seeing as a lean expert was brought in to give advice on placement. With the machines fixed, the scope was narrowed to other areas.

A systematic approach to facilities design is utilized. First, a goal needs to be defined. The goal is to reduce the time wasted during the inspection process. The next step is to define the departments. The departments are broken up into two types, those that were possibly applicable to the project, and those that should be disregarded. Next, the relationships between the possibly applicable departments are quantified. A to-from chart was developed to identify the most important department relationships. This chart yielded three important relationships, but the proposed layout of the machines by the LEED expert showed that there was a large distance between one of these three important relationships. This relationship was between the Tool and Gage Crib, and the Inspection Area.

A very important process, which involves these two departments, is the Tool Check-out System. This system was analyzed in depth, and simulated in a software package called ProModel. Once the current system was fully understood, Alternative solutions were discussed, the most viable of which being the implementation of an RFID Tool Crib Portal. This proposed system was

defined, analyzed, and simulated using ProModel. The simulations of the two tool checkout systems yielded the following results.

- Save 6.89 minutes per job
- Save 2.87 hours per day
- Save 840 ft of walking
    - 84% less
- Save $22,386 per year on employee time
    - 78.5% less per year
- An overall payback period of approximately 2.5 years

An A3 report was then developed, in order to help educate the entire company efficiently. This A3 shows the entire life-cycle of this problem-solving effort in a user-friendly format.

Much was learned during this project. Multiple facets of Industrial Engineering were used in the development of this report, and many more could be applied once ATI moves into the new facility. Implementing the RFID Tool Crib Portal is recommended, as the overall benefits of the system should outweigh the initial costs within a matter of a few years. Also, the A3 report should be available to every employee who will be affected by the changes implemented. In order for this proposal to work to its full capacity, everyone should be on-board, and up to date with the overall direction of the company.

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Introduction

The purpose of this project is to provide a facilities layout for Absolute Technologies Inc (ATI). The company is moving to a larger facility and this project will propose to help with the layout of the machines, tools, and inspection equipment. The goal of the layout is to reduce the amount of waste throughout the manufacturing process. A full analysis of the current and proposed layouts will be provided, along with implementation plans. Utilizing the space that will be given efficiently is of utmost importance. This new building will be used for decades and starting with a well thought out design will be important to the lasting success of ATI.

This report will give a background on the history of ATI; next it will review why facilities design should be utilized, and how it can improve the facility. A systematic facilities design approach will be taken, by defining the goal, departments, and relationships, then developing alternative solutions, deciding the best layout, and finally defining/installing/and maintaining these changes. Computer simulations will be used to verify these changes, and an A3 report will be generated to help introduce these processes in a user-friendly manner.

Background

ATI began as in 1968 as a humble machine shop providing service repairs for Bell Helicopters. Over the last 44 years their products and abilities have greatly

increased in scope. With an arsenal of over 50 CNC machines, they are well equipped to provide quality precision parts on time to various customers. ATI has about 200 employees, more than half of which are shop workers. All of these assets are used to create a wide variety of parts for companies such as Parker, Goodrich, and Honda. CNC machines are divided up into various cells, each of which having a specific family of parts that it caters to. Certain cells specialize in making pistons, other specialize in housings, shafts, cylinders, etc.

In recent years, this family owned company has increased its production significantly. Adding machines, employees, and equipment has led to the decision to move out of the cramped, 40,000 sq. ft. facility in Yorba Linda, CA, to a building approximately double that size, nearby in Anaheim, CA.

Along with the CNC machines, there are countless tool chests, work stations, manual machines, kanban areas, work in progress (WIP) storage areas, inspection equipment, etc. These all need to be organized so as to reduce clutter, while still keeping travel time low and efficient. Main focuses for reduction of waste are inventory, transportation, and motion.

Why Look to Facilities Design?

This literature review aims to provide a background in facilities design, and the effects it can have on a manufacturing facility. These changes to the facility can have expansive effects on material flow, which is why flow must be taken into account during

the design process. Inspection processes are reviewed upon, as well as techniques and methodology for facilities design, to help approach these topics with a proper basis.

Facilities Planning and Design is essential to help an organization improve their supply chains (Anji). The most desirable characteristic of a facility layout is its ability to maintain its efficiency over time while coping with the uncertainty in product demand (Krishnan). This efficiency can help to improve many facets of a company, including:

- Increased return on assets by maximizing inventory turns, minimizing obsolete inventory, maximizing employee participation, and utilizing continuous improvement.
- Improved customer satisfaction by decreasing lead times and increasing the company's responsiveness to customers' needs.
- Reduced costs due to decreasing a wide variety of costs, such as transportation, inventory, packaging, and many others (Tompkins).

Reduction in material handling cost is essential in order to maintain a competitive edge in the market (Dai). Material handling cost is estimated to contribute up to 20-50% of the operating expenses and 15-70% of the total cost for manufactured goods in a manufacturing facility (Mohamadghasemi). This expense can be reduced by 10-30% with efficient facility layout design (Krishnan).

In general, the facilities layout travels through a life cycle which consists of the following phases: design, implementation, growth, maturity and obsolescence. It is estimated that 8% of the gross national product of the United States has been spent on new facilities in each year. This statistic doesn't even include modifications of existing

buildings. To support the above decision making process suitable measurement models are required as a pre-requisite, as these models act as an aid in decision making. These models are often in the form of a linear programmed optimization problem (Raman).

Material Flow

A facility layout can be generally represented as a fully packed collection of right angle polygons assigned to various work centers. A material handling network benefits by using sharper angles and rounded facilities. Integration of these two systems can be quite complex.

In a large assembly facility, parts are typically received through a dock, transferred to a storage location, and finally transferred to a line location. Even when locations of receiving docks, storage locations, and line locations are predetermined, the assignment of parts to dock locations and storage locations and the material flow paths through the facility are important decision variables (Ellis).

When it comes to material flow patterns, rectangular, square, and diamond floor patterns are much less efficient than using other geometric structures, specifically a hexagonal structure (Chung).

The most common flow patterns in existing facilities are based on rectangular floor plans with conventional material flow patters such as spine flow, I-flow, ladder flow, circular flow, and U-flow. One of the advantages of a rectangular floor plan is its compatibility with machines or products being placed in the layout since most of them

are rectangular. However, for larger-scale facilities, with heavy traffic volumes, space utilization is less important than that of material handling efficiency (Asef-Vaziri).

Maintaining a layout designed to have material flow through a loop which covers all of the necessary work centers is very advantageous to a company (Asef-Vaziri). Linear Programming can help to minimize the length of this material flow loop. In other terms, a linear programming problem can be formulated with the intent of minimizing the length between nodes of a network.

There are two main types of formulations for calculating the shortest loop covering all work centers in a manufacturing facility layout, Primal and Dual (Steele). Below are examples of both the Primal (left) and Dual (right) graphs (Figure l). As you can see, the primal graph shows individual distances of lengths between edges of a work center. The dual graph shows paths (and will define distances) between the centroids of the work centers. These graphs prove as effective visual representations of a layout, which will help better understand the justifications of change that the linear programming formulations will suggest.

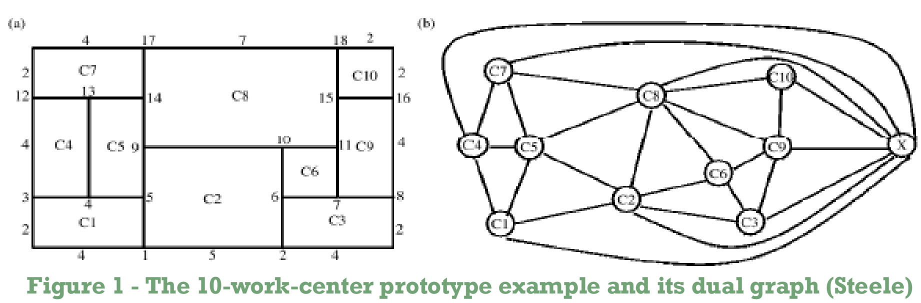

Figure 1 - The 10-work-center prototype example and its dual graph (Steele)

However, this is not the only way to develop an efficient floor plan. Multi-Channel Manufacturing, or MCM for short, is based on the simple observation that in an effective

manufacturing system multiple channels (or paths) are provided for each manufactured product as it flows through the system; that is, instead of having one channel through the manufacturing system for each product (as many traditional manufacturing systems are often designed), multiple channels are provided. This allows the product to flow through the facility by choosing the channel that allows for the greatest manufacturing system efficiency at that time (Meller).

This method is most advantageous with a company that has a smaller, job-shop type manufacturing cycle. When there are many batches of smaller quantities of parts, there is a more likely chance that machines will have small amount of downtime. When this happens, products should have the option to stray from an original plan, where they are queuing for another machine, and follow the new path of less resistance. This can be kept in mind when planning a facility layout. Machines which can be substituted for one another should be kept close, and in line with the most likely material flow loop.

