ETM
ENGINEERING & TECHNOLOGY MANAGEMENT

Financial Analysis of Automated CNC Systems for Nike's Mold and Tooling Center

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Professor:	William Eisenhauer

Team Members:
Zuhair Alheayk
Ahlam Alsuwaida
Shihab Hanayneh
Shane Iverson
Sridharkumar Paneerselvam
Zachary White

Portland State
UNIVERSITY

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Does Nike needs new automated CNC machines?

Abstract

The aim of this paper is to document the process of investigating the option of replacing existing machines used to create new design molds for shoes. Nike's management is aware of production inefficiencies at the Mold and Tooling Center (MTC), which are causing orders backlog. As a result, many design departments outsource new design processes to third party venders in order to keep their schedules on time.

This paper discuss analysis of three options that management might consider prior to make a final decision. First, keep using the existing machines and maintain the same capacity level; which would allow some design departments to outsource services through a third party. Second option, is to hire more machinist to operate the existing system with the objective of eliminating backlog. The third option is to replace three non-automated machines with a new set of CNC fully automated machines; and implement a policy of zero outsourcing.

Introduction

Nike's Mold and Tooling Center (MTC), located in Beaverton, Oregon at the Nike World Headquarters Campus, is responsible for developing prototype molds and tooling for future Nike products. The MTC's customers are various internal departments and category divisions such as Cushioning Innovation, Running, Jordan, Converse, and Man Rev.

These customers create product concepts in the form of drawings, rapid prototypes, and computer aided design (CAD) models as a means of formulating and communicating new ideas. New concepts and breakthrough innovations go through many concept iterations and design reviews often involving virtual simulation, finite element analysis, hand modeling and rapid prototype testing. Once the design details finalized, CAD models of the various parts created and files sent to the Product Creation Center (PCC) for prototyping.

The PCC consists of several departments including Stitching, the Digital Creation Center, the Plastics Lab, and the MTC. Each of these departments is responsible for different components in the creation and construction of prototype products. The MTC has the responsibility to get all the files for plastic, rubber, phylon, and metal parts that need to be made and creates molds for forming these parts, or directly creates the parts if they are to be made of metal. The molds and most of the metal parts typically made from aluminum, but other materials occasionally used including steel, titanium, brass, carbon fiber, and plastics.

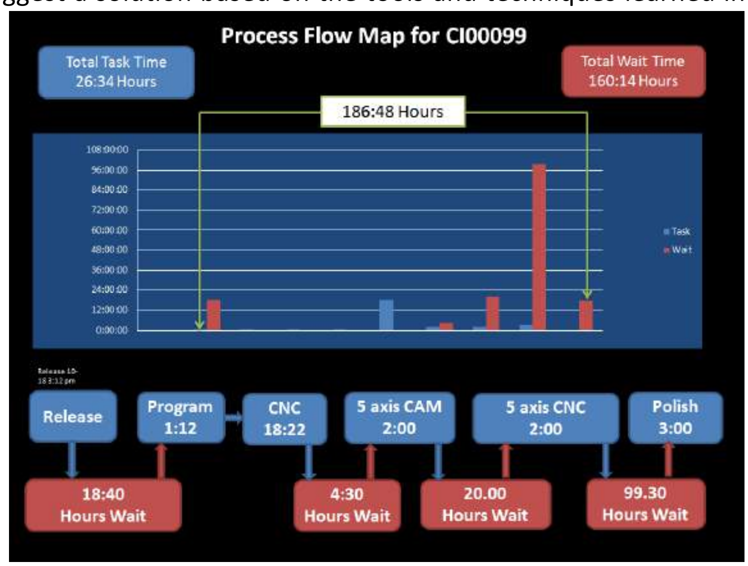
The process for making these parts involves using CAD software for modeling and designing the molds, followed by using Computer Aided Manufacturing (CAM) software to develop the toolpaths that a computer numeric controlled (CNC) machine uses to remove material from a raw block.

CNC machining process used in the manufacturing sector that involves the use of computers to control machine tools. With CNC machining, the computer can control exact positioning and velocity, which is faster and more precise than manual machining, and can be repeated in exactly the same manner. Because of the precision possible with CNC Machining, this process can produce complex shapes that would be almost impossible to achieve with manual machining. CNC Machining used in the production of many complex three-dimensional shapes and it is because of these qualities that CNC Machining used in jobs, which need a high level of precision or very repetitive tasks and assumes a key part in the field of cutting-edge production [1].

The time required for this process from beginning to completion has been more than acceptable to expected workflow. On average total task time is about 26:34 hours; however, total wait time can reach 160:14 hours. The actual CNC machine in use time is 18:22. This has resulted in project backlog.

MTC team is looking at several alternatives to improve the process flow and to reduce total wait time. The less wait time between projects, the more projects are completed.

It is the team objective in this paper to suggest a solution based on the tools and techniques learned in engineering economics.



MTC workflow can get very involved as product design gets more innovative. The CAM software creates a set of instructions, called G-code, for the control and cutting movements of CNC machines. Once the G-code program generated, Machinists load the program files into the CNC controller and set up cutting tools, fixtures, and raw stock for making the parts. The G-code program customized for each different part and the machines programmed to control features such as feed rate, coordinate location, and spindle speeds. Therefore, prior and after the CNC machine operation there are number of hours needed to prime the machines. It is believed that the wait time can be managed more effectively, which would reduce wait time for projects going through the MTC.

Advantages and disadvantages of automated CNC machines in manufacturing:
Contemporary firms are widely using the automation system in manufacturing industry. There are many advantages of using automated system in manufacturing, which are [2] [3] CNC machines that can operate all day, 365 days a year, unless they are halted and switched off during maintenance. These machines designed, and programmed in a way to serves a specific purpose to maximize benefits. Furthermore, the automated CNC machines known to reduce the need for bringing skilled people to run these machines, which reduces labor cost. It is possible to, easily; improve the functionality of these machines by updating their software.

However, there is large initial investments needed to acquire the automated machines. The more advanced the technologies of these machines, the more money firms need to pay for them. Relying on automated machines may have an effect on countries' economies by decreasing the needed number of employees, which may results in an increase of unemployment. Adopting automated systems could increase the energy requirements in order to operate these machines. This could cause increase to the overall pollution level.

Needless to say, if automated CNC machines were acquired by Nike, it is believed that the employment level would not change at MTC. The team made such deduction based on the understanding that the current number of machinist are working one shift and it is assumed that replacement of three CNC machines only, which would mean the more output for every man-hour.

