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Systems Integration for Manufacturing Applications Program 1995 Annual Report

James E. Fowler
Mark E. Luce

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Institute of Standards
and Technology
Manufacturing Engineering Laboratory
Manufacturing Systems Integration Division
Gaithersburg, MD 20899

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May 1996

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The program manager for the first two years of the SIMA effort was Mark Luce (luce@cme.nist.gov). Mr. Luce is now the Deputy Director of the NIST Manufacturing Engineering Laboratory.

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Executive Summary

The goal of the U.S. government's High Performance Computing and Communication (HPCC) Program is to accelerate the development of future generations of high performance computers and networks and the use of these resources in the government and throughout the U.S. economy. The Information Infrastructure Technology and Applications (IITA) component of HPCC supports research and development efforts that will enable integration of critical information systems and demonstrate feasible solutions to problems of national importance. NIST's Systems Integration for Manufacturing Applications Program (SIMA) is the agency's coordinating focus for its activities supporting IITA advanced manufacturing goals. Specifically, the SIMA Program addresses the IITA manufacturing goals of performing research and development to:

- prototype advanced computer-integrated manufacturing systems and computer networks linking these systems,
- work with industry in implementing information exchange standards for these advanced manufacturing systems and processes, and
- transfer the manufacturing process to the new scalable computing and networking technology base.

The SIMA Program is focussing on technologies and standards that enable manufacturing systems integration. The program involves all seven NIST laboratories and emphasizes both product and process data exchange for manufacturing in conjunction with electronic data interchange for electronic commerce. Through FY95, the SIMA effort has developed, tested, validated, and demonstrated multiple integration approaches for manufacturing software applications supporting design, planning, and production. Combining advanced integration approaches with network communication infrastructure technologies will advance the state-of-the-practice in industry towards modular, open, reconfigurable, and intelligent manufacturing systems.

The systems integration requirements of U.S. manufacturing firms can best be captured by close interaction with industry representatives possessing first hand experience in addressing the integration problems of software systems supporting manufacturing activities. SIMA is guided by these interactions to set priorities supporting U.S. industries. These interactions have included both conferences and workshops convened by NIST before and after the SIMA Program was initiated. Based on the industry input received, the SIMA Program consolidated its efforts into three major program categories and prioritized the focus of each so that each addresses requirements as defined by industry. The three major categories defined for SIMA support of manufacturing systems integration were: (1) technology development, (2) standards development, and (3) testbeds and technology transfer. These three categories are reflected in the organization of SIMA technical activities into three program areas: (1) Manufacturing Systems Environment, (2) Standards Development Environment, and (3) Testbeds and Technology Transfer Environment.

The SIMA Program is directed by a manager who is located in the Manufacturing Systems Integration Division (MSID) of NIST's Manufacturing Engineering Laboratory (MEL). The Program Manager oversees the SIMA technical projects which are carried out by staff from all of NIST's laboratories. SIMA projects must satisfy certain criteria. Projects are aimed at providing a "standards solution" for manufacturing systems integration while applying HPCC technology. In particular, each project must:

- address well defined industry needs,
- establish collaborations with industry for development and/or validation of results,
- be structured to provide for timely implementation of results, and
- provide a focus on standards or standards-related issues.

In the Manufacturing Systems Environment (MSE) there are twelve projects. Two of these projects focus on different aspects of integration approaches to be used in the manufacturing systems domain. The Integration Mechanisms project focussed on advanced integration technologies such as Object Request Brokers and their application to engineering and manufacturing software. The project successfully demonstrated the integration of engineering analysis tools using this technology in conjunction with Sandia Laboratory. The Reference Model Architecture project focussed on development of a reference architecture for manufacturing control systems. The project deployed the software components of the architecture in the Next Generation Inspection System program in collaboration with the National Center for Manufacturing Sciences.

The majority of the projects in MSE address different aspects of the discrete mechanical parts lifecycle. The Design Applications project investigated data requirements for the representation, manipulation, visualization, and planning of assemblies with Caterpillar. The Modeling of Manufacturing Resources project developed a data model for machine and cutting tools in conjunction with members of the Rapid Response Manufacturing consortium. The Process Planning Applications project developed models for process planning and leveraged this work for development of pilot implementation of a proposed international standard with the Institute of Advanced Manufacturing Sciences. The Production Applications project focussed on the interfaces between production, scheduling, and simulation systems and produced a simulated production system based on work with Black & Decker.

