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Partnership

*PARTNERING TO STRENGTHEN MANUFACTURING TECHNOLOGY IN THE
DEPARTMENT OF ENERGY AND THE UNITED STATES MACHINE TOOL INDUSTRY.*

A U.S. DEPARTMENT OF ENERGY PROGRAM

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NATIONAL MACHINE TOOL PARTNERSHIP (NMTP)
FY 1998

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INTRODUCTION

The Department of Energy (DOE) Defense Programs (DP) National Machine Tool Partnership (NMTP) program has been active since February 1993.¹² The NMTP program is an element of the DP Technology Partnership Program. From February 1993 through September 1995 the primary activity of the NMTP was Technical Assistance (TA), wherein up to 80 hours of technical assistance from DP laboratories was provided to U.S. machine tool users and builders at no expense. Due to DP programmatic changes the TA portion of the NMTP was terminated, and the primary interaction with U.S. industry since September 1995 was through short term partnering programs where industry provided in-kind cost sharing of partnership projects. These projects had to be in support of DP weapons programs.

In FY-93, FY-94, and FY-95 the NMTP was an identified DP program with allotted funding coordinated by the Office of Development and Technology Transfer, DP-17, at DOE headquarters. In FY-96 and FY-97 the support for NMTP was altered from direct DP-17 funding to DP budget allocations at each of the NMTP sites³. The DP-17 advocated that some portions of these budgets be directed to NMTP type activities for partnering with machine tool users and/or builders. Concurrently, the DP budget was markedly reduced for these activities. Shrinking budgets reduced the amount of industry partnering and a coordinated NMTP program among the laboratories was limited. Nevertheless, partnering efforts were undertaken to maintain a small, but viable, NMTP program. The Industrial Advisory board (IAB), which offers industrial oversight to the program, continued to provide excellent advice and encouragement during this era of the shrinking program

The NMTP has assisted the Association of Manufacturing Technology (AMT) in the formulation of a technology roadmap for the machine tool industry. This roadmap has been developed to provide a clearer step-by-step plan for technology development and implementation to help close the gap between user requirements and industry implementation. The document⁴ outlines a suggested path for the development of technologies for the machine tool industry. The plan details the technology

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¹ Report Y/EN-5593 "National Machine Tool Partnership" describes the formation and activities of the NMTP.

² Report UCRL-LR-113247 contains details on the formation of the NMTP.

³ Sites—Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Y-12 Plant, Allied Signal Federal Manufacturing and Technology (KCP), Sandia National Laboratories (SNL)

⁴ Distribution of the AMT Technology Roadmap is administered through AMT headquarters at 7901 Westpark Drive, McLean, Virginia, 22102; attention Mr. Paul Wamdorf.

issues or needs analysis facing the machine tool industry. In a parallel effort, the NMTP has prepared a needs analysis of machine tool related technologies needed in various DP laboratory weapons core programs, including the Advanced Design and Production Technologies (ADaPT) initiative.

All NMTP partnership projects will continue to be administered under the DP-17 Technology Partnership Program and must support the DP Stockpile Stewardship and Management Program (SSMP) objectives, and in particular, the ADaPT initiative and other laboratory weapons core programs. The primary objective of the NMTP program is assurance of availability of the required machine tool technologies for manufacturing needs of weapons production in the next century.

Current NMTP projects underway are as follows:

- Sandia National Laboratory
  - predictive maintenance,
  - hexapod machining,
  - micro-machining, and
  - on-machine acceptance.
- AlliedSignal FM&T
  - predictive maintenance (with Sandia),
  - use of artifacts for process evaluation,
  - development of coolant sump sensor to detect coolant contamination,
  - development of performance support systems for
    - cellular manufacturing,
    - maintenance and programming,
    - cylindrical die rolling, and
    - preventive maintenance checklists.
- Y-12
  - expert system for selecting machining coolants,
  - development of a photolytic iodine narrow beam laser for cutting,
  - applied instructional system for machinists,
  - machine process assurance, and
  - open architecture system
- Los Alamos National Laboratories
  - alternative turning centers
  - agile manufacturing.

