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Business Case Analysis for Replacing the Mazak 30Y Mill-Turn Machine in SM-39—Summary

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Summary

Important experiments related to nuclear weapons often require precision-machined parts of various materials in both classified and unclassified shapes. Due to the integrated nature of testing, delays in parts manufacturing can lead to cascading schedule issues for important programmatic milestones. The machining tools currently employed for these programs are relatively old, necessitating time-consuming inspections and potential scrapping of parts. Establishing what equipment and facilities are needed to maintain necessary and optimal capabilities is crucial for the long term success of the weapons experimental mission.

Business case studies are underway to support procurement of new machines and capital equipment in the SM-39 and TA-03-0102 machine shops. The first effort conducted economic analysis of replacing the Mazak 30Y Mill-Turn Machine located in SM-39. To determine the value of switching machinery, a baseline scenario was compared with a future scenario where new machinery was purchased and installed. The conditions under the two scenarios were defined via interviews with subject matter experts in terms of one-time and periodic costs.

The results of the analysis were compiled in a life-cycle cost/benefit table. The costs of procuring, installing, and maintaining a new machine were balanced against the costs avoided by replacing older machinery. Productivity savings were included as a measure to show the costs avoided by being able to produce parts at a quicker and more efficient pace. The analysis for this project estimated a savings of $4.5M over seventeen years with a break-even point in the project's fifth year.

Background

The Mazak Integrex 30Y in SM-39 was obtained from Sandia National Laboratories in Albuquerque when their machine shop was closed. The 30Y is a mill-turn machine that works well for hydrodynamic experiment (hydro) parts. Unfortunately, it is a 1986 vintage machine that cannot hold tolerances well. The requirements-based tolerances for the machine need to fall within a band that is 0.013 mm wide. This accuracy is not consistently being reached due to the age of the machinery and a number of other factors.

The lack of accuracy with the Integrex 30Y leads to a need for continual "in-process" inspections, which require that a part be removed and reinstalled from the machine multiple times. This is a time-intensive process that dramatically increases production time and can further affect the integrity of the product. The machines also require far more maintenance as they age and pass their intended useful lives. In addition, some of these machines are so old that the original manufacturers no longer provide maintenance services.

Methodology

When comparing a scenario consisting of an older currently operated machine to a possible future scenario with a newer machine, the most important consideration is how to quantify the costs and benefits associated with a switch to the future scenario. This requires an analysis of the one-time and periodic costs associated with the machines, along with an understanding of the annual costs of meeting mission requirements. To ascertain these details, performance of equipment was predicted based on the recent history of actual on-site experience. A seventeen-year time horizon was projected to identify the payback period of the new equipment, while applying discounting to account for the time value of money.

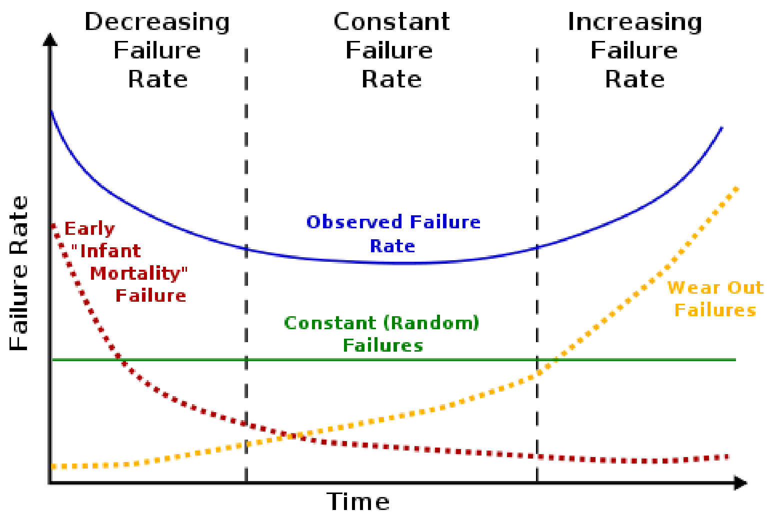

Figure 1: The "bathtub curve" shows a relatively high equipment failure during early and late ages.