Maintenance costs

It is anticipated that the maintenance cost will go up. Based on detailed work document at various sections within this paper we find annual expenses will increase from $418.8k to $1,826.3k if the automated CNC machines purchased. Throughout this paper, the team reflected such change is annual maintenance costs.

Literature review

The objective of this paper is answer the question *Does Nike needs new automated CNC machines.* In other words if three automated CNC machines replaced three out of the nine CNC machines would the MTC operate more efficiently. It is believed that using automated CNC machines would reduce time significantly, as automated machine process is not subjected to time-consuming variable such as operator preference [6]. Automated process may also results in cost-efficiency due to increased capacity, and consistent machining results.

No prior theoretical literature, surveys, or technical analysis was available for the team prior to this study. However, the team used engineering economics tools to answer the key question of this paper. Furthermore, the team recommends future Portland State students follow up on the conclusion of this paper and assess if the recommendation of this paper achieved the sought after results.

Problem definition

The team's objective is to look into the analysis of three options that management might consider prior to make the final decision. First, keep using the existing machines and maintain the same capacity level; which would allow some design departments to outsource services from a third party. Second, replace the existing machines with a new set of CNC fully automated machines and implement a policy of zero outsourcing. The third option is to hire more machinist to operate the existing system with the objective of eliminating backlog.

Methodology
A seven step engineering economic analysis procedure was used to organize the decision making process. Sullivan, Wicks and Koelling warn that key learnings and improvements to the decision making process will be missed if the impact of uncertainty is not examined as part of a post-evaluation of the decisions [5]. However, the last step in the analysis, "performance monitoring and post-evaluation", will take place in the months following this report and therefore, no information has been collected on this part of the analysis to date.

To assess the three identified options the team implemented the following methodology. First, clearly identify the scope of the project and the choices (alternatives) that are available. Second, the team aims to identify the different outcomes that result from each choice. Third, the team will develop a defined viewpoint that is consistent in assessing each option. Fourth, the team will identify the measurement units to enumerate as many outcomes as possible. Fifth, a consideration of all relevant criteria including monetary units will be included to each option. Sixth, estimating the risk and uncertainty resulting from each future outcomes. Seventh, review the recommend decision and identify other comparable actual results and outcomes.

Study overview
Nike is an American and multinational corporation engaged in developing innovative sports products and services. Nike is pioneer in the design, development, manufacturing and worldwide marketing and sales of footwear, apparel, equipment, accessories and services to athletes.

The company's 10K year-end 2014 report shows that total revenues reached USD 27.7 billion in 2014, an increase of about 10% over 2013 figures. The year-end report indicates that total employees worldwide including retail and part-time employees has reached has approximately 56,500.[7]

Increase in overall Nike's revenues at FY 2014 highly correlated with the competitiveness and resilience of the corporate culture. Nike has a complex worldwide operation; however, company's financial success has been a reflection of its ability to stay ahead of competition and maintain a favorable market position due to unique innovative product design, market development and above par manufacturing processes.

Problem recognition

The Mold and Tooling Center (MTC) at Nike has the mission to make prototypes products designed by different departments. Nonetheless, project deadlines missed and customers (design departments) are reporting that they are turning to outside vendors to get their projects done.

This team was able to verify such a conclusion by analyzing data for the number of new projects per month from February 2014 to April 2015. The graph below indicates that the trending is decreasing in number of new projects requested by MTC customers as time per project trending is increasing to complete on time.

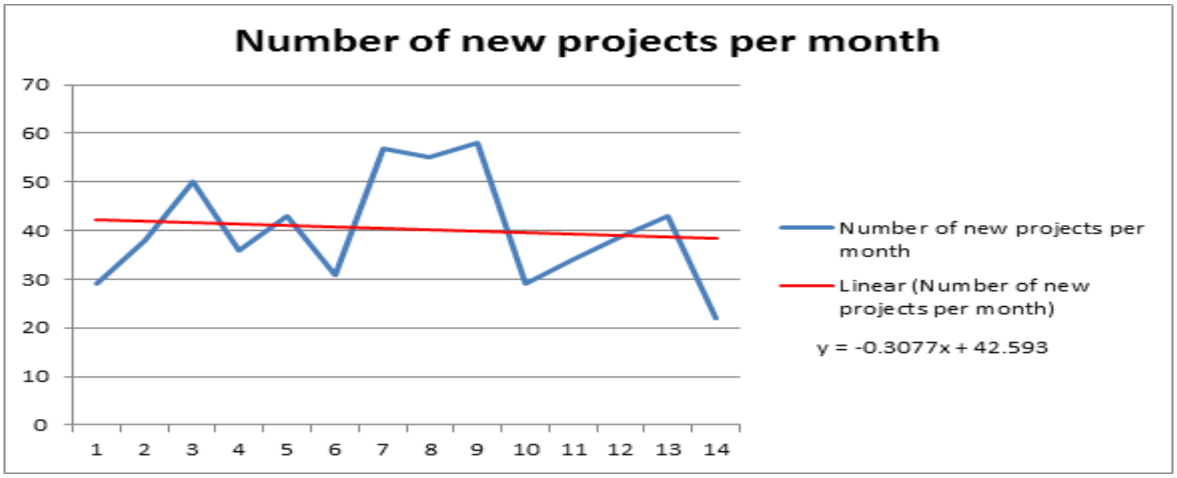


Fig1. Number of new projects per month from February 2014 to April 2015.

Furthermore, data collected by the MTC project tracking system, AtTask, shows that over the past year requests for new projects has decreased by -0.3077 projects per month, or an average a decrease of 0.72% per month. **The Scope of this paper is to identify the solution for such trending, by considering the replacement of existing machines and discussing number of alternatives. The objective is to improve the overall workflow, and address the concern of why MTC is not able to respond promptly to requests form customers**.

On the other hand, as competition within the market place increases between the main international suppliers of athletic, wear products and services, Nike continues to thrive financially due to corporate culture that promotes innovative solutions to all types of sport activities. Nonetheless, this comes with an increase in the complexity of new projects, which has led to an increase in the time required to complete overall projects processed at the MTC.

This conclusion was verified from data collected using, AtTask, which shows on average there is 16.2 more "combined project days" per month to complete. In other words, there is an average increase of needed 2.73% more days per month to complete projects.