STOCKPILE STEWARDSHIP AND MANAGEMENT PLAN

Since the end of the Cold War, the climate in which the nuclear weapons complex must fulfill its mission has changed dramatically. The U.S. arms control and nuclear nonproliferation policies and pressures on the federal budget put constraints on the nuclear weapons program that require significant adjustments to ensure nuclear deterrence. The most prominent of these constraints are:

- There are no plans to conduct underground nuclear tests or design new nuclear weapons
- The overall size of the enduring stockpile has been greatly reduced.
- The size and capacity of the nuclear weapons complex has been reduced.
- The budget for the Department of Energy's nuclear weapons program is less than half it was at its peak in 1986.

To ensure the continuing performance, safety, and reliability of the enduring U.S. nuclear weapons stockpile under these constraints, Defense Programs developed the SSMP to address this new environment.

SSMP will advance the understanding and use of science, engineering, and simulation in the design and manufacture of nuclear weapons and components in order to certify nuclear weapons with a high degree of confidence. An enhanced science-based understanding equips the nuclear weapons complex to more effectively engage in the functions of maintenance, surveillance, assessment, and annual recertification of the stockpile. Capitalizing on the enhanced science base, the nuclear weapons design and production capability will also advance to a highly integrated, flexible, and rapid capability to effect refurbishment or, if necessary, new production.

In order to maintain and refurbish the stockpile with a high degree of confidence, future manufacturing processes must be designed to prevent the introduction of new defects, reduce the rate of mid-life random failures, and extend total weapon life. This requires a dramatic change in the design and production of weapons hardware. New technologies must be employed that eliminate the opportunities for defect formation traditionally encountered during the design and fabrication of weapon components. In addition, the new nuclear weapons complex must have the capability and capacity to respond flexibly to unanticipated events.

NMTP SUPPORT OF SSMP GOALS

Experience has shown that laboratory/industry partnerships can leverage limited resources, complement capabilities of the NMTP sites, provide access to additional funding and enrich the science and technology base. Collaboration with industry also helps DP meet mission requirements better, faster, and at lower cost by providing access to unique expertise in areas such as advanced manufacturing and computer modeling and simulation.

Collaboration with industry can do all this by:

- establishing links with current or potential suppliers of critical DP components and systems:

- adapting commercially available tools, technologies, and equipment that match DP requirements;
- refining DP tools, technologies, and equipment to make them more suitable for commercial use (enabling shorter delivery time and lower price); and
- keeping pace with the continuously evolving state of the art for replacement of sunset technologies.

Also, the NMTP program contributes significantly to the SSMP by enlisting the intellectual and financial support of the private sector to address the following situations.

- products built with old, obsolete equipment or software no longer supported by the private sector;
- components made by suppliers who are either no longer in business or no longer willing to supply parts to the Department of Energy;
- parts produced with processes that cannot meet environmental or safety regulations; and
- products made with processes no longer affordable.

The NMTP and the weapons complex will strive to create and maintain partnerships that contain some or all of the following characteristics:

- Achieves DP R&D objectives more effectively (DP would perform the activity whether or not there is an industrial partner)
- Endorsed by DP program managers at sites and DOE Headquarters
- Collaborative cost-shared R&D with industry
- Partner(s) contributes significant technology, equipment, and funds
- Partner(s) ready and willing to commercialize the technology and/or make it more robust
- Strong benefits for industry as well as DP

Since new weapons production has ceased, the demand for weapon components and related goods and services has dropped precipitously. This diminished DP market is too small to sustain many suppliers who cannot be economically responsive to small volume specialized needs. As a result the complex must often incur higher costs in purchasing needed goods and services, and, in some cases, can no longer find qualified suppliers. Developing collaborative partnerships with current and potential suppliers will help maintain current suppliers and develop new ones. For example, collaborative projects designed to advance and deploy specific new technologies which improve the quality of the industrial partner's products and service could lead to lower costs, a stronger market position, and thus a more viable commercial market for these products and services.

OBJECTIVES AND STRATEGIES

The objectives of the NMTP are:

- Ensure on-shore availability of manufacturing capability needed for nuclear weapons production in the 21st century, and
- Retain a strong manufacturing technology base within the DOE nuclear weapons complex,
- Assist in strengthening and enlarging the U.S. machine tool industry.