Source: Wikipedia, http://upload.wikimedia.org/wikipedia/commons/thumb/7/78/Bathtub_curve.svg/500px-Bathtub_curve.svg.png

The "bathtub curve" provides a convenient paradigm to consider the differences between the two scenarios. This curve reflects experience from reliability engineering whereby equipment failures tend to be relatively more prevalent in the early and late periods of equipment lifespan. New equipment can have "infant mortality" failure as problems are encountered during start-up. This is shown by the red curve in Figure 1 that starts high but declines rapidly as defective products are identified and removed. At the other end of the time scale, equipment begins to fail more often as it reaches the end of product life, shown by the orange "Wear-Out Failures" curve. The new versus old scenarios considered in this paper are at the extreme ends of the bathtub curve—new equipment is at the infant stage, whereas existing machine shop equipment is at the wear-out stage. According to the curve, it is not unexpected for both scenarios to experience higher than average maintenance expenditures.

A facility life-cycle management perspective as presented by LANL's Long-Range Infrastructure Development Plan[1] is also useful in examining the scenario differences. Figure 2 shows that the new equipment scenario would be at the beginning of operations whereas the baseline scenario is at the stage of disposition/recapitalization planning.

[1] Operations Infrastructure Program Office (OI-PO), "Long-Range Infrastructure Development Plan," LA-UR-13-27510, September 2013.

Business Case Analysis

During the interview process, information on downtime and workers required was gathered for the two scenarios to determine the yearly costs over a 17-year horizon. The main areas of focus for the baseline scenario relates to maintenance and productivity. While preventative maintenance costs are assumed to be the same for both scenarios, the age of the current Mazak Integrex 30Y causes corrective maintenance to occur far more often than with a newer machine. This involves a number of minor repairs every three to five years, an expected medium repair once per year, and a major repair once every ten years. In terms of productivity, the current machinery is able to create six parts for hydrodynamic experiments over the course of a 48-week year (six parts per year).

Figure 2: In terms of the maintenance life cycle, the new equipment scenario is at the beginning of operations and the baseline scenario is at the disposition/recapitalization decision stage.

Source: Operations Infrastructure Program Office (OI-PO), "Long-Range Infrastructure Development Plan," LA-UR-13-27510, September 2013, p. 17.

The main areas of focus for the new machine scenario are the procurement/installation process and the change in productivity due to increased efficiency. Installing the new machine costs about $950k over the first two years, and there is an assumed two-year transition to full efficiency while the machine is fully qualified. This also accounts for the early part of the bathtub curve during the "infant mortality" period. The productivity savings per part are determined by looking at the amount of parts that could be produced in a year if the machine were run at full capacity. As seen in Figure 3, the cost per part is estimated for this production rate and then compared to the cost per part in the baseline scenario. The difference between the two costs is used as the cost savings per part during production.

After estimating the costs of these variables within the two scenarios, a life-cycle cost/benefit table was created to determine the eventual payback of the new scenario. The Best Estimate line of Figure 4 reflects a modest assumed demand of ten hydro experiment parts per year. The Maximum line assumes that the machine

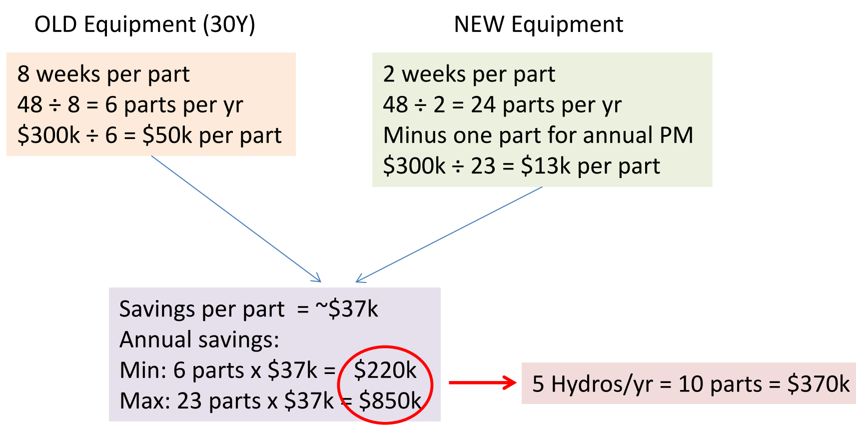

Figure 3: The range of potential productivity savings is $220k to $850k per year. For conservatism, a value of $370k/y is used in the business case model.

will be used at full capacity once it is fully operational, producing 23 parts per year. The Minimum line reflects the new machinery operating at the current output of only six parts per year. These are the same assumptions in the annual savings estimates shown in Figure 3.

