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Business Case Analysis of Prototype Fabrication Division Recapitalization Plan

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National Nuclear Security Administration

Illustration:

Front Cover – Mazak 30Y mill-turn machine in SM-39, vintage 1986.

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I. INTRODUCTION

Important experiments related to nuclear weapons often require precision-machined parts of various materials (including special nuclear material—SNM) in both classified and unclassified shapes. Because of the integrated nature of these experiments, delays in parts manufacturing can lead to cascading schedule issues for important programmatic milestones. Consequently, machining is often on the critical path of the schedules.

The machinery currently employed for these programs is relatively old, which leads to a loss of accuracy in part manufacturing. In turn, lack of confidence in the machinery leads to lengthy time delays due to errors and additional cautionary inspections. 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. Economic analysis can provide valuable support to LANS management decisions on maintaining and growing LANL machining capability, and for improving performance.

Three tiers of economic analysis studies are relevant to these decisions, with scopes ranging from narrow to broad. Tier 1 has a narrow perspective and consists of business case studies to support procurement of individual machines and capital equipment. Tier 2 focuses on intra-laboratory issues of optimizing machining capabilities across LANL. Studies that examine redundancy and consolidation across divisions and facilities would be under this tier. Other topical areas include the business model for funding machine shops, and matching mission requirements with an appropriate level of resources in machinists, facilities and equipment for sustaining a long-term capability. Tier 3 considers the broadest inter-laboratory or Weapons Enterprise issues related to how LANL machining capability relates to that of other NNSA institutions. The possible expansion of market share into machining parts beyond LANL experiments can be considered, along with efficiencies across the Enterprise.

This report describes a Tier 1 study narrowly focused on machines in the PF shops. This is just one part of the LANL "recapitalization" scheme. LANL managers are currently working on a recapitalization plan and are addressing about a dozen issues. There is a long legacy at LANL of lack of maintenance and continuity of funding. Work is so heavily "projectized" that funding often does not cover base capability. This means enduring capability is not always maintained through regular preventative maintenance, and the deferred maintenance backlog can accumulate to be one-half to two-thirds of an annual operating budget. Materials Science and Technology (MST) and Prototype Fabrication (PF) divisions want to put a 20-year recapitalization plan in place. This plan would cover the life of machinery, the replacement of machinery every 15-20 years, and a budget to cover those costs.

In general, RTBF "warm standby" money covers more aspects of a facility than does Site Support funding. The national RTBF execution plan guidance document for FY2008 includes under RTBF the "cost of all labor, equipment and projects required to maintain RTBF facilities 'mission capable' to perform programmatic tasks identified by Campaigns or Directed Stockpile Work (DSW), and excludes all work and costs required to perform Campaign or DSW work."[1]

[1] National Nuclear Security Administration, "Readiness in Technical Base and Facilities FY2008 Site Execution Plan Guidance, Appendix A: RTBF National Work Breakdown Structure and Dictionary," Revision 0, July 2007.

Site Support funds cover facility operations, engineering, and maintenance. This is where there can be a critical funding gap: there is defined institutional funding for the buildings but equipment relies on program funds that are often less reliable.

While this report does not cover the creation of an appropriate business model to fund the enduring machining capability, it is a discussion worthy of consideration. This issue has been addressed previously at LANL. For example, there is a report describing the selection of a business model for cost recovery for waste management.[2]

II. METHODOLOGY

The business case methodology used here is based on comparing multiple scenarios. A baseline scenario, that is, the world that exists today, is compared with a future scenario that could exist if a new machine were purchased and installed. The conditions under the two scenarios are defined via interviews with subject matter experts in terms of one-time and periodic costs, and annual costs of meeting mission requirements. Performance of equipment is predicted based on recent history of actual experience. Costs that could be avoided by the use of new equipment, along with other benefits such as improved ability to meet programmatic deadlines, are also considered. A 15-year operating time horizon is projected to identify the payback period of the new equipment, while applying discounting to account for the time value of money.

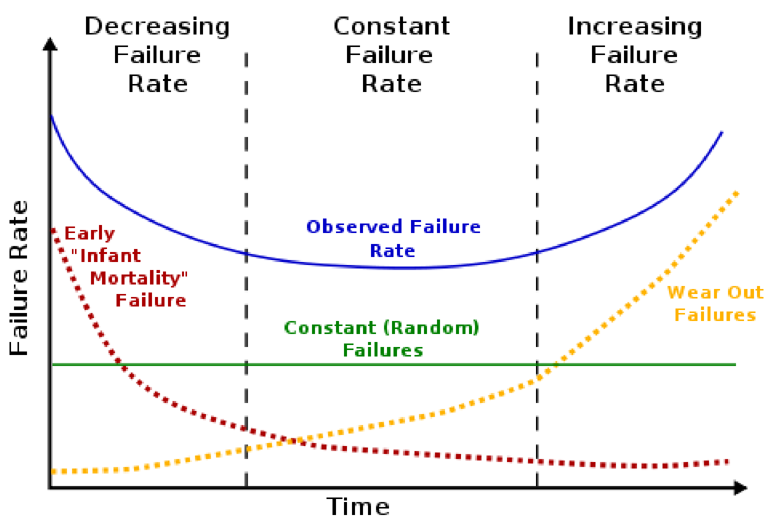

Figure 1. Bathtub curve showing relatively high equipment failure during early and late ages.

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

[2] Booth, Steven R. et al, "Cost Recovery for Waste Processing at Los Alamos—Analysis and Recommendations," Official Use Only, LA-CP-08-0404, April 30, 2008.

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 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. This decision requires up-to-date mission, sustainability, and condition data "to provide the best basis for informed decisions on assets approaching end-of-life and that have the potential to increase the flexibility and agility of the infrastructure portfolio when recapitalization or repurpose of the asset remains an option."[3]

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

In measuring the difference between the scenarios for new versus old machines, one area of potential savings is in programmatic impacts. This report considers these impacts qualitatively and relies on an understanding of the various factors that can contribute to the overall cost of making a part, including the cost of delays in getting a part out (schedule slips). Another factor that should be considered is that for most projects there is staff in place, regardless of delays, that are still on-site working and getting paid. This cost of the "marching army" can make schedule slippage very expensive.

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

Programmatic impacts involve the broader infrastructure associated with the machine shops as opposed to equipment infrastructure. The heavily "projectized" nature of the parts production process often creates difficulties in maintaining capability. For example, a large program with funding of $160M/year and $1B over the life of a program might fund a large degree of infrastructure and capability sustainment during its lifetime, but the infrastructure (such as production control, maintenance, and coordination) can rapidly evaporate when the program ends.

The absence of stable, long-term large-program infrastructure support has led to devolution in PF machine shops from a schedule-driven process to a priority-driven process. This can lead to projects being stopped mid-stream in order to facilitate a new project that has been deemed a priority. Such stoppages incur large costs for lower priority programs. One major reason for these added costs is that there is no process to track where the job left off. Many of these projects have to start over entirely after a stoppage, incurring repeated costs and wasting time. For example, when a part is removed from a machine midway through production, it can lose a minimum of one-1000th of an inch, which is significant given the required tolerances in these shops. This could lead to having to scrap the part and start over. Depending on the material, PF might not scrap the part when it should have been scrapped because it is too valuable. This incurs greater costs at a later date due to issues relating to quality of the product and its overall functionality.

Using a recharge business model instead of utilizing dedicated funding can also lead to an erosion of preventative maintenance. Because of having to add in costs for downtime, training, vacation, maintenance, etc., the recharge rate can be high—shops charged up to $400/hr per machinist in some instances. Programs resist paying these high amounts, and preventative maintenance can become one of the first things to fall off the table during budget negotiations. One funding crisis after another can delay preventative maintenance indefinitely to where it turns into a de facto run-to-failure situation.

When the machine goes down it affects the time it takes to produce a part, which in turn affects the schedules of all programs relying on that machine, creating a domino effect. In these situations, schedulers typically change the baseline (lengthen the schedule), and so there is no accurate way to track accumulating costs due to such delays. Below are two examples of schedule slips that were due, at least in part, to a delay in getting a part or parts from PF.

Example 1: Hydro #3653 blast hardware being made in Building 102 was originally scheduled for delivery in October 2014. The parts have not been delivered as of February 2015—a delay so far of five months. This delayed the entire hydrodynamic experiment, along with delaying subsequent experiments.

Example 2: Another experiment was scheduled to be executed on May 19, 2014, but actually occurred on August 11, 2014. In turn, this delayed a subsequent experiment. The majority of the three-month slip was because of part manufacturing delays. There were some other issues with the test that perhaps could have contributed two to four weeks of project delays. However, these were resolved during the delay caused by the parts.

Another factor is the idea of "it takes three (or four) to get two." That is, projects often begin by planning to make four PF parts hoping to get two that are operational. This shows how production inefficiencies are built into costs and schedules. In addition, the high scrap rate can impact material production beyond PF division, such as with MST.

In evaluating the seriousness of a delay, programs can be ranked by importance from low to high:

- Surveillance programs;
- Significant Finding Investigations (SFIs); and
- Life-Extension Programs (LEPs).

There has been an evolution in philosophy in recapitalization planning for PF. In the past, machines were selected to be versatile and able to match a changing mission. The detriment of such machines is generally lower performance when used in a repetitive production mode. Today's more stable weapons experimental programs implies the purchase of more specialized machines that can reliably and efficiently produce parts with required accuracy.

This report considers the business case for purchasing three types of equipment for PF division: mill-turn machines that can build parts with complex contours such as saddles for hydrodynamic experiments; lathes; and electrical discharge machines that can make precision cuts. The old versus new scenarios for each of these is shown in Figure 3. Total net present value results are also shown.

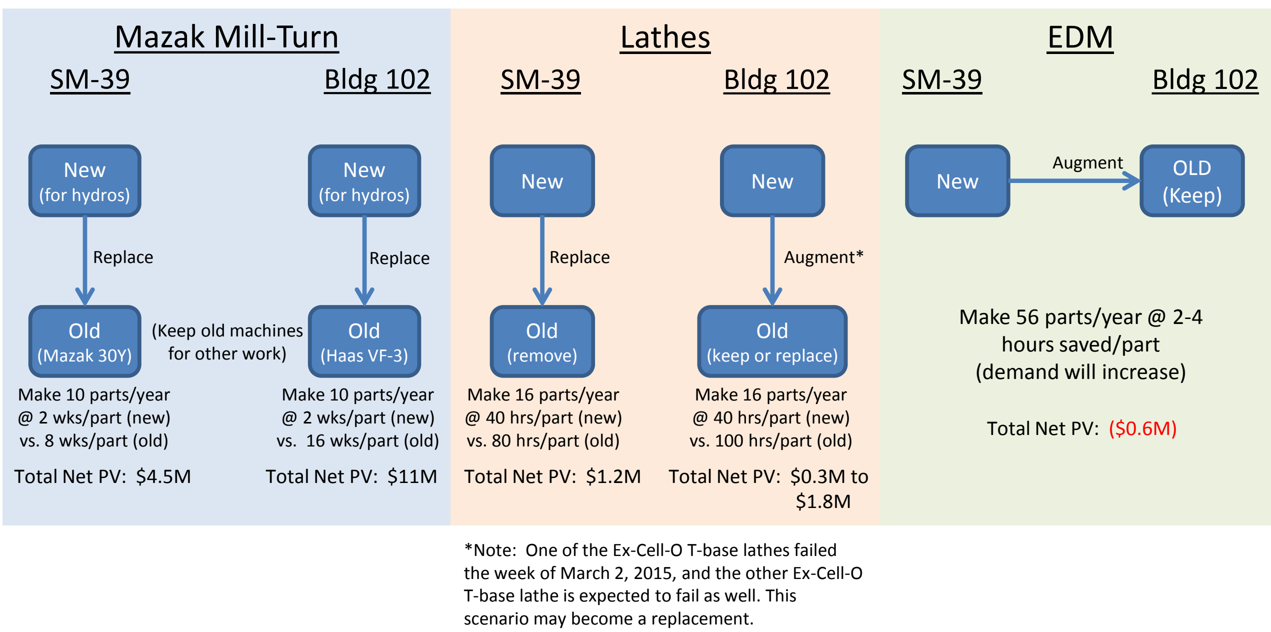

Figure 3. Comparison of scenarios described in this report shows the relative net present value of each business case analysis.

III. MAZAK 30Y MILL-TURN MACHINE IN SM-39 AND TA-3-102

A. Baseline Scenario

1. Discussion/Background

The current estimated demand for parts coming out of PF is ~35-40 parts per year.[4] This number includes parts from the lathes (Hardinge), and is the total sum of all programs (hydros, experiments, joint test assemblies, etc.). However, the mills that are currently in use and can share the load are not capable of providing the desired output any longer (the mills in Building 102—the Haas machine and the Horizontal mill—are no longer functional or practical in their usage). At one time, the Mazaks in SM-39 could handle this level of work; but, due to age and a lack of preventative maintenance over the years, they are no longer robust enough to meet this demand. This is especially true now that many parts are machined from tungsten. Tungsten is a hard, dense, heavy metal that is very tough to machine. It is abrasive, and requires exceptionally sharp cutting tools and greater cutting forces than other materials. Machining equipment must have rigid tooling fixtures for resistance to vibration, coupled with high spindle torque at low speeds.[5] PF machinists have encountered issues with tungsten in meeting design specifications for surface finish. They initially obtained a rough finish that was due to the toughness of the material. It has taken some time to optimize spindle speed and speed rates to achieve specification.[6] With new, improved equipment, the expected demand for parts of all materials could be fully met.

Table 1 lists all of the CNC Lathes located in SM-39, plus the Haas VF-3 CNC mill (manufactured by Haas Automation, Inc.) located in TA-3-0102. The highlighted equipment shows the specific equipment discussed during the initial subject matter expert (SME) interview on January 12, 2015 with Earl Vest, Jacob Tafoya, and Dino Farfan.

Precision work on complex geometry with radiological parts is currently done on a Haas VF-3 CNC mill in TA-03-102 (see Figure 4). This option is less than optimal as shown by recent experiences building inner and outer saddle parts for several hydrodynamic tests. For the 3630 hydro shot (~2010 to 2011), the VF-3 had a hard time keeping the profile within tolerance. Subsequently, the PF maintenance team conducted a “laser-shoot” of the machine to check tolerance and geometries in a precise mapping of performance. The results showed the machine was out of specification in all three axes. A corrective map was added to the controller with the goal of bringing the machine back into specification.

The next shot in the series was the 3614 in the spring of 2013. Unfortunately, the Haas VF-3 had the same problems plus a new one: the contour definition kept shifting off-center. The tolerance issues with the VF-3 may be related to past machining of heavy DAHRT vessel doors. However, this is a low-end machine that may not have been able to meet close tolerances even when new.

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[4] Information in this section was obtained via personal communication with Earl Vest, Jacob Tafoya, and Dino Farfan of PF-WFS, January 2015.
[5] http://www.mmsonline.com/articles/what-it-takes-to-tackle-tungsten.
[6] Earl Vest, personal communication via e-mail, April 27, 2015.

Table 1
CNC Lathe Equipment List as of 6-18-14

Location	Skid Type	Machine Type	OEM	Model #	Vintage
TA-03-39-28	CNC Lathe	Engine Lathe	American	40	1977
TA-03-39-28	CNC Lathe	Flatbed Turning Center	Hardinge	CHNC-III	2001
TA-03-39-28	CNC Lathe	Flatbed Turning Center	Hardinge	CHNC-III	2000
TA-03-39-28	CNC Lathe	Gang Tool Turning Center	Hardinge	Conquest GT-27	1999
TA-03-39-28	CNC Lathe	Integrex	Mazak	E-410-HS	2003
TA-03-39-28	CNC Lathe	Integrex	Mazak	30Y	~1986?
TA-03-39-28	CNC Lathe	Integrex	Mazak	e650	2002
TA-03-39-28	CNC Lathe	Slant Bed Turning Center	Mazak	Slant Turn 60	1983
TA-03-39-28	CNC Lathe	Slant Bed Turning Center	Mazak	Quick Turn 25	1988
TA-03-39-28	CNC Lathe	Twin Turret Turning Center	Hardinge	Conquest TT-65	2000
TA-03-39-28	CNC Lathe	Twin Turret Turning Center	Okuma	LH55-N	1986
TA-03-39-34B	CNC Lathe	Slant Bed Turning Center	Hardinge	Q10/65-SP	2002
TA-03-39-34B	CNC Lathe	Slant Bed Turning Center	Hardinge	Q10/65-SP	2002
TA-03-39-34B	CNC Lathe	Turning Center	Hardinge	Conquest T-51-SP	1999
TA-03-39-36A	CNC Lathe	Slant Bed Turning Center	Hardinge	Q10/65-SP	2001
TA-03-102-118	CNC Mill	VMC	Haas	VF-3B	2007

The blast hardware for the later 3659 experiment was made out of tungsten. The parts were made on the VF-3 and results were again off-center. Figure 5 shows the results of the repeated attempts using the machine, and shows essentially a random walk off center specification. The PF maintenance team does not know why this is happening. There is quite a bit of play in the spindle and they have been dealing with this issue for at least five years. As mentioned above, full laser-shoot re-specification has not solved the problem.

The move to all tungsten for blast hardware allows machining to occur in SM-39. (The same parts are machined in Building 102 but with different material.) This building has a Mazak Integrex 30Y that was obtained from Sandia National Laboratories-Albuquerque when they closed their machine shop. See Figure 6. The 30Y is a mill-turn machine that works well for hydro parts. Unfortunately, it is a 1986-vintage machine that cannot hold tolerances well. The desired tolerances need to fall within a band that is 0.013 mm wide.

With the Integrex 30Y, there is a need for continual “in-process” inspections, which require that the part be removed and reinstalled from the machine multiple times. This increases production time and can affect the integrity of the part.