Two other MSE projects focus on the discrete parts manufacturing domain from the simulation perspective. The Operator Interfaces for Virtual and Distributed Manufacturing project addressed the human-computer interface issues for remote control and monitoring interactions. The project successfully demonstrated a prototype graphical interface to a simulated gear factory in conjunction with Advanced Technology Research Corporation. The Virtual Reality for Manufacturing project investigated the applicability of virtual reality technologies to a manufacturing environment and has established simulations of product assembly lines in conjunction with Black & Decker.

MSE projects also cover the manufacturing domains of plant construction, custom footwear production, and electronic system design. The Process Plant Engineering and Construction project investigated the emerging international protocols for steelwork specification in light of U.S. requirements with the American Institute of Steel Construction. The STEP for the Process Plant Industries project worked in the development and validation of data exchange protocols supporting the design of process plants; the project helped establish the PlantSTEP consortium for testing of these proposed standards. The Virtual Enterprise Frameworks for Small Manufacturers project investigated the interface protocol issues relating to the integration of processes supporting the design and production of custom footwear. The Electronic Commerce for the Electronics Industry project worked to develop the protocols needed for electronic component design data access in conjunction with SEMATECH.

In the Standards Development Environment there are three projects. The Application Protocol Development Environment project worked on an integrated suite of software tools expediting the creation of international standard data exchange protocols. The project worked with Concurrent Technologies Corporation for testing of remote collaborative mechanisms. The STEP Conformance Testing project worked to establish the testing methodologies and software tools which will ensure that data exchange protocols conform to the international standards. The project worked with the PDES, Inc. consortium on validation of the testing tools in the consortium's pilot implementation projects. The STEP Implementations project worked to establish mechanisms facilitating implementation of STEP data exchange protocols in practice through participation in the Automotive Industry Action Group Supply Chain Integration effort and the U.S. Army's Defense Systems Supply Chain Integration effort.

In the Testbeds and Technology Transfer Environment there are five projects. The Advanced Manufacturing Systems and Networking Testbed (AMSANT) project established a facility for use by all SIMA projects providing them with high-performance scientific workstations and high-speed networking capabilities. The facility's networking capabilities has been put to use for remote access to Sandia Laboratory for establishment of a virtual, collaborative manufacturing engineering prototype. The AMSANT for Process Plant Industries project provided a distributed link to the primary AMSANT facility and specifically provides capabilities supporting the process plant projects. The Analysis Tools for Assessment and Optimization of Process and Product Design project worked to establish an on-line environment providing engineers with access to statistical tools fundamental to design and manufacturing processes. The project worked closely with SEMATECH to define the capabilities needed. The Manufacturing Information Technology Transfer project worked to provide the internet infrastructure tools necessary to support

SIMA project technical activities as well as to disseminate project information. The Standard Reference Data Delivery and Use project worked to make NIST databases of evaluated scientific data accessible through the internet to manufacturers developing new products and processes.

The SIMA Program is managed to ensure that the technical activities of the program address the requirements of U.S. industry, are appropriate to the mission of the NIST Laboratories, and are consistent with the overall HPCC/IITA goals. NIST's unique focus on working with industry to develop voluntary, consensus standards will be a key feature of SIMA projects as their technology developments mature. In FY96 the SIMA Program will be instituting a process that responds to the need for activities leading to the development of standards at a more rapid pace.

Initial Manufacturing Exchange Specifications (IMES's) are protocols that will cover interfaces between manufacturing applications, interfaces between manufacturing applications and manufacturing data repositories, and interfaces between users and the applications themselves. Industry participation throughout the IMES development process will ensure that the IMES satisfies the intended requirements with a viable solution. This formal IMES development process should ensure that the resulting specifications are high quality, industry-tested solutions ready for the voluntary standardization process.

Introduction

The Systems Integration for Manufacturing Applications (SIMA) Program is a major intramural effort being undertaken at the National Institute of Standards and Technology (NIST) to support the application of advanced computing and networking technologies to the manufacturing domain. The purpose of this report is to describe the organization of the program and to summarize the program's accomplishments during FY94 and FY95 -- the first two years of the program. With the publication of this report, the SIMA Program also intends to promote interest in the technical activities of the program and establish new partnerships.