Inspection

Inspection is an important step to any manufacturing line. Repeatability and Reproducibility (R&R) must utilize an inspection step to track the accuracy of the value-added processes in a production line. However, inspection sometimes seems unnecessary as it cuts into the time spent at value-added processes. Optimal sublot sizes are determined by studying the trade-off between cost and time spent in restoration and rework. In addition, the economical batch sizes, number of sublots, and

processing rates are affected by these decisions. Therefore, dividing runs of parts into separate, smaller batches, or sublots, and putting these parts through inspection at separate intervals so that parts in the same run could be concurrently inspected and machined could be advantageous to a company (Hassini).

Facilities Design Techniques and Methodology

Facilities design has three interrelated components; structure, layout and the determination of a network system to support material flow interaction, e.g., material handling systems. Many techniques for developing layouts have been developed and most focus on minimization of material handling costs--usually in terms of rectilinear distance between departmental centroids. These techniques give good results so far as they go, however, their performance may be poor in terms of applicability because the layouts usually ignore aisles. Or, if there are aisles, they include dead ends, short aisles and other characteristics that would make them difficult to physically implement (Alagoz).

There are two Facility Layout Problems (FLP's), static and dynamic. Static arises when there is no variability in product demands. Dynamic FLP (DFLP) assumes that product demands vary constantly. Two main solutions to a DFLP are to either create a single layout which generates an optimal layout for various product demands, or to create an 'agile' (Kochar and Heragu) layout which can be easily customized to adapt to the change in production.

Uncertainty in product demand and product path results in a FLP. Two procedures are presented to address this problem. The first is utilized to assess the risk associated with the layout, while the second procedure is used to develop the layout that minimizes the risk (Krishnan).

A network flow model is solved to identify the shortest path from dock door, via temporary storage location, to the assembly line locations. An optimal configuration of each temporary storage location is determined based on the results of the network flow model (Ellis).

Network flow sub problem determines the path each unit load will take from the dock location to a line location in order to minimize the total material handling time.

A linear programming model can be utilized, using parameters such as locations of dock, storage, part, line, daily demand/capacity, time to pickup and deposit, and finally travel time between locations. The decision variable is the number of parts assigned to flow from dock to storage to line location. An objective function aims at minimizing the sums of the products of the decision variables and the times needed to pickup, deposit, and travel the parts. The capacities are used as constraints.

Consumers' demand for a greater variety of products in smaller quantities makes maintaining efficiency in batch operations of a traditional, process oriented manufacturing facility very difficult. A technique that overcomes the usual problems of the traditional production system is Group Technology (GT). This is a philosophy that organizes and uses information for grouping various parts and products with similar

machining requirements into families of parts and corresponding machines into machine cells (Hu).

There are three main clustering approaches. The most common, and the most useful for this application, is the machine-part incidence matrix technique. A machine-part incidence matrix is an effective way of deciding which parts should be paired with which machines in order to minimize the number of intercellular moves. This will help simplify the process and will help to identify where the bottlenecks are. Once bottlenecks are identified, machine additions/improvements can be easily justified. (Sofianopoulou).

The Quartic Assignment Problem (QrAP) has been proposed as a formal quantitative attempt to incorporate minimization of material handling interruptions in layout design. The Full Assignment Problem with Congestion (FAPC) model incorporates material handling congestion as a criterion and aims at reducing congestion by allowing both re-layout and flow re-routing (Zhang)

Conclusion

This project will justify manufacturing facility designs based on techniques described above. An efficient facility layout is an integral part of a successful manufacturing line. It is beneficial for companies like Absolute Technologies Inc. to utilize their space effectively to minimize waste and, in turn, maximize profits.

Design

Using a systematic approach to Facilities Planning, there are four general steps: Know the Operations, Develop an Alternative Solution, Decide the Best Layout, and Define/Install/Maintain.

Know the Operations

Understanding the current operations of the system being analyzed is very important. Before any changes or adjustments are made to the system, it must be fully understood.

Define Problem/Goal

Initially, a specific problem/goal may not readily present itself. The following questions can be helpful to define a specific problem or goal. Why must a new layout be created? What is it we are trying to accomplish? Who asked for this to happen, and why did they ask?

At ATI, there is much that can be improved. In preparation for the move in the winter, ATI hired a lean expert to develop the layout for all of the machines in the new building. With this major step out of the way, it is important to find what problems this layout will produce, as no layout is without flaws.

Manager recommendations led to a focus on the inspection area, where there has been an increase in workload, with little help to alleviate the flow. The overall goal of the project now, is to reduce time wasted in the inspection processes at ATI.

At this point in the approach, the goal of the project must be solution independent. This means that the goal should define *what* will be done, not *how*.

This is a very important distinction to make when it comes to this type of problem solving. Many who attempt to solve a problem such as this quickly jump to a solution that they could have in mind, and they quickly attempt to put this solution in place. This type of thinking can cause many problems. Without gathering an encompassing knowledge of the entire system, solving a single problem can cause other portions of the system to fail. This is equivalent to taking aspirin to cure pain due to a broken toe. Although the pain was alleviated, the full problem was not solved. With an expansive knowledge of the interconnections of the system in place, problem solving patterns will be identified, and a solution can be developed which lessens the possibility of issues down the line.

Define Departments

The inspection department, which is where work needs to be alleviated, interacts with many other departments. These departments were then divided up into two categories, to help narrow the search for a viable topic.

- Possibly Applicable Departments
    - Machines – Divided into various manufacturing cells
        - Piston Cell
        - Cylinder Cell
        - Small/Mid Shaft Cell
        - Mill-Turn/Prismatic
        - Housing Cell
        - Shaft Cell
        - Long Shaft Cell

        - Grind
        - Gear
        - Deburr
        - Blast
    - Tool and Gage Crib
    - Inspection
        - Inspection Stations with various inspection equipment
        - Tool Checkout Inbox
    - Work In Progress (WIP) Storage
    - Finished Goods Inventory Storage
- Disregarded Departments
    - Lobby
    - Shipping & Receiving
    - Offices
        - Engineering
        - Customer Service
        - Management
    - Restrooms
    - Break/Lunch Room
    - Conference Room

Define Relationships

Department Relationships has to do with how closely, and how often, certain departments interact with each other. It is important to look at the flow patterns throughout the facility. There are three different types of flow patterns in manufacturing facilities such as this.

- Flow within workstations – Mostly deals with work methods and ergonomics of a specific workstation.
- Flow within departments – Deals with flow within the various workstations of a department.
- Flow between departments – More of a Macro view of flow through an entire facility. This type of flow is important when looking at reducing congestion in a facility. An uninterrupted path from origination to destination leads to a much more organized and efficient workplace.

In order to quantitatively analyze the relationships between the various departments, a To-From Relationship Chart is utilized.

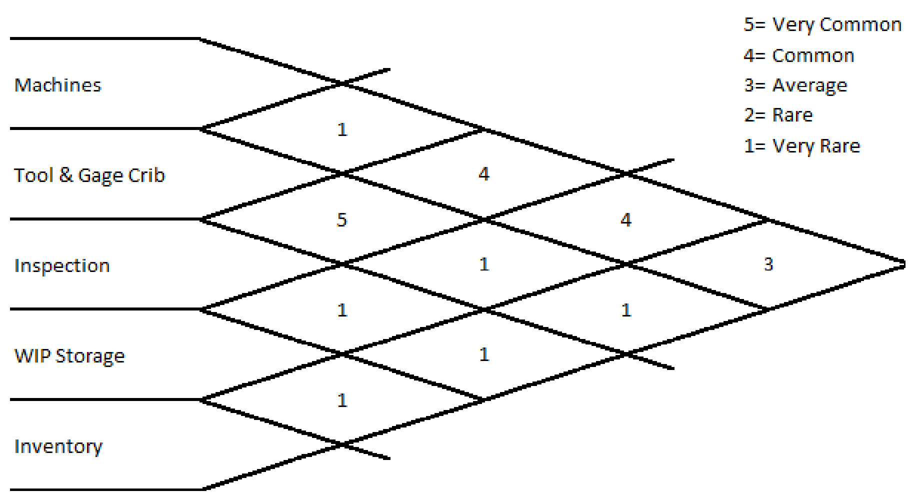

Figure 2 - To-From Relationship Chart

In this example, the most important departments are taken and listed to the left. Say we choose to look at the interactions between the Machines and Inspection. Following each column diagonally to the point where they meet yields a 4. This shows that flow from the inspection department to the Machines is common.