It should be noted that age is not the only issue that can affect the machine’s ability to hold tolerances; the facility can contribute as well. Tunnels under the SM-39 floor can cause the foundation of the machine to be inadequate. Stabilizers and dampeners on pillars are currently in use to improve machine performance. Widely fluctuating room temperatures are also a factor. In

HAAS VF-3 Vertical CNC Mill

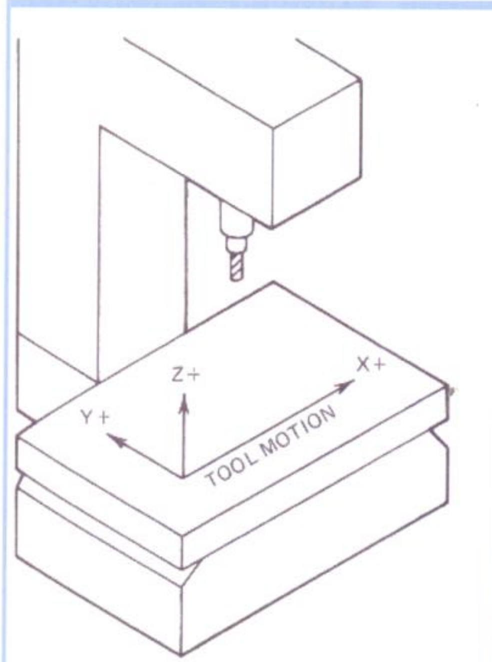

FIGURE 2.1 Axis nomenclature for a vertical spindle N/C mill.

Figure 4. Haas Vertical CNC Mill located in TA-3-102, Room 118.

a perfect world, the temperature would not fluctuate more than ±1° or 2°, but that is not the case in the main shop area of SM-39 and this is currently beyond PF's control. Even though TA-03-0102 is ostensibly "environmentally controlled," its temperature can vary by ±4°. Locating a new machine in a temperature-controlled room within SM-39 (such as where the Hardinge lathes are) may be a good solution to this problem.

The Integrex *e*410 is newer and is physically larger (with a larger capacity) than the 30Y. See Figure 7. It was also obtained from Sandia and is about 20 years old. The turret on the *e*410 can rotate continuously from 0 to 90 degrees, whereas the 30Y's turret is locked at either 0 or 90 degrees. PF has been successful cutting saddles on the *e*410, but there are issues meeting tolerances, principally between 0.1 and 89.9 degrees on the turret position. The *e*410 is accurate on the inner saddle, but the outer saddle does not meet the same tight tolerance. If tolerances are tightened, PF could not do it on this machine. The Integrex 30Y meets tolerances, but it is less flexible.

Since the machines are computer-controlled, classified red-network hookup can be an issue in SM-39. The more modern *e*410 machine uses the Windows 95 system on an internal hard drive. PF had a hard time putting this machine on the red network because the hard drive is not removable. The Haas and the 30Y do not have an internal hard drive, which makes it much easier to connect to the classified network. (This issue must be addressed when selecting a replacement machine.)

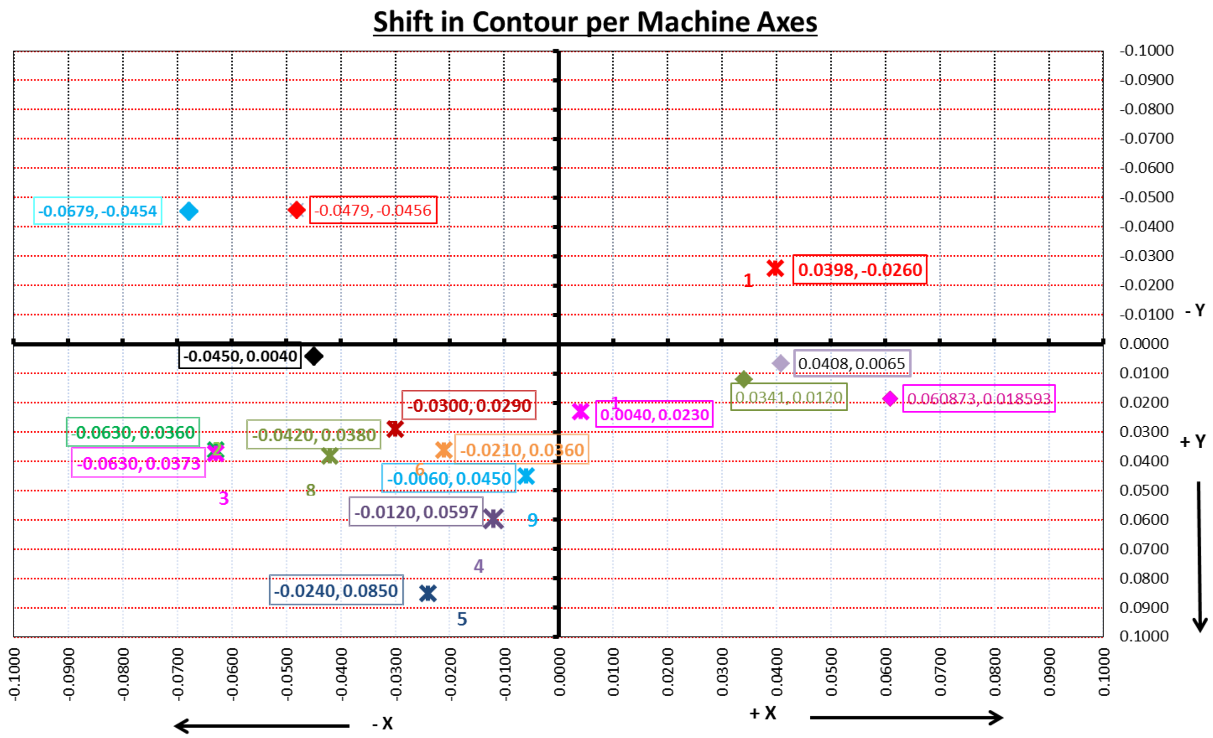

Figure 5. Shift in contour on the Haas VF-3 Vertical CNC Mill.

The Integrex is a very complicated machine and maintenance training is intensive. However, no one in the shop has had any formal training for it. This causes problems when the machine breaks down.

Recent maintenance on the Mazak 30Y included replacing seals for a major hydraulic fluid leak in the turret. This job encountered difficulties because the manufacturer no longer had drawings for the machine and could not determine which seals were needed. In the end, the vender sent a bag of seals to allow LANL to choose the most effective ones. A second problem with the 30Y was that the main “Z” axis was out of specification because of a worn lead screw, carrier, and thrust bearings. The vender happened to have a replacement lead screw, which saved months of time to remanufacture a new one. Overall, the 30Y machine was down for approximately eight calendar weeks in late 2014, and involved the time and labor of two techs (two weeks), one engineer (one week), one welder (one week), and one procurement specialist (one week).

This corrective maintenance (CM) activity took a lot of time to break down the machine and diagnose the problem. It is helpful that Mazak has technical support in Los Angeles and Kentucky; however, if the LANL staff had the proper training, their resulting knowledge would have helped a great deal in working with Mazak’s tech support. Lost time could have been avoided if the technicians had been properly trained (it could have possibly cut the downtime in half). This does not address programmatic impacts caused by the delay in completing parts.

Figure 6. Mazak Integrex 30Y located in SM-39.

Figure 7. Mazak Integrex e410 located in SM-39.

It should be noted that technical support for this older equipment is decreasing as well. Along with the lack of off-the-shelf replacement parts, the new vendor technical support people are not familiar with the older equipment and this will only get worse with time as senior people retire.

2. Preventative Maintenance

Basic preventative maintenance (PM) includes regularly scheduled tasks such as changing fluids, filters, geometry checks using a ball bar, and software backup. These activities can have the machine down for a total of two weeks over the course of a year. On newer equipment, PM is usually scheduled with the manufacturer, but the 30Y equipment is so old that is not an option. New equipment would most likely also require a two-week downtime over the course of each year, but it would extend the life of the machine rather than keep older, nearly obsolete equipment “limping along.” Two maintenance technicians are needed for two weeks each year for PM at a cost of about $23k. See Table 2. It is important that PF have their own trained maintenance technicians because of issues related to classification and hazardous operations.

Common equipment failures include the hydraulic system and seal blow outs, and PF is in a “crisis mode” most of the time to keep the old machines running. In 2014, a full preventative maintenance schedule was developed for twenty machines. PF division currently has seven maintenance FTEs to service nine shops. See APPENDIX A: MAZAK Integrex 30Y.

PM for the Haas VF-3 in Building 102 is similar to that of the Mazak 30Y in SM-39. However, the Haas is in much worse condition than the Mazak 30Y; as a result, downtime throughout the course of the year is longer—six weeks over the course of the year. See Table 3.

3. Corrective Maintenance

Due to the age of the 30Y, the shop staff has to deal with issues such as electronic component failure, major components breaking, servo drives, and power supplies going out. CM includes the laser-shoot activity, which is an extension of the geometry check in PM. This is used when a problem holding tolerances is encountered and a correction is needed.

There are currently no mechanical problems with the Mazak 30Y, but issues are expected (as described below). If there is a major crash (tool into spindle), the entire machine would need to be inspected and can put the machine out of commission for two weeks or longer. A major crash can be caused by operator error, power outage, or other situation.

The latest issue with the Mazak hydraulic leak was never completely resolved, and PF may need to repair the machine in the future. They found a company that will rebuild the turret, but turn-around could put the machine down for weeks, creating a major CM issue. If this were a newer machine, parts would be more readily available and the machine could be back up in a couple of days. In general, the older a machine gets, the more likely it becomes that parts are lacking or unreliable.

It is possible that CM and repairs on new equipment for common issues (e.g., hydraulics) would be required every five years as opposed to annually, as is the case with old equipment. “Uncommon” maintenance issues may not show up during its lifespan if the new equipment is properly maintained.

Table 2
Assumptions and Factors for Life Cycle Analysis of Mazak in SM-39

Assumptions		Comments
Real Discount Rate {1}	0.01	
Engineer, SLR	$246	R&D Eng
Programmer, SLR	$199	JST
Machinest, SLR	$170	JTM
Maintenance TEC, SLR	$142	AKN
Other Support, SLR (e.g., procurement)	$170	
Productive Hours per year	1730	for R&D Eng
New Machine		
Equipment Cost ($)	550,000	
Procurement Support Cost ($) {2}	75,592	
Facility Preparation ($) {3}	85,197	
Installation ($) {4}	54,602	
Training ($) {5}	117,064	
Qualification ($) {6}	52,291	
Maintenance		
Preventative Maintenance ($ per year) {7}	22,773	
Corrective Maintenance {8}		
Minor	8,540	
Medium	34,159	
Major	69,298	

{1} Source: 10-year real discount rate, OMB Circular No. A-94, Appendix C (Revised December, 2013).

{2} Decision Analysis: 1 FTE @ 4 wk; Procurement Team: 1 FTE @ 3wk; Acceptance Artifact: 1 FTE @ 2wk.

{3} Choose location, power supply, floor foundation, reconfigure shop space, crafts: 2 FTE @ 4wk. 1 Engineer @ 2wks. $20k for procuring screwjacks.

{4} Off-load and level machine, connect to power/air, laser verify: 2 FTE @ 3wk. Run acceptance artifact: 1 FTE @ 2wk. 4 FTE @ 1 day to bring equipment into building.

{5} Two maintenance technicians for 4 weeks training with class cost of $2k/week per person, plus travel expenses ($5k/person). Two programmers and two machinists with 1 week training at a cost of $2k/wk plus travel of $2k/person.

{6} Maintenance corrections with factory rep: 2 maint FTE @ 2wk. 5-axis verification artifact, build & test post-processor, confirm Vericut SG Tech, cut surrogate classified shape and inspect: 1 pgrm FTE @2wk + 1 machinist FTE @ 2wk.

{7} 2 maint FTE @ 2 weeks per year for scheduled PM based on manufacturer recommendations.

{8} Assumed CM for an old machine (we assume that parts for CM have a cost equal to 50% of the labor cost):
• Minor repair: 1 week downtime assuming parts are immediately available and simple to install with 1 maint FTE @ 1wk.
• Medium repair: 3 weeks downtime with 2 maint FTE @ 1wk for evaluation, 1 maint FTE @ 1wk to find part, 1 maint FTE @ 1wk to replace part and laser-shoot machine.
• Major repair: 5 weeks downtime with 2 maint FTE @ 2wk, 1 engineer @ 1wk, 1 welder @ 1wk, 1 procurement specialist @ 1wk.

Table 3
Assumptions and Factors for Life Cycle Analysis of Mazak in Building 102

Assumptions		Comments
Real Discount Rate {1}	0.01	
Engineer, SLR	$246	R&D Eng
Programmer, SLR	$199	JST
Machinest, SLR	$170	JTM
Maintenance TEC, SLR	$142	AKN
Craft (Iron worker), SLR	$160	
Other Support, SLR (e.g., procurement)	$170	
Productive Hours per year	1730	for R&D Eng
New Machine		
Equipment Cost ($)	550,000	
Procurement Support Cost ($) {2}	75,592	
Facility Preparation ($) {3}	160,345	
Installation ($) {4}	54,602	
Training ($) {5}	21,630	
Qualification ($) {6}	52,291	
Maintenance		
Preventative Maintenance New ($ per year) {7}	22,773	
Preventative Maintenance Old ($ per year) {8}	68,318	
Corrective Maintenance {9}		
Minor	8,540	
Medium	34,159	
Major	69,298	

{1} Source: 10-year real discount rate, OMB Circular No. A-94, Appendix C (Revised December, 2013).

{2} Decision Analysis: 1 eng FTE @ 4 wk; Procurement Team: 1 Procurement FTE @ 3wk; Acceptance Artifact: 1 Programmer FTE @ 2wk.

{3} Choose location, power supply, floor foundation, reconif shop space, crafts: 2 FTE @ 4wk. Entry Ramp Reinforcement: 5 iron worker FTE@ 1 wk, Drilling Cores: 2 FTE @ 1 wk. $50k purchase of fixaters, $20k for moving one piece of equipment within Building 102.

{4} Off-load and level machine on fixaters, connect to power/air, laser verify: 2 FTE @ 3wk. Run acceptance artifact: 1 FTE @ 2wk. 4 FTE @ one day to bring new machine into building.

{5} Two machinists with 1 week training at a cost of $2k/wk plus travel of $2k/person.

{6} Maintenance corrections with factory rep: 2 maint FTE @ 2wk. 5-axis verification artifact, build & test post-processor, confirm Vericut SG Tech, cut surrogate classified shape and inspect: 1 pgrm FTE @ 2wk + 1 machinist FTE @ 2wk.

{7} Two maint FTE @ 2 weeks per year for scheduled PM based on manufacturer recommendations.

{8} The HAAS VF-3 is in much worse condition than the Mazak 30Y. It is down for six weeks over the course of the year.

{9} Assumed CM for an old machine (we assume that parts for CM have a cost equal to 50% of the labor cost):

• Minor repair: 1 week downtime assuming parts are immediately available and simple to install with 1 maint FTE @ 1wk.

• Medium repair: 3 weeks downtime with 2 maint FTE @ 1wk for evaluation, 1 maint FTE @ 1wk to find part, 1 maint FTE @ 1wk to replace part and laser-shoot machine.

• Major repair: 5 weeks downtime with 2 maint FTE @ 2wk, 1 engineer @ 1wk, 1 welder @ 1wk, 1 procurement specialist @ 1wk.

As described above, the age of these machines and lack of maintenance training can have a tremendous effect on productivity and efficiency. When the lead screw assembly broke, it took a week of evaluation to determine the problem. PF then waited one week for the part to arrive, and spent one week installing and recalibrating before the machine was operational again. Fixing a broken turret took about the same amount of time. Between the seal leak, lead screw assembly and turret, the Integrex 30Y was down for at least two months in calendar year 2014. PF could potentially run into these same issues on the Integrex e410. It should also be noted that tungsten is harder to machine—PF can machine tungsten in SM-39 but it has caused major leaking and wore out the lead screw assembly. The state of the Integrex 30Y is as good as it is going to get and it cannot be upgraded; the same holds true for the Haas VF-3.

Below are the assumed schedules for CM, FTE durations, parts and cost estimates for the Mazak 30Y in SM-39 and the Haas VF-3 in Building 102.

Assumed schedule for CM for an old machine (Mazak 30Y in SM-39):

- Hydraulic/electronic issues (medium repair): once a year;
- Turret and lead screw (major repair): once per 10 years;
- Software operating system (minor repair): once per 3 years;
- Computer hardware failure (minor repair): once per 5 years; and
- Repack bearings (medium repair): once per 5 years.

Assumed schedule for CM for an old machine (Haas VF-3 in 102):

- Spindle and axes (medium repair): once a year – technical skill is needed for this job;
- Electronic (medium repair): once a year;
- Software OS (minor): once 3 years;
- Computer hardware failure (minor repair): once per 5 years; and
- Probing (different sub-system, batteries, recalibrating) (minor): once a year.

Assumed FTE durations for an old machine (30Y in SM-39 and Haas in Building 102):

- Major repair: 8 weeks calendar downtime with 2 TECs @ 2wk, 1 engineer @ 1wk, 1 welder @ 1wk, 1 procurement specialist @ 1wk;
- Medium repair: 3 weeks calendar downtime with 2 TECs @ 1wk for evaluation plus 1 TEC @ 1wk to find parts plus 1 TEC @ 1wk to replace part, do a geometry check, and laser-shoot the machine; and
- Minor repair: 1 week downtime assuming parts are immediately available and simple to install with 1 FTE @ 1wk.

Parts cost is estimated based on the FTE value of the repairs listed above:

- Parts for major repair: 0.5 x major repair FTE cost;
- Parts for medium repair: 0.5 x medium repair FTE cost; and
- Parts for minor repair: 0.5 x minor repair FTE cost.

These activities are translated into costs in Table 4 and Table 5.

Table 5
Cost of Corrective Maintenance for Haas VF-3 in Building 102

Corrective Maintenance Schedule, Bldg 102 Haas VF-3	Cost ($)
Every year: One Minor + Two Medium Repairs	76,858
Every 3 and 5 years: Two Minor + Two Medium Repairs	85,397
Every 15 years: Three Minor + Two Medium Repairs	93,937

Table 4
Cost of Corrective Maintenance for Mazak 30Y in SM-39

Corrective Maintenance Schedule, SM-39 Mazak 30Y	Cost ($)
Every year: One Medium Repair	34,159
Every 3 years: One Minor + One Medium Repair	42,699
Every 5 years: One Minor + Two Medium Repairs	76,858
Every 10 years: One Minor + Two Medium + One Major Repair	146,156
Every 15 years: Two Minor + Two Medium Repairs	85,397

4. Productivity and Efficiency

a. <u>Mazak 30Y in SM 39</u>

New technology will increase efficiency because of features such as improved memory capacity and the ability to achieve finer granulation or definition and better contour (more accurate/ smoother results). These features cannot be retrofitted to the 30Y.