This report provides an overview of the program, describes the technical projects comprising the program, and highlights key accomplishments for each project. In addition, the appendices provide a detailed listing of project collaborators, as well as a listing of project publications and other available project resources. The intended audience for this document includes NIST staff working on SIMA-supported projects, private sector organizations collaborating with NIST, government agencies supporting the government initiative on High Performance Computing and Communications (HPCC), and the general public. This report is available via the SIMA external home page (http://elib.cme.nist.gov/msid/projs/sima-pm/sima.htm) or by electronic mail request to the SIMA Program office secretary (blthomas@cme.nist.gov).

Background

The goal of the U.S. government's High Performance Computing and Communication (HPCC) Program is to accelerate the development of future generations of high performance computers and networks and the use of these resources in the government and throughout the U.S. economy. The HPCC Program was formally established by the High Performance Computing Act of 1991 (Public Law 102-194). The four original components[1] of the HPCC Program were augmented in FY94 with a new component known as Information Infrastructure Technology and Applications (IITA) [1]. The IITA component supports research and development efforts that will enable integration of critical information systems and demonstrate feasible solutions to problems of national importance [2]. Twenty-first century manufacturing, i.e., advanced manufacturing processes and products, is one of the challenges to be addressed by IITA activities [3]. NIST's SIMA Program is the agency's coordinating focus for its activities supporting IITA advanced manufacturing goals. The goals and supporting plans for the Program were originally described in [4]. Specifically, the SIMA Program addresses the IITA manufacturing goals of performing research and development to:

- prototype advanced computer-integrated manufacturing systems and computer networks linking these systems,
- work with industry in implementing information exchange standards for these advanced manufacturing systems and processes, and
- transfer the manufacturing process to the new scalable computing and networking technology base.

These efforts will allow manufacturing industries to make use of the National Information Infrastructure (NII) as a mechanism for communicating product and process data among various manufacturing applications such as product/ process design, analysis, planning, scheduling, and quality control. Manufacturing applications require standard protocols for data exchange to communicate with each other via NII technologies. The SIMA Program is supporting IITA goals through development of protocols for data exchange, through development of mechanisms for testing and validation of such protocols, and through development of advanced manufacturing application prototypes demonstrating these capabilities.

1. High Performance Computing Systems, National Research and Education Network, Advanced Software Technology and Algorithms, and Basic Research and Human Resources.

The SIMA Program is focussing on technologies and standards that can improve manufacturing systems integration. The program involves all seven NIST laboratories and emphasizes both product and process data exchange for manufacturing in conjunction with electronic data interchange for electronic commerce. Through FY95, the SIMA effort has developed, tested, validated, and demonstrated multiple integration approaches for manufacturing software applications supporting design, planning, and production. Frameworks and industry-accepted integration methodologies guide the selection of integration approaches. Integration tools used include state-of-the-art commercial software, pre-commercial software, and prototype software as necessary. Combining these integration approaches with network communication infrastructure technologies will advance the state-of-the-practice in industry towards modular, open, reconfigurable, and intelligent manufacturing systems.

The SIMA Program is built upon the premise that standards are necessary to integrate manufacturing systems and that the availability of the NII accelerates the need for voluntary industry standards. ISO 10303, commonly known as the Standard for Exchange of Product Model Data or STEP [5], is considered to be a key standard for integration efforts. STEP is expected to accelerate the evolution of concurrent engineering, support electronic data interchange and electronic commerce, and enable business partners to share sophisticated product data representations throughout the product lifecycle. As such, STEP promises to be one of the most influential standards that has ever been developed in the industrial automation field.

Industry Needs

The systems integration requirements of U.S. manufacturing firms can best be captured by close interaction with industry representatives possessing first hand experience in addressing the integration problems of software systems supporting manufacturing activities. As a NIST program, SIMA is guided by these interactions to set priorities supporting U.S. industries. These interactions have included both conferences and workshops convened by NIST before and after the SIMA Program was initiated.