The results of this chart show a few important relationships. It has now been made apparent that the focus of this project should regard one of the following interactions:

- Tool & Gage Crib vs. Inspection – Very Common
- Machines & Inspection – Common
- Machines & WIP Storage – Common

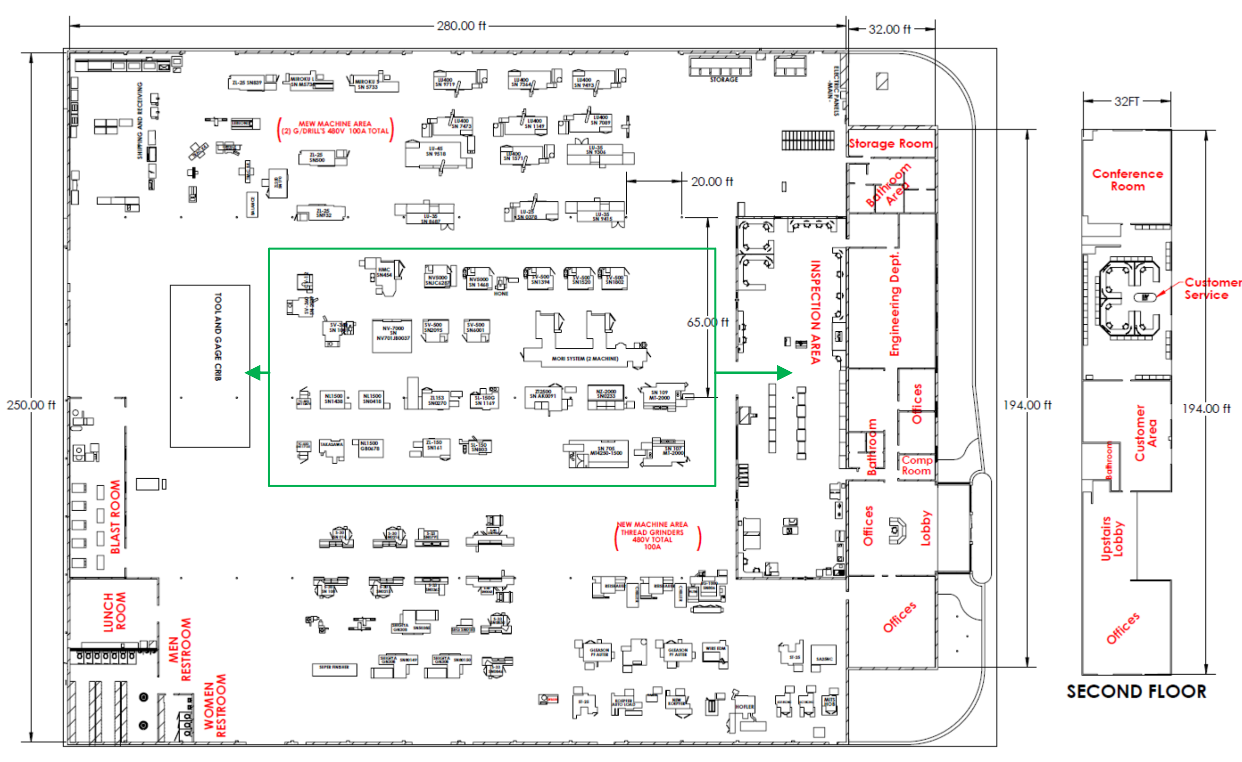

Figure 3 - Path Between Tool & Gage Crib & Inspection

Given the three most important relationships, deduced from the To-From Chart (Figure 2), it is now viable to analyze a proposed layout of the facility that ATI plans to move in to this winter. The Machines were placed in these positions by a Lean expert who was brought in to help with the cell manufacturing process.

The green path network shown in Figure 3 shows that there is a rather large disconnect between the Inspection area and the Tool and Gage Crib. In the current, smaller facility in Yorba Linda, CA, the Tool and Gage Crib is adjacent to the Inspection area. This is the most common relationship that is pertinent to this project. Therefore, it is imperative that this relationship be analyzed further.

The Tool Check-Out System is a commonly used process that must be repeated by every set-up machinist, before every job.

Current Tool Check-Out System

There are three main ways that machinists currently check out tools:

1. Machinists come to a retriever with a part number and vendor. From there the Retriever can open up a list of tools necessary for that part and fill out a Tool Control Request Form (Figure 4).

ATI

TOOL CONTROL REQUEST FORM

PN: ____________________

Name: ____________________ **Job #** ____________________

Op # ____________________

TOOL DISCRIPTION: GAGE TYPE: PIN TYPE:	TOOL ID#: RSP# : PIN SIZE:	TOOL LOCATION	DATE/TIME REQUEST	DATE/TIME OUT	DATE/TIME IN	Comments

Figure 4 - Tool Control Request Form

From there he issues the tools to the machinist, and the machinist is held accountable for the tools. This method can only be used if there is an established list of tools specified for that job. Specified tool lists only exist for repeat jobs. Repeat jobs are fairly common, but a large portion of jobs cannot be processed in this way. Even if the company has manufactured this same part number before, there may have been various revisions to the process plan, which can have a large effect on the tool list.

2. The second way is if the machinist fills out the Tool Control Request Form, and an identical copy, and gives them to the Retriever. The Retriever still handles the tool check out. This is a much more common method for this process. This method is slow and possibly inaccurate. Due to the large variability in user handwriting, tool names/types can be easily misread, leading to a hold pattern later in the manufacturing process.

3. Machinist can go to the tool chests and check out tools themselves with the Tool Control Log (Figure 5).

TOOL CONTROL LOG

NAME STAMP NUMBER	TOOL DESCRIPTION GAGE TYPE PIN TYPE	TOOL ID # RSP # PIN SIZE	TOOL LOCATION	DATE OUT	DATE IN	JOB #

Figure 5 - Tool Control Log

This option is taken if only a few specific tools are needed. However, the main issue is that many of the machinists either don't fill the log out completely or at all. When a machinist fails to completely fill out the tool control log, there is little or no accountability for the location and use of the tools. This method is therefore highly undesirable; as having dozens of employees with constant access to a tool crib exacerbates the issue of lost/stolen tools. The average cost of tools lost per month is approximately $20,000.

Current Tool Check-In System

To return tools, the machinist simply drops them off in the ATI Tool Return Box with the copy of the Tool Control Request Form, which has stayed with the tools since they were initially pulled from the crib. Then the tools are verified with both copies of the Tool Control Request Form, processed, and marked 'return' in the system. If they were signed out at the tool crib, then they are then signed back in.

Develop Alternative Solutions

Due to the constraints of the project, moving entities around the warehouse is not an option. Because of this, other solutions must be analyzed. Finding a way to reduce the travel distance between two objects without actually moving any objects is impossible, at least on a two-dimensional floor plan. The quanitity of tools, gages, and other inspection equipment is immense, so providing enough tools for each employee to keep is wasteful. Therefore, the actual tool checkout system must be altered.

One way to do this is to cut the retriever out of the system. Ideally, the machinists would have full access to the tool crib, all of their actions would be prompt and flawless, and no wrongdoing would be committed in the form of theft. With over 100 employees, granting general access to the tool crib would result in an increase in tool loss, and a decrease in organization. There are already issues with employees not filling out the Tool Control Log properly, and this method is rarely used as it is.

So, if there were to be stricter regulations on the machinists during the tool checkout process, tool loss would lessen. However, this requires an incredible amount of time, as the general likelihood of the machinists going out of their way to do more paperwork is doubtful. The best method of tool checkouts would be to record all tool checkout processes without requiring more work by any employees, this would surely be most desirable.

Tool Management Options

There are many alternatives to the current tool checkout system. ATI is slowly moving towards a paperless manufacturing system in many ways. For instance, they are looking into implementing a software package called Predator, which is a Program & Data Management package which is designed to help organize and control CNC programs, setup sheets, safety procedures, quality documents, etc. With the forward trend of paperless manufacturing, it would be a positive step to introduce a paperless tool checkout system as well.

AutoCrib Offerings

AutoCrib is an industrial tool management solutions company, with many options to offer. A few of their products include the RoboCrib, AutoLocker, and Remote Dispensing Station.

The RoboCrib is a type of vending machine which utilized divided, rotating plates to hold and dispense tools to the user. This machine can hold between 500 and 2000 items depending on their sizes. This product is good for tool control, but very inefficient at dispensing a various amount of tools quickly.

The AutoLocker is similar to the RoboCrib, but the tools are grouped into individually locked compartments. This option would be great if ATI worked with more repeatable processes. If a specific part were certain to be processed multiple times, then the tools and inspection equipment necessary for this job could be packaged together, and stored as a set for future use. However, ATI is a build-to-print shop, and orders are mostly unpredictable. Even if a part number were sure to be reordered, there is a decent chance that either their blueprint revision would change, adjusting the part dimensions directly, or ATI's manufacturing process revision would change slightly, changing the process in which the part is made, possibly adjusting the tools needed for that operation.

The Remote Dispensing Station is essentially the same as a standard candy bar vending machine. This machine is decently efficient, and it is easy to use, however, the tools necessary would have to fit within the limited helical space provided. The tools and gages ATI uses vary in size greatly, so this product could only be used for a specific range of these products.

The aforementioned three products have many pros and cons. They all have a digitized check-in process, recording all changes to the inventory, which is perfect for keeping track of the tools; however, they all have their deficiencies when dealing with the type of quantity and control that ATI is dealing with.