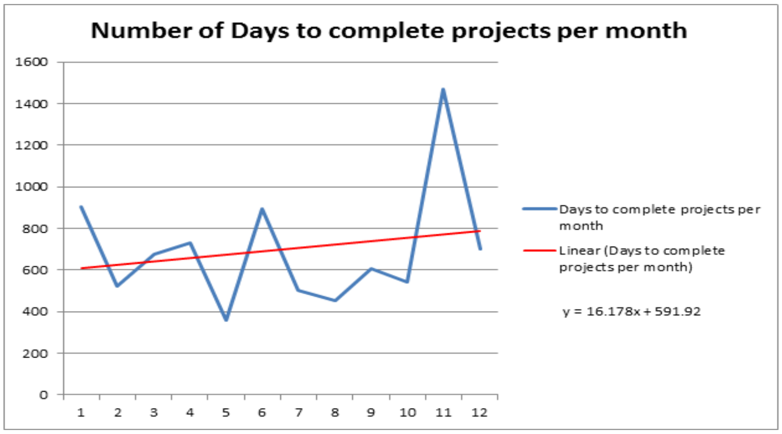


Fig 2. Number of days to complete projects per month from April 2014 to April 2015.

As a result, the overall project flow at MTC affected negatively. The belief that missed deadlines are due to the increasing complexity of projects requests from new experimental and design departments. As new projects become much more complicated than what the existing machines can process; alternative solutions need to be discussed.

Development of feasible alternatives

First, keep using the existing machines and maintaining the same capacity level is not an acceptable option due to inefficiencies and backlog. Furthermore, increasing the number of the same machine type is also not an option due to space scarcity and limit on the total number of floor employees.

Second, increasing number of machinist (number of shifts) to increase existing machine utilization is not believed a viable option as the downtime between projects becomes larger as need to prime machines becomes more frequent to meet projects complexities. Furthermore, skilled machinists are difficult to find and additional head-count for the shop is difficult to acquire because head-count is determined on a campus wide need bases.

Third alternative is to replace the existing machines with a new set of CNC fully automated machines. Coupled with a zero tolerance of outsourcing projects to be integrated over time.

Development of the outcomes and cash flows for each alternative

Engineering economy offers number of tools and techniques for the analyst to infer and select between options. Conceptually, the first and the second alternatives discussed in the section above are not within the scope of this paper.

Thus, to assess the third alternative, several tools were used. It is imperative to discuss these tools and their importance prior to reporting on the computed findings. The objective is to select the "superior alternative" between two mutually exclusive.

Therefore, annual net worth computed to compare between the two options. (a). the rational for computing annual worth as appose to estimating present worth of either given option, is that the objective is to determine the capital recovery between two alternatives over mutual useful lives. (b) in principle, the task is to reason between continuing to use the existing system (defender) as appose with the replacement (challenger). Thus, finding the Equivalent Uniform Annual Cost (EUAC) between the two alternatives, establishes the so-called outsider viewpoint between the two choices. Lastly (c) by equating the equivalent annual worth of the two alternatives was used to determine capacity utilization between the two alternatives.

Computation and analysis

The objective of the computation and analysis framework is to provide the decision maker at Nike with engineering economy, scientific, tools to make a better conjecture as whether to keep using the same set of CNC machines or purchase and replace a three set out of the total nine machines with a new automated CNC machines.

The team had to make some general operational and business assumptions. In addition, to specific assumptions, which discussed at each computational analysis section. The general operational and business assumptions included the following:

1. The MTC has a problem with operational efficiency, which currently stands at 13.5%. An increase in efficiency will resolve the problem of project back long and improves total overall prototype testing at Nike.
2. Minimum Acceptable Rate of Return (MARR) at Nike was unknown to the team. An 18% base-line assumption was made; however, it is believed to be higher than 18% as Nike is considered to have a highly innovative business culture.
3. The driving assumption is that the team based alternative analysis between having the existing set machines compared to the new automated system. To ensure “reasonability” in the analysis, the team decided to frame the question as comparison between purchasing brand new CNC machines verses brand new automated CNC machines.
4. No parametric cost estimate mythologies used to compute the capital investment costs or the operational costs, as no index data was available to the team. Costs for capital investment taken directly from venders’ price list.
5. Operational data for the new automated CNC machines was not available. By using Excel Solver, the team extrapolated operational costs for the new automated CNC data from the existing machines data.
6. The team assumed figures “normalization” by maintaining comparison based on identical data set for both machines with different utilization capacity i.e. existing is the baseline verses automated as an alternative.

1. Comparison and selection among alternatives (Equivalent – Worth Method):

To compare and select among alternatives the team's strategy was to compute the equivalent – worth to determine the capital recovery for each alternative i.e. non-automated baseline verses automated. The rational for selecting this method supported by the assumption that comparing annual worth between presumably two equivalent alternatives yields the annual cost per each alternative to Nike's overall annual cost analysis.

The team decided that present worth and future worth computation do not pertain to the objective of selecting between alternatives used as a fixed asset by Nike. Furthermore, the machines were not expected to generate revenues; therefore, no IRR or ERR computations for comparison purposes deemed necessary. Moreover, incremental analysis of investment alternatives would not suffice as this technique used when the objective is to qualify between alternatives that generate incremental revenues and compared between mutually exclusive others.

The overall mathematical model for comparison and selection among alternatives is:

P (A/P, 18% 7) where; $A = P\left[\frac{i(1+i)^N}{(1+i)^N+1}\right]$ …………… (1)

Comparing capital worth between alternatives is using annual worth computation to recommend the least annual worth expense as the superior alternative. Thus, the model includes capital investment and annual operating and maintenance cash expenses only, all noncash expenses and estimated salvage value excluded. The findings summarized in the table below:

MARR	18%	CNC non-automated system	CNC automated system
Total machines hours /year	26,298		
Annual available hours		3,556	23,668
Utilization		13.5%	90%
Scrap rate		5%	1%
Capital investment (3 machines)		1,485,000	2,235,000
Total annual operational cash expenses		418,801	1,826,379
	EOY	Computed cash flow	
	0	(1,485,000)	(2,235,000)
	1	(418,801)	(1,826,379)
	2	(418,801)	(1,826,379)
	3	(418,801)	(1,826,379)
	4	(418,801)	(1,826,379)
	5	(418,801)	(1,826,379)
	6	(418,801)	(1,826,379)
	7	(418,801)	(1,826,379)
AW (EOY 1 to 7) + (EOY at 0) value @ 18%		(808,409)	(2,412,758)

The table above indicates that CNC non-automated system has an annual worth less than the CNC automated system. However, since the capacity is not the same when comparing such conclusion is needs further adjustment.

To normalize the computed AW computed value for each of the alternatives divided by the maximum available capacity available to each set of machines. The normalized AW found to be $227 and $102 respectively. Thus, we can conclude that the CNC automated system is a superior alternative when compared to the CNC non-automated system.