A workshop entitled "System Integration Needs of U.S. Manufacturers" was held at NIST in 1993 to identify the key systems integration needs of U.S. manufacturers in the areas of technology development, standards development, and technology transfer [6]. These needs were defined in terms of the objectives set forth for NIST by the advanced manufacturing application focus planned for the IITA component of HPCC. The results of that workshop have been used to define the role of the SIMA program with respect to the requirements of U.S. industry and to help identify mechanisms by which NIST can respond to industry priorities.

A second workshop entitled "SIMA Interactive Management Workshop" was held at the Defense Systems Management College in November 1994 [7]. The workshop brought together representatives from industry and government programs in the area of manufacturing systems integration resulting in the definition of actions for the SIMA Program and the identification of leveraging opportunities between SIMA and other government and/or industry programs. Another result of that workshop was identification of opportunities for collaboration between programs to maximize the resources being applied to system integration.

In addition to the focused workshops described above, SIMA sponsored a background study of industry requirements in the area of manufacturing systems integration [8]. The study assessed integration requirements for design, planning, and production software applications that support manufacturing. Existing technologies and emerging standards were reviewed to identify technical obstacles faced by industry in developing integrated manufacturing systems. The results of this study provide an understanding of the scope of integration problems related to the design, planning and production of mechanical products. The background study provides a useful overview of why SIMA is focusing on integration problems and establishes a baseline for SIMA efforts in manufacturing systems integration. Additionally, the report provides a rationale for developing collaborative efforts among NIST, industry, other government agencies, research organizations, and standards bodies.

The workshops and background study are examples of the many formal mechanisms the SIMA Program uses to solicit industry priorities for technology and standards efforts. These workshops have resulted in the identification of numerous integration problems and a wide range of recommendations for the direction of the SIMA Program. However, given that SIMA is a program with limited resources, and given the priorities, mission and direction of NIST laboratory programs, SIMA must focus its primary efforts on traditional NIST products (measurements, standards, databases, process models, etc.) that fit within the scope of the program. Given those constraints, the SIMA Program focussed its efforts in three areas defined so that each addresses system integration needs identified by industry. The three areas defined for SIMA support of manufacturing systems integration were: (1) technology development, (2) standards development, and (3) testbeds and technology transfer.

In the area of technology development, the following key activities were identified for SIMA:

- establish a data model for systems integration,
- determine attributes of a complete and consistent model for an industrial process,
- develop neutral test and validation technology, and
- identify and test integration mechanisms for software applications.

In the area of standards development, the following key activities were identified for SIMA:

- reengineer critical standards development processes,
- assume responsibility for assisting standards groups,
- provide more training, testing, and evaluation, and
- establish testing methodologies for interoperability.

In the area of testbeds and technology transfer, the following key activities were identified for SIMA:

- establish computer support systems for an electronic network, on-line databases, and user-friendly search techniques.
- study electronic transfer mechanisms, develop pilot examples for these mechanisms, and perform demonstrations that illustrate the transfer of technology over the world wide web.
- provide on-line access to standard reference data, technical publications, and/or information on standards development activities.
- provide a supporting computing and communications testbed to perform tests, support electronic collaboration and demonstration.

Program Strategy

To align the resources of the program with the needs defined by industry and still ensure support for the IITA initiative goals, the SIMA Program has been organized into three program areas. All SIMA efforts fall within one or more of these three areas. The program areas are known as: (1) Manufacturing Systems Environment, (2) Standards Development Environment, and (3) Testbed and Technology Transfer Environment. Activities within each area satisfy a unique NIST role in support of the HPCC/IITA goals and address the major technology and standards issues outlined in the IITA program report [2]. The focus of each of the three program areas is described below.

Manufacturing Systems Environment (MSE)

The objectives of this environment are to develop integration technologies and standards in support of a broad range of industrial manufacturing domains that include mechanical products, apparel, electronics, construction, and chemical processing. The application systems of interest within these domains include design (product, process, and enterprise), planning, scheduling, process modeling, shop control, simulation, inspection, assembly, and machining. The problem scope includes manufacturing systems integration both within and among multiple enterprises. The MSE projects focus on the development of infrastructure technologies, interface protocols, and information models with the intention of applying these integration solutions to application system incompatibilities. Typical integration and interface technology solutions include network communications, information protocols for product and process data, database technologies, and frameworks. The major result of MSE activities are integration specifications for manufacturing systems and prototype process models for use throughout the manufacturing environment.