IntelliPort

Figure 6 - Intelliport

The Intelliport is an RFID-based tool tracking system for an unlimited number of tools. It's essentially an entrance/exit structure that would act as a door to a tool

room, and every tool inside of it would have an RFID tag on it with embedded information such as:

- Type of tool
- Who can use it
- What job it's for
- Condition
- Any desired pertinent information

Proposed Tool Check-out process:

- Enter employee number and pin to the exterior pad (or magnetic swipe/proximity) and enters tool crib to gather necessary tools
- User grabs whatever tools desired, and walks back to the exit. There the user will select 'check-out' on computer inside. There are RFID antennae around where the employee is standing at this point and those will scan what tools are being checked out.
- If all items are usable and the employee has access, then the door will grant access and open.

Proposed Tool Check-in process:

- Follow same steps to get into tool crib, and once inside the user presses ‘check in’ on computer inside.
- Computer can print an optional receipt that will tell the user where to place the items, but if not then the user is free to put them back. User then goes back towards the door and presses ‘check out’ and computer confirms that there are no items in hand, then allows user to exit.

Decide the Best Procedure

There are many factors that are affected with this type of implementation. The most important factor with any business decision like this is cost. Obviously, keeping the system that is currently in place has no initial cost, but implementing this alternative layout will have its initial costs, such as:

- New machinery cost
- Installation costs
- Tagging the tools with RFID tags
- Implementation Training

The benefits of implementing this alternative layout, however, are not as easily quantifiable. Here are some of the benefits, which can be estimated, based on a few assumptions

- Less travel time – More throughput
- Less travel time – Lower labor costs
    - Due to the retriever not needing to walk from inspection, to the tool crib, then the machine, and back to inspection.
- Less errors – saving time and materials
- Less tool loss – both theft and misplacement
- Increased employee satisfaction

Evaluate Procedures

Using a simulation software package ProModel, the current and proposed systems were simulated. A few assumptions were made to make this simulation possible.

- Walking speed of a constant 150 ft/min
- $30/hr labor costs for machinist and retriever
- Equal machine variance (tool requests came from all machines equally)
- 20-30 Tool Request Forms initiated per day (distributed exponentially)

Current Condition

The Current Condition yields the following results:

- Time Spent per Job (- Tool Gathering) 8.79 Minutes
- Time Spend per Day (- Tool Gathering) 3.66 Hours
- Money Spent Per Year $28,548
- Distance Traveled per Job 1,000 Feet

- Tool Losses per month Approx $20,000

Tool Gathering Time is the actual time spent by an employee gathering tools from the tool crib. The reason that tool gathering time is not included in the time results is to better point out the differences between this system and the proposed condition. Seeing as both of these systems will eventually have similar tool gathering times, given a slight learning curve, this variable was omitted.

There are also a few outlying issues with this system, which are harder to quantify in a simulation. First, retrieval time can exceed machine set-up time, causing an immediate hold pattern until tools are retrieved. This happens rarely, and is mostly due to a machinist forgetting to fill out the Tool Control Request form until he/she is finished with the setup. Second, if the machinist finds that a tool he receives from the retriever is either missing or incorrect, this machinist has no direct access to the tool crib, and must utilize the retriever to solve the problem.

Proposed Condition

The Proposed Condition yields the following results:

- Time Spent per Job (- Tool Gathering) 1.9 Minutes
- Time Spend per Day (- Tool Gathering) .79 Hours
- Money Spent Per Year ($30/hr) $6,162
- Distance Traveled per Job 140 Feet
- Tool Losses per month Minimal

This system is vastly streamlined compared to the current condition. The differences are immense, seeing as travel time has been reduced by over 80%. These numbers are based on total time spent in the system. Since a designated tool retriever is no longer necessary, the total time spent, and distance travelled in the system are drastically decreased.

Select Process

The total differences, all in favor of the proposed condition, are shown below:

• Time Saved per Job (- Tool Gathering)	6.89 Minutes
• Time Saved per Day (- Tool Gathering)	2.87 Hours
• Money Saved Per Year ($30/hr)	$22,386
• Less Distance Traveled per Job	840 Feet
• Tool Losses lessened per month	Up to $20,000

These reductions are possible, in part, due to a few reasons. First, it is no longer necessary for the machinist to record extraneous details which were formerly required on the Tool Control Request Form. Secondly, if tools are missing or incorrect, the problem is addressed and solved very quickly, without a need to incorporate other employees in the issue. Third, as tools are scanned back into the tool crib, missing tools will be immediately pointed out. Lastly, any time a product changes hands between employees, there is a much larger chance that problems will occur. Overall, this system requires much less employee time, and reduces the amount of tool loss, resulting in a net profit gain for Absolute Technologies Inc.

Define/Install/Maintain

Employee Mentality of Implementing Change

Most humans are naturally initially resistant to change. People find comfort in a process that they are confident in, and it's not common that one would desire to stray from this. However, change is imperative for companies who wish to continue growing, especially to stay competitive in the manufacturing market.

Toyota, who pioneered many of the Industrial Engineering standards which are used today, was one of the first companies to stop blaming employees for their mistakes. Although this seems counterintuitive at first, Toyota realized something more important. Toyota understood that their company was a team. They trusted that everybody was working towards the same goal, and nobody was intending to fault the system. Although mistakes do happen, Toyota would blame the system for not being strong enough to withstand errors which were going to happen, regardless of how attentive and accurate an employee may be. Mistakes are seen as an opportunity on how to better the system that is in place.

A common misconception is to blame an employee for keeping a tool at their station. Most companies call this theft, and it slows down other departments of the facility. However, it is important to understand why this employee would want to keep this tool. The employee is only looking to speed up the process that he/she is working on. This act is surely beneficial to the company, and the employee is, in a way, helping the company. Now, it is on the shoulders of management to discover why the employee sees returning the tool as such a hassle that he/she would risk punishment for trying to do a task quicker. In this case, the tool checkout system is sluggish. No employee would want to return a tool, only to

have to check it back out in the near future, but to make this process simple, would encourage the employee to act in accordance with the desires of the entire company, and not only of that specific employee.

Implementation Plan

ATI is planning on moving in late December, 2012. This move is intended to be a two week halt to production, while all machines, tools, office equipment, etc. is being moved into the new building and re-calibrated. It will take a few weeks for everyone to settle into the new building, and for production to return to its normal rate.

After things calm down, and production is running smoothly, implementation of the Intelliport should begin.

1/28/2013	Take Inventory of entire tool crib
2/4/2013	Install RFID Portal
2/6/2013	Trial use period begins with few retrievers to ensure system is working properly
2/18/2013	Inventory taken to ensure two-weeks of error-free use
2/25/2013	Introduce Tool Checkout System to machinists
2/26/2013	Assign RFID Portal users to badge numbers. Allow access for soft opening
3/25/2013	Take Inventory again, pending satisfactory results, widen access to more employees

Maintain

Once the RFID Tool Checkout System is in place, it is important to consistently check up on the system. If observed results don't match the simulation expectations, the differences must be investigated. Any observed variation

should be documented. If this variation is an impedance to the company, then a new system should be defined, evaluated, and installed. This process should be repeated until expectations are met.

This system will eventually be outdated. There is a Japanese term "Kaizen" which means continuous improvement. Kaizen is used to explain that changes aren't usually made in large steps such as the ones recommended in this report. Changes should be constant. It is undesirable for a company to put a system in place, and then never to alter this system until is it entirely outdated. Management should continue to look at this system as new technologies arise. Also, machinists will be the ones who live with this system every day, their judgment and suggestions should never be taken lightly.

As new technologies present themselves, management should always keep an eye on where these technologies could be implemented to better the throughput of the company. For instance, while more computers make their way either onto the manufacturing floor, or to each machine, it is imperative to keep an eye on ways to integrate these improvements with the tool checkout systems. Networking capabilities between all machines, computers, and RFID tool cribs will lead to a paperless tool checkout system.

ATI has been expanding steadily for years, and hopefully it will continue to grow for years to come. Currently, 20-30 Tool Control Request forms are processed per day. This number of processes should be easily handled by the limited space in the current tool crib, even with a single Tool Crib Portal Entrance/Exit. However, as production continues to grow, so will the traffic through the Tool Crib. Management should record the instances of crowding to

help identify when it is economically justifiable to increase either the number of portal entrance/exit points, or the total number of tool cribs.

Methods

Throughout the project, a few engineering methods were used to form solutions in various sections.

Simulation

The software package *ProModel* was utilized to develop the simulation of both the current and proposed systems.

Current System Model

Locations:

Machines - The machines square is centrally located. This is where the tool request forms are generated by the machinist.

Tool Checkout Inbox/Queue - The Machinists drop off their tool request form in the tool checkout queue, where they are filed into the tool checkout inbox.

Tool Crib - Once the retriever is ready, he/she walks the tool request form to the tool crib to gather the correct tools. The retriever then moves the tools to the machine, and returns to the tool checkout inbox with the copy of the tool request form.

Entities:

Tool Request Form - This form travels through the path network by being moved by one of the resources (Machinist or Retriever). Sometimes, this entity becomes grouped with others to create a Batch entity.

Tools - At the tool crib, the tool request form becomes the tools that the machinist needs. Once the tools get to the machinist, they are used, then returned to the retriever with the copy of the tool request form.