2. Estimated Uniform Annual Cost (EUAC) method.

Equivalent uniform annual cost analysis was performed for the automated CNC system, the current system as purchased brand new, and the current system as is. The lifespan for each system is assumed to be equal at 7 years as well as the decrease in market value is equal to the decrease in book value from depreciating the asset using the straight line method. The capital cost was calculated and included as the lost opportunity cost at MARR from the previous year's market value.

The calculated EUAC is then normalized by the maximum utilization of each system. The defender and the non-automated replacement are assumed to be at 14% utilization taken from gathered data supplied by Nike. This is a valid assumption for the life span of the machines as the tooling center has already stated that they are at max capacity. The automated replacement is assumed to be at a 90% utilization. This value is used in an initial analysis because the manufacture has specified that the machines when set up properly can run with a less than 10% total down in a year.
The EUAC was calculated using the formula listed below.

$$EUAC_k = \left[\sum_{j=1}^{k} (Total\ Annual\ Costs)_j (P/F\ , MARR, j)\right] (A/P\ , MARR, k)$$

The initial results show that when the EUAC is normalized with respect to the maximum machine utilization, the automated machines outperform both the current CNC machines as well as the replacement. This result is not sensitive to a change in MARR.
Further, a production utilization break-even analysis for was performed to show what the production utilization would need to be in order for the normalized EUAC of the automated CNC system to equal the current system and the replacement system. A non-linear solver program was set up to solve for the production plan. The formulation is as follows

$$Max\ Z = \sum_{i=1}^{7} E_{ij}\ for\ j = 1$$

$$S.T\ E_{i1} = E_{i2}\ for\ all\ i$$

The results are as follows:

Solver for Break Even of current system							
EOY	1	2	3	4	5	6	7
Annual Expense	1,086,744	1,071,063	1,056,481	1,042,957	1,030,448	1,018,911	1,008,299
Production units	686	673	660	649	638	628	619
Utilization	49%	48%	47%	46%	45%	44%	44%

Solver for Break Even Production Replacement CNC							
EOY	1	2	3	4	5	6	7
Annual Expense	621,719	621,732	621,744	621,756	621,767	621,779	621,789
Production units	288	288	288	288	288	288	288
Utilization	20%	20%	20%	20%	20%	20%	20%

The assumptions listed below are all related to the calculation of the total annual expense that would be realized for running the machines.

Assumptions

Annual Cost calculation is variable based on utilization. The higher the utilization the higher the annual cost. This is due to the fact that the more projects produced the more material must be purchased. The cost calculation is as follows:

1. Operator Cost – Salary cost per employee needed
2. Mold Design Cost – Salary cost per employee needed
3. Maintenance for robot per year – Yearly cost of maintenance for the robot guided system as specified by the vender
4. Materials Cost – The per unit cost of materials multiplied by the number of projects
5. Utilities Cost- Flat cost per machine per year
6. Recycling - Amount per project and is sold to help offset materials cost
7. Operator $/year + Mold Design/year + Maintenance costs per machine per year + Maintenance costs for robot per year + Materials cost + Perishable Tooling per year + Utilities + Consumables – Recycling
8. Utilization – number of projects multiplied by the cycle time per project divided by the total number of hours in a year.
9. Cycle time per project doesn't change. This assumption states that the variable time to complete a project doesn't change. This assumption is valid because the automated system decreases down time between projects and not time to produce projects.

3. Sensitivity Analysis

Sensitivity analysis technique used in engineering economics to survey what happens to profitability when an estimated value in the model is changed. However, since the essence of the problem at hand does not include a profitability component, then the question becomes why we would include sensitivity analysis in this paper. The team debated the value added from such analysis and discussed the pros and cons of including such analysis this paper.

The team concluded there are number challenges result in including sensitivity analysis. The two big unknowns are total number of projects and the cost of contracting a project to an external vender. However, including sensitivity analysis in this paper helps to examine and identify the key drivers for having successful MTC operations at Nike.

To estimate total number of projects the team extrapolated that number from existing number of projects based on 13.5%. The estimated total number of projects expected to reach 12,073 at 90% utilization. Due logistical challenges, at Nike, the team was not able to verify the validity of the estimated total number of projects at 90% utilization. In addition, the team was not able to survey design departments to model a regression to verify future number of projects. Nonetheless, the team is comfortable with the 12,073 project at 90% of machine utilization for the purpose of this paper.

To estimate the cost of contracting a project to an external vender the team had to make two embedded assumptions. 1) All the 12,073 projects assumed to be worked by external venders. 2) The cost of (value) each project charged by external vender at which all sensitivity values are at zero is equal to $1880. The objective is to estimate PW savings generated with no factor change. The following is summary of findings and discussion:

Capital investment		2,235,000		2,235,000
Annual savings		2,418,933		2,303,133
Annual expenses		1,826,379		1,826,379
Useful life		7		7
MARR		18%		18%
% change in factor	Capital Investment	Annual Savings	Annual Expenses	MARR
-20%	470,537	(1,820,429)	1,415,796	275,299
-15%	358,787	(1,359,437)	1,067,731	208,248
-10%	247,037	(898,446)	719,667	144,038
-5%	135,287	(437,454)	371,602	82,516
0%	23,537	23,537	23,537	23,537
5%	(88,213)	484,529	(324,528)	(33,032)
10%	(199,963)	945,520	(672,592)	(87,318)
15%	(311,713)	1,406,512	(1,020,657)	(139,439)
20%	(423,463)	1,867,503	(1,368,722)	(189,506)

Table XX is PW values for varied factor values.