Currently, PF can complete approximately six parts per year. This is based on the assumption of one machinist assigned to one machine to produce saddles for JOPIN hydrodynamic experiments. (A part is assumed to be an upper or lower saddle.) If additional machinists were available, the *e*410 machine could be used to perhaps double production. W Division has a goal of ten hydro shots per year, half of which will be JOPIN experiments. Each of the JOPINs needs two PF saddle parts, which would be ten parts per year. The time it takes to make one part with the current situation is approximately eight weeks. This includes several machining cycles and inspection cycles. This happens over several weeks in which a part is machined and then repeatedly taken out of the machine for inspections. The current inability to hold high tolerances can cause up to ten iterations per final part. Note that the material cost of scrap is currently not counted. Typically, PF does not scrap these parts because of the availability and cost of the material. They continue to machine the part until is usable, in both SM-39 and Building 102.[7] Therefore, imputing eight weeks of machinist time as the value of machining one part adequately captures the scrap rate.

[7] Earl Vest (PF-WFS), personal communication, February 17, 2015.

Under the current circumstances, the machinist can lose confidence in the system over time due to lack of maintenance and wants to constantly check the quality and integrity of the product being produced—there are typically at least four "in-process" inspections per part. This can cause more problems with the integrity of the part and not only slows down the project, but also takes up the time of other resources. Some of the inspections take place in controlled environments, in which case the part has to sit in that controlled environment for a day or two before it could be checked; it can turn into a week for these "in-process" inspections. Overall production performance ends up to be eleven to twelve months per part in some extreme cases. More precise parts have as many as 23 "in-process" inspections. The optimal situation would be using on-machine gauging (OMG), which would not require any "in-process" inspections. With OMG, there is a better than 95% acceptance rate with harder-to-work-with materials, and includes a very robust maintenance program.

In the cost table we assume that the current PF plan of one machinist per machine would be maintained. That is, no new staff would be required to run the new machine. Training of two or three machinists on the new machine would be desirable.

b. Haas VF-3 in Building 102

Productivity and efficiency in Building 102 is lower than that described for SM-39, above. Also, as noted above, new technology will increase efficiency because of features such as improved memory capacity and the ability to achieve finer granulation or definition and better contour (more accurate/smoother results). These features cannot be retrofitted to the Haas VF-3. Currently, the VF-3 in Building 102 can produce approximately three new parts per year. Given that the machine is off-line for PM each year, the machinist time available each year to produce these parts is reduced by four weeks relative to productive hours for the Mazak 30Y in SM-39.

B. New Scenario

1. Selection of Machine

There are several variables that must be considered when selecting a new machine, including cost, facility requirements, and security requirements. For example, any new technology that would be brought in would need to be able to work on classified parts. Many PCs that are internal to machines cannot be updated and/or do not easily accommodate patching, and the ability for LANL to customize the software to accommodate the Red (classified) environment is an important requirement.

Purchasing new equipment typically takes six to twelve months. The process includes LANS labor to accomplish various tasks:

- Determining "rough cost";
- Making a decision about what to buy (1 FTE @ 4wk for replacing the 30Y in both SM-39 and Building 102);
- Bidding process/review by procurement team (1 FTE @ 3wk);
- Acceptance artifact—the manufacturer is provided with a design and raw material and they make the item and return it for inspection. (1 FTE @ 2wk); and

- Once the chosen manufacturer shows they can meet the criteria, the bid is presented to the LANL procurement office.

The cost of the new equipment in Building 102 will be same as that for the new equipment in SM-39 because the intention is to purchase identical equipment for both shops.

Table 6 is the primary equipment tooling replacement prioritization as of 9-15-14. The orange highlighted rows show the Mill/Turn CNCs that are to be replaced in SM-39 and TA-3-102.

Table 6
Equipment Tooling Prioritization Compilation as of 9-15-14

Priority	Shop	Type of Equipment	Current Equipment to Replace	New Equipment Description	Amount	Notes
1	03-039	Mill/Turn-CNC	Intigrex 30Y (~1986)	Mazak Integrex i300	$550,000	Based on previous successes with older equipment of this type PF needs a modern supported platform to gain efficiencies in the fabrication of blast hardware and other weapons components.
1	03-102	Mill/Turn-CNC	TBD	Mazak Integrex i300	$550,000	Same as above.
2	03-039	Lathe-CNC	Hardinge Lathes (2001)	Nano Tech ultra precision Turning platform	$800,000	High precision platform needed to replace existing slant bed lathes to gain efficiencies and accuracy in the fabrication of shells, and as a replacement for aging T-base platforms.
2	03-102	Lathe-CNC	Hardinge Lathes	Nano Tech ultra precision Turning platform	$800,000	Same as above.
3	03-039	Wire EDM		Mitz FA-40/Charmilles cut 500	$450,000	Consistency of tooling designs for mouse holes.

2. Equipment Cost and Procurement

The entire procurement process could take up to one year. New equipment options that are being considered to replace the Mazak 30Y are listed in Table 7.

Once the equipment is ordered, depending on the specifications, it could take five to six months before the equipment is received. This is for off-the-shelf equipment that typically requires some adjustments to meet LANL specs. A total custom build would take longer.

Table 7
New Equipment Options for Replacing the Integrex 30Y

Machine	Manufacturer	Notes	Price Quote
Integrex i200R 40" / 1000U Mazatrol Matrix 2 Control	Mazak Corporation 8025 Production Drive P. O. Box 970 Florence, KY 41042 (859) 342-1700		$341,300
Integrex i300R 40" / 1000U Mazatrol Matrix 2 Control	Mazak Corporation 8025 Production Drive P. O. Box 970 Florence, KY 41042 (859) 342-1700		$409,900
DMG Mori Seiki Model NT540 Multitasking CNC options: • NT4250DCG/1000S Fanuc System 31iA5 Control • NT4250DCG/1500S Fanuc System 31iA5 Control • NTX 2000/1500S Fanuc System 31iB5 Control	Mori Seiki Iga, Japan	The possibility of securing the controller for classified processing with a FANUC gives these machines an advantage.	 $704,270 $739,970 $595,660
MULTUS B300II MULTUS U3000	Okuma America Corp. 11900 Westhall Drive Charlotte, NC 28278 (704) 588-700		

There is typically a one- to two-week delay in the shop receiving the equipment after it arrives at LANL because Receiving must verify that what was received is what was ordered. This is not always easy because there are times when Receiving is not allowed to open the crate. When this is the case, verification is done via documentation.

3. Facility Preparation

a. SM-39

The SM-39 shop will keep the Mazak Integrex 30Y that is currently in use; therefore, space would need to be prepared for the new machine. Facility preparation is an added cost and includes an evaluation of available power, floor/foundation suitability and classified computing capability. Crafts are usually scheduled to bring in ground penetrating radar (GPR) to determine if there are any floor or foundation issues that need to be addressed. In most cases, Information Technology (IT) support would have been involved during the new equipment selection process and would already be aware of the software/hardware issues involved with the new equipment.

As a result, classified computing issues will have been taken into consideration and the equipment and facility prepared to deal with any issues (such as disabling vulnerable software or hardware). Facility preparation typically requires two FTEs for four weeks and is completed while waiting for the new equipment to arrive at LANL. This assumes that no coring or fixaters will be required to accommodate the new equipment in SM-39. However, structural supports will be needed in order to move the new Mazak into SM-39. There is a tunnel under the floor of SM-39, and PF will need to install temporary screw jacks in order to accommodate the weight of the new Mazak when it is moved in. This will require one FTE (engineer) for two weeks, and the cost of the screw jacks will be $20,000. No additional FTEs (crafts) will be needed for installation and removal of the screw jacks.[8]

A study was done about eight years ago that focused on the cost of simply moving a similarly large piece of equipment from one place to another in the same shop. The FTE cost was about $40k. This is considered to be a high estimate. This report uses $20k as the estimated cost for relocation of existing equipment; this includes moving equipment out of the way to make room when new equipment is moved in.[9]

b. Building 102

The Building 102 shop will keep the Haas that is currently in use in order to augment capability; therefore, a new space would need to be prepared for the new machine. As with the installation of the new equipment in SM-39, facility preparation would include an evaluation of available power, floor/foundation suitability and classified computing capability. Crafts are usually scheduled to bring in ground penetrating radar (GPR) to determine if there are any floor or foundation issues that need to be addressed. In most cases, Information Technology (IT) support would have been involved during the new equipment selection process and would already be aware of the software/hardware issues involved with the new equipment. As a result, classified computing issues will have been taken into consideration and the equipment and facility prepared to deal with any issues (disabling software or hardware, etc.). The cost for this basic facility preparation is the same as for SM-39: 2 FTE for 4 weeks.

There would be no D&D at this point, but it would cost $20k per machine move if reconfiguration were needed in Building 102. Only one machine would need to be moved to accommodate the new equipment in Building 102 at this time.[10]

The issues that would differ from SM-39 are that coring and drilling would be more difficult in Building 102 and the facility will need to be shut down while this work is taking place. Also, the existing ramp to the building would need to be reinforced with 1-inch steel plates, requiring several days of iron worker effort. We include costs for 5 FTEs (craft workers) for a week to put up and take down the ramp that will be needed to move the new equipment in. The cost of crafts is about $160/hour.[11]

[8] Derrik Stafford of PF-WFS, personal communication, February 17, 2015.
[9] Derrik Stafford, personal communication, February 17, 2015.
[10] Earl Vest of PF-WFS, personal communication, February 12, 2015.
[11] Derrik Stafford, personal communication, February 17, 2015.

Eight-inch diameter cores into the existing foundation will be needed to accommodate fixaters that will be put in place to support the new Mazak. Twelve fixaters will be needed (one under each foot of the new machine), and coring the twelve holes will require two FTEs for one week. Twelve fixaters would need to be purchased for the new Mazak at a total cost of about $50K.[12] In an extreme case, a new 18-inch slab would need to be poured, which could cost upwards of $2M. However, that scenario is beyond the scope of this report.

The total cost of facility preparation for Building 102 includes the following activities.

- Basic preparation (same as for the Mazak in SM-39): 2 FTE @ 4wk.
- Entry ramp reinforcement: 5 FTE iron workers @ 1wk.
- Drilling cores (12): 2 FTE @ 1wk.
- Purchase fixaters: $50k.
- Move equipment (1): $20k (relocate/repurpose old equipment).

4. Installation

a. SM-39

Once the facility is prepared and ready for the equipment, it can take three weeks for the equipment to be installed (2 FTE @ 3wk). An additional two weeks should be added to allow for another acceptance artifact to be produced after installation (1 FTE @ 2wk). This ensures that the equipment is working as required and that no damage occurred during shipment or installation.

The move into SM-39 itself would require a minimum of four FTEs for one day to offload, uncrate, and bring the equipment into the shop. Once in the shop, the following activities will be performed.

- Level the equipment.
- Connect to power and compressed air.
- A factory representative turns on the machine to verify that it is operating correctly. (LANL staff does only the bare minimum during initial installation of equipment to avoid voiding the warranty). A PF maintenance technician then will do a laser shoot, and a machinist will create a new artifact to make sure the machine meets specifications.

Total staff time is:

- 4 FTEs to move the equipment in (1 day);
- 2 FTEs for the remainder of the install (3 weeks); and
- 1 FTE to re-run the acceptance artifact (2 weeks).

Depending on the new equipment, there will most likely be new software/hardware issues that will require that IT people approve and ensure compatibility with existing equipment and

[12] Several years ago, 16 fixaters were purchased for another piece of equipment at a cost of approximately $40K-$50K; the estimate is based on this.

procedures. Enabling a machine to handle classified can be even more intensive. Any IT issues will be taken care of during facility preparation.

Ancillary equipment, materials and supplies could include things such as a crane and sub-contractor. However, in the case of the Mazak PF may only need a forklift, which LANL could supply. However, that would still require that another LANL facility provide the forklift and driver. Either of these options would incur some cost.

It should also be noted that there will still be ongoing maintenance costs associated with the upkeep of the old equipment throughout this entire process.

b. Building 102

Installation of the new Mazak in Building 102 will be similar to the installation of the same equipment in SM-39 and assumes diskless technology. If an internal hard drive is involved, that will create other IT issues that will need to be addressed. The biggest difference is that a ramp for moving the equipment will need to be reinforced and that the shop will need to be shut down during installation. This is addressed under “Facility Preparation” above.

5. Training

New technology can be complicated and require intensive training. PF-WFS would need two machinists, two programmers, and two maintenance personnel to be trained on the new equipment. The Integrex is a complicated machine and the training is complex, but there is extant knowledge with that brand within PF. Training in the new Mazak machine would build on that experience. If a different manufacturer were chosen, more training might be required.

In the current scenario in both SM-39 and Building 102, PF is only “one deep” with trained staff to use certain equipment and this leaves them vulnerable if that one person is out or leaves the organization. Having two of each capability trained on the equipment would limit this vulnerability. In addition, having complete, up-to-date training helps technicians solve problems and maintain equipment effectively.

The cost of the training depends on the manufacturer. Typically, a manufacturer offers training for new machines. Training for the two maintenance technicians is assumed to be four weeks long with a class cost of $2k/week per person, plus travel expenses ($5k/person). Training for two programmers and four machinists (two machinists from SM-39 and two machinists from Building 102) will take one week at a cost of $2k/wk plus travel of $2k/person.

Note that the training scenario for the new Mazak in Building 102 is the same as that for SM-39; therefore, the only additional training cost would be for training two machinists for each shop because the machinists in Building 102 are different than the machinists in SM-39.

6. Qualification

Qualification begins after installation of the equipment while PF works with the factory representative making sure the equipment is ready. Qualification requirements are the same for the shop in Building 102 as for the shop in SM-39. This will require two maintenance FTEs for two weeks to work with the factory representative. Next, the equipment will require two FTEs (programmer and machinist) for two weeks in order to program the equipment and produce a 5-axis verification artifact to make sure that everything is positioning correctly in a basic state. During this process they will:

- Confirm machine performance by using Vericut software;
- Cut a classified test part using surrogate material; and
- Machinist verifies the process.

7. Preventative Maintenance

For new equipment in both SM-39 and Building 102, regular preventative maintenance (PM) is scheduled per manufacturer requirements. In addition, the new smarter technology will have the ability to "self-monitor," run reports, and send diagnostics to the manufacturer and maintenance technician. The new equipment would require similar preventative maintenance as with current machines—about two weeks per year. This is expected to double or triple the life of the machine and almost eliminate major corrective maintenance repairs that are common to the old equipment.

8. Corrective Maintenance

It is assumed that corrective maintenance on medium repair issues (e.g., hydraulics and electronics) in both SM-39 and Building 102 would be required every five years on new equipment as opposed to annually with old equipment. Major repairs that show up every ten years with old machines are not expected to occur on a new machine (assuming a fifteen-year lifetime) if the equipment is properly maintained. For example, the lead screw should last the life of the machine. In the cost table we assume no major repairs during the fifteen years of operation.

Unanticipated occurrences, such as lightning strikes or operator error, can cause catastrophic failures. This can happen with old equipment as well but older equipment could be harder to repair.

The operating systems on new equipment can be updated regularly (as opposed to the Windows 95 platform in the Mazak *e*410). It is worth noting that this also depends on the controller. New equipment would most likely use an "emulated drive" which would make software updates and repairs much easier than with the internal hard drives that are currently on the older equipment. The emulated drive would also eliminate the risk of losing everything due to a bad battery. This has happened with older equipment and it lead to a two-week downtime. If the 30Y has a board failure, it is extremely difficult to replace because the hardware is obsolete. The hard drive on the *e*410 is unique and internal to the machine and cannot be easily replaced.[13] This would not be an issue with new equipment. A non-hard drive based controller, like on the current Haas, will not have as many issues. Overall, new machines will only have computer hardware CM issues, whereas old machines have both software and hardware problems. The cost table assumes a hardware failure as a minor repair occurs every five years.

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[13] This drive has already been replaced once since LANL took possession of the Mazak *e*410. Dino Farfan, personal communication, January 2015.

9. Productivity and Efficiency

a. Mazak 30Y in SM-39

Tolerances of the new machine will be similar to those of the Integrex 30Y, but with less random errors and fewer operational issues. Less maintenance and the ability to hold tolerances will result in faster throughput, which will have a direct effect on productivity.

New equipment is assumed to have a feature called “on-machine gauging” (OMG). This reduces the need for numerous stop-and-start inspections during machining, since only one or two inspections would be needed for each part. Minimizing part removal and reinstall makes production much more efficient and accurate. (A one-thousandth of an inch error can be added during each removal cycle.) A new machine with OMG could produce at best one saddle part per week; a new machine without OMG would have a maximum productivity of about two weeks per part. The cost analysis assumes the new machine has OMG and produces one part every two weeks including inspection and acceptance. To add conservatism, we assume a two-year period during which confidence in OMG is established. To reflect this, the cost model begins with the new machine requiring four weeks per part in the first year of operations. By the third year of operations, once confidence in the on-machine gauging (OMG) is fully established, productivity and efficiency is improved to the point where productivity is two-weeks per part.

The current equipment produces six parts over the course of a year, whereas the new equipment could produce a maximum of 23 parts per year.[14] This productivity increase implies a lower cost per part. Cost per part using the old machine is calculated by dividing the annual cost of one machinist by six—a single part requires the expenditure of one-sixth of a machinist-year. Assuming a machinist cost of $300k/yr means the part cost is $50k with the old machine. The high production rate of a new machine means the cost per part is $13k ($300k ÷ 23)—it requires only 1/23 of a machinist year to produce a part on the new machine. Consequently, the productivity savings of the new scenario over the baseline scenario is about $37k per part.

The appropriate annual productivity savings to use in the cost analysis depends on how many parts are assumed to be produced on the new machine. Clearly, the new machine offers much more capability—a 400 percent increase. To get the maximum possible savings, we assume the machine is aggressively used such that 23 parts are produced in each year, indicating an annual savings of $850k (23 × $37k). The minimum savings would be if only six parts are produced on the machine—$222k (6 × $37k). Of course, this means the machine would be left idle the remainder of the year. See Figure 8.

Estimating the number of parts produced on the new machine relies on several assumptions and questions.

- Is there sufficient demand for hydro saddle parts to warrant full production?
- Can all aspects of the parts process support the maximum rate, e.g., inspection, measuring and test equipment (MT&E), coordinate measuring machine (CMM)?

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[14] Old machine makes 6 parts = 48 wk per yr ÷ 8 wk per part; new machine makes 23 parts = (48 wk per yr – 2 wk PM downtime) ÷ 2 wk per part.