Path Network:

Net1 - The path on which the retriever walks. The distances are as follows

Tool Checkout Inbox > Tool Crib ---- 250 feet

Tool Crib > Machines------------------- 150 feet

Machines > Tool Checkout Inbox---- 200 feet

Net2 - The Path on which the Machinist walks. The distance from the machines to the Tool Checkout Inbox is 200 feet, as seen above.

Resources:

Machinist - Moves with Tool Request Form to the Tool Checkout Inbox, along Net2. When idle, Machinist returns to the machine.

Retriever - Moves with the Tool Request Form to the Tool Crib, then to the Machines, then back to the Tool Checkout Inbox, along Net1.

Processing:

- The Tool Request Forms arrive at the Machines at a rate of N(19.2, 1.6)
  - Arrival rate based on employee estimation of 20-30 arrivals per day
  - If clock <=8, then they move to the machines
  - Else they exit the system
- When they exit, the system checks to see if total processed = total arrivals. If it does, then the system stops.
- Machinist moves with Tool Request Forms to drop them off in the Tool Checkout Queue
- At the inbox wait N(2,1), if clock <=5, the retriever waits for 3 to accumulate so he can group them into a batch and process them together.
  - If clock >5, then the retriever processes them individually
- The Tool Request form or Batch moves with the Retriever to the tool crib and processes for e(5,3) per tool request form.

- The Retriever brings the tools to the Machines, then returns to the Tool Checkout Inbox to await more forms.

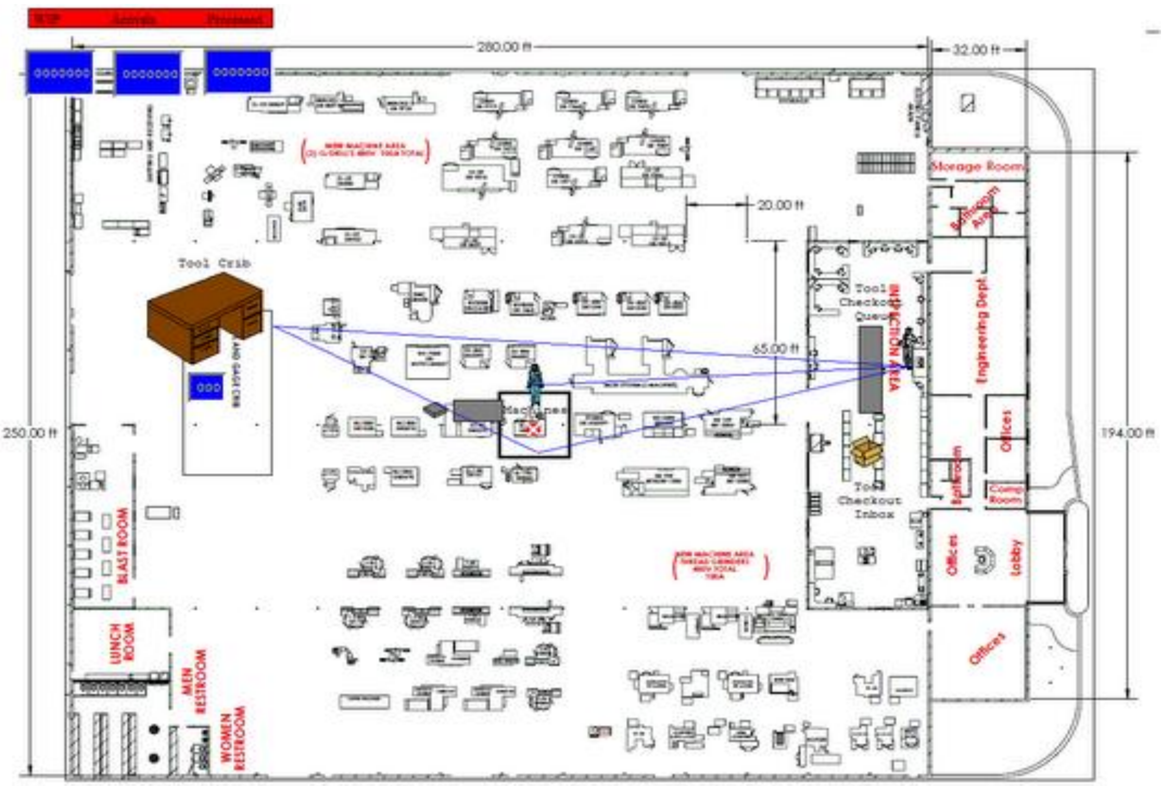

Figure 7 - Current System Simulation

Proposed System Model

Locations:

Machines - The machines square is centrally located. This is where the tool request forms are generated by the machinist.

Tool Crib - Once the retriever is ready, he/she walks the tool request form to the tool crib to gather the correct tools. The retriever then moves the tools to the machine, and returns to the tool checkout inbox with the copy of the tool request form.

Entities:

Tool Lists - This form travels through the path network by being moved by the Machinist.

Tools - At the tool crib, the tool request form becomes the tools that the machinist needs.

Path Network:

Net1 - The Path on which the Machinist walks. The distance from the machines to the Tool Checkout Inbox is 70 feet, as seen above.

Resources:

Machinist - Moves with Tool Request Form to the Tool Checkout Inbox, along Net1. When idle, Machinist returns to the machine.

Processing:

- The Tool Lists arive at the Machines at a rate of N(19.2, 1.6)
  - If clock <=8, then they move on with the process
  - Else they exit the system
- When they exit, the system checks to see if total processed = total arrivals. If it does, then the system stops.
- Machinist moves to the Tool Crib with the Tool List.
- The Tool List moves with the Machinist to the tool crib and processes for e(5,3).
- The Machinist moves back to the Machines to continue work.

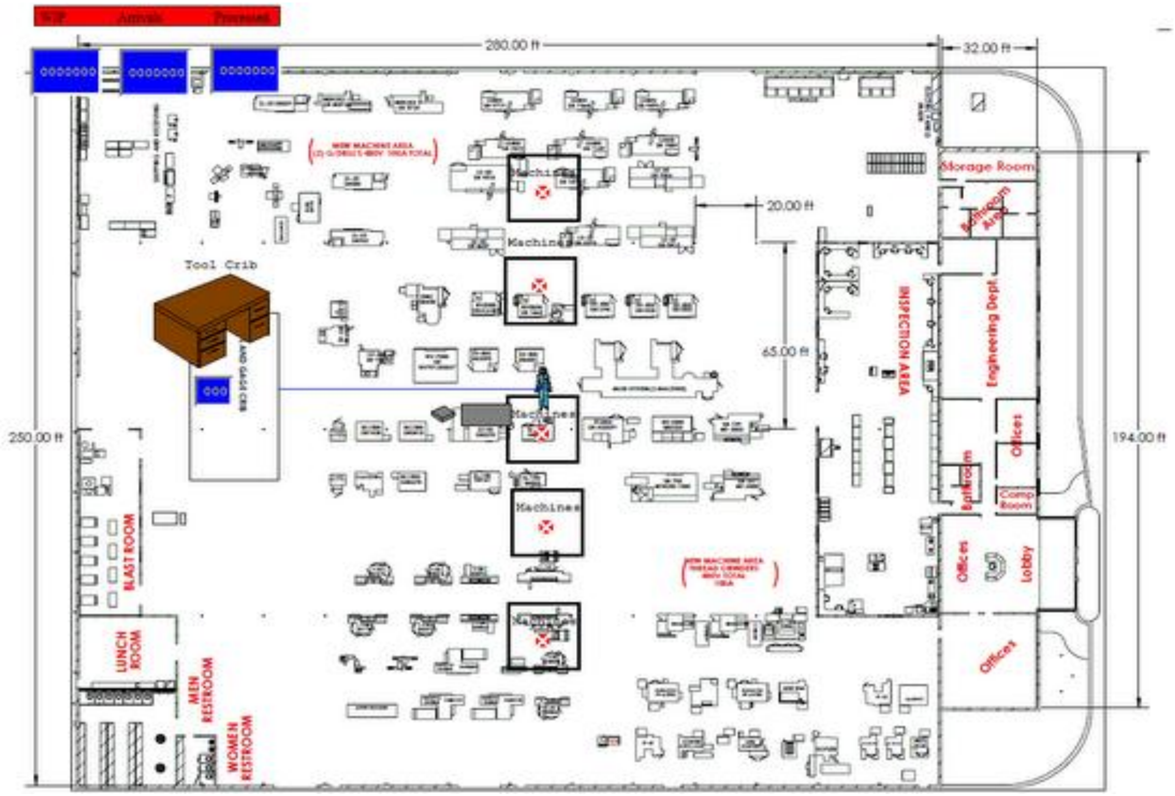

Figure 8 - Proposed System Simulation

A3 Report

An A3 Report is a simple method used to outline the entire life cycle of a problem. Originally developed by Toyota, and now utilized internationally, an A3 Report is a deceptively simple tactic in sharing the inner workings of a systems change. The name A3 represents the paper size that an A3 report is printed on, making it small enough to be easily read and accessible to any employee involved in the process, and yet detailed enough to contain all of the necessary information involved in the problem solving cycle. Since getting employees on-board with change is difficult, this report helps make it easy for every employee to see not only why change must be implemented, but it shows how this change benefits this company.