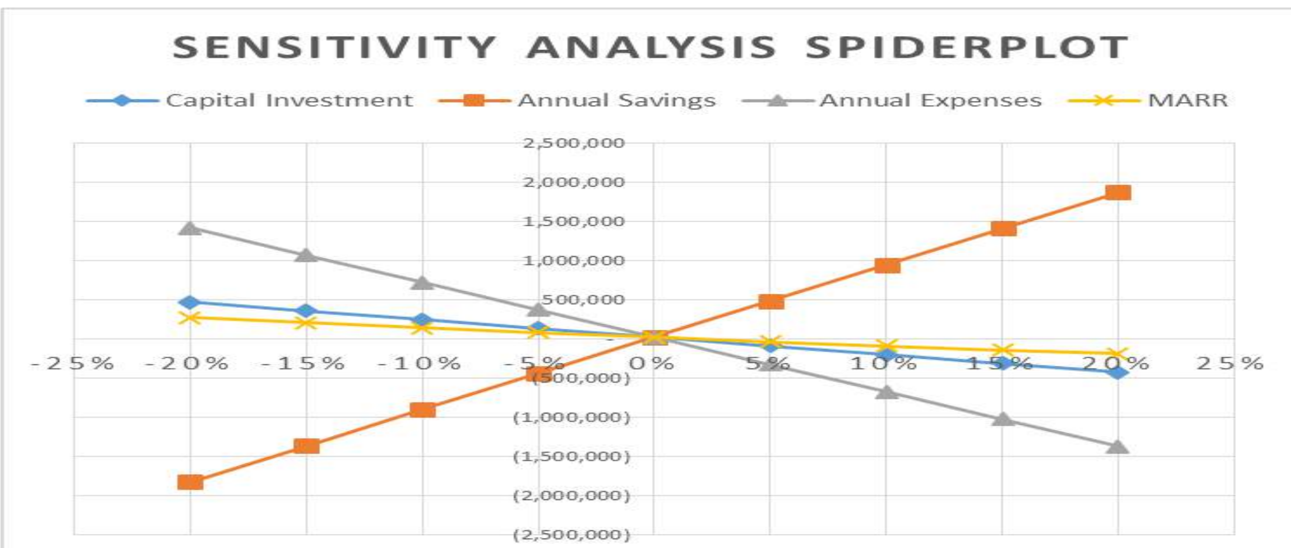
The table above highlights the results of the sensitivity analysis. The values for capital investment, annual expenses, useful life and MARR all defined and discussed in prior sections of this paper. However, the new line item introduced in this section is “annual savings”. Annual savings are attend if the automated machines were selected, and computed by multiplying the total number of projects times the estimated cost of each project at zero percent factor change in factor.

The objective of the table above is to measure the explicit impact of variability (percentage change in factor) in the estimate of each factor at the present value. By plotting the results of such changes in the estimates of several factors, separately, if the automated machines were selected.

The driving mathematical model to estimate each factor's decision reversal point and its sensitivity based on computing the Present worth. The following is representation of PW

$$(P/A, 18\%, 7); \text{ where } P = A\left[\frac{(1+i)^N - 1}{i(1+i)^N}\right]$$

The spiderplot graph provides insightful information. The value of favorable PW shown at the intersection point of the percent deviation graphs for the four separate factors of the automated option. The relative degree of sensitivity of the PW to each factor indicated by the slope of the curves. The steeper the curve the more sensitive the PW is to the change factor



Another interesting point here is that the intersection is at zero. This shows the decision reversal point i.e. the percentage change from each factor, most likely, the value at which PW is equal to zero. The spiderplot graph indicates that PW values of each factor are insensitive to both MARR and capital investment. However, PW values are positively sensitive to changes in the annual savings and negatively sensitive to annual expenses.

Limitations

The team had access to two sets of data. The first set of data was gathered from venders[*] to estimate the capital investment to replace the existing machines with similar new ones at the MTC. The second set of data were values of capital investment need to finance the purchase of new set of automated CNC machines. Annual expenses computation based on historic actual operating expenses and extrapolation of other costs estimates to forecast the new automated CNC operating cost.

The team did not have the opportunity to visit or interview any of MTC management team during the time of the study. However, Shane Iverson is an employee of Nike and he works in the MTC department. Shane was able to provide the team with internal non-confidential data on the existing operating costs and on the vender specification of the automated machines. The following is a list of constraint the team had faced on preparing this study.

1. No access to the Nike's accounting records or estimate of minimum acceptable MARR.
2. In order to develop PW sensitivity analysis had to extrapolate a quasi-revenue figures, which are not necessary accurate. The object was to identify the reversal decision point.
3. Total number of projects during the fiscal year, April to May of next year, were not know. The team based the capital work and EUAC analysis on the assumption that the number of hours need to process an order (project) through a CNC machine is 18:20 hours.
4. Automated CNC machines expected to improve on the wait time. However, process time needed to do a project not expected to change. Nonetheless, the quality expected to improve and scrape rate expected to decrease.
5. Utilization or capacity for each set of machines was critical to estimate; however, the team computed such key value by extrapolation figures based on working hours and average number of project per month. Such estimate to finding the annual worth. To find out the utilization for the existing set of machines and might not be accurate.

Moreover, the team understands that the minimum attractive rate of return (MARR) is a policy issue decided by Nike's top management based on recommendation usually prepared by the Treasury department based on number of considerations among which are the following:

1. The amount of money available for investment, and the sources and the cost of such funds. Excess funds generated from operations usually have a steep average cost for a company operating in a highly competitive and innovative spectrum of products. Thus, MARR expected to be above the selected 18% in this paper.
2. Usually corporations have a range of MARR percentages, as each level of MARR attached to a specific type of project. Investment project generally have lower MARR value as they tend to contribute to the bottom line and vice versa.
3. Corporate perceived risk level associated with a project plays a big role in determining MARR value. The team inferred that an investment in machinery to improve MTC operations would be seen as a risk averse project for Nike.

Conclusion

The objective of this paper is develop a detailed systematic and formal comparison analysis to provide decision maker with a rational to conjecture if a set of automated CNC machines would eliminate the backlog challenge at the MTC.

The team narrowed the set of alternatives to three options that management might consider prior to make a final decision.

1. Keep using the existing machines and maintain the same capacity level; that is do nothing approach.
2. Hire more machinist to operate the existing system with the objective of eliminating backlog.
3. Replace three non-automated machines with a new set of CNC fully automated machines; and implement a policy of zero outsourcing.

Based on the analysis provided in this paper the team acclaims that new automated CNC machines would make available additional capacity. Such additional capacity, generated by new technologies in automated CNC machines eliminates unnecessary wait and to prime machine time. Assuming time to produce a project i.e. time used by CNC machines to produce output stays constant; then we can infer that total process time will be less if automated used.

It is given that initial investment cost and operating cost for the automated machines are going to be higher; however, the total capacity will also increase. Increase in capacity will create the following:

1. Less cost per project.
2. Reduce time to work on each project.

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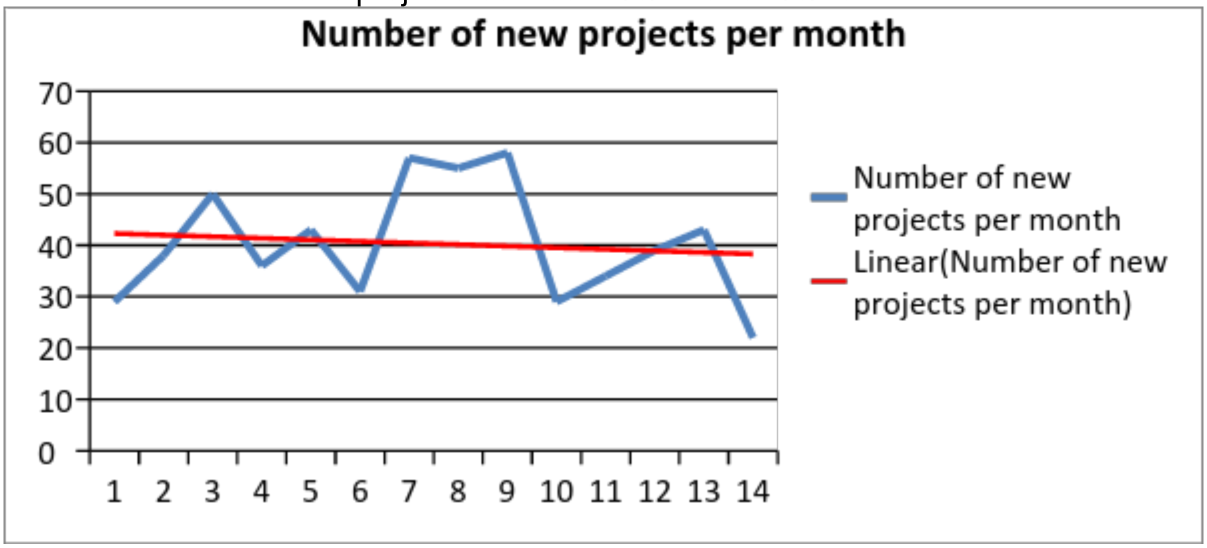
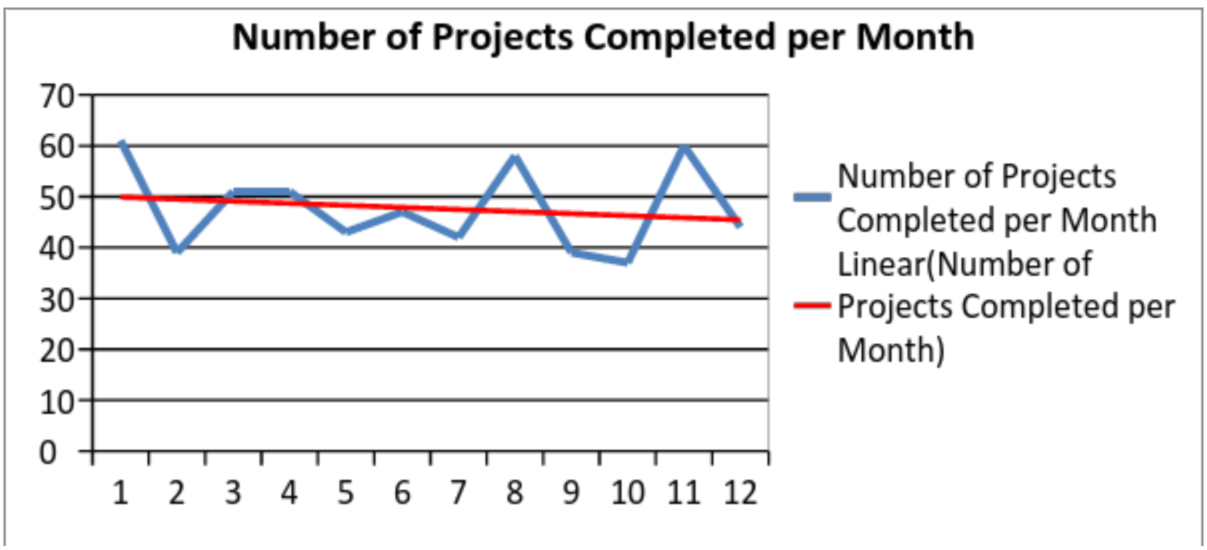
Appendix A
Data charts collected from The MTC's job tracking system (AtTask)

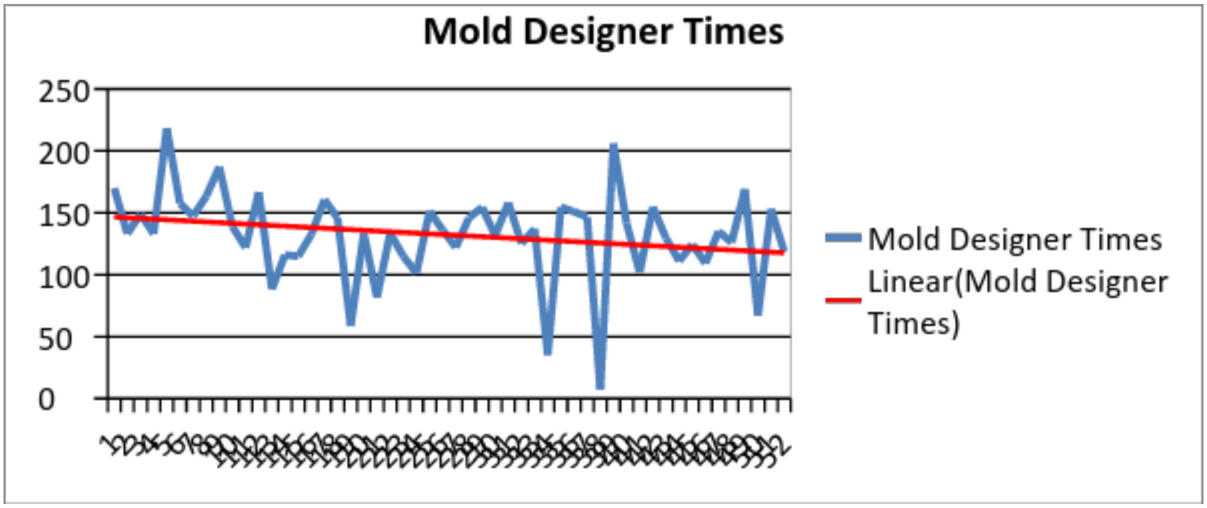
- The MTC did **579** projects between 4/3/14 and 4/3/15.



