

Y-12

**OAK RIDGE
Y-12
PLANT**

LOCKHEED MARTIN



MODEL-BASED ENGINEERING AND MANUFACTURING CAD/CAM BENCHMARK

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April 26, 1999

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Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 37831
Managed by
Lockheed Martin Energy Systems, Inc.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400**

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Executive Summary

Model-Based Engineering and Manufacturing CAD/CAM Benchmark

The Benchmark Project was created from a desire to identify best practices and improve the overall efficiency and performance of the Y-12 Plant's systems and personnel supporting the manufacturing mission. The mission of the benchmark team was to search out industry leaders in manufacturing and evaluate their engineering practices and processes to determine direction and focus for Y-12 modernization efforts. The companies visited included several large established companies and a new, small, high-tech machining firm. As a result of this effort, changes are recommended that will enable Y-12 to become a more modern, responsive, cost-effective manufacturing facility capable of supporting the needs of the Nuclear Weapons Complex (NWC) and Work For Others into the 21st century.

The benchmark team identified key areas of interest, both focused and general. The focus areas included Human Resources, Information Management, Manufacturing Software Tools, and Standards/ Policies and Practices. Areas of general interest included Infrastructure, Computer Platforms and Networking, and Organizational Structure. The method for obtaining the desired information in these areas centered on the creation of a benchmark questionnaire. The questionnaire was used throughout each of the visits as the basis for information gathering. The questionnaire is found in Appendix A of this report.

The results of this benchmark showed that all companies are moving in the direction of model-based engineering and manufacturing. There was evidence that many companies are trying to grasp how to manage current and legacy data. In terms of engineering design software tools, the companies contacted were using both 3-D solid modeling and surfaced wire-frame models. The manufacturing computer tools were varied, with most companies using more than one software product to generate machining data and none currently performing model-based manufacturing (MBM) from a common model. The majority of companies were closer to identifying or using a single computer-aided design (CAD) system than a single computer-aided manufacturing (CAM) system. The Internet was a technology that all companies were considering to either transport information more easily throughout the corporation or as a conduit for business, as the small firm was doing successfully.

Because Pro/Engineer is the de facto CAD standard for the NWC, the Benchmark Team targeted companies using Parametric Technology Corporation (PTC) software tools. Most of the companies used Pro/Engineer for design to some degree, but found the PTC CAM product, Pro/Manufacture lacking as compared to alternate CAM solutions.

All of the companies visited found the data exchange between CAD/CAM systems problematic. It was apparent that these companies were trying to consolidate their software tools to reduce translation but had not been able to do so because no single solution had all the needed capabilities.

In regard to organizational structure and human resources, two companies were found to be using product or program teams. These teams consisted of the technical staff capable of completing the entire task and were maintained throughout the project. This same strategy was evident at another of the companies but with more mobility of members. For all companies visited except the small firm, work structure breakdown and responsibility were essentially the same as Y-12's at this time. The functions of numerical control (NC), design, and process planning were separate and distinct.

As a company, Lockheed Martin Energy Systems, Inc. (LMES) is aware of technology trends and is leading similar companies visited, but lags the small and medium sized new companies. Immediate improvement could be made in business methods, particularly in process planning and legacy data management. There were several areas of potential improvement that should be implemented on a pilot basis to verify benefits justifying a wider implementation.

The team made numerous recommendations that are detailed in the report. In response to specific concerns the team concluded the following.

1. Low cost, PC-based CAD/CAM systems could perform a portion of LMES work, but do not address the complex work that defines Y-12's uniqueness.
2. Engineers can perform machining and inspection programming, but specialized group is still needed for complex jobs.
3. A common CAD/CAM system is a desired direction, but a separate CAM only system may offer the best solution at present.
4. Maintenance of Y-12 legacy CAD/CAM systems is costly and the business practices requiring them should be examined with the goal of phasing them out.
5. Electronic Information management and distribution are important elements of the manufacturing environment.

Background

The Model-Based Engineering and Manufacturing CAD/CAM Benchmark Project was initiated and funded by the Advanced Design and Production Technologies (ADaPT) Initiative. One of the ADaPT goals is to identify and demonstrate new manufacturing systems employing new advanced technologies in the NWC. The Y-12 Plant is moving in the direction of a smaller, more flexible manufacturing facility. A key to accomplishing a more productive and cost effective manufacturing facility is new technologies, new processes, and the methods by which these technologies and processes are applied.