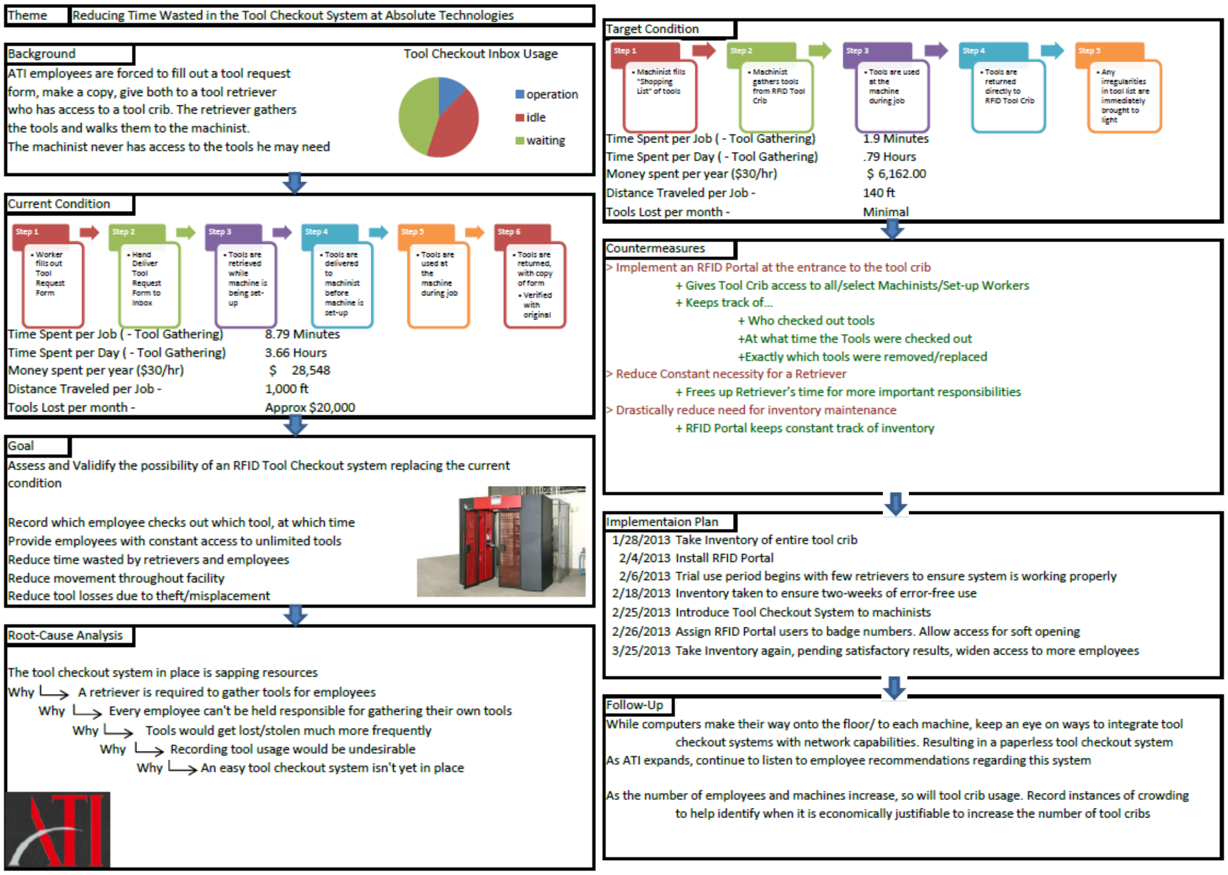

Figure 9 - A3 Report

This A3 report consists of 9 Boxes, each with a specific purpose. This report is read in a specific manner. Starting at the top left, the report progresses in a logical, and chronological sense downwards, then back up to the top right side, then down again.

Figure 10 - A3 Report Theme

First is the Theme, above, which is essentially the title of the report. It is important to make sure that the theme is a single sentence, and shows clearly what the purpose of the report is.

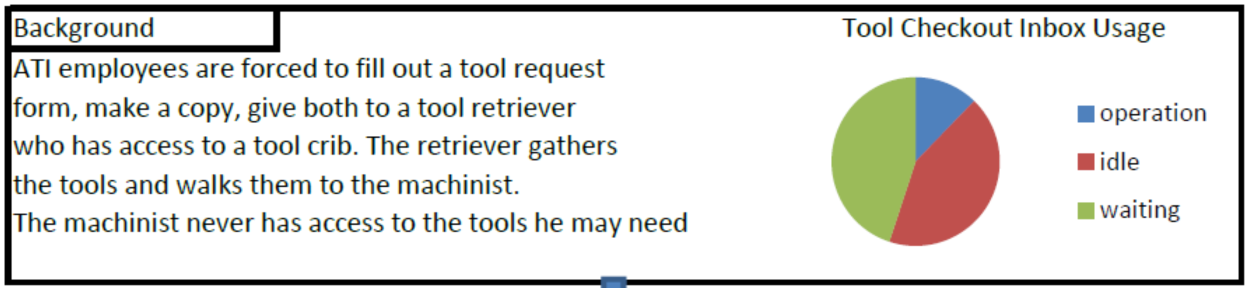

Figure 11 - A3 Report Background

Second is the Background, above. This section aims to establish the business context and importance of a specific problem or issue.

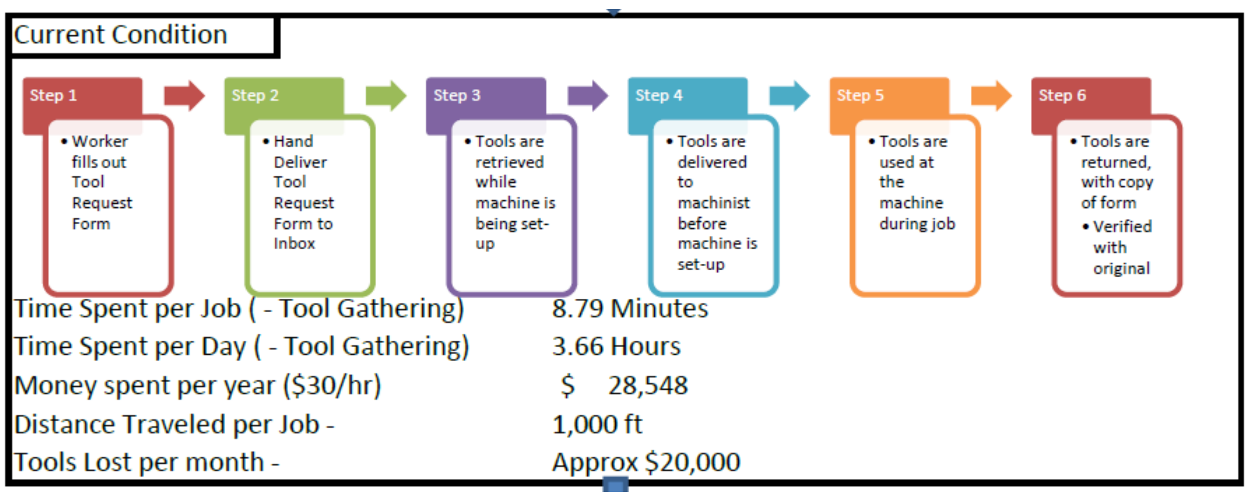

Figure 12 - A3 Report Current Condition

Third is the Current Condition, above. This section simply looks to describe the current condition of the problem. The process outlined in this section was developed by witnessing the process first hand. A simple flow diagram helps to show each step in the process, in chronological order. The results at the bottom of Figure 12 quantify the magnitude of the problem. These numbers were generated using the ProModel Simulation.

Goal

Assess and Validify the possibility of an RFID Tool Checkout system replacing the current condition

Record which employee checks out which tool, at which time
Provide employees with constant access to unlimited tools
Reduce time wasted by retrievers and employees
Reduce movement throughout facility
Reduce tool losses due to theft/misplacement

Figure 13 - A3 Report Goal

Fourth is the Goal, above. The goal should show exactly what needs to be accomplished in the report. Sometimes projects can stray from their original direction; this section can be referred to in the future to stay on track. Also, this section sets an endpoint to the implementation process, acting as a checklist to be reviewed after implementation.

Root-Cause Analysis

The tool checkout system in place is sapping resources
Why → A retriever is required to gather tools for employees
Why → Every employee can't be held responsible for gathering their own tools
Why → Tools would get lost/stolen much more frequently
Why → Recording tool usage would be undesirable
Why → An easy tool checkout system isn't yet in place

Figure 14 - A3 Report Root-Cause Analysis

Fifth is the Root-Cause Analysis, above. This analysis can be done in many ways. Some of the most common of which include the fish-bone diagram, and the 5-why's method. In this application, the 5-why's method was chosen. This step is important when looking into

developing an alternative solution. 5 why's are sometimes necessary to dig into the meat of the issue and fish out the real cause of the problems which appear on the surface.