To attain these objectives the NMTP program has the following strategies:

- Develop a needs analysis of manufacturing technology for weapons production in the 21st century,
- Establish vertical partnerships to support weapon core programs, including the ADaPT initiative, among U.S. machine tool builders, DOE labs, and where applicable, other government agencies (NIST, DoD, NSF), and
- Facilitate an industry-driven program to enhance the technology base of the U.S. machine tool industry.

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PARTNERSHIP PROJECTS

Project Acceptance Criteria

1. Projects must meet ADaPT and other weapons core programs machine tool needs (including control units and dimensional inspection).
2. Projects must include a machine tool builder or user as one of the project partners.
3. Projects will involve machine tool technology development and/or deployment.
4. Projects require "in-kind" funding from participants. Total DP costs are to be matched by total of all industrial participants.
5. Projects involving teaming among several builders, DP laboratories and sites, or between builders and users will receive priority.

NOTE: A company qualifies as a machine tool builder if:

- It manufactures non-portable, power-driven manufacturing machinery used in the process of transforming man-made materials into discrete durable goods,
- It manufactures parts and components, accessories, attachments, or tools and tooling for equipment above,
- It manufactures control units for equipment in 1. above,
- It manufactures dimensional inspection/ certification equipment for goods produced on or for machinery in 1. above, or
- Provides software for machinery, control units, or dimensional/certification equipment above.

Project Selection

1. Laboratory and facility projects required for ADaPT or other weapons core programs
2. Expand past TA projects
3. Direct interaction with machine tool builders and users
4. AMT roadmap (see Table 1)
5. Commercialization

Guidelines for In-Kind Funding

- ***Computer Codes***

1. Market cost of partner computer codes currently marketed can be used as a portion of cost sharing
2. Anticipated market cost of partner codes not complete or under test but meant to be marketed can be used as a portion of cost sharing.
3. Partner computer codes which are proprietary in-house codes for internal use cannot generally be used as a portion of cost sharing

NOTE:

Special codes, which will reduce amount of DP software costs in a partnership project, can be used as a portion of cost sharing.

- ***Equipment***

The lease cost of equipment can be used as a portion of cost sharing. If there is not a lease cost for the particular machine, then the lease cost of a comparable machine can be used as a portion of cost sharing.

- ***Hours***

In cases where there is a disparity in hourly rates between NMTP and partner participants, the partner cost sharing should be based on the hourly rate of the NMTP site. Rates should be evaluated on similar skill levels.

PROJECT OVERSIGHT

Oversight, including technical advice and support, project prioritization, and selection and execution of appropriate partnership agreements, are provided to the NMTP by an Industrial Advisory Board (IAB), site Weapons Advisory Councils, and a Laboratory Coordinating Board (LCB).

The IAB consists of executives from U.S. machine tool builder companies, companies that use machine tools, and executives of AMT, and the National Tooling and Machining Association (NTMA). The AMT and NTMA participation of the IAB provides interaction with the vast majority of machine tool builders and users in the U.S. Formal meetings are scheduled with the IAB semi-annually.

The site Weapons Advisory Councils consist of senior weapons program managers active in process development and weapons production. The objective of the councils is to assure that the priority ranking of NMTP and other site weapons projects are consistent with DP benefits and the importance of the weapons missions at the respective sites.

The LCB is a senior-management committee with members from each of the DP laboratories and the Y-12 and Kansas City production plants with advisory responsibility to DP-17. Common issues of the NMTP program among the sites that require advice/direction from the Technology Partnership Program (e.g., improving timing of partnership agreements) are reviewed by the LCB.

PROJECT MANAGEMENT

Project oversight of the NMTP is centered with the DOE Office of Development and Technology Transfer in Washington, DC. Ronald Miskell from the Oak Ridge Y-12 Plant is the project manager of the NMTP program and is responsible for maintaining the program and reporting progress and substantive issues to the IAB and the LCB.

Primary responsibility of the day to day activities of the NMTP program at the various DP facilities resides with the various NMTP site managers.