The benchmark effort began with the development of areas of interest. The areas identified as important to Y-12 modernization were the following:

- information technology,
- organization structure,
- human resources,
- manufacturing software tools,
- standards/business policies and practices,
- manufacturing infrastructure, and
- computer platforms and networking.

Although a broad number of topics were identified, certain ones were determined to be more important to the overall success of the effort. Those areas identified as focus areas included information technology, manufacturing software tools, human resources, and standards policies and practices.

The development of a questionnaire and the list of potential benchmark companies was accomplished keeping in mind the Team mission and the objectives.

This questionnaire was used during the site visits. It can be found in Appendix A. It was used as a framework to record the raw data for documentation and later analysis.

Benchmark Team

The Benchmark Team consisted of members from a cross-section of manufacturing engineering organizations. The goal was to have participation and buy-in from as many organizations as possible. Each member was to represent their respective organizational interests and feedback data from the benchmark activities. The Team members are listed below.

Scott Underwood, Chair	Technical Services/ Manufacturing Engineering
Donna Bennett, Chair	Technical Services/ Manufacturing Engineering
Jeff Bohanan*	Technical Services/ General Manufacturing
Daryl Boyer	Defense Programs/ Program Management
Terry Domm	Technical Services/ Computer-Aided Engineering
Carolyn Fogelman	Technical Services/ Manufacturing Engineering
Dean Shipley	Technical Services/ Design Engineering

* No longer with the company.

Mission & Objectives

The mission developed by the team revolved around the need for modernization and revitalization of the Y-12 manufacturing capabilities. The mission statement evolved from the Objective 3 of the Y-12 Strategic Plan, which states, "Create a revolution in manufacturing to meet the next-generation needs of the Stockpile Stewardship Program." The mission defined by the benchmark team was to search out industry leaders in manufacturing and evaluate their manufacturing engineering practices and processes to determine direction and focus for Y-12 modernization efforts.

There were four basic objectives defined for the effort:

1. Identify the best practices and processes through benchmark evaluation of selected industry leaders.
2. Analyze the best practices to determine compatibility with the business environment within the Y-12 Plant.
3. Based on best practice analysis, generate recommendations and strategies for implementation within Y-12.

4. Develop strategies for changing the business environment [within Y-12 or the U.S. Department of Energy (DOE)] so that other best practices that can be incorporated.

Methodology

At each of the site visits, at least two members of the Benchmark Team consisting of representatives from computer-aided engineering, manufacturing engineering, and general manufacturing participated. At the visits, the team members talked to various company representatives and toured the facilities. During these discussions and tours, the questionnaire was used as a guide. After the site visit, the team members compared their notes and generated a visit report for use in generating the final report. Additional data from several companies not visited were gathered by other means and included. Below are the observations and recommendations gleaned from the data gathered from the visits.

Conclusions and Recommendations

ORGANIZATIONAL STRUCTURE

Observations

- Some companies operate in a team structure, while others have separate design and NC programming functions with little apparent collaboration.
- Functional job structure was the norm for large, established companies similar to Y-12.
- The small, new, high-tech company, was the exception, where engineers performed estimation, design, NC, and process planning. Tight collaboration with customers in design was used by this firm.
- The medium-sized, high-tech company used a team approach to estimate, plan, and execute the job. A team was formed for the purpose of estimating new work. This team would then be responsible for the work if selected. In other words, those who capture the work, do the work.

Recommendation

A team approach to manage and execute tasks should be employed at Y-12, where the team would include design, process planners, NC programmers, and others as needed. This team would be involved with the job from estimation to execution.

HUMAN RESOURCES

Observations

- An aging workforce was typical for the large companies visited. Concerns were raised about back filling these slots with qualified staff.
- The small company was finding it difficult to fill needed staff positions, especially in the area of machinists. The company owner was taking active role in area community to generate interest in careers in this area. The company had instituted a co-op program with local schools and was working with the University of Central Florida to address training needs.
- Large and medium companies have dedicated NC groups of professional employees (mostly degreed) for production support of computer numerical control (CNC) machining and inspection, much like what exists at Y-12. Technical people who do both programming and machining were used for some prototyping applications. CAD/CAM software employed tended to be suitable for complexity of the work.
- The small company used individual engineers to do design, NC programming, and follow the production. This environment used "easy-to-use" software designed for casual users and customization of software to limit users' choices to standard solutions. The customization was performed in close collaboration with the software vendor.
- None of the companies benchmarked used subcontract NC programmers.
- Training level in the use of CAD/CAM software varied, but often was viewed as inadequate and under-funded. It was considered a problem area.
- Pressure by PTC for extensive vendor training seems excessive, and the training is not always productive.