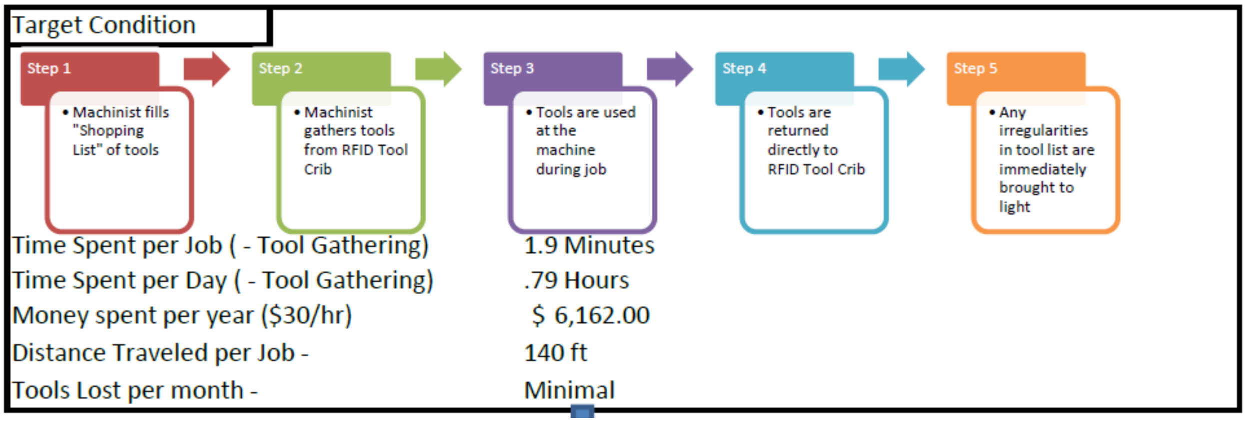

Figure 15 - A3 Report Target Condition

As we move to the top right of the report, we see the sixth box, the Target Condition. This section is very similar to the current condition; however, it shows the system with the new implementations in place, whatever they may be. In this case, an RFID crib is utilized instead of a retriever. Again, a ProModel simulation was utilized to generate the results.

Countermeasures

> Implement an RFID Portal at the entrance to the tool crib
    + Gives Tool Crib access to all/select Machinists/Set-up Workers
    + Keeps track of...
        + Who checked out tools
        +At what time the Tools were checked out
        +Exactly which tools were removed/replaced
> Reduce Constant necessity for a Retriever
    + Frees up Retriever's time for more important responsibilities
> Drastically reduce need for inventory maintenance
    + RFID Portal keeps constant track of inventory

Figure 16 - A3 Report Countermeasures

Seventh is the Countermeasures Step, shown above. Once the current situation is fully understood and the root cause for the main problem has been unveiled this section shows the actions necessary to implement the Target Condition.

Implementaion Plan

1/28/2013	Take Inventory of entire tool crib
2/4/2013	Install RFID Portal
2/6/2013	Trial use period begins with few retrievers to ensure system is working properly
2/18/2013	Inventory taken to ensure two-weeks of error-free use
2/25/2013	Introduce Tool Checkout System to machinists
2/26/2013	Assign RFID Portal users to badge numbers. Allow access for soft opening
3/25/2013	Take Inventory again, pending satisfactory results, widen access to more employees

Figure 17 - A3 Report Implementation Plan

Eighth is the Implementation Plan, above. This should include a list of the general actions necessary to realize the target condition, along with the dates at which these actions are due. Once verified as possible, these dates should be followed closely, or the target condition may never be fully realized.

Follow-Up

While computers make their way onto the floor/ to each machine, keep an eye on ways to integrate tool checkout systems with network capabilities. Resulting in a paperless tool checkout system

As ATI expands, continue to listen to employee recommendations regarding this system

As the number of employees and machines increase, so will tool crib usage. Record instances of crowding to help identify when it is economically justifiable to increase the number of tool cribs

Figure 18 - A3 Report Follow-Up

Last is the Follow up, above. This section may initially seem unnecessary, as it doesn't directly apply to solving the problem, and the goals have technically all been realized. However, there is much value in keeping track of the system's progress. Continuous improvement can't be realized if systems are put in place without intentions of further change down the line. Here, actions should be foreshadowed, in order to keep system improvement in the minds of the management capable of doing so.

Results and Discussion

Results

The ProModel Simulation yielded the following savings:

- Save 6.89 minutes per job
- Save 2.87 hours per day
- Save 840 ft of walking
- 84% less
- Save $22,386 per year on employee time
- 78.5% less per year

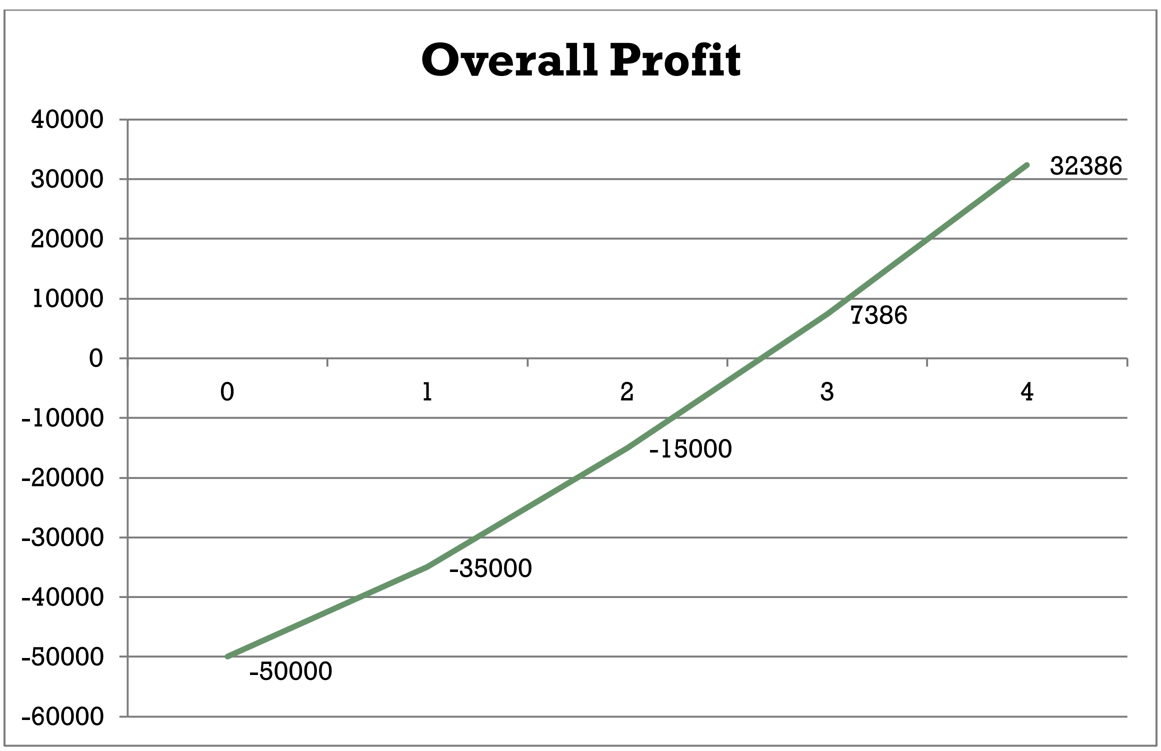

Figure 19 - Cost-Benefit Analysis Graph

Given the approximated initial cost of $50,000, Figure 19 shows the cost-benefit analysis over the following 4 years. This graph takes into account a slight learning curve with the proposed system. The first year, instead of the ideal annual savings of $22,386, the inefficiencies of the employees while they get used to the system drop that savings to $15,000. The following year, the benefits of the proposed system will result in a savings of $20,000 over the current system. After the second year, the system should move past the growing pains and will be running as smoothly as calculated, resulting in the full savings of $22,386 per year. With these estimates, the point at which the savings of the proposed system match the initial cost of implementation will be about 2.6 years. After this time, the proposed system will only serve to be far more efficient that the current system, and financially beneficial to the company.

In addition to these quantifiable savings, there are many more benefits to the proposed system. Due to the fact that tools change hands less often, tool losses because of exchanged tools will be dramatically decreased, resulting in an overall reduction in the average $20,000 spend on tool recovery.

Discussion

These results were expected, seeing as giving the machinists direct access to the tool crib would reduce the amount of time they must deal with a retriever. The goal of this project was hopefully to see if the quantifiable savings based off of the proposed implementations would quickly offset the initial cost of the RFID crib system. The results should prove to be accurate over time. If there is much deviation from the predicted numbers, it would likely be that the savings were

underestimated. In most calculations, the conservative costs of operations were utilized, to ensure that at the very least, this change would prove profitable.

Due to limiting constraints, some assumptions were made while gathering information. Due to the long process times, and irregularities of the repetitive process, an ATI employee was asked for estimates of process times. If more time was available, and more accuracy was necessary, then time studies would likely prove useful in accurately calculating the benefits of the proposed system.