- Kansas City Plant (KCP) - James P. Dycus
- Lawrence Livermore National Laboratory (LLNL) - Thomas M. Barlow
- Los Alamos National Laboratory (LANL) - Renida R. Carter
- Sandia National Laboratory (SNL) - Donald L. Plymale
- Oak Ridge Y-12 Plant (Y-12) - Ted L. Williams

These responsibilities include:

1. Participate with the respective site Weapons Advisory Council in the selection of NMTP projects;
2. Implementing and carrying out NMTP projects consistent with DP policy and guidelines;
3. Project planning and management, multi-site coordination, and integration with various DP programs and objectives;

4. Collecting evidence of performance to be used to determine how well DP-17 expectations are being met;
5. Provide project status reports to the NMTP project manager who will compile periodic NMTP reports for the DOE program manager, and
6. Provide project closeout/accomplishment summaries.

PARTNERSHIP AGREEMENTS USED IN THE NMTP PROGRAM

The preferred partnership mechanisms are:

- Cooperative Research and Development Agreement
- Modular CRADA
- Small Business CRADA

Other types of agreements may be used with the approval of the local DOE Operations Offices and DOE headquarters.

DP AND INDUSTRY BENEFITS FROM THE NMTP PROGRAM

DP Benefits

1. Develop diamond tools to facilitate more precise machining of pits and reduced costs for weapon components through reduction of tool erosion and decreased machining;
2. Develop infrared camera system which can be used in the Accelerator Production of Tritium project;
3. Assure availability of highly accurate milling machines with a rotary axis;
4. Provide high drill tip quality for machining pits and initiators requiring high precision drilled holes;
5. Lower cost and reduced waste stream with use of plasma source ion implantation;
6. Prove design that incorporates characteristics of a vertical turning lathe and a multi-axis mill to permit the fabrication of both turned and prismatic parts;
7. Ensure availability of MAXIM horizontal machining centers for use at SNL;
8. Establish ability to produce small lot high strength weapon components via powder metal sintering enhancement;
9. Ensure integrity of weapon components machined from castings;
10. Prevent inaccurate machining due to early deterioration of spindle bearings;
11. Enhance forming operations for preparation of weapon components for machining;

12. Improve surface finish by reducing machine tool vibration during machining operations; and
13. Attain high accuracy requirements on weapon components by increasing machine tool rigidity during grinding.

Industry Benefits

1. Added new product to vacuum product line;
2. Saved \$100,000 by not needing to build a temperature controlled laboratory;
3. Saved several thousand dollars by having confidence in tooling accuracy;
4. Purchased a \$40,000 milling machine to adequately perform work in lieu of a \$70,000 milling machine, saved \$30,000;
5. Placed otherwise idle CNC turning machine into operation;
6. Realized increased sales of \$100,000;
7. Saved \$900,000 due to new capabilities of small lot production;
8. Improved quality of parts by correcting an alignment problem on a critical machine tool;
9. Improved sensitivity of an emissions monitoring instrument by a factor of 5 to 10;
10. Led to needed product development of a new punch press;
11. Reduced lapping time on silicon carbide disks from 5-7 days to 4 hours;
12. Saved \$70,000 by elimination of the cost of a non-contact measuring system;
13. Enhanced U.S. competitiveness in lapping and polishing zinc-ferrite components;
14. Reduced camming on a turntable from 0.001 to 0.000016 inch;
15. Modeled, characterized, and analyzed vibration of an ultra-high precision optical grinding machine;
16. Increased sales of precision temperature and humidity controlled laboratories by \$1 million;
17. CNC training provided a cost avoidance of \$30,000; and
18. Reduced manufacturing costs of air and mist filters by \$25,000.

INDUSTRY PARTNERS FOR NMTP SHORT TERM PARTNERSHIP PROJECTS—FY '93 THROUGH FY '96

<i>Facility</i>	<i>Industry Partner</i>
1. Los Alamos National Laboratory	◆ Whirlpool ◆ Osran/Sylvania ◆ North American Lighting ◆ ADCO/Dia-Tool ◆ IBH Automation ◆ Empire Hard Chrome ◆ Kaman Sciences