Recommendations

Training in critical functional areas needs to be planned and funded.

- Investigate restarting the Training and Technology (TAT) Program or a similar program.
- Work with area schools to develop interest and programs for craft skills.
- Expand or reinstate a co-op program for professional staff replenishment and back fill for retirement losses.

Plan for transition of employees into slots being vacated as a result of retirement. That is, plan to hire new employees and move existing employees into slots formed by retirement.

Standard practices should be encouraged in the area of manufacturing and design.

A close relationship with vendors is critical to the success in the use of their product. It is recommended that LMES place a higher priority on customer relations and customer support for vendor evaluation. LMES should consider development of a list of preferred vendors for future purchases.

STANDARDS, BUSINESS POLICIES, AND PRACTICES

Observations

- Solid models often have defects caused by the methods used during modeling. Larger companies tended to have conventions in place to minimize such problems. The small company provided feedback to customers who supplied design models.
- Large companies certified software to a varying degree, but a formalized process similar to the LMES Series 80 did not appear to be in place. Vendor quality assurance (QA) was generally accepted for commercial, off-the-shelf (COTS) software, although some companies verified critical functionality.
- All companies were ISO 9000 certified. The major business reason given was that it established credibility, especially in European markets. The small business needed accreditation to do work for some customers.

Recommendation

A key to Model-based Engineering and Manufacturing (MBE/M) is establishing design modeling conventions with an emphasis on downstream applications, such as manufacturability.

INFORMATION TECHNOLOGY

Observations

- All companies had access to paper drawings. Those companies with legacy data generally maintained it in paper form.
- Companies stated that it was difficult to transition to a new CAD/CAM system. Solutions being examined to solve this problem focused on translation of legacy data to a neutral format for archiving.
- When it made business sense, companies regenerated models in a new CAD/CAM system.
- The small company kept files in a format usable by current system. They did not have an in-house legacy data problem since they do not own the data and they have not changed CAD/CAM systems.
- The large companies had older Product Data Management (PDM) systems, many of them developed in house. All were interested in current PDM systems, but were only in the early stages of system evaluation.
- The team did not witness accessing or launching of applications across the World Wide Web (WWW). All companies had interest in use of the Internet. The small company was using the Web for business and data transfer. One large company was performing design collaboration across the Web with dispersed sites across the globe.
- Standards being used by most companies included IGES, DXF, and DMIS. STEP was only being used by one company.

- Most of the companies were doing some type of translation of CAD models into a CAM system. This translation was necessary in large companies because most were still using the legacy CAM tool for production while the CAD tool had changed.
- Paper is still largely used in the companies visited. The big push away from paper appeared to be in the area of work instructions.

Recommendations

Consider placing legacy data in a standard format where it can be retrieved either through later versions of similar software or into new systems. Initiate a pilot project on a selected CAD/CAM system (e.g., Anvil 4000). Explore options for conversion of Automatically Programmed Tools (APT) legacy programs to the new Houtzeel APT system.

Continue to migrate along the current path to a plant wide PDM system and explore options for standardization. Develop applications to move in the direction of the Intranet being the backbone for information flow through the plant. Customize the PDM to provide a manufacturing engineering view for information management and launching applications.

Investigate the perceived business practice of reuse of legacy models in the original CAD/CAM format for remanufacture of weapons components.

MANUFACTURING SOFTWARE TOOLS

Observations

- All large companies benchmarked have made corporate decisions to move to PTC software for design. They were satisfied with PTC for design and embraced the vision of a solid and feature-based , associative system.
- The medium company was moving toward CATIA for design and manufacturing.
- The small company used Solidworks and TekSoft ProCAD for CAD and CAM respectively. PTC tools were viewed as too difficult to use and too expensive.
- There tended to be a top-down corporate decision to adopt a standard CAD system.
- Legacy software is still in existence and use at many of the facilities.
- APT is part of the legacy of many companies and continues to be viewed as easy to modify. APT expertise is becoming difficult to find, and companies are not training new people to use it.
- A single software solution does not appear to be on the horizon at the companies visited.
- Migration of software tools over time is the norm to provide the best tools available.