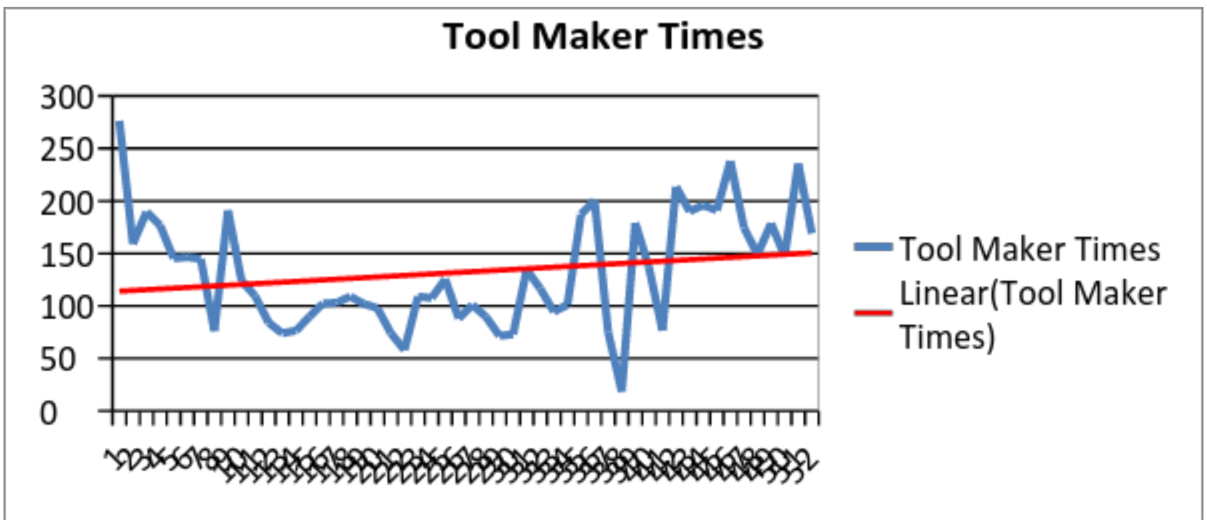
- New projects have decreased by -0.3077 projects per month (Average decrease of -0.72% per month).



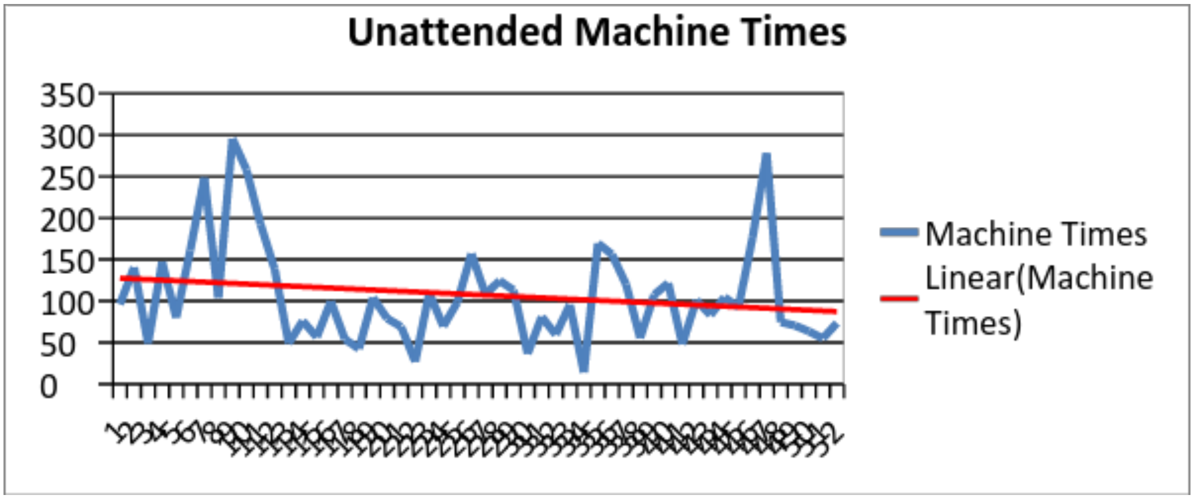
- Projects completed have gone down by -0.4056 projects per month (Average decrease of -0.81% per month).



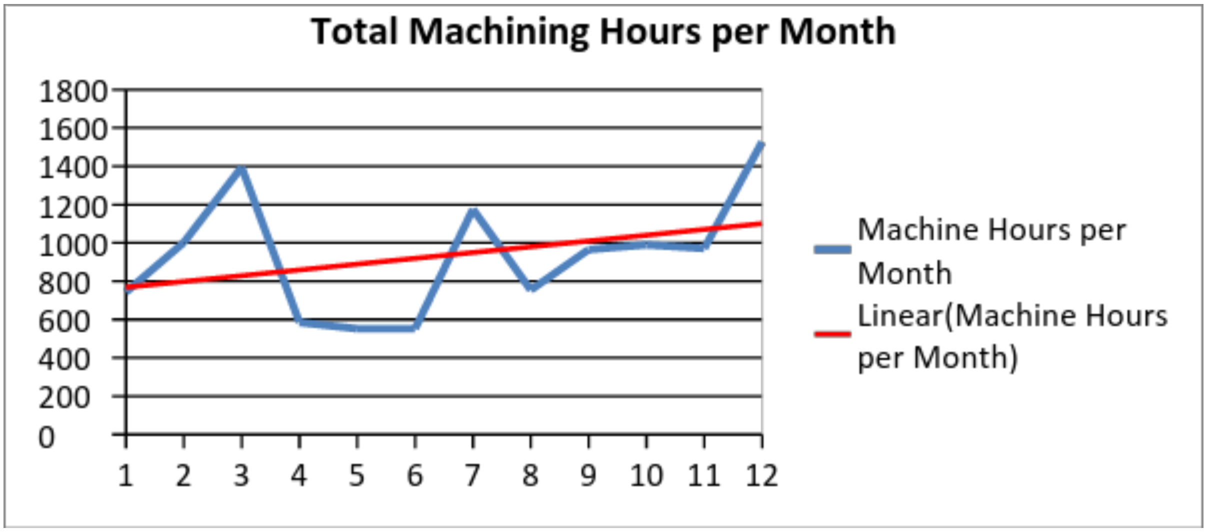
- Mold Designer times went down by -0.5679 hours per week (Average decrease of 1.54% per month).



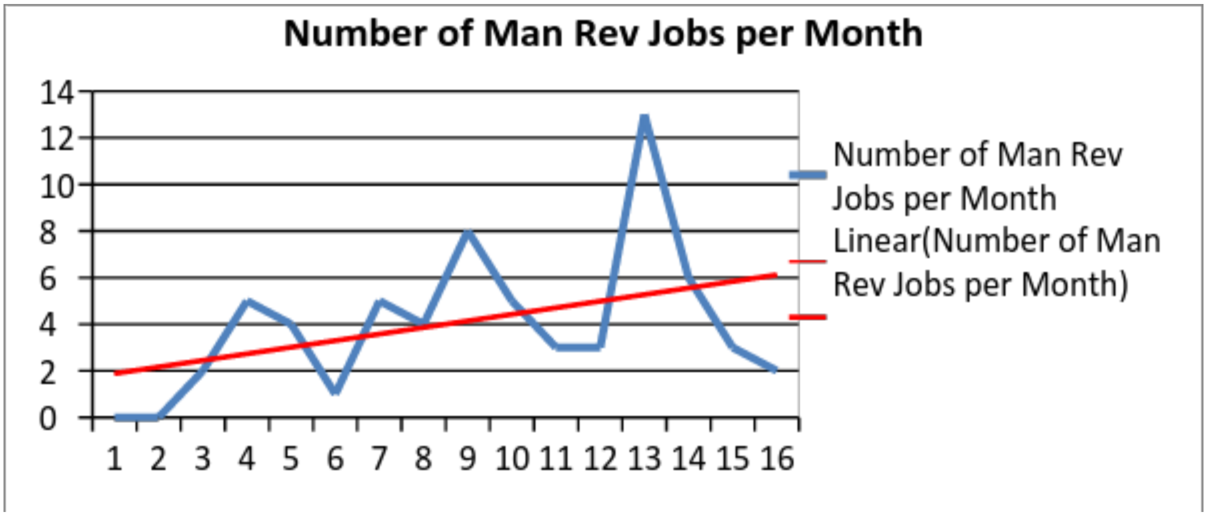
- Tool Maker times went up by +0.7151 hours per week (Average increase of 2.52% per month).