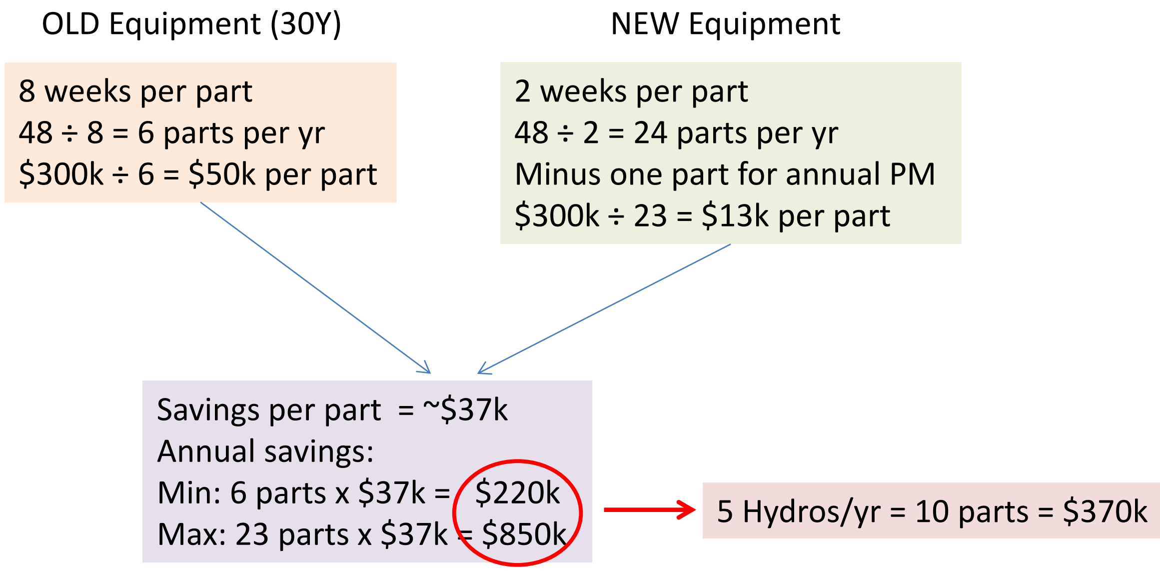

Figure 8. For the Mazak 30Y replacement in SM-39, an approximate range of potential productivity savings is $220k to $850k per year. If ten parts/y is the demand, a productivity value of $370k/y would be predicted.

- If full capability is not used by saddle manufacturing, are there other parts that could be produced, e.g., LANL parts that are currently sent to subcontractor machine shops?
- Could the new machine take on scope currently at other sites, e.g., classified shapes currently produced at the Nevada National Security Site (NNSS)?
- Given that the machine is new and the most capable in the shop, will PF try to maximize its use?

In the absence of further discussion, the best estimate assumes ten saddle parts are made each year to satisfy five JOPIN hydrodynamic experiments annually.

The improvement in production efficiency does not necessarily lead to a reduction in the number of machinist FTEs. Rather, we assume existing machinists will be able to work on other programmatic issues requiring their attention and expertise. That is, their time will be productively used elsewhere and no reduction in staff occurs.

b. Haas VF-3 in Building 102

The new scenario is the same as for Mazak i300 in SM-39 above, and assumes that the new equipment will produce ten parts per year. However, different material is used in Building 102 than in SM-39.

C. Business Case Results

a. <u>Mazak 30Y in SM-39</u>

After estimating the costs of maintenance and productivity variables within the two scenarios, a life-cycle cost/benefit table was created to determine the eventual payback of the new scenario. See Table 8. The *Best Estimate* line of Figure 9 reflects a modest assumed demand of ten hydro experiment parts per year. The *Maximum* line assumes that the machine 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 six parts per year.

The estimated total net present value of replacing the Mazak Integrex 30Y in SM-39 with a Mazak Integrex i300 is $4.5M over fifteen years of operation. The project achieves pay back of its investment in the fifth year after procurement. 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. Under the minimum production case there would be a net present value of $2.9M and a breakeven point in the sixth year after procurement.

a. <u>Haas VF-3 in Building 102</u>

Table 9 shows the life-cycle benefits for the Mazak Integrex replacement in Building 102. To account for the Haas VF-3's annual PM of six weeks, machinist labor time imputed for the three parts produced each year is lowered by 160 hours. For the SM-39 Mazak analysis this was not done because its two weeks of PM is typical and adequately captured in the 1730 total labor hours per year.

Figure 10 shows that under the best estimate assumptions of ten parts per year, replacing the old Haas VF-3 with a new Mazak Integrex has a total net present value of $11M over a seventeen-year project life. Using the new machine for the minimum six parts per year leads to a $7M total value, whereas a maximum production of 23 parts per year has a $23.5M value. The project has a pay back in the fourth year under all three production assumptions.

IV. HARDINGE LATHES IN SM-39 AND TA-3-102

A. Baseline Scenario

1. Background

The Hardinge Q10/65-SP lathes in SM-39 and TA-3-102 are next in order of priority to be considered as part of the PF recapitalization plans (see Table 6). The Q10/65-SP lathes are used for cutting components for weapons programs and experiments. The current annual demand is about 10 stainless steel parts and sixteen depleted uranium (DU) parts. (See Figure 11.) The demand could ramp up to 40 to 80 parts per year to meet future programmatic needs. The addition of new lathes will accommodate this anticipated increase. Currently, PF has available two Ex-Cell-O T-base lathes to make pit components in Building 102, and is also using old Hardinge lathes to handle the DU part demand. These machines are assumed to remain in Building 102 to supplement the new NanoTech machine. To make space for new equipment, a Haas EC-500 machine will be removed. Since the NanoTech does not directly replace the Haas, we cannot count avoided maintenance on the Haas as cost savings. Depleted uranium part production will be shared by existing and new lathes in Building 102.

It should be noted that this analysis assumes the two existing Ex-Cell-O T-Base lathes in Building 102 are fully functional and any new equipment would augment what is currently in use. (See Figure 12.) However, during the week of March 2, 2015, PF shut down one of the Ex-Cell-O T-base lathes and found damage on one of the spindles indicating the entire spindle housing needs to be replaced. There are a couple of options to address this issue. The best case scenario would be that a replacement part is available from Manufacturing Engineering and Technologies Division (MET-DO) at LANL, in which case PF would repair the lathe. However, these Ex-Cell-O T-base lathes are over 40 years old and PF is fairly confident that the other Ex-Cell-O has the same problem. Therefore, the issue will have to be addressed on that lathe as well. MET *might* have two spindles available, but PF is not sure.

The second option is to have a new spindle made. The company that would manufacture a new spindle is in Britain and is currently shut down. That company would need to restart before they could start manufacturing a new spindle. At best, PF could get a replacement spindle in eight months to a year at an approximate cost of $350k each. As a last resort, they could contact Y-12 and see if they have any spare spindles.

In the SM-39 Advanced Manufacturing Laboratory where space is at a premium, an existing Hardinge will be directly replaced by the new NanoTech lathe. Table 10 lists all of the Hardinge Q10/65-SP and Ex-Cell-O T-Base lathes located in SM-39 and Building 102.

2. Preventative Maintenance

Basic preventative maintenance (PM) on the Hardinge Q10/65-SP lathes in SM-39 and Building 102 includes regularly scheduled tasks such as changing fluids, filters, geometry checks using a ball bar, and software backup. These tasks have the machine down for a total of two weeks over the course of a year. Two maintenance technicians are needed for two weeks each year for PM (see Table 11 and Table 12). It should be noted that it is important that PF have their own trained maintenance technicians because of issues related to classification and hazardous operations.

3. Corrective Maintenance

Due to the age of the Hardinge Q10/65-SP lathes in SM-39 and Building 102, the shop staff has to deal with issues such as electronic component and servo drive failure, and major components breaking. The bulleted lists below are the assumed schedules for CM, FTE durations, parts and cost estimates for the Hardinge Q10/65-SP lathes in SM-39 and Building 102. These activities are translated into costs in Table 13.

Table 8
Life-Cycle Benefits and Costs of Mazak 30Y Replacement in SM-39

	Recapitalization Costs, Mazak Integrex ($)						Costs Avoided (Benefits) ($)					
Year	Procurement	Installation & Transition	Preventative Maintenance	Corrective Maintenance	Total Annual Cost	Discounted Total Annual Cost	Preventative Maintenance	Corrective Maintenance	Productivity Improvement {1}	Total Annual Benefits	Discounted Total Annual Benefits	Cumulative Discounted Cash Flow
2015	625,592				625,592	625,592				0	0	-625,592
2016		309,154			309,154	306,093				0	0	-931,686
2017			22,773		22,773	22,324	22,773	34,159	245,625	302,557	296,595	-657,414
2018			22,773		22,773	22,103	22,773	34,159	327,500	384,432	373,126	-306,392
2019			22,773		22,773	21,884	22,773	42,699	363,098	428,569	411,847	83,571
2020			22,773		22,773	21,667	22,773	34,159	363,098	420,030	399,644	461,547
2021			22,773	42,699	65,471	61,677	22,773	76,858	363,098	462,728	435,911	835,781
2022			22,773		22,773	21,240	22,773	42,699	363,098	428,569	399,734	1,214,275
2023			22,773		22,773	21,030	22,773	34,159	363,098	420,030	387,890	1,581,135
2024			22,773		22,773	20,822	22,773	34,159	363,098	420,030	384,050	1,944,363
2025			22,773		22,773	20,616	22,773	42,699	363,098	428,569	387,978	2,311,725
2026			22,773	42,699	65,471	58,684	22,773	146,156	363,098	532,026	476,868	2,729,910
2027			22,773		22,773	20,210	22,773	34,159	363,098	420,030	372,755	3,082,455
2028			22,773		22,773	20,009	22,773	42,699	363,098	428,569	376,568	3,439,013
2029			22,773		22,773	19,811	22,773	34,159	363,098	420,030	365,410	3,784,612
2030			22,773		22,773	19,615	22,773	34,159	363,098	420,030	361,792	4,126,789
2031			22,773	42,699	65,471	55,835	22,773	85,397	363,098	471,268	401,907	**4,472,861**
Total	**625,592**	**309,154**	**341,590**	**128,096**	**1,404,433**	**1,359,214**	**341,590**	**752,478**	**5,293,398**	**6,387,466**	**5,832,075**	

{1} New machine labor per part improves as on-machine gauging is qualified during the first two years of operation: Year 1 = four weeks; Year 2 = three weeks; Year 3 = two weeks.

Table 9
Life-Cycle Benefits and Costs of Haas Replacement in Building 102

	Recapitalization Costs, Building 102 Mazak Integrex ($)						Costs Avoided (Benefits) ($)					
Year	Procurement	Installation & Transition	Preventative Maintenance	Corrective Maintenance	Total Annual Cost	Discounted Total Annual Cost	Preventative Maintenance	Corrective Maintenance	Productivity Improvement {1}	Total Annual Benefits	Discounted Total Annual Benefits	Cumulative Discounted Cash Flow
2015	625,592				625,592	625,592				0	0	-625,592
2016		288,868			288,868	286,008				0	0	-911,601
2017			22,773		22,773	22,324	68,318	76,858	646,008	791,184	775,594	-158,330
2018			22,773		22,773	22,103	68,318	76,858	727,883	873,059	847,382	666,949
2019			22,773		22,773	21,884	68,318	85,397	763,481	917,196	881,408	1,526,473
2020			22,773		22,773	21,667	68,318	76,858	763,481	908,657	864,556	2,369,361
2021			22,773	42,699	65,471	61,677	68,318	85,397	763,481	917,196	864,041	3,171,724
2022			22,773		22,773	21,240	68,318	85,397	763,481	917,196	855,486	4,005,970
2023			22,773		22,773	21,030	68,318	76,858	763,481	908,657	839,129	4,824,069
2024			22,773		22,773	20,822	68,318	76,858	763,481	908,657	830,821	5,634,068
2025			22,773		22,773	20,616	68,318	85,397	763,481	917,196	830,326	6,443,778
2026			22,773	42,699	65,471	58,684	68,318	85,397	763,481	917,196	822,105	7,207,199
2027			22,773		22,773	20,210	68,318	76,858	763,481	908,657	806,387	7,993,376
2028			22,773		22,773	20,009	68,318	85,397	763,481	917,196	805,906	8,779,273
2029			22,773		22,773	19,811	68,318	76,858	763,481	908,657	790,498	9,549,959
2030			22,773		22,773	19,615	68,318	76,858	763,481	908,657	782,671	10,313,015
2031			22,773	42,699	65,471	55,835	68,318	93,937	763,481	925,736	789,487	**11,046,667**
Total	**625,592**	**288,868**	**341,590**	**128,096**	**1,384,147**	**1,339,129**	**1,024,770**	**1,221,184**	**11,299,143**	**13,545,097**	**12,385,796**	

{1} New machine labor per part improves as on-machine gauging is qualified during the first two years of operation: Year 1 = four weeks; Year 2 = three weeks; Year 3 = two weeks. Four weeks of machinist time per year on Haas VF-3 is lost due to preventative maintenance.

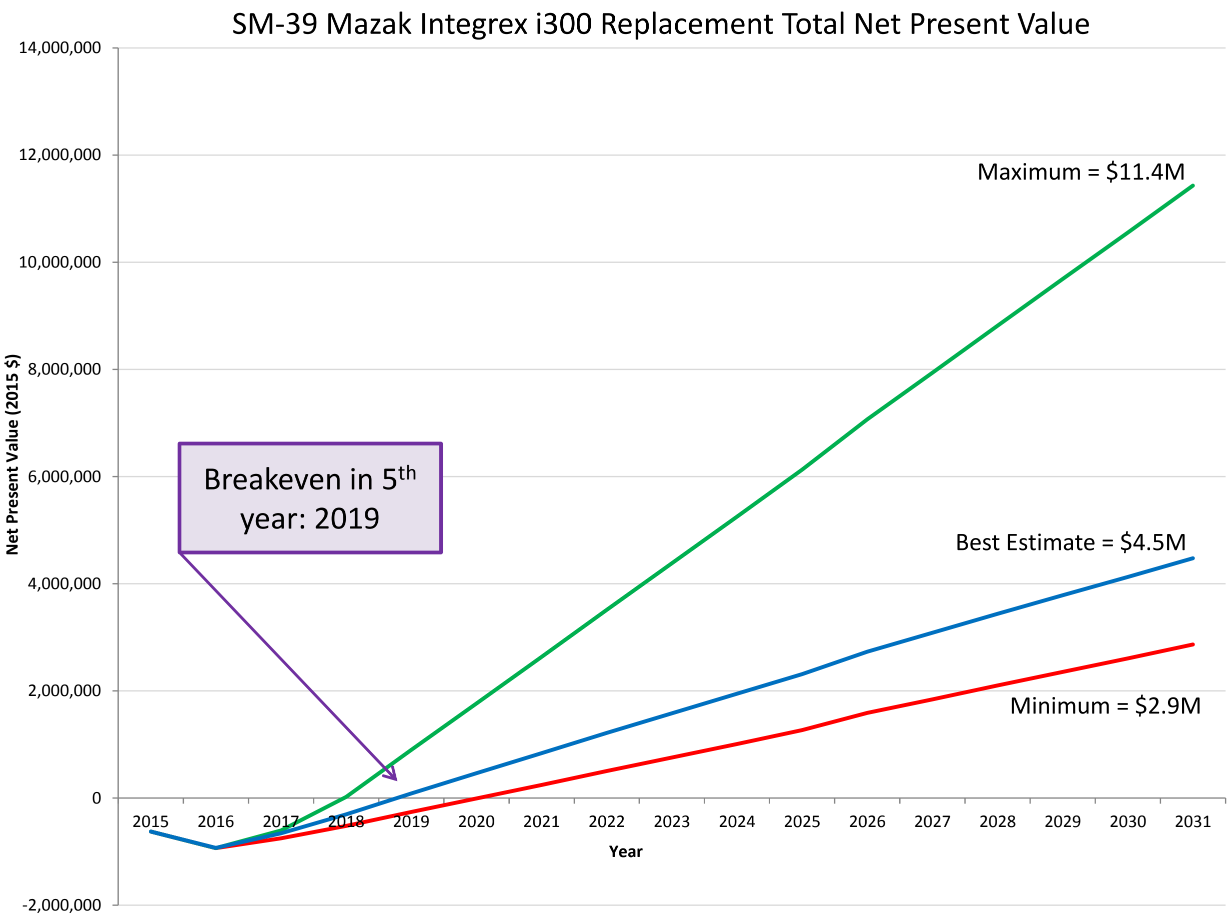

Figure 9: The payback period for installing a new Mazak mill-turn machine in SM-39 under the best-estimate assumptions is in the fifth year, with a $4.5M savings over a 17 year project life.