- The driving force for the small company in selection of software tools was price and ease of use.
- All companies viewed solid models as the base for design and for future manufacturing when complete CAM capabilities exist.
- Vendor support was viewed as a key component for success of software tools. PTC was generally viewed as less than cooperative and not customer-oriented.
- The larger companies used the ICAM generalized post processor and developed their own posts internally with in-house staff. The small company used a vendor to write posts. NC knowledge and experience with the local environment is viewed as criteria for post development personnel.
- Several of the companies built intelligence into the post processors to simplify the NC programming process.
- Most companies made information on the process available at the shop floor level. This was done through the distributed numerical control (DNC) system or shop floor control software. Evidence was found at all companies of the use of process planning/manufacturing resource planning (MRP) software.
- Most companies used simulation to verify NC/inspection software programs. The software used for verification varied from more expensive Unix-based tools to personal computer (PC) products.
- Most companies viewed the PTC CAM system, Pro Manufacture, as inadequate or immature for their needs. There was indication that companies were not satisfied with the progress made over the last several years.
- Most large companies use CamPost and the PTC suite of tools. The medium and the larger companies were continuing to use existing systems being replaced by PTC or others.

Recommendations

Give PTC a full evaluation and test in the manufacturing environment using the latest version and training. (ADaPT Nuclear Assembly Project)

Evaluate low-cost, easy-to-use, CAM-centric systems designed for the casual user. Include feature recognition and the ability to capture strategies and processes. This evaluation should include a CAM tool not linked to same vendor CAD to emphasize translation capability.

Establish a pilot project for post conversion using a vendor consultant.

Provide a right-sized process and planning system (MRP) with a graded implementation strategy. Evaluate small platform COTS solution and the TEAM WIM software.

MANUFACTURING INFRASTRUCTURE

Observations

- Advances in machining technology (high speed and new configurations, such as mill-turn machines) were in evidence at the newer small company. Mill-turn technology reduces setup time and setup changes and could reduce NC programming time.
- New modern controllers and adding PCs to older machines gave superior DNC performance and easy access to information on the floor.
- The small company emphasized vendor relationships and used one vendor almost exclusively.
- The small company was always looking at new systems and was quick to try them out in an effort to enhance its competitive edge. Larger companies also tried to keep abreast of new technology in machining by maintaining a prototype shop or a technology center.
- Medium and small companies are making investments in the latest machining technology. This included advanced PC-based machine controllers.
- No one is using or moving to BCL (basic control language) controllers.

Recommendations

Evaluate new advanced machining technology for Y-12 use.

Evaluate the mechanism for equipment purchases. Look at doing cost study of buying new equipment vs retrofitting existing machines. Examine potential increased productivity and cost saving with purchase of new equipment.

COMPUTER PLATFORMS AND NETWORKING

Observations

- All companies were either using an NT-based PC environment or moving in that direction.
- The small company was entirely PC-based using PC-based CAD/CAM tools.
- Larger companies were using data on the shop floor sent through networks to dumb terminals or NT PCs.

Recommendations

Continue on current path of migrating from the workstation environment to NT.

Provide networked computer access for shop floor personnel.

SUMMARY

In summary, it appeared that the sun is setting on the formal benchmark era. Many companies were reluctant to participate in our effort and eventually turned down our request to participate. However, those companies that did participate were gracious and open with us.

Overall, the benchmark accomplished its goals. Information was gathered that will be useful in planning for modernization. For the most part, Y-12's direction was consistent with that of other similar large companies (existing infrastructure and legacy data), and Y-12 is ahead of the pack in migration to new technology in most areas. The biggest challenges lie with trying to change Y-12/NWC/DOE business practices to fully achieve our goals.

Several perceptions were addressed as the practices of other companies were examined:

1. **Low-cost, PC-based, CAD/CAM systems can replace current Y-12 production systems achieving cost savings and use by casual users.**

It is possible that these systems could address a portion of the work. There is a definite trend toward PC solutions with easier to use interfaces. Since these systems will not address the complex work that defines Y-12's uniqueness, they will not completely replace the current systems and the professionals that use them. They do add another system to support. The team noted a trend in migration to use of CAM-only small platform solutions at the companies visited. It appears feasible to pilot the use of these tools for appropriate work.

2. **Engineers can perform NC and inspection programming as a part of the design task.**

The team did not find this concept in common use, except for the small high-tech company. The tools described in item 1 above are easier to use in routine applications and could be applied to some jobs. A specialized support group is still needed for complex jobs.