A few other critical assumptions were the paths taken by the employees through the future facility, a constant walking speed of 150 ft/min, and a standard $30/hr across the board for every employee. In this case, distances from each machine to the RFID Portal were estimated, and equal variance between machines was assumed. More analysis would show that some groups of machines change jobs often, and would require a greater weight attributed to their position. As these distances and frequencies would change, the hourly rates of the corresponding employees would alter the results of the simulation. Getting more accurate information on all of these assumptions would take a considerate amount of time, but the amount of pressure put on this project to be accurate could justify those efforts.

Summary and Conclusions

Absolute Technologies Inc. will be moving to a much larger facility this winter. They are looking for an efficient way to utilize this space. The machine positions were taken as fixed, seeing as a lean expert was brought in to give advice on placement. With the machines fixed, the scope was narrowed to other areas.

A systematic approach to facilities design was utilized. First, a goal needed to be defined. The goal was to reduce the time wasted in the inspection processes of ATI. Next, to narrow the scope, was to define the departments. The departments were broken up into two sections, those that were possibly applicable to the project, and those that should be disregarded. Next, the relationships between the possibly applicable departments should be quantified. A to-from chart was developed to identify the most important department relationships. This chart yielded three relationships, but the proposed layout of the machines by the LEED expert showed that there was a large distance between one of these three important relationships. This relationship was between the Tool and Gage Crib, and the Inspection Area.

A very important process which involves these two departments is the Tool Check-out System. This system was analyzed in depth, and simulated in a software package called ProModel. Once the current system was fully understood, Alternative solutions were discussed. The most viable of which being the implementation of an RFID Tool Crib Portal. This proposed system was

defined, analyzed, and simulated using ProModel. The simulations of the two tool checkout systems yielded the following results.

- Save 6.89 minutes per job
- Save 2.87 hours per day
- Save 840 ft of walking per job
    - 84% less walking per job
- Save $22,386 per year on employee time
    - 78.5% less per year
- An overall payback period of approximately 2.5 years

An A3 report was then developed, in order to help educate the entire company efficiently. This A3 shows the entire life-cycle of this problem-solving effort, and it shows it in a user-friendly format.

Much was learned during this project. Multiple facets of Industrial Engineering were used in the development of this report, and many more could be applied once ATI moves into the new facility. Implementing the RFID Tool Crib Portal is recommended, as the overall benefits of the system should outweigh the initial costs within a matter of a few years. Also, the A3 report should be available to every employee who will be affected by the changes implemented. In order for this proposal to work to its full capacity, everyone should be on-board, and up to date with the overall direction of the company.

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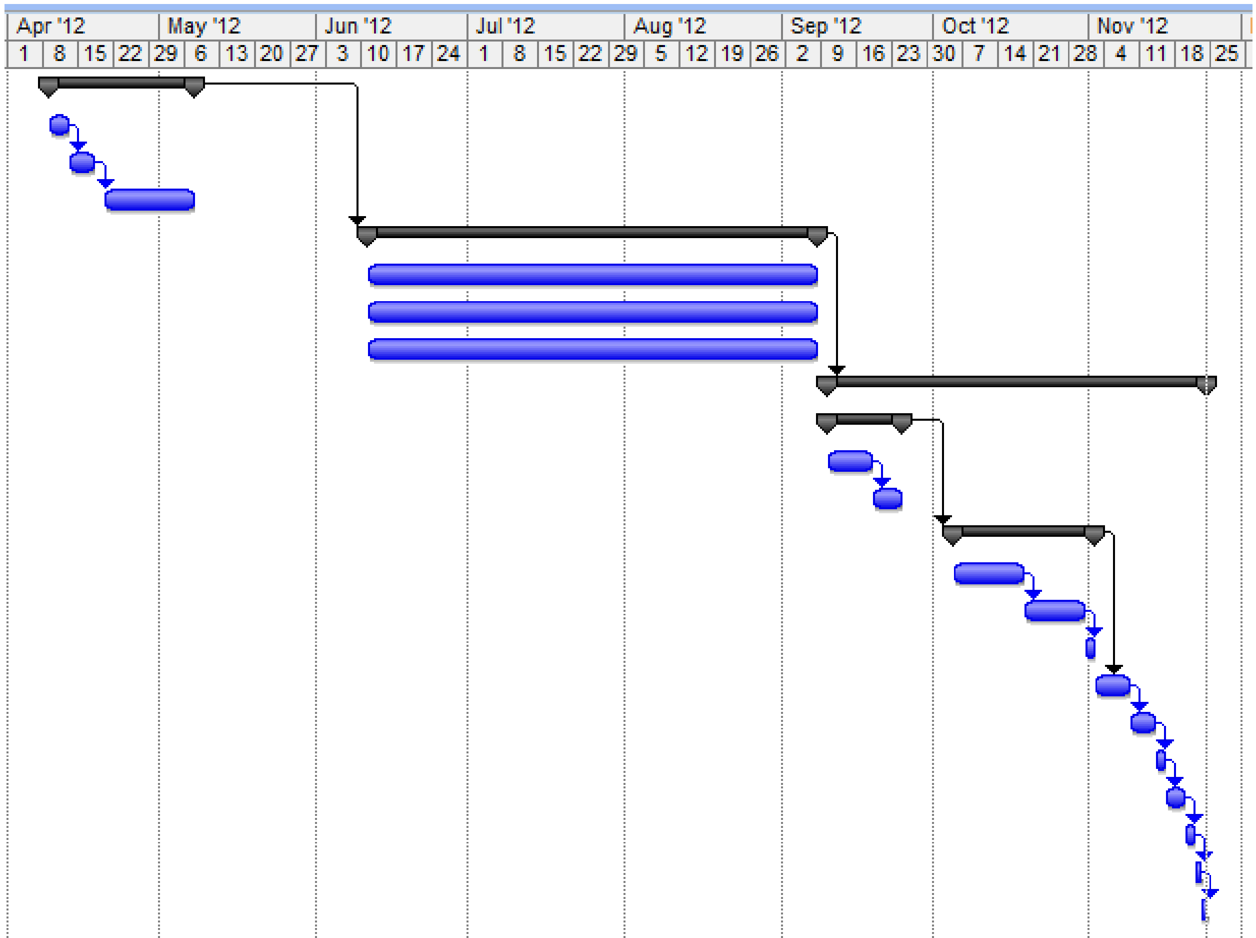
Appendix

Appendix A: Project Management Gantt Chart Schedule

		Task Name	Duration	Start	Finish	Predecessors
1		**Prepare for summer**	**21 days**	**Mon 4/9/12**	**Mon 5/7/12**	
2		write introduction	4 days	Mon 4/9/12	Thu 4/12/12	
3		write background	3 days	Fri 4/13/12	Tue 4/17/12	2
4		write lit review	12 days	Fri 4/20/12	Mon 5/7/12	3
5		**Summer Internship**	**65 days**	**Mon 6/11/12**	**Fri 9/7/12**	**1**
6		Define Departments	65 days	Mon 6/11/12	Fri 9/7/12	
7		Define Relationships	65 days	Mon 6/11/12	Fri 9/7/12	
8		Define Requirements	65 days	Mon 6/11/12	Fri 9/7/12	
9		**IME 482**	**55 days**	**Mon 9/10/12**	**Fri 11/23/12**	**5**
10		**Analyze Systematic Approach**	**11 days**	**Mon 9/10/12**	**Mon 9/24/12**	
11		Identify Problems	7 days	Mon 9/10/12	Tue 9/18/12	
12		Plan solutions for Layout	4 days	Wed 9/19/12	Mon 9/24/12	11
13		**Create Projected Facility Plan**	**20 days**	**Fri 10/5/12**	**Thu 11/1/12**	**10**
14		Develop Alternative Layouts	10 days	Fri 10/5/12	Thu 10/18/12	
15		Compare Layouts based on simulati	8 days	Fri 10/19/12	Tue 10/30/12	14
16		Select Layout	2 days	Wed 10/31/12	Thu 11/1/12	15
17		Write Design Section	5 days	Fri 11/2/12	Thu 11/8/12	13
18		Write Methods/Experimentation	3 days	Fri 11/9/12	Tue 11/13/12	17
19		Write Results & Discussion	2 days	Wed 11/14/12	Thu 11/15/12	18
20		Write Conclusions	2 days	Fri 11/16/12	Mon 11/19/12	19
21		Write Abstract	2 days	Tue 11/20/12	Wed 11/21/12	20
22		Peer Review	1 day	Thu 11/22/12	Thu 11/22/12	21
23		Final Presentation/Turn In	1 day	Fri 11/23/12	Fri 11/23/12	22

Appendix B: Project Management Gantt Chart Calendar



Appendix C: Cost-Benefit Analysis

	Year				
	0	1	2	3	4
Total Saved		15000	35000	57386	82386
Initial Cost		-50000	-50000	-50000	-50000
Cost-Benefit	-50000	-35000	-15000	7386	32386

Appendix D: Department Definition