	◆ Gillette ◆ OCA Applied Optics ◆ Quality Control Braze
2. Sandia National Laboratories	◆ Cincinnati-Milacron ◆ McDonnell Douglas Aerospace ◆ Crystallume, Inc.
3. Y-12	◆ Hypervelocity ◆ Cincinnati-Milacron ◆ Eaton Corporation ◆ Vanenite Corporation ◆ Masco Machine Inc. ◆ Allen-Bradley ◆ Cargill
4. Lawrence Livermore National Laboratory	◆ Cincinnati-Milacron ◆ New Venture Gear ◆ Kingsbury ◆ Ultratech Stepper Inc. ◆ Motor Wheel ◆ Boulder Laser Systems
5. Kansas City	◆ Aeromotive, Inc. ◆ C-K Engineering ◆ Cincinnati-Milacron ◆ Eaton Corporation ◆ Gates Rubber Company ◆ Honsa Ergonomic Technologies, Inc. ◆ Huffman Corporation ◆ Kinefac Corporation ◆ Kingsbury Corporation ◆ Leonard's Metal, Inc. ◆ Light Machines Corporation ◆ Megamet Industries ◆ National Center for Manufacturing Sciences, Inc. ◆ Optodyne, Inc.

RELATION OF DP MANUFACTURING NEEDS AND THE AMT TECHNOLOGY ROADMAP

A major contribution of the NMTP program has been the support provided to the AMT in the creation of a roadmap for steering the technology development and deployment of the U.S. machine tool industry into the 21st century. The roadmap defines the technology issues or needs of the machine tool industry to meet the growing requirements of U.S. machine tool users. The guidance will promote the competitive posture of the U.S. machine tool industry in global markets and will help regain the world leadership in machine tool technology that the U.S. once held.

The NMTP has assembled information (see Table 1) of manufacturing needs of the DP SSMP and needs of U.S. industry as compiled from the AMT roadmap. The needs analyses track quite well and further the dual support role (defense and industry) that the Bush administration envisioned when the charter of the NMTP was formulated almost six years ago.

TABLE 1
MANUFACTURING NEEDS ANALYSIS

Defense Programs Manufacturing Needs	AMT Roadmap
FLEXIBILITY	
1. Agile Manufacturing	1. Setup techniques and procedures
2. Integration of enhanced T-base lathe into cells	2. Multipurpose tooling
3. Flexible tooling	3. Flexible fixturing
4. Use of slant bed lathes for turning pits	4. Multiple process capability
5. Systems Engineering	5. Modular designs
6. Machine uranium and beryllium on standard machines	6. Universal designs
7. Dry machining	7. Minimize first part tryout time
8. Rapid prototype models for tooling and fixturing	8. Elimination or reduction for foundation requirements
9. Integration of diverse fabrication processes	
10. Implementation and deployment of electronic work instructions	
11. Geometric reasoning for designing fixtures, tools, and gauges	
12. Flexible inspection/certification systems	
13. Improved powder metal machining	
14. Laser drilling	
PRODUCTION RATE	
1. Modeling and Simulation	1. Increased percent of total cut time per machining cycle time
2. Model based mfg. (design validation through full integration and control of factory floor), design to process capability	2. Computer models which reflect machine features and dynamics to optimize cutting
3. Verify effectiveness of alternate courses of action	3. Cooling effect
4. Concurrent engineering	4. Motor technology
5. Virtual prototyping	5. High speed spindles
6. Production directly from CAD drawings	6. Advanced lubrication technology
7. On-machine and in-process inspection technologies	7. Tool and part verification sensing
8. Hexapod	8. Adaptive/flexible fixturing
9. CNC multiaxis milling and turning	9. Adaptive work handling techniques
10. Intelligent controllers	10. Methods for improved separation of chips, stringers, etc.
11. CMM production capability for precision hemishells	11. Universal chip breaking techniques
12. Integrated process and product design	12. Oil free coolant removal
13. Near net shape casting of uranium and high explosives	13. Improved tool and work changing designs
14. Intelligent closed loop processing	14. Improved probing time
15. Predictive maintenance	
16. Improvements in tool wear and life cycle	
17. Cooling cutting tools	

18. Grinding uranium and ceramic components
19. Near net shops forming of beryllium plutonium lithium compounds
20. Adaptive intelligent controllers for machining explosives
21. Controls to optimize spinforming