3. **MBE/M is best done with a common CAD/CAM system.**

This goal is good, but the team did not find MBE/M in general use. This lack results from the fact that no CAD/CAM vendor was identified as best in class at both functions. The goal remains a desired direction, but, in the short term, a separate CAM system may be required. There are several CAM-only systems that appear to be gaining in popularity. These CAM-centric systems must provide the capability to easily receive design models from many sources to be viable.

4. The Y-12 legacy CAD/CAM systems should be phased out.

The moratorium on testing of nuclear weapons has resulted in direction that remanufacture of components be accomplished using the original methods. This has resulted in the Y-12 perception by some that the original NC programs and post processors must be used in manufacturing of these parts. The cost of maintaining all legacy CAD/CAM systems is large, and consideration should be given to remodeling in current systems from plot files or storage of legacy data in a neutral format.

The team found consensus that APT is easy to modify and many companies continue to use it, but are not training new people in its use. The prime value of APT is for reuse of old NC programs and retrieval of original manufacturing methods. It is expected to become obsolete as existing users retire.

5. Information management (PDM) is a key to competitiveness.

The value of information management is much higher for companies that have a long term interest in its use, including those that support a product line over a long period of time or customize existing designs routinely to meet customer specifications. Job shops, on the other hand, do not need to maintain data after the job is complete. The technology is maturing so that vendor products offer increased functionality at reduced cost. Companies visited seemed to appreciate the need for and value of this technology, but were slow to move. Most large companies had existing home-grown systems, and one had a bad experience in an earlier attempt to migrate.

Distribution of the information is important as well. Interest in electronic access to current manufacturing information at the shop floor was evident. Design/manufacturing collaboration between geographically separated sites was facilitated by Internet-based software applications.

LMES personnel are aware of technology trends and LMES is leading similar companies visited but lags behind the small and medium new companies. Immediate improvement could be made in business methods, particularly in process planning and legacy data management. There were several areas of potential improvement that should be implemented on a pilot basis to verify benefits that justify a wider implementation.

Appendix A
Benchmark Questionnaire

Benchmark Questionnaire

Company Profile

■ Company name: _____

■ Company address: _____

■ Date of visit: _____

■ Trip participants: _____

■ Primary point(s) of contact at the company (include phone and fax number):

■ Overall company size (e.g., annual sales, number of employees, etc.): _____

■ Company's primary product(s) and/or service(s): _____

■ Company's primary customers: _____

Organizational Structure

■ How is your Manufacturing organization structured?

Matrix: _____

Functional: _____

Other: _____

■ How are process planning and the work priority tied in with the manufacturing group?

■ How do you manage projects? Teams? Other?

■ Who does your design and NC approval, and how are these functions handled?

Human Resources

■ What size is your manufacturing operation?

_____	Small	(0-300 employees)
_____	Medium	(300-1000 employees)
_____	Large	(greater than 1000 employees)

■ Who has responsibility for generating CNC tapes?

• Do design engineers do CNC work?

YES: _____

NO: _____

• Do machinists have responsibility for CNC programs?

YES: _____

NO: _____

• If yes, are they limited to certain types of work?

- How do you manage training to keep staff current on new technologies?
- _____
- _____

- Does the type machine they support segregate your NC staff, or do they support all types?

Segregated: _____

All types: _____

- Do you use subcontractors for NC and design work?

- Do you subcontract manufacturing?

YES: _____

NO: _____

- What is your ratio of support (computer systems) personnel to your manufacturing staff?
- _____
- _____

- Do you have in-house development for manufacturing software tools?
- _____
- _____

Standards/Business Policies & Practices

- Do you have conventions for CAD modeling?

YES: _____

NO: _____

- What are your performance measures for manufacturing engineering?
- _____
- _____

- Do you certify production software?

YES: _____

NO: _____

- If yes, do you certify commercial off-the-self (COTS) software?

YES: _____

NO: _____

- Do you follow a formal configuration control plan?

YES: _____

NO: _____

- Are you ISO 9000 certified?

YES: _____

NO: _____

- What types of internal QA do you have in place?
- _____
- _____

- Do you perform rapid prototyping of new products?

YES: _____

NO: _____

Information Technology

■ How is legacy data handled?

■ What is the significance of your legacy?

■ Are you currently using a PDM system?

YES: _____ NO: _____

- If yes, what extent of data is managed by the PDM system?