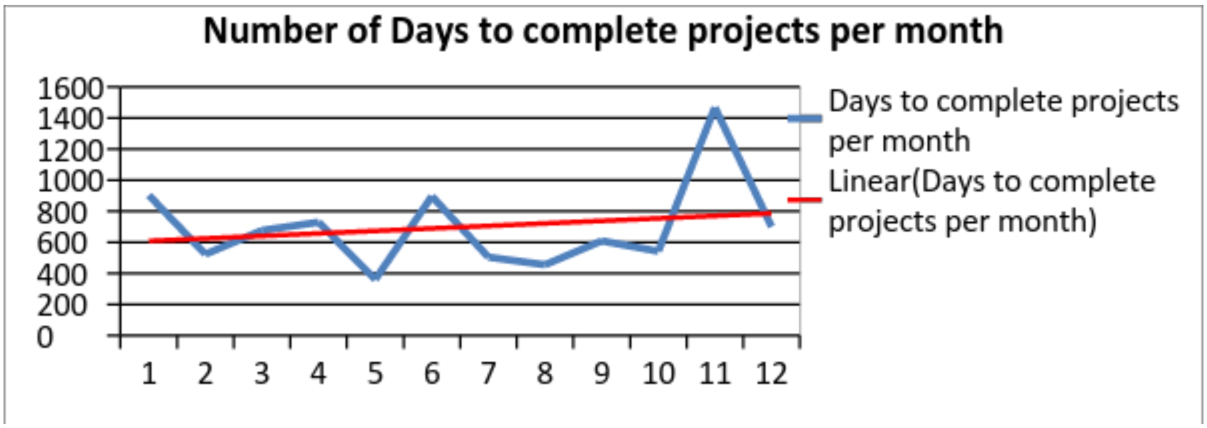
- Unattended machine hours went down by -0.788 hours per week (Average decrease of -2.46% per month). This represents time that machines are running by themselves.
- Total unattended machine time was 5584.1 hour for the year.



- Actual machine hours went up by +30.21 hours per month (Average increase of 4.09% per month).
- Total machine hours for the year were 10,660.
- Total machine utilization was 15.39%.



- The number of more complex jobs has risen dramatically. Man Rev has risen by +0.2824 projects per month (Average increase of 17.65% per month).



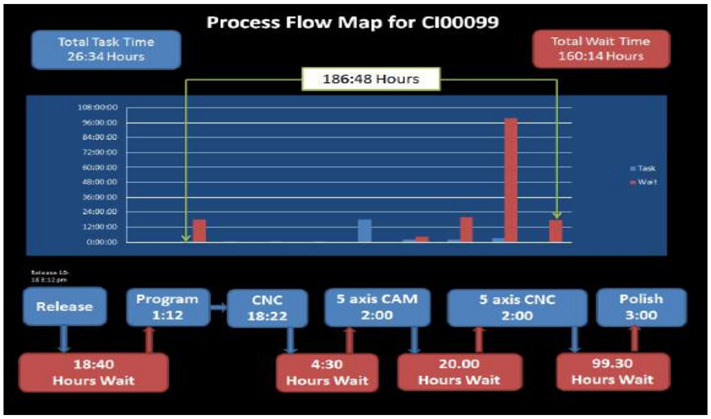
- It takes an average of 16.178 more combined project days per month to complete projects (Average increase of 2.73% more combined project days per month).

What does it all mean?

Even though the number of projects has decreased by 0.72% per month, the types of projects are becoming more complex as seen by the average increase of 17.65% per month for Man Rev Projects. Man Rev Projects are typically more difficult to design and program. The added complexity of projects can also be seen in the longer times it takes to complete projects which can be seen in the 2.73% rise for combined project days per month. As a result, the number of completed projects per month has decreased by an average of 0.81% per month. Another consequence of the added complexity of projects is that Mold designers have had to spend more time in meetings and coordinating projects with customers as well as trying to improve design processes to meet the new demands of more complex work. These coordination and improvement hours are currently not tracked. However, Mold designers report being busier than in the past even though their design and programming hours show a decrease of 1.54% per month. It is believed that the additional time needed to program projects is being shifted to the Tool Makers where we see an increase in Tool Maker times of 2.52% per month. The more demanding work is also seen in the average decrease of 2.46% per month in unattended machining time as the result of needing more complex setups and more time spent attending to the machines. At the same time, total machining hours have increased by an average of 4.09% per month, which can be explained by the added geometric complexity of parts, which require longer machining cycles.

Appendix B

Study CI00099 was conducted from October 18th, 2012 to October 24th, 2012. Subsequent studies showed similar non-value added times occurring outside the typical eight-hour work shift.



- Files for project CI00099 were received on Thursday 10/18/12 at 3:12PM.
- The files wait until Friday the 19th, 9:52AM, when they are programmed. Most of this time is over night.
- The part program is loaded on the CNC at 11:04 on Friday the 19th.
- The CNC machine cuts the part until 5:26AM Saturday the 20th.
- Someone actually comes in on Saturday to program the 5axis toolpaths. The part has been waiting for 4.5 hours and the CNC has been idle.
- The part and machine then wait until until Sunday morning when someone comes in and loads the part on the 5axis machine at 8:56AM. The part and machine have been waiting idle for over 24 hours, but this is during the weekend. Toolmakers are not required to work on the weekends. So, this 24 hour wait period occurs outside normal business hours.
- The part is then cut on the 5axis machine for 2 hours, finishing at 10:56AM on Sunday.
- From here the part waits for four days before it is hand polished and finally sent to the customer. During that four days, the Toolmaker was busy tending to other projects.