USER FRIENDLINESS

1. Open architecture controllers	1. Use of video technologies for training
2. Sealable work zone, modular cells/viable hoods	2. Universal canned easy-to-use programming packages
3. Upgrade inspection machines, CMM YZ, and dual YZ	3. Commonality of control and operator systems (standard interfaces, layouts, features)
4. CMM/rotocon capability	4. Help screens
5. Software standardization for CMM's	5. Bulletin boards for documentation updates
6. CMM calibration upgrade	

ACCURACY CAPABILITY

1. CAD control of joining and machining operations	1. Cost effective and easy to use measuring techniques and devices
2. Active control with sensors	2. Sensing and compensation
3. Integration of ISO 9000 quality procedures	• Controls, sensors, etc. for compensating dynamics/mechanics/thermals • Compensation techniques, thermally stable materials • Use of multiple sensor techniques • Compensation for ambient temperature changes • Wireless sensors for rotating/moving parts
4. sigma processes	3. Process monitoring and compensation
5. New technologies for certifying products	• Real-time sensing/monitoring, measurement, and correction for part size surface geometry • In-process inspection and probing capabilities and techniques • Improved process controls and compensation • Low-cost, high accuracy tool compensation technique
6. Laser cutting workstation using titanium sapphire laser	4. Access to process control information and data
7. Intelligent inspection systems	5. Dynamic balancing of machine components and workpieces
8. Real time process controls	6. Improved cutter technology
9. In-process gauging	
10. Vector displacement interferometer	
11. LLNL error correction methods	
12. Sensor development	
13. Hemishell distortion prediction	
14. Free state inspection of hemishells	
15. On-line inspection data to control final machining	

FY '98 PLANS

Current Projects

- *Sandia National Laboratories—*

- Real-time Predictive Maintenance (PdM) ... Currently working with AS/FM&T, Y-12, Tecumseh, Eaton, McDonnell Douglas, and G&L to install on the Kansas City Plant FMS cell. The machine portion is planned for demonstration this fall and the total FMS installation is planned for September 1998. In FY98 the partnership agreement for PdM takes the form of individual licenses with each of the industry partners. All four companies have the license agreements and G&L has already signed and paid. Sandia is working to find a third party company to commercialize and license Sandia's PdM system, currently Duke Engineering seems to be most interested.
- Hexapod Machining ... Sandia is involved in two areas of hexapod technology partnership/collaboration. We currently have a U.S. users group that periodically meets and shares technology problems and advancements; however, no formal agreements exist among this group. Only public information is shared among the group. Private industry has shown considerable interest in hexapod machining and is closely following the national labs' efforts through the users group interactions. Secondly, we are in the process of developing two partnerships among National Science Foundation, University of Florida (UF), and Sandia related to hexapod technology. This agreement takes the form of an NSF GOALI proposal/grant between UF and NSF. Between Sandia and UF it will take the form of a contract which will define intellectual property and the statement of work.
- Micro-machining ... Is a relatively new area of research and development at Sandia. This work is important to meeting Sandia's component miniaturization goal. Collaboration is currently under way at the university level and may result in an NSF GOALI proposal endeavor in January 1998. Currently there is limited interaction with private industry, except for supplier of potentially related equipment and tools (Extrude Hone, AGIE, and National Jet)
- On-Machine Acceptance (OMA)...Plans are underway to install OMA on the production floor at both Kansas City and Sandia in FY98. The Sandia application will eventually impact portions of neutron generator production in Building 840. Some private companies are already moving to install OMA. Discussions continue with several private companies regarding Sandia's OMA approach. Sandia's past work in OMA did not lead to licensable intellectual property. However, Sandia and AS/FM&T work to turn a machine tool into a combination machining/measuring tool may eventually lead to third party commercialization. In FY98 Sandia NMTP funds will be used to support interaction with

the private sector and third party commercialization efforts. Sandia (NMTP) does not plan to use the memorandum of agreement (MOA) approach to authorize partnership projects with industry in FY98.