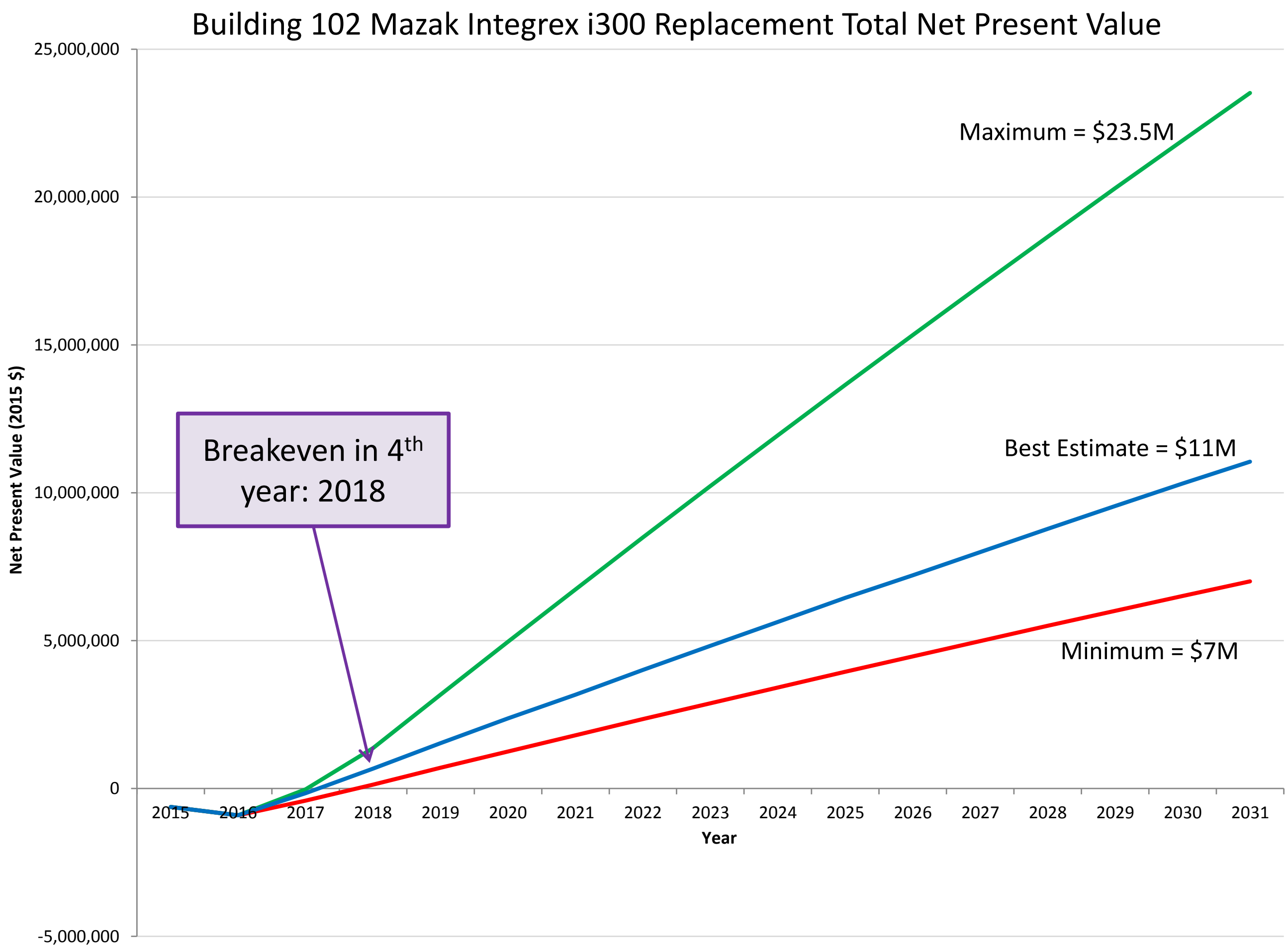

Figure 10. The payback period for installing a new Mazak mill-turn machine in Building 102 as a replacement for the old Haas VF-3 is in the fourth year, with an $11M savings over the 17 year project life for the Best Estimate production rate of ten parts per year.

Figure 11. Hardinge Q10/65-SP Lathe

Table 10
Hardinge Q10/65 and T-Base Lathe Equipment List as of 6-18-14

Location	Room	Skid Type	Machine Type	OEM	Model #	Vintage
TA-03-102	118	CNC Lathe	Slant Bed Lathe	Hardinge	Quest 10/65-SP	2002
TA-03-102	118	CNC Lathe	Slant Bed Lathe	Hardinge	Quest 10/65-SP	2002
TA-03-102	118	CNC Lathe	Slant Bed Lathe	Hardinge	Quest 10/65	2006
TA-03-39	34B	CNC lathe	Slant Bed turning center	Hardinge	Q10/65-SP	2002
TA-03-39	34B	CNC lathe	Slant bed turning center	Hardinge	Q10/65-SP	2002
TA-03-39	36A	CNC lathe	Slant bed turning center	Hardinge	Q10/65-SP	2001
TA-03-102	118	CNC Lathe	T-Base	Ex-Cell-O	921	1973
TA-03-102	118	CNC Lathe	T-Base	Ex-Cell-O	921	1973

Figure 12. Ex-Cell-O T-Base Lathe

Assumed schedule for CM for an old machine (Hardinge Q10/65-SP) is as follows.

- Hydraulic/electronic issues (medium repair): once a year.
- Turret and lead screw (major repair): once per ten years.
- Software operating system (medium repair): at least once per year.
- Computer hardware failure (minor repair): once per five years.
- Mechanical repairs (major) once every five years.

Table 11
Assumptions and Factors for Life Cycle Analysis of Hardinge Lathe Replacement in SM-39

Assumptions		Comments
Real Discount Rate {1}	0.01	
Engineer, SLR	$246	R&D Eng
Programmer, SLR	$199	JST
Machinest, SLR	$170	JTM
Maintenance TEC, SLR	$142	AKN
Other Support, SLR (e.g., procurement)	$170	
Productive Hours per year	1730	for R&D Eng
New Machine		
Equipment Cost ($)	800,000	
Procurement Support Cost ($) {2}	55,940	
Facility Preparation ($) {3}	65,545	
Installation ($) {4}	54,602	
Training ($) {5}	69,347	
Qualification ($) {6}	52,291	
Maintenance		
Preventative Maintenance ($ per year) {7}	22,773	
Corrective Maintenance {8}		
Minor	8,540	
Medium	34,159	
Major	69,298	

{1} Source: 10-year real discount rate, OMB Circular No. A-94, Appendix C (Revised

{2} Decision Analysis: decision requires 1 FTE @ 2 wk (shared equally with machine in Bldg. 102); Procurement Team: 1 FTE @ 3wk; Acceptance Artifact: 1 FTE @ 2wk.

{3} Choose location, power supply, floor foundation, reconif shop space, crafts: 2 FTE @ 4wk. Plus $20,000 for moving one machine to make space.

{4} Off-load and level machine, connect to power/air, laser verify: 2 FTE @ 3wk. Run acceptance artifact: 1 FTE @ 2wk. 4 FTEs for one day to move machine.

{5} One-half the cost of two maintenance technicians for 4 weeks training with class cost of $2k/week per person, plus travel expenses ($5k/person). One programmer and two machinists with 1 week training at a cost of $2k/wk plus travel of $2k/person.

{6} Maintenance corrections with factory rep: 2 maintenance technician FTE @ 2wk. 5-axis verification artifact, build & test post-processer, confirm Vericut SG Tech, cut surrogate classified shape and inspect: 1 programmer FTE @2wk + 1 machinist FTE @ 2wk.

{7} 2 maint FTE @ 2 weeks per year for scheduled PM based on manufacturer recommendations.

{8} Assumed CM for an old machine (we assume that parts for CM have a cost equal to 50% of the labor cost):

• Minor repair: 1 week downtime assuming parts are immediately available and simple to install with 1 maint FTE @ 1wk.

• Medium repair: 3 weeks downtime with 2 maint FTE @ 1wk for evaluation, 1 maint FTE @ 1wk to find part, 1 maint FTE @ 1wk to replace part and laser-shoot machine.

• Major repair: 5 weeks downtime with 2 maint FTE @ 2wk, 1 engineer @ 1wk, 1 welder @ 1wk, 1 procurement specialist @ 1wk.

Table 12
Assumptions and Factors for Life Cycle Analysis of New NanoTech Lathe in Building 102

Assumptions		Comments
Real Discount Rate {1}	0.01	
Engineer, SLR	$246	R&D Eng
Programmer, SLR	$199	JST
Machinest, SLR	$170	JTM
Maintenance TEC, SLR	$142	AKN
Craftsperson (Iron workers), SLR	$160	
Other Support, SLR (e.g., procurement)	$170	
Productive Hours per year	1730	for R&D Eng
New Machine		
Equipment Cost ($)	800,000	
Procurement Support Cost ($) {2}	55,940	
Facility Preparation ($) {3}	140,025	
Installation ($) {4}	54,602	
Training ($) {5}	69,347	
Qualification ($) {6}	52,291	
Maintenance		
Preventative Maintenance ($ per year) {7}	22,773	
Corrective Maintenance {8}		
Minor	8,540	
Medium	34,159	
Major	69,298	

{1} Source: 10-year real discount rate, OMB Circular No. A-94, Appendix C (Revised

{2} Decision Analysis: 1 FTE Engineer @ 2 wk; Procurement Team: 1 FTE Procurement Team @ 3wk; Acceptance Artifact: 1 FTE Programmer @ 2wk.

{3} Choose location, power supply, floor foundation, reconif shop space, crafts: 2 FTE @ 4wk. (Entry Ramp Reinforcement: 5 FTE iron workers @ 1 wk, Drilling Cores: 2 FTE's @ 1 wk) * 0.5. $25k purchase of fixaters, $20k for decontamination of piece of equipment, 10k for disposal box, and 3 FTE @1k for decontamination.

{4} Off-load and level machine, connect to power/air, laser verify: 2 FTE @ 3wk. Run acceptance artifact: 1 FTE @ 2wk. 4 FTEs for one day to move machine into building.

{5} One-half the cost of two maintenance technicians for 4 weeks training with class cost of $2k/week per person, plus travel expenses ($5k/person). One programmer and two machinists with 1 week training at a cost of $2k/wk plus travel of $2k/person.

{6} Maintenance corrections with factory rep: 2 maint FTE @ 2wk. 5-axis verification artifact, build & test post-processer, confirm Vericut SG Tech, cut surrogate classified shape and inspect: 1 programmer FTE @2wk + 1 machinist FTE @ 2wk.

{7} 2 maint FTE @ 2 weeks per year for scheduled PM based on manufacturer recommendations.

{8} Assumed CM for an old machine (we assume that parts for CM have a cost equal to 50% of the labor cost):

- Minor repair: 1 week downtime assuming parts are immediately available and simple to install with 1 maint FTE @ 1wk.
- Medium repair: 3 weeks downtime with 2 maint FTE @ 1wk for evaluation, 1 maint FTE @ 1wk to find part, 1 maint FTE @ 1wk to replace part and laser-shoot machine.
- Major repair: 5 weeks downtime with 2 maint FTE @ 2wk, 1 engineer @ 1wk, 1 welder @ 1wk, 1 procurement specialist @ 1wk.

Table 13
Cost of Corrective Maintenance for Hardinge Lathe

Corrective Maintenance, Hardinge Lathe	Cost ($)
Every year: Two Medium Repairs	68,318
Every 5 years: One Minor + Two Medium + One Major Repairs	146,156
Every 10 years: One Minor + Two Medium + Two Major Repairs	215,454

Assumed FTE durations for an old machine (Hardinge Q10/65-SP):

- Major repair: 8 weeks calendar downtime with 2 TECs @ 2wk, 1 engineer @ 1wk, 1 welder @ 1wk, and 1 procurement specialist @ 1wk;
- Medium repair: 3 weeks calendar downtime with 2 TECs @ 1wk for evaluation plus 1 TEC @ 1 wk to find parts plus 1 TEC @ 1wk to replace part, do a geometry check, and laser-shoot the machine; and
- Minor repair: 1 week downtime assuming parts are immediately available and simple to install with 1 FTE @ 1wk.

Parts cost is estimated based on the FTE value of the repairs listed above:

- Parts for major repair: 0.5 x major repair FTE cost;
- Parts for medium repair: 0.5 x medium repair FTE cost; and
- Parts for minor repair: 0.5 x minor repair FTE cost.

4. Productivity and Efficiency

The Hardinge Q10/65-SP lathes in the SM-39 Advanced Manufacturing Lab are used to cut stainless steel components. Each part requires about 80 hours of machinist time to produce, and the current demand from the weapons program is ten parts per year. The Hardinge lathes in Building 102 are used to cut depleted uranium parts. Current production is about sixteen parts per year; machinist time is about 100 hours per part including in-process inspections. As mentioned above, the demand for parts is anticipated to increase. Note that the material cost of scrap is currently not counted. Typically, PF does not scrap these parts because of the availability and cost of the material. They continue to machine the part until it is usable, in both SM-39 and Building 102. (See footnote 5.)

B. New Scenario

1. Selection of Machine

The Moore NanoTech 450UPL Ultra Precision Lathe is the example machine being considered to replace (or augment, as in the case of Building 102) the current Hardinge lathes. This is based on Kansas City Plant experience with a recent successful procurement of the NanoTech. The machine dimensions are 1.8m wide by 1.8m deep by 2m high. The weight is about 2,650 Kg (roughly 6,000 pounds).[15] The estimated cost of the Moore Nanotech 450UPL is $800,000 (see Table 6).

The decision for the NanoTech will consider the same variables as described above for the Mazak replacement including cost, facility requirements, and security requirements. Classified machining and secure Red network capabilities are required. If Windows 8 is the operating system, this would present a problem because Windows 8 is not currently supported by the classified network at LANL.

Purchasing new equipment typically takes six to twelve months. The process includes LANS labor to accomplish various tasks:

- Determining “rough cost”;
- Making a decision about what to buy (1 FTE @ 4wk; this cost is shared equally by the SM-39 and Building 102 cost analyses, two weeks for each);
- Bidding process/review by procurement team (1 FTE @ 3wk);
- Acceptance artifact—the manufacturer is provided with a design and raw material and they are to make the item and return it for inspection. (1 FTE @ 2wk); and
- Once the chosen manufacturer shows they can meet the criteria, the bid is presented to procurement.

2. Equipment Cost and Procurement

The cost of the new NanoTech lathes in SM-39 and Building 102 will be same because the intention is to purchase identical equipment for both shops. Based on Table 6, the expected cost is $800k per lathe.

The entire procurement process could take up to one year. Once the equipment is ordered, depending on the specifications, it could take five to six months before the equipment is received. This is for off-the-shelf equipment that typically requires some adjustments to meet LANL specs. A total custom build would take longer. There is typically a one to two week delay in the shop receiving the equipment after it arrives at LANL because Receiving must verify that what was received is what was ordered.

3. Facility Preparation

a. <u>SM-39</u>

Similar categories of facility preparation will be needed as with the Mazak in SM-39. The NanoTech is much lighter and smaller than the Mazak. No screw jacks will be needed to reinforce the tunnel during installation,[16] and the basic facility preparation cost will be two FTEs for four weeks.

[15] Moore Nanotech homepage, http://www.nanotechsys.com/machines/nanotech-450uplv2-ultra-precision-lathe-1/.
[16] Derrik Stafford, personal communication, February 23, 2015.

The existing Hardinge Q10/65-SP in SM-39 is assumed to be relocated to another LANL shop at a cost to PF division of about $20k. (It is assumed the receiving shop, not PF, would cover installation costs at the new location.)

b. Building 102

The shop in Building 102 will continue maintaining and using the two Hardinge and two T-base lathes that are currently there. Facility preparation for installing the NanoTech will be similar to that of the new Mazak, but less intensive because the lathe is much lighter. Fewer fixaters will be needed and the build-up and tear-down of the ramp to move the equipment into the shop will be less robust than will be needed for the Mazak. We apply a cost factor of 0.5 for ramp cost and fixator installation as compared to the Mazak in Building 102. However, there will be additional cost for decontamination and removing an old Haas EC-500 machine to make room for the new equipment.[17] Decontamination to acceptable low-level waste (LLW) levels plus packaging will cost $20k; the cost of the disposal box is $10k/machine; and labor is three FTEs for one week. It is assumed that the institution covers the disposal cost.[18]

4. Installation

We assume the installation effort is similar to the Mazak in both SM-39 and Building 102. The move into SM-39 itself would require a minimum of four FTEs for one day to offload, uncrate, and bring the equipment into the shop. Once in the shop, the following activities will be performed.

- Level the equipment.
- Connect to power and compressed air.
- A factory representative turns on the machine to verify that it is operating correctly. (LANL staff has minimal participation during initial installation of equipment to avoid voiding the warranty). A PF maintenance technician then will do a laser shoot, and a machinist will create a new artifact to make sure the machine meets specs.

Total staff time:

- 4 FTEs to move the equipment in (1 day);
- 2 FTEs for the remainder of the install (3 weeks); and
- 1 FTE to re-run the acceptance artifact (2 weeks).

5. Training

This will be similar to that of the Mazak training situation in SM-39 and Building 102. Training for two maintenance technicians will be four weeks long with a class cost of $2k/week per person, plus travel expenses ($5k/person). Maintenance training is shared equally between the two building analyses. Training for two programmers and four machinists (two machinists from SM-39 and two machinists from Building 102) will take one week at a cost of $2k/wk plus travel of $2k/person. The cost of training the programmers is shared equally by the two analyses.

[17] Earl Vest, personal communication, March 10, 2015.
[18] Darrik Stafford, personal communication, February 17, 2015.

6. Qualification

This will be similar to the Mazak experience for both SM-39 and Building 102. This will require two maintenance FTEs for two weeks to work with the factory representative. In addition, two FTEs (programmer and machinist) for two weeks in order to program the equipment and produce a 5-axis verification artifact to make sure that everything is positioning correctly in a basic state. During this process they will:

- Confirm machine performance by using Vericut software;
- Cut a classified test part using surrogate material; and
- Machinist verifies the process.

7. Preventative Maintenance

This is similar to the Mazak PM in both SM-39 and Building 102. The new equipment would require similar preventative maintenance as with current machines—about two weeks per year.

8. Corrective Maintenance

It is expected that the NanoTech lathes will be used more intensively than the Mazaks. The assumed lifetime is fifteen years.

Assumed schedule for CM for a new machine (NanoTech) is as follows.

- Hydraulic/electronic issues (medium repair): once per five years.
- Software operating system (minor repair): once per three years.
- Computer hardware failure (minor repair): once per five years.
- Other mechanical repairs (major repair): once every ten years.

Table 14 shows the costs associated with these repairs.

Table 14
Cost of Corrective Maintenance for NanoTech Lathe

Corrective Maintenance, NanoTech Lathe	Cost ($)
Every 3 years: One Minor Repair	8,540
Every 5 years: One Minor + One Medium Repairs	42,699
Every 10 years: One Minor + One Medium + One Major Repairs	111,997

9. Productivity and Efficiency

The Hardinge Q10/65-SP lathes in the SM-39 advanced manufacturing lab cut stainless steel and currently produce ten parts per year at about 80 hours per part. The new NanoTech lathe will produce at a rate of 40 hours per part, and sixteen parts per year is assumed for the best estimate of total output.

The lathes in Building 102 cut DU parts and currently produce about sixteen parts per year at about 100 hours per part. As mentioned above, the demand for parts is anticipated to increase to a rate of 40 to 80 parts per year. It is assumed that the new NanoTech lathe will share the increased production load with existing lathes in Building 102, but at a more efficient rate of 40 hours per part for sixteen parts/year. This is considered maximum productivity when OMG is fully operational.

Two years are allotted for OMG qualification of the Nanotech lathes in both SM-39 and Building 102. The NanoTech machines will be new equipment for PF division and there is little specific knowledge to build upon. The parts are currently made on T-base and Hardinge lathes that are significantly different than the NanoTech. Therefore, PF will have to develop a new process for making these parts on the NanoTechs.[19] In light of this, productivity in SM-39 is assumed to be 80 hours/part in year 1, 60 hours/part in year 2, and 40 hours/part in operational years 3 through 15. With DU parts in Building 102, the productivity assumption is 100 hours/part in year 1, 70 hours/part in year 2, and 40 hours/part in operational years 3 through 15.