Conclusions

The total net present value of replacing the Mazak Integrex 30Y with a Mazak Integrex i300 is $4.5M over the course of 17 years using the best estimate. The project achieves pay back of its investment in the fifth year of operation. Assuming maximum production of the new machine, the net present value could be as high as $11.4M and would break even in the fourth year of operation. Under the minimum production case there would be a net present value of $2.9M and a breakeven point in the sixth year of operation.

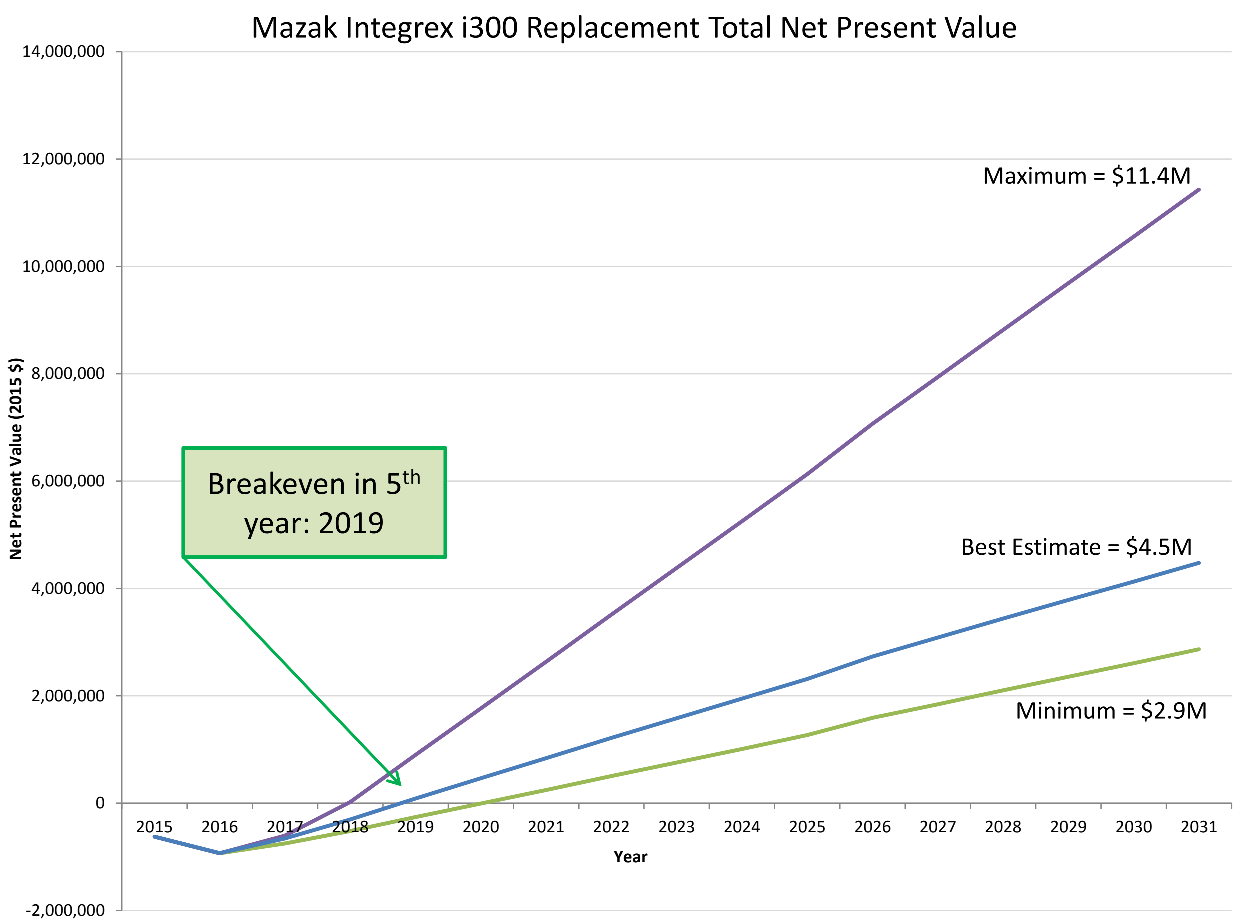

Figure 4: The payback period for the new scenario under the best-estimate assumptions is in the fifth year, with a $4.5M savings over 17 years.