- ***Kansas City AlliedSignal FM&T--***

- Artifacts ... Working jointly with Cincinnati Milacron, Cincinnati, Ohio, Department of Energy, Kansas City Plant (KCP) engineers are developing an artifact and evaluation process capable of detecting machine tool inaccuracies before they are large enough to adversely affect product quality. Artifacts are stable devices with fixed target locations that are measured using machine touch probes. The use of artifacts allows the technicians to more easily detect changes in the machine geometry due to wear or damage (e.g. a machine crash). Use of the artifact will allow verification of a machine's condition that would normally require performing machine squareness and laser alignment.
- Coolant Sump Sensor ... This project has the objective to develop a coolant sump sensor capable of identifying the need for coolant changeout due to contamination.
- Cellular Manufacturing ... Develop a performance support system for cellular manufacturing providing hardware/software specifications, description, cost savings, software demonstration, training information and resources.
- Maintenance and Programming ... Develop a performance support system that runs in the background of CNC software. Design and develop software to be used by technical vocational institutions. Transfer maintenance and programming knowledge to the partner's personnel.
- Cylindrical Die Rolling ... Develop a multimedia data collection tool that is designed to identify cylindrical die rolling parts needed for specific job performance needs.
- Performance Support ... Provide multimedia assistance to identify technologies capable of delivering expert system troubleshooting, maintenance procedures and electronic support manuals to the machine floor for Just-In-Time information delivery provided through a performance support system.
- Preventive Maintenance ... Develop an on-line preventive maintenance checklist in the form of a manual with hyperlinks for the Vertical Turning Center (VTC) 5. Design/develop a troubleshooting performance support system on links to the on-line manual. Integrate the two components with a custom browser that would support intranet/internet delivery.
- Real-Time Predictive Maintenance (PdM) ... The AlliedSignal FMS consists of 6 four-axis milling machines, three pallet pools, two coordinate measuring machines, one wash station, and two wire-guided vehicles to move work through the system. The FMS is served by a central coolant system and central compressed air. This project would take place in two phases. In the first phase, one or more milling machines will be instrumented

and the predictive maintenance system will be installed using the local computer network. The first phase will be completed by the end of November, 1997. The second phase will instrument the remaining milling machines along with other selected equipment in the FMS and will demonstrate application of WinR_PdM to a machining cell. This two-phase approach is necessitated by limited availability of funding and time during the remainder of FY98.

- ***Y-12 Plant***

- Expert System for Selecting Machining Coolants...A computer program (expert system) that helps an applications specialist select the proper metal cutting coolant information to solve a coolant production scenario.
- Development of a Photolytic Iodine Narrow Beam Laser for Cutting...The project will provide a rapid cutting mode that results in a cut that appears to be performed with a machining operation. Attributes include reduced waste generation, precise cutting zone, minimal material removal, and enhanced operator safety.
- Applied Instructional System for Machinists...A simulation based educational system for training machinists in the use of control units for numerically controlled machines will be developed. The training will consider the need to be proficient with control units built by a number of different builders of control units.
- Machine Process Assurance...An intelligent data acquisition system and appropriate sensors has been added to monitor machining conditions to detect system degradation and predict impending failure of critical components. Tests are being conducted on a multi-axis mill under continuous high metal removal rates.
- Open Architecture System...A series of software-based control modules will be developed to augment the use of multi-vendor hardware components for computer based numerical control units. Local academia will participate to further the development of the modules.

- ***Los Alamos National Laboratory***

- Alternative Turning Centers...A comparison is being made of commercially available lathes and turning machines with custom made T-base lathes to determine if less expensive machines can be used to produce accurate hemishells.
- Agile Manufacturing...A broad machining and inspection capability for pit manufacturing is being developed. The machines include both T-base and slant bed lathes, and CNC milling and drilling machines for various materials in the physics package. The machines will have features such as in-process gauging, on-machine inspection and intelligent controllers.

In accordance with IAB recommendations, the NMTP is providing the AMT and NTMA details on the past and current activities of the NMTP program in support of U.S. machine tool builders and users. This data will be used in an effort to gain additional support for the NMTP program in FY '99 so that the lauded work of past laboratory/industry partnership activities can be continued. This additional support is necessary for the continuation of a coordinated NMTP program among the sites.

Concurrently, data will be assembled for the TPP program manager for reviews of the NMTP program at DOE Headquarters.

In anticipation of a positive outcome on the additional support, the NMTP is working with the AMT and NTMA in drafting a partnering forum for establishing laboratory/industry partnerships.

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