C. Business Case Results

a. Replace Hardinge Lathe in SM-39

After estimating the costs of maintenance and productivity variables within the two scenarios, a life-cycle cost/benefit table was created to determine the eventual payback of the new scenario. See Table 15. The *Best Estimate* line of Figure 13 assumes a modest demand of sixteen parts per year. The *Maximum* line assumes that the machine will be used at full capacity once it is fully operational, producing one part per week, or 46 parts per year after accounting for PM that shuts down the machine for two weeks per year. The *Minimum* line reflects the new machinery operating at the current output of ten parts per year.

The estimated total net present value of replacing a Hardinge Q10/65 lathe in SM-39 with a NanoTech is $1.2M over fifteen years of lathe operation. The project achieves pay back of its investment in the tenth year after procurement. Assuming maximum production of the new machine, the net present value could be as high as $3.7M and would break even in the seventh year. Under the minimum production case there would be a net present value of $0.7M and a breakeven point in the twelfth year after procurement.

b. Install NanoTech in Building 102

Table 16 shows the life-cycle costs and benefits to determine the eventual payback of adding capacity to Building 102 by the purchase of a NanoTech lathe. The *Best Estimate* line of Figure *14* reflects a modest assumed demand of sixteen parts per year for the new machine. The *Maximum* line assumes that the machine will be used at full capacity once it is fully operational, producing one part per week, or 46 parts per year after accounting for PM that shuts down the machine for two weeks per year. The *Minimum* line reflects the new machinery operating at an output of ten parts per year.

[19] Earl Vest, personal communication via email, March 9, 2015.

The estimated total net present value of installing a NanoTech in Building 102 is $0.3M over fifteen years of lathe operation. The project achieves pay back of its investment in the fifteenth year after procurement. Assuming maximum production of the new machine, the net present value could be as high as $4M and would break even in the seventh year. Under the minimum production case there would be a net present value of ($0.4M), with no breakeven point.

c. Replace T-base Lathe in Building 102

Due to the potential need to retire a current T-base lathe in Building 102, a best estimate of costs and benefits for installing a new NanoTech as a replacement lathe is necessary. This involves using most of the same assumed costs and benefits associated with the installation of a NanoTech lathe to augment capabilities. However, the replacement of the existing lathe will see increased benefits due to costs avoided in the areas of Preventative Maintenance (PM) and Corrective Maintenance (CM). Table 17 shows the costs and benefits over the time horizon for this scenario. Maintenance costs for a T-base lathe are assumed to be the same as for a Hardinge model.

The dashed best-estimate line in Figure 14 shows the life-cycle costs and benefits of replacing a T-base lathe in Building 102. This line reflects a modest assumed demand of sixteen parts per year for the new machine. The estimated total net present value is $1.8M over fifteen years of lathe operation. The project achieves pay back of its investment in the ninth year after procurement.

Table 15
Life-Cycle Benefits and Costs of Hardinge Lathe Replacement in SM-39

	Recapitalization Costs, SM-39 Hardinge Lathe Replacement ($)						Costs Avoided (Benefits) ($)					
Year	Procurement	Installation & Transition	Preventative Maintenance	Corrective Maintenance	Total Annual Cost	Discounted Total Annual Cost	Preventative Maintenance	Corrective Maintenance	Productivity Improvement {1}	Total Annual Benefits	Discounted Total Annual Benefits	Cumulative Discounted Cash Flow
2015	855,940				855,940	855,940				0	0	-855,940
2016		241,785			241,785	239,391				0	0	-1,095,332
2017			22,773		22,773	22,324	22,773	68,318	0	91,091	89,296	-1,028,360
2018			22,773		22,773	22,103	22,773	68,318	54,520	145,611	141,329	-909,134
2019			22,773	8,540	31,312	30,091	22,773	68,318	109,040	200,131	192,322	-746,903
2020			22,773		22,773	21,667	22,773	68,318	109,040	200,131	190,418	-578,152
2021			22,773	42,699	65,471	61,677	22,773	146,156	109,040	277,969	261,859	-377,970
2022			22,773	8,540	31,312	29,206	22,773	68,318	109,040	200,131	186,666	-220,510
2023			22,773		22,773	21,030	22,773	68,318	109,040	200,131	184,818	-56,722
2024			22,773		22,773	20,822	22,773	68,318	109,040	200,131	182,988	105,444
2025			22,773	8,540	31,312	28,347	22,773	68,318	109,040	200,131	181,176	258,273
2026			22,773	111,997	134,769	120,797	22,773	215,454	109,040	347,267	311,264	448,740
2027			22,773		22,773	20,210	22,773	68,318	109,040	200,131	177,606	606,136
2028			22,773	8,540	31,312	27,513	22,773	68,318	109,040	200,131	175,848	754,471
2029			22,773		22,773	19,811	22,773	68,318	109,040	200,131	174,107	908,766
2030			22,773		22,773	19,615	22,773	68,318	109,040	200,131	172,383	1,061,534
2031			22,773	51,238	74,011	63,118	22,773	146,156	109,040	277,969	237,058	**1,235,473**
Total	**855,940**	**241,785**	**341,590**	**240,093**	**1,679,409**	**1,623,663**	**341,590**	**1,327,581**	**1,472,047**	**3,141,218**	**2,859,136**	

{1} New machine labor hours-per-part improves as on-machine gauging is qualified during the first two years of operation: Year 1 = 80 hours/part; Year 2 = 60 hours/part; Year 3 = 40 hours/part.

Table 16
Life-Cycle Benefits and Costs of Installing NanoTech in Building 102

	Recapitalization Costs, Building 102 NanoTech ($)						Costs Avoided (Benefits) ($)					
Year	**Procurement**	**Installation & Transition**	**Preventative Maintenance**	**Corrective Maintenance**	**Total Annual Cost**	**Discounted Total Annual Cost**	**Preventative Maintenance**	**Corrective Maintenance**	**Productivity Improvement {1}**	**Total Annual Benefits**	**Discounted Total Annual Benefits**	**Cumulative Discounted Cash Flow**
2015	855,940				855,940	855,940				0	0	-855,940
2016		316,265			316,265	313,133				0	0	-1,169,074
2017			22,773		22,773	22,324	0	0	0	0	0	-1,191,398
2018			22,773		22,773	22,103	0	0	81,780	81,780	79,375	-1,134,125
2019			22,773	8,540	31,312	30,091	0	0	163,561	163,561	157,179	-1,007,037
2020			22,773		22,773	21,667	0	0	163,561	163,561	155,622	-873,082
2021			22,773	42,699	65,471	61,677	0	0	163,561	163,561	154,082	-780,678
2022			22,773	8,540	31,312	29,206	0	0	163,561	163,561	152,556	-657,327
2023			22,773		22,773	21,030	0	0	163,561	163,561	151,046	-527,312
2024			22,773		22,773	20,822	0	0	163,561	163,561	149,550	-398,584
2025			22,773	8,540	31,312	28,347	0	0	163,561	163,561	148,069	-278,861
2026			22,773	111,997	134,769	120,797	0	0	163,561	163,561	146,603	-253,055
2027			22,773		22,773	20,210	0	0	163,561	163,561	145,152	-128,113
2028			22,773	8,540	31,312	27,513	0	0	163,561	163,561	143,715	-11,911
2029			22,773		22,773	19,811	0	0	163,561	163,561	142,292	110,569
2030			22,773		22,773	19,615	0	0	163,561	163,561	140,883	231,837
2031			22,773	51,238	74,011	63,118	0	0	163,561	163,561	139,488	**308,207**
Total	**855,940**	**316,265**	**341,590**	**240,093**	**1,753,888**	**1,697,405**	**0**	**0**	**2,208,070**	**2,208,070**	**2,005,612**	

{1} New machine labor hours-per-part improves as on-machine gauging is qualified during the first two years of operation: Year 1 = 100 hours/part; Year 2 = 70 hours/part; Year 3 = 40 hours/part.

Table 17
Life-Cycle Benefits and Costs of T-base Lathe Replacement in Building 102

	Recapitalization Costs, Building 102 NanoTech ($)						Costs Avoided (Benefits) ($)					
Year	Procurement	Installation & Transition	Preventative Maintenance	Corrective Maintenance	Total Annual Cost	Discounted Total Annual Cost	Preventative Maintenance	Corrective Maintenance	Productivity Improvement {1}	Total Annual Benefits	Discounted Total Annual Benefits	Cumulative Discounted Cash Flow
2015	855,940				855,940	855,940				0	0	-855,940
2016		316,265			316,265	313,133				0	0	-1,169,074
2017			22,773		22,773	22,324	22,773	68,318	0	91,091	89,296	-1,102,102
2018			22,773		22,773	22,103	22,773	68,318	81,780	172,871	167,787	-956,418
2019			22,773	8,540	31,312	30,091	22,773	68,318	163,561	254,651	244,715	-741,794
2020			22,773		22,773	21,667	22,773	68,318	163,561	254,651	242,292	-521,169
2021			22,773	42,699	65,471	61,677	22,773	146,156	163,561	332,489	313,220	-269,626
2022			22,773	8,540	31,312	29,206	22,773	68,318	163,561	254,651	237,518	-61,314
2023			22,773		22,773	21,030	22,773	68,318	163,561	254,651	235,166	152,822
2024			22,773		22,773	20,822	22,773	68,318	163,561	254,651	232,838	364,838
2025			22,773	8,540	31,312	28,347	22,773	68,318	163,561	254,651	230,533	567,024
2026			22,773	111,997	134,769	120,797	22,773	215,454	163,561	401,787	360,131	806,358
2027			22,773		22,773	20,210	22,773	68,318	163,561	254,651	225,990	1,012,139
2028			22,773	8,540	31,312	27,513	22,773	68,318	163,561	254,651	223,753	1,208,379
2029			22,773		22,773	19,811	22,773	68,318	163,561	254,651	221,537	1,410,104
2030			22,773		22,773	19,615	22,773	68,318	163,561	254,651	219,344	1,609,833
2031			22,773	51,238	74,011	63,118	22,773	146,156	163,561	332,489	283,554	**1,830,269**
Total	**855,940**	**316,265**	**341,590**	**240,093**	**1,753,888**	**1,697,405**	**341,590**	**1,327,581**	**2,208,070**	**3,877,241**	**3,527,673**	

{1} New machine labor hours-per-part improves as on-machine gauging is qualified during the first two years of operation: Year 1 = 100 hours/part; Year 2 = 70 hours/part; Year 3 = 40 hours/part.

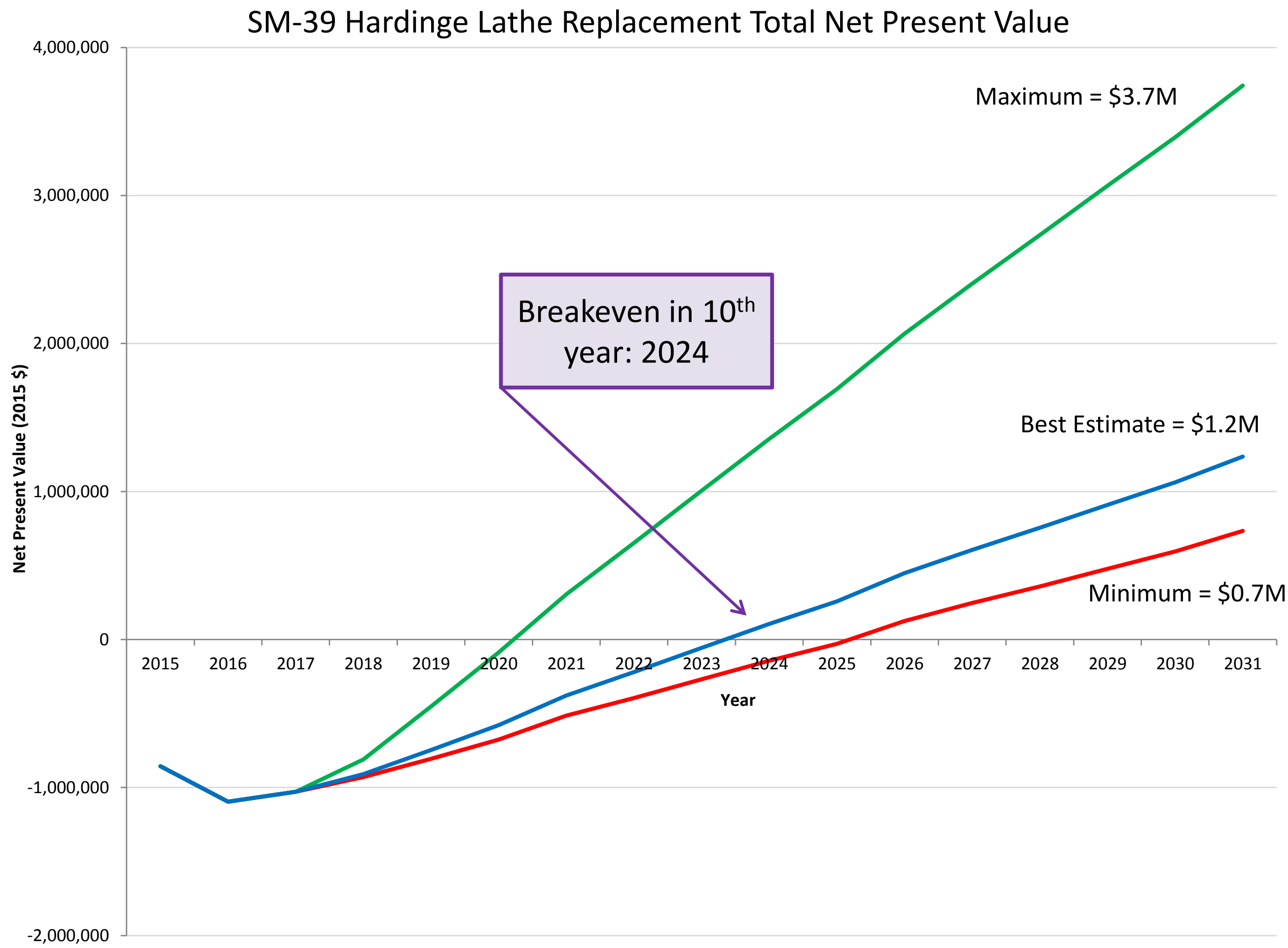

Figure 13. The payback period for installing a new NanoTech lathe to replace an old Hardinge machine in SM-39 under the best-estimate assumptions is in the tenth year, with a $1.2M savings over a 17-year project life.

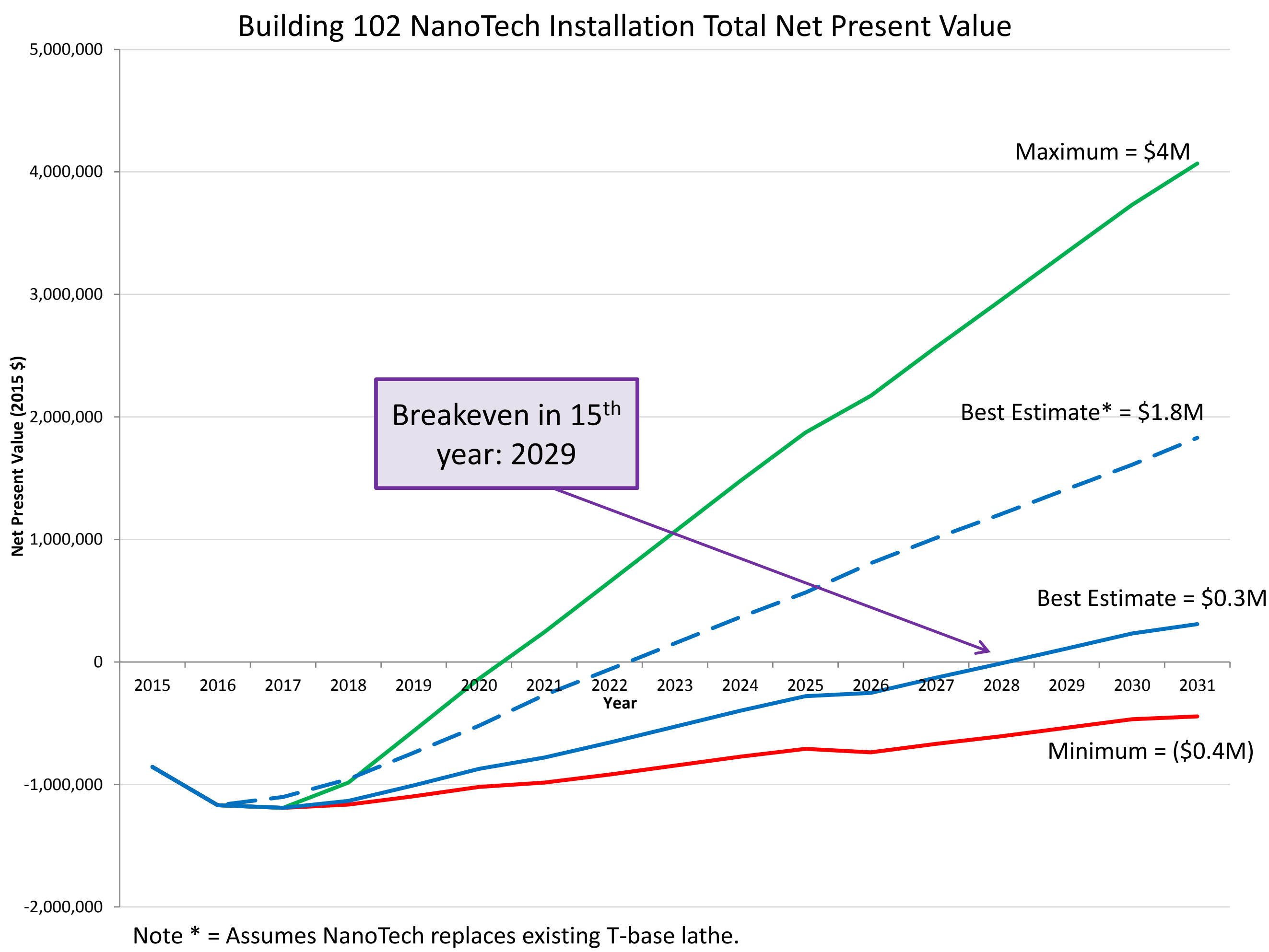

Figure 14. The payback period for installing a new NanoTech lathe to augment capacity in Building 102 under the best-estimate assumptions is in the fifteenth year, with a $0.3M savings over a 17-year project life. The payback period for installing a new NanoTech lathe to replace capacity in Building 102 under the best estimate assumption is in the ninth year, with a $1.8M savings over a 17-year project life.