■ Do you use paper drawings?

YES: _____ NO: _____

■ What form is your design of record?

Paper: _____

Electronic: _____

Other: _____

■ How is the Web utilized for manufacturing?

■ Who manages and writes post processors?

Manufacturing/NC engineer: _____

Computer Science Dept: _____

Specialty Support Dept: _____

Other: _____

■ What collaborative engineering tools do you have available and use?

Video teleconferencing: YES _____ NO _____

Web-based red lining: YES _____ NO _____

Other: _____

■ Does your company utilize principles of concurrent engineering (e.g., integrated approach to design, manufacturing, and product support)?

■ What set of standards is your company using?

STEP: YES _____ NO _____

DMIS: YES _____ NO _____

SGML: YES _____ NO _____

IGES: YES _____ NO _____

Other: _____

■ How are electronic product data (models) used by Manufacturing?

- Can Manufacturing make changes (e.g., add edge breaks, move to split) to the design model?

■ In the utilization of the model in downstream processes, is the model maintained in native format or is it translated to other formats (e.g., STEP, IGES, STL, other)?

■ Do you use the same model for machining and inspection applications?

- Do paper drawings accompany models for use in developing NC programs for machining and inspection?

- Do you incorporate all information on the drawings into the model (e.g., surface finish, dimensions, other notes)?

- Do you employ model-based manufacturing?

[Model-based-manufacturing: Model-based engineering/manufacturing is the use of advanced computer-based methods to simulate production in an integrated product and process information environment. It is the application of modern computer tools to design, analyze, optimize, assemble, and manufacture a product in a virtual environment. In a more limited definition, it can be considered as the use of a common computer model of the product as the basis for downstream applications (analysis, verification, NC, etc.), but we tend to view it in a much broader sense.]

Manufacturing Software Tools

- What CAD system(s) do you use?

- What CAM system(s) do you use?

- Do you use simulation tools to verify toolpaths?

YES: _____

NO: _____

- If yes, which system(s) do you use?

- Who has access to the tools (machinist, programmer, other)?

- Do you maintain an APT system?

YES: _____

NO: _____

- If yes, do you funnel all your NC, including CAM output, through it before posting?

YES: _____

NO: _____

- Do you train NC staff in the use of APT?

YES: _____

NO: _____

- Do you utilize knowledge-based systems for manufacturing (i.e., machining or inspection)?

YES: _____

NO: _____

Are you currently or planning to implement DMIS for inspection tool programming?

YES: _____

NO: _____

- Do you do your inspection programming (e.g., CMM, other) on-line or off-line?

On-line: _____

Off-line: _____

- Do you use a process planning software tool? If so, how is it applied?

YES: _____

NO: _____

- Who does the process planning?

- Do you generate your own post or purchase?

YES: _____

NO: _____

- What generalized post do you use?

- Who maintains your post?

- How are software tools selected and justified?

- What is the degree of integration between CAD, CAM, and CAE?

- How do you verify product definition models?

- What is an acceptable model (standards used for validation)?

- Do you use software tools to validate models?

- Who gives the final approval for utilization of model?

Manufacturing Infrastructure Issues

- How many NC machines do you have?

0-25: _____

25-100: _____

>100: _____

- What lot sizes do you typically run?

0-10: _____

10-50: _____

50-100: _____

>100: _____

- What types of CNC equipment (e.g., lathes, 5-axis milling, etc.) do you primarily support?

2-Axis lathes: _____

3-Axis lathes: _____

Wire EDM: _____

Multi-axis milling: _____

- Do you support Basic Control Language (BCL) controllers?

YES: _____

NO: _____

- Are you utilizing In-Process Verification (IPV) with On-Machine Gauging (OMG)?

YES: _____
NO: _____

- How do you handle machine scheduling?

- Do you use open architecture controllers?

YES: _____
NO: _____

- If you don't currently, do you plan to in the future?

Computer Platforms & Networking

- What is your preferred computer platform?

Personal computer: _____
Unix workstation: _____
Other: _____

- Do you run across a network or use a stand-alone system?

Network: _____
Stand-alone system: _____

- Does data/information flow to the shop floor electronically (e.g., Web instructions for operations)?

- Do you use wireless communications on the shop floor?

YES: _____
NO: _____

Results

- Benefits to the company (in terms of measured improvements) of using model-based manufacturing?

- Lessons learned:

Distribution

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