V. ELECTRICAL DISCHARGE MACHINE (EDM) IN SM-39

A. Baseline Scenario

1. Background

Electrical discharge machining (EDM) is a technology that is useful for cutting intricate contours or cavities/holes in very hard metals that are difficult to machine using traditional milling and turning methods. EDM cuts via a large number of current discharges or "sparks," each of which remove small amounts of material from the tool and work piece creating tiny craters on both surfaces. A wire EDM uses a continuously replaced wire fed by a spool to handle this "wear" on the electrode-tool. The cutting takes place in a tank of dielectric fluid such as deionized water.[20] Table 18 lists the wire EDMs that are currently located in SM-39 and Building 102.

Table 18
Wire EDMs Located in SM-39 and Building 102 as of 6-18-14

Location	Room	Skid Type	Machine Type	OEM	Model #	Vintage
TA-03-39	28	EDM	Wire EDM	Mitsubishi	MD8	2012
TA-03-102	118	EDM	Wire EDM	Agie-Charmilles	FL-440-CC	2008

The purchase of a new EDM machine to augment the existing Mitsubishi MD8 Wire EDM in SM-39 is next in order of priority (see Table 6). The MD8 wire EDM is a small capacity machine that was purchased with operational funds for about $80k. The Agie-Charmilles Cut 300 Wire EDM in Building 102 is fairly new (vintage 2008) and will not be replaced at this time. See Figure 15.The new wire EDM for SM-39 will be similar to this machine and will allow non-hazardous parts that are currently handled in Building 102 to be produced at lower expense in SM-39. The EDM will be used for weapons experiments to cut holes with precise angles and semi-circular "mouse holes" in spherical objects. In addition, the flexibility of the machine will encourage an increased number of production tasks in the future.

2. Preventative Maintenance

Because a new wire EDM would be augmenting current capabilities in the shops and not replacing an old machine that has outlived its usefulness, preventative maintenance on the current Building 102 machine cannot be avoided. Consequently, no cost savings are counted for this activity.

[20] http://en.wikipedia.org/wiki/Electrical_discharge_machining.

Figure 15. AGIE-Charmilles Cut 300 Wire EDM in Building 102.

3. Corrective Maintenance

This activity would not be avoided by purchasing an additional wire EDM for SM-39, so no cost savings are counted.

4. Productivity and Efficiency

The wire EDM is used for a variety of parts, including mock weapons components. One of the main jobs that the wire EDM is used for is cutting “mouse holes” in blast hardware, with a very precise, projected angle. Currently, PF cuts “mouse holes” in about 30 parts per year in Building 102. About one-third to one-half of these parts is non-hazardous, and could be produced in SM-39 if the capacity existed. (The small size of the current Mitsubishi MD8 precludes its use for these activities.)

Machining non-hazardous parts in Building 102 adds about 25 percent more to the labor cost because of machinist contamination protection, part decontamination, and radiological control technician (RCT) inspection time. Currently, each mouse hole requires eight hours of machinist time, plus half-a-day for inspection. About two hours of machinist time could be saved by doing the operation in SM-39. Skirting operations takes about four hours per part on an EDM as opposed to eight hours per part on a manual machine.

B. New Scenario

1. Selection of Machine

PF Division is considering the purchase of a Mitsubishi FA-40 EDM or a Charmilles CUT 300 for SM-39, and the prioritization spreadsheet lists $450k as the cost of the new equipment. (Note that GF Machining Solutions is the new name of Agie Charmilles, the manufacturer of the EDM in Building 102.) This wire EDM would be similar in capability to the one currently in use in Building 102; therefore, there are no anticipated problems with selecting this particular machine. For this reason the cost for machine selection is lower than that used for the Mazak machines. See Table 19.

Purchasing new equipment typically takes six to twelve months. The process includes LANS labor to accomplish various tasks:

- Determining “rough cost”;
- Making a decision about what to buy (1 FTE @ 2wk);
- Bidding process/review by procurement team (1 FTE @ 3wk); and
- Once the chosen manufacturer shows they can meet the criteria, the bid is presented to procurement.

2. Equipment Cost and Procurement

The Mitsubishi or Charmilles EDM has an estimated cost of $450k.[21] Procurement support is expected to be similar to that of the Mazak purchase.

Once the equipment is ordered, depending on the specifications, it could take five to six months before the equipment is received. This is for off-the-shelf equipment that typically requires some adjustments to meet LANL specifications. A total custom build will take longer.

There is typically a one to two week delay in the shop receiving the equipment after it arrives at LANL because Receiving must verify that what was received is what was ordered. This is not always easy because there are times when Receiving is not allowed to open the crate. When this is the case, verification is done via documentation.

[21] See Table 6. This is what PF paid in 2013 for the EDM that is currently in Building 102

Table 19
Assumptions and Factors for Life Cycle Analysis of New Charmilles Wire EDM in SM-39

Assumptions		Comments
Real Discount Rate {1}	0.01	
Engineer, SLR	$246	R&D Eng
Programmer, SLR	$199	JST
Machinest, SLR	$170	JTM
Maintenance TEC, SLR	$142	AKN
Other Support, SLR (e.g., procurement)	$170	
Productive Hours per year	1730	for R&D Eng
New Machine		
Equipment Cost ($)	450,000	
Procurement Support Cost ($) {2}	40,052	
Facility Preparation ($) {3}	45,545	
Installation ($) {4}	38,714	
Training ($) {5}	86,291	
Qualification ($) {6}	22,773	
Maintenance		
Preventative Maintenance ($ per year) {7}	22,773	
Corrective Maintenance {8}		
Minor	8,540	
Medium	34,159	
Major	69,298	

{1} Source: 10-year real discount rate, OMB Circular No. A-94, Appendix C (Revised December, 2013).

{2} Decision Analysis: 1 FTE @2 wk; Procurement Team: 1 FTE @ 3wk. No acceptance artifact needed.

{3} Choose location, power supply, floor foundation, reconfigure shop space, crafts: 2 FTE @ 4wk. No screw jacks needed for tunnel reinforcement.

{4} Off-load and level machine, connect to power/air, laser verify: 2 FTE @ 3wk. 4 FTE @ 1 day to bring equipment into building.

{5} Two maintenance technicians for 2 weeks training with class cost of $2k/week per person, plus travel expenses ($5k/person). Two programmers and two machinists with 1 week training at a cost of $2k/wk plus travel of $2k/person.

{6} Maintenance corrections with factory rep: 2 maint FTE @ 2wk. No artifact needed.

{7} 2 maint FTE @ 2 weeks per year for scheduled PM based on manufacturer recommendations.

{8} Assumed CM for an EDM machine (we assume that parts for CM have a cost equal to 50% of the labor cost):

• Minor repair: 1 week downtime assuming parts are immediately available and simple to install with 1 maint FTE @ 1wk.

• Medium repair: 3 weeks downtime with 2 maint FTE @ 1wk for evaluation, 1 maint FTE @ 1wk to find part, 1 maint FTE @ 1wk to replace part and check machine.

• Major repair: 5 weeks downtime with 2 maint FTE @ 2wk, 1 engineer @ 1wk, 1 welder @ 1wk, 1 procurement specialist @ 1wk.

3. Facility Preparation

The SM-39 shop will keep the Mitsubishi MD8 Wire EDM that is currently in use; therefore, space would need to be prepared for the new machine. Facility preparation includes an evaluation of available power, floor/foundation suitability and classified computing capability. Crafts are usually scheduled to bring in ground penetrating radar (GPR) to determine if there are any floor or foundation issues that need to be addressed. In most cases, Information Technology (IT) support would have been involved during the new equipment selection process and would already be aware of the software/hardware issues involved with the new equipment. Facility preparation typically requires two FTEs for four weeks and is completed while waiting for the new equipment to arrive at LANL. This assumes that no coring or fixaters will be required to accommodate the new equipment in SM-39.

As an example, the Mitsubishi FA40V has dimensions (W × D × H, in inches) of 122.6 × 163.4 × 107.2, with a weight of 16,500 pounds.[22] The Charmilles CUT 300 Sp is 102” × 102” × 92” with a weight of about 7300 pounds.[23] No screw jacks will be needed for tunnel reinforcement during installation[24].

4. Installation

Once the facility is prepared and ready for the equipment, it can take three weeks for the equipment to be installed (2 FTEs @ 3wks). The move into SM-39 itself would require a minimum of four FTEs for one day to offload, uncrate, and bring the equipment into the shop. Once in the shop, the following activities will be performed.

- Level the equipment.
- Connect to power and compressed air.
- A factory representative turns on the machine to verify that it is operating correctly. (LANL staff has minimal participation during initial installation of equipment to avoid voiding the warranty). A PF maintenance technician then will do a laser shoot, and a machinist will create a new artifact to make sure the machine meets specifications.

Total staff time is:

- 4 FTEs to move the equipment in (one day); and
- 2 FTEs for the remainder of the install (three weeks).

In the case of the new EDM PF will only need a forklift, which LANL can supply. Once inside, PF could move the equipment with an existing 20-ton crane.

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[22] Source: company brochure, http://www.performancemachineryllc.com/uploads/4/9/7/7/4977564/2010_fa40v_flyer.pdf.

[23] http://www.gfms.com/content/gfac/com/en/Products/EDM/wire-cut-edm/high-speed-machining/cut-300-sp.html.

[24] Derrik Stafford of PF-WFS, personal communication, March 12, 2015.

5. Training

New technology can be complicated and require intensive training. PF-WFS would need two machinists, two programmers, and two maintenance personnel to be trained on the new equipment. There is extant knowledge about both the Mitsubishi and Charmilles brand EDM machines within PF—training on the new machine would build on that experience. If a different manufacturer were chosen, more training might be required.

In the current scenario in SM-39, PF is only "one deep" with trained staff to use certain equipment and this leaves them vulnerable if that one person is out or leaves. Having two of each capability trained on the equipment would limit this vulnerability. In addition, having complete, up-to-date training helps FTEs to solve problems and maintain equipment effectively.

The cost of the training depends on the manufacturer. Typically, a manufacturer offers training for new machines. Training for the two maintenance technicians will be two weeks long with a class cost of $2k/week per person, plus travel expenses ($5k/person). Training for two programmers and two machinists will take one week at a cost of $2k/wk plus travel of $2k/person.

6. Qualification

Qualification begins at the tail end of the installation of the equipment while PF works with the factory representative making sure the equipment is ready. This could require two FTEs for two weeks.

7. Preventative Maintenance

Two weeks of annual preventative maintenance is included for the new EDM. There are no avoided costs gained by replacing an old machine. The wire EDMs utilize a water pumping system, therefore, preventative maintenance will include such things as adding/replacing deionized water and regular filter changes.

8. Corrective Maintenance

It is assumed that corrective maintenance on medium repair issues would be required every five years on the new machine. Major repairs are assumed to be avoided during its lifetime if the equipment is properly maintained. See Table 20.

Table 20
Cost of Corrective Maintenance for New EDM in SM-39

Corrective Maintenance Schedule, SM-39 New EDM	Cost ($)
Every 3 years: One Minor Repair	17,079
Every 5 years: One Minor + One Medium Repairs	42,699

The assumed CM schedule for a new machine (e.g., Mitsubishi FA-40) is:

- Water pumping system/electronic issues (medium repair): once per five years;
- Software operating system (minor repair): once per three years;
- Computer hardware failure (minor repair): once per five years;
- Mechanical repairs (major repair): none during 15-year life time; and
- Realign/replace guides (minor repair): once per three years.

9. Productivity and Efficiency

A new wire EDM in SM-39 would increase productivity and extend the capability for non-hazardous parts. About ten to fifteen mouse-hole parts are expected as demand for a new wire EDM in SM-39. Additional demand is expected to be mock cases, angled holes on tungsten flanges, and cutting off skirts from blanks. A projected annual demand for a new wire EDM in SM-39 totals to 56, along with associated net machinist labor time savings, as follows.

- Mouse holes: 15 per year; net time savings of two hours/part.
- Skirts: 20 per year; save four hours/part.
- Mock cases: five per year; save four hours/part.
- Tungsten flanges: six per year; save four hours/part.
- Other parts: ten per year; save four hours/part.

PF experience indicates that a new wire EDM will stimulate additional demand for it. As described above, some processes could be transferred off the old (manual) platform and onto the Wire EDM, which would result in a time saving gain. The new EDM will also allow for increased development work by PF division, which could lead to new areas of machining activity. For example, when JTAs are machined in Building 102, the remnant left after skirting could be used for tensile specimens. Doing this on the manual machine takes ~8 hours, using the Wire EDM could cut that time in half. Also, stainless steel components currently made in Building 102 could be transferred to SM-39.

The productivity improvements category includes some small expense items:

- RCTs, 1 hour/part for support; and
- Potential contaminated parts, 3 hours/part × 0.1.

The costs saved from laundry of personal protective equipment and waste management for rags, wipes, etc. are insignificant. Therefore, they are not included in the analysis as cost savings.

C. Business Case Results

After estimating the costs of maintenance and productivity variables of adding new EDM capability in SM-39, a life-cycle cost/benefit table was created to determine the eventual payback of the new scenario. See **Error! Reference source not found.**. The *Best Estimate* line of Figure 6 assumes an expected demand of fifty-six parts per year. The *Maximum* line assumes that the machine will be used at full capacity once it is fully operational, producing one part per day, or 206 parts per year after accounting for PM that shuts down the machine for two weeks per year. The *Minimum* line reflects the new machinery operating at an output of twenty parts per year.

The estimated total net present value of installing a new EDM in SM-39 is ($0.6M) over fifteen years of EDM operation. The project does not achieve pay back of its investment over the fifteen year life of the machine. Assuming maximum production of the new machine, the net present value could be as high as $1.1M and would break even in the eighth year. Under the minimum production case there would be a net present value of ($0.9M) with no breakeven point.

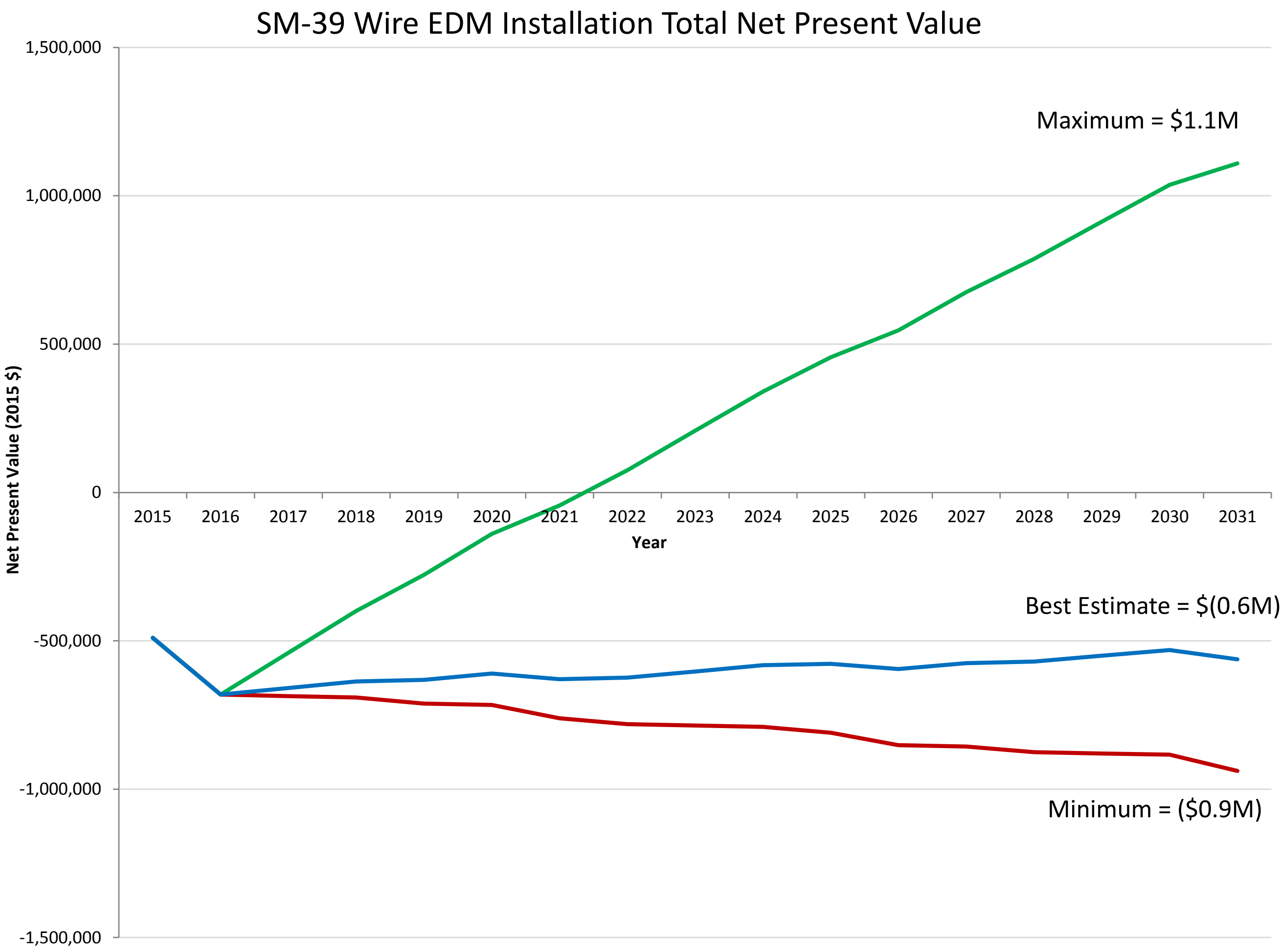

Figure 16. There is no payback period for installing a new Wire EDM in SM-39 to augment capacity in Building 102 under the best-estimate assumptions. There will be a savings of ($0.6M) savings over a 17-year project life. This number represents the net cost of installing this new capability over the life of the recapitalization project.

Table 21
Life-Cycle Benefits and Costs of Installing EDM in SM-39

	Recapitalization Costs, EDM in SM-39 ($)						Costs Avoided (Benefits) ($)					
Year	**Procurement**	**Installation & Transition**	**Preventative Maintenance**	**Corrective Maintenance**	**Total Annual Cost**	**Discounted Total Annual Cost**	**Preventative Maintenance**	**Corrective Maintenance**	**Productivity Improvement**	**Total Annual Benefits**	**Discounted Total Annual Benefits**	**Cumulative Discounted Cash Flow**
2015	490,052				490,052	490,052						-490,052
2016		193,323			193,323	191,409						-681,461
2017			22,773		22,773	22,324			45,435	45,435	44,540	-659,245
2018			22,773		22,773	22,103			45,435	45,435	44,099	-637,249
2019			22,773	17,079	39,852	38,297			45,435	45,435	43,662	-631,883
2020			22,773		22,773	21,667			45,435	45,435	43,230	-610,321
2021			22,773	42,699	65,471	61,677			45,435	45,435	42,802	-629,196
2022			22,773	17,079	39,852	37,171			45,435	45,435	42,378	-623,988
2023			22,773		22,773	21,030			45,435	45,435	41,959	-603,060
2024			22,773		22,773	20,822			45,435	45,435	41,543	-582,339
2025			22,773	17,079	39,852	36,078			45,435	45,435	41,132	-577,284
2026			22,773	42,699	65,471	58,684			45,435	45,435	40,725	-595,243
2027			22,773		22,773	20,210			45,435	45,435	40,321	-575,131
2028			22,773	17,079	39,852	35,017			45,435	45,435	39,922	-570,226
2029			22,773		22,773	19,811			45,435	45,435	39,527	-550,510
2030			22,773		22,773	19,615			45,435	45,435	39,136	-530,990
2031			22,773	59,778	82,551	70,401			45,435	45,435	38,748	**-562,643**
Total	**490,052**	**193,323**	**341,590**	**213,494**	**1,238,458**	**1,186,367**	**0**	**0**	**681,528**	**681,528**	**623,724**	

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APPENDIX A: MAZAK INTEGREX 30Y PM CHECKLIST/TICKETS

MAZAK 30Y Integrex Preventative Maintenance Check List

Model	LANL Property # 1214991	Serial Number
Operator's Comments		
Record Hour Meter		
Engineered Safety Devices		
Interlocks		
Main Door		
Electrical Cabinet Door		
Tool Carousel Door		
E-Stop Switches		
Guarding-Inspect for damage & proper function		
Note any physical damage		
Alignments		
Level		
Squareness X Axis to Z Axis		
Straightness (2 Planes) X & Z Axis		
Main Spindle ℄ ɔ Z Axis (2 Planes)		
Main Spindle Perpendicularity to X Axis		
Measure Pitch, Yaw, Roll (All Axis)		
Backlash All Axis		
Positioning Accuracy All Axis		
Repeatability All Axis		
Y Axis Home position on Spindle Centerline		
Perform Ballbar testing		
Perform Spindle analysis (Main)		
Perform Spindle Analysis (Milling)		
Lubrication		
Z Way Cover Guide Rail		
Front Door Guide Rail		
Check Initial Levels		
Way Lube (Vactra 2)		
Hydraulic Unit (Tank Level) DTE 13M		

Visually inspect trucks/rails, ballscrew/nut for proper lubrication and wear.		
Apply grease to tool pockets		

Hydraulic System		
Inspect Hoses		
Check for leaks		
Drain, clean or replace suction filter, if required, reset the red button		
Change out hydrolic fluid. (DTE 13M)		
Clean Oil Cooler Fins		
Check Pressure (650psi)		
Check cooling fans , 3 each		
Air Filters		
Electrical Cabinet Filter		
Incoming Air Filter/Seperator		
Head Stock Filter		
Headstock/Spindle		
Check for Abnormal Noise/Load		
High PRM		
Low RPM		
Speed Tac every 500 RPM		
Measure run out		
Vibration		
Heat		
Spindle Cooler Service	Record Set Point Temp	
Clean Filter		
Clean Condenser		
Check Fluid Level		
Sub Spindle		
Check for Abnormal Noise/Load		
High PRM		
Low RPM		
Speed Tac every 500 RPM		
Measure run out of taper		
Vibration		
Heat		

Edit Details Copy/Move Link Subtask Report Add to KB

Created by Dino A. Farfan 4 yrs ago Updated by Dino A. Farfan 4 yrs ago

Request 48 in PF Division Machine Tool Support

Title
MAZAK INTEGREX 30Y - Install

Priority
High

Status
Closed

Assignee
Oliver I. Trujillo, knutt

Contact Information

Z number:
102094

Shop Informatiom

If this is a Move request type you must attach a floor layout plan before approvals can occur.
Approvals from ESO, Maintenance, and IT are necessary prior to moving/salvaging equipment. Once the approvals are obtained you will receive a notification that the request has been released for work and the move can occur.

Request Type:
Support

Shop Location:
TA-3-39

Equipment Information

Property Number:
1214991

Make:
MAZAK

Model:
Integrex 30Y

Description of Service

Description of Service

Entered on 08/24/2010 at 17:55:45 MDT (GMT-0600) by Dino A. Farfan:
8/24
Relocation of the main power trunk line, and testing of the coolant pumps is all that's needed before provisional release.

Entered on 04/15/2010 at 15:54:16 MDT (GMT-0600) by Dino A. Farfan:
4/15/10
Electricians currently drilling and setting anchors.

Entered on 04/01/2010 at 18:01:42 MDT (GMT-0600) by Dino A. Farfan:
Machine received from Sandia.

Moved into place at the north end of the main shop, currently waiting for a GPR.

Assignees and Notifications

Assignee
Oliver I. Trujillo, knutt

CCs
No CCs

History

Edit Details Copy/Move Link Subtask Report Add to KB

Created by Aaron K. Nohl 4 yrs ago; Updated by Aaron K. Nohl 4 yrs ago

Request 247 in PF Division Machine Tool Support

Title
Mazak 30Y coolant leak, broken wireway, chip conveyer jam.

Priority
Medium

Status
Closed

Assignee
Aaron K. Nohl, Oliver I. Trujillo, knutt

Contact Information

Z number:
147172

Name:
Aaron Nohl

Email:
nohl@lanl.gov

Phone Number:
664-0665

Shop Informatiom

If this is a Move request type you must attach a floor layout plan before approvals can occur.
Approvals from ESO, Maintenance, and IT are necessary prior to moving/salvaging equipment. Once the approvals are obtained you will receive a notification that the request has been released for work and the move can occur.

Request Type:
Support

Shop Location:
TA-3-39

Equipment Information

Property Number:
1214991

Make:
Mazak 30Y

Model:
Integrex

Serial Number:
133748

Description of Service

Description of Service

Entered on 09/21/2010 at 09:21:00 MDT (GMT-0600) by Aaron K. Nohl:
Repaired coolant leak primed pump and replaced 5amp fuse.
Repaired broken flexible wire-way above door.
Repaired chip conveyor jam.
Returned to service.

Assignees and Notifications

Assignee
Aaron K. Nohl, Oliver I. Trujillo, knutt

CCs
No CCs

History

Edit Details Copy/Move Link Subtask Report Add to KB

Created by 102103 3 yrs ago; Updated by Tuhy M. Mills 2 yrs ago

Request 396 in PF Division Machine Tool Support

Title
Mazak Integrex 30Looks like the tool pockets are shown as from Mazak and not from magnum where they were ordered from -----Original Message----- From: Workflow Mailer [mailto:seedec

Priority
Low

Status
Closed

Assignee
Tuhy M. Mills, Aaron K. Nohl, markam

Contact Information

Z number:
102103

Name:
Timothy N. Pollat

Email:
tpollat@lanl.gov

Phone Number:
+1 505 667 4800

Shop Informatiom

If this is a Move request type you must attach a floor layout plan before approvals can occur.
Approvals from ESO, Maintenance, and IT are necessary prior to moving/salvaging equipment. Once the approvals are obtained you will receive a notification that the request has been released for work and the move can occur.

Request Type:
Support

Shop Location:
TA-3-39

Equipment Information

Property Number:
1214991

Make:
Maza 30

Description of Service

Description of Service

Entered on 05/02/2012 at 12:39:17 MDT (GMT-0600) by Tuhy M. Mills:
I retrieved a packing slip from a box down at the drop point that lists:
Description QTY
Turning Pocket 80T Magzl 2
Is this the same package or is this an additional one?

Entered on 04/24/2012 at 11:08:49 MDT (GMT-0600) by Tuhy M. Mills:

Looks like the tool pockets are shown as from Mazak and not from magnum where they were ordered from

-----Original Message-----
From: Workflow Mailer [mailto:seeded_wf_mailer@lanl.gov]
Sent: Wednesday, April 18, 2012 12:03 AM
To: Mills, Tuhy M
Subject: Oracle Alert : Package 949843 Delivered

THIS IS AN AUTOMATED EMAIL ***DO NOT REPLY TO THIS EMAIL***

Delivery Notice(s) for 949843:

YOU are responsible for safeguarding the contents of this package from theft or damage. Please immediately retrieve the package from the Designated Drop Point. If you are unable to locate this package at the Designated Drop Point, immediately notify your (Designated Delivery Drop Point Administrator) and send an E-mail to delivery@lanl.gov or call 665-9465.

On 04/17/2012 at 02:49 PM, ASM Material Management delivered a shipment to your drop point, 03-0039-01S, in Building 0039. The following information about this shipment is available:

ERP PTN	949843
Carrier	UPSN - Unite
Waybill	1Z4480140258
Deliver To	Mills, Tuhy Marie, 505-665-2047
Contents	small box 2lb
Supplier	mazak
Quantity	1
Order Type	NAMES_ONLY Package 949843
Comments	<NONE>

When YOU have custody of this package, please inspect the contents and verify its condition and count. If there is a discrepancy between what you ordered and what was delivered, please contact the ASM-MM Receiving Office within 10 days of receipt at 667-4186.

If the item you received is ELECTRICAL, it must be inspected before use by your electrical safety officer (ESO) unless the item is marked with a NRTL symbol.

Examples of NRTL symbols can be found at

http://www.osha.gov/dts/otpca/nrtl/nrtlmrk.html

The list of ESOs can be found at

http://int.lanl.gov/safety/esc/group_list.shtml

Entered on 04/19/2012 at 14:37:14 MDT (GMT-0600) by Aaron K. Nohl:
Received the new tool pocket insert installed it tested for proper operation and returned to service.

never received a notification that part had been delivered...

Entered on 04/13/2012 at 10:03:21 MDT (GMT-0600) by Tuhy M. Mills:
Order has been placed.

Entered on 04/13/2012 at 09:51:52 MDT (GMT-0600) by markam:
This purchase request is approved.

Entered on 04/13/2012 at 09:19:10 MDT (GMT-0600) by Aaron K. Nohl:
Tool Pocket insert on tool carousel is broken and will not accept tool. Contacted Magnum Precision for a quote and requesting the purchase of a replacement.

Entered on 02/02/2012 at 11:23:25 MST (GMT-0700) by markam:
Assigned to Aaron.

Entered on 03/03/2011 at 14:18:05 MST (GMT-0700) by 102103:
Ridgid Tapping not working.
Tool holder #6 has broken piece inside and throws alarm when tool is called up.

Attachments

Filename	Size	Date	
Integrex 30y tool pocket purchase request_20120413091809.pdf	117 KB	04/13/2012 8:18 AM	Download
INTEGREX 30y tool pocket quote_20120413092245.pdf	65 KB	04/13/2012 8:22 AM	Download

Assignees and Notifications

Assignee
Tuhy M. Mills, Aaron K. Nohl, markam

CCs
markam

History

Edit | Details | Copy/Move | Link | Subtask | Report | Add to KB

Created by 102103 3 yrs ago; Updated by Oliver I. Trujillo 2 yrs ago

Request 405 in PF Division Machine Tool Support

Title
Mazak Integrex 30

Priority
Low

Status
Closed

Assignee
Aaron K. Nohl, Oliver I. Trujillo

Contact Information

Z number:
102103

Name:
Timothy N. Pollat

Email:
tpollat@lanl.gov

Phone Number:
+1 505 667 4800

Shop Informatiom

If this is a Move request type you must attach a floor layout plan before approvals can occur.
Approvals from ESO, Maintenance, and IT are necessary prior to moving/salvaging equipment. Once the approvals are obtained you will receive a notification that the request has been released for work and the move can occur.

Request Type:
Support

Shop Location:
TA-3-39

Equipment Information

Property Number:
1214991

Make:
Mazak Integrex 30

Description of Service

Description of Service

Entered on 02/07/2012 at 13:02:25 MST (GMT-0700) by Oliver I. Trujillo:
Air line installed with regulator.

Entered on 02/02/2012 at 11:20:08 MST (GMT-0700) by markam:
Assigned to Oliver.

Entered on 03/04/2011 at 10:45:18 MST (GMT-0700) by 102103:
Need air line

Assignees and Notifications

Assignee
Aaron K. Nohl, Oliver I. Trujillo

CCs
No CCs

History

Edit | Details | Copy/Move | Link | Subtask | Report | Add to KB

Created by 102103 3 yrs ago; Updated by Dino A. Farfan 3 yrs ago

Request 459 in PF Division Machine Tool Support

Title
Mazak integrex 30 oil leak.

Priority
High

Status
Closed

Assignee
Dino A. Farfan, Oliver I. Trujillo

Contact Information

Z number:
102103

Name:
Timothy N. Pollat

Email:
tpollat@lanl.gov

Phone Number:
+1 505 667 4800

Shop Informatiom

If this is a Move request type you must attach a floor layout plan before approvals can occur.
Approvals from ESO, Maintenance, and IT are necessary prior to moving/salvaging equipment. Once the approvals are obtained you will receive a notification that the request has been released for work and the move can occur.

Request Type:
Support

Shop Location:
TA-3-39

Equipment Information

Property Number:
1214991

Make:
Mazak

Model:
integrex 30

Description of Service

Description of Service

Entered on 04/26/2011 at 09:37:02 MDT (GMT-0600) by 102103:
Oil leak.

Assignees and Notifications

Assignee
Dino A. Farfan, Oliver I. Trujillo

CCs
markam

History

Edit Details Copy/Move Link Subtask Report Add to KB

Created by 102103 3 yrs ago; Updated by Dino A. Farfan 1 yr 8 mos ago

Request 580 in PF Division Machine Tool Support

Title
Mazak Integrex 30 oil leak

Priority
Low

Status
Closed

Assignee
Dino A. Farfan, knutt

Contact Information

Z number:
102103

Name:
Timothy N. Pollat

Email:
tpollat@lanl.gov

Phone Number:
+1 505 667 4800

Shop Information

If this is a Move request type you must attach a floor layout plan before approvals can occur.
Approvals from ESO, Maintenance, and IT are necessary prior to moving/salvaging equipment. Once the approvals are obtained you will receive a notification that the request has been released for work and the move can occur.

Request Type:
Support

Shop Location:
TA-3-39

Equipment Information

Property Number:
1214991

Make:
Mazak

Model:
30

Description of Service

Description of Service

Entered on 08/19/2011 at 10:08:27 MDT (GMT-0600) by Dino A. Farfan:
Machine to be locked out in order to remove sheet metal for the purpose of locating and repairing the oil leak.

Entered on 08/18/2011 at 14:44:56 MDT (GMT-0600) by 102103:
Oil Leak.

Assignees and Notifications

Assignee
Dino A. Farfan, knutt

CCs
markam

History

Edit Details Copy/Move Link Subtask Report Add to KB

Created by 102103 3 yrs ago; Updated by Aaron K. Nohl 2 yrs ago

Request 659 in PF Division Machine Tool Support

Title
Mazak 30 Sticky buttons on the controller

Priority
Low

Status
Closed

Assignee
Kathleen M. W Wright (Kathie), Dino A. Farfan, Tuhy M. Mills, Aaron K. Nohl, Christopher A. Smith

Contact Information

Z number:
102103

Name:
Timothy N. Pollat

Email:
tpollat@lanl.gov

Phone Number:
+1 505 667 4800

Shop Information

If this is a Move request type you must attach a floor layout plan before approvals can occur.
Approvals from ESO, Maintenance, and IT are necessary prior to moving/salvaging equipment. Once the approvals are obtained you will receive a notification that the request has been released for work and the move can occur.

Request Type:
Support

Shop Location:
TA-3-39

Equipment Information

Property Number:
1214991

Make:
Mazak

Description of Service

Description of Service

Entered on 03/09/2012 at 11:16:07 MST (GMT-0700) by Aaron K. Nohl:

Step 15 of the "New" Parts Procurement Process was not entertained for this job. Another Technician recognized this part while opening several other boxes trying to locate one of his parts. (which wasn't there even though he received notification it was.)
No parts received notification was sent for this part/job. (Step 15 Parts Procurement Process)
A new soft key pad still managed to successfully be installed on the Machine.
It was tested for proper operation and returned to service.

Entered on 03/06/2012 at 10:40:13 MST (GMT-0700) by Tuhy M. Mills:
Order has been placed.

Entered on 03/06/2012 at 08:27:19 MST (GMT-0700) by markam:
Purchase request is approved for order.

Entered on 03/05/2012 at 15:25:58 MST (GMT-0700) by markam:
Aaron, please correct cost string for soft keypad order.

Entered on 03/05/2012 at 14:50:04 MST (GMT-0700) by Aaron K. Nohl:
After re evaluation of the machine determined the soft key pad is worn, and confirmation with a senior tech validates the need of a new one.
Requesting approval to purchase a new soft keypad for this machine.

Entered on 03/02/2012 at 08:51:21 MST (GMT-0700) by Aaron K. Nohl:
The status of this job is unchanged at this time. The operator usually has the machine on a job and is unable to relinquish it to maintenance. It remains a low priority.
When I originally scoped this job it appeared to be more of a controller operating system or memory/ram issue which seems to lag when given a command rather than an actual button sticking.
I will continue to work with the operator's schedule in the repair of this issue.

Entered on 03/02/2012 at 07:46:05 MST (GMT-0700) by markam:
Status on this job?

Entered on 11/07/2011 at 11:43:25 MST (GMT-0700) by markam:
Assigned to Aaron.

Entered on 11/02/2011 at 06:22:24 MDT (GMT-0600) by 102103:
Sticky buttons on the controller

Attachments

Filename	Size	Date	
Integrex 30 keypad quote.pdf	68 KB	03/05/2012 2:41 PM	Download
Integrex 30 Keypad Purchase Request.pdf	118 KB	03/06/2012 7:45 AM	Download

Assignees and Notifications

Assignee
Kathleen M. W Wright (Kathie). Dino A. Farfan. Tuhy M. Mills, Aaron K. Nohl, Christopher A. Smith

CCs
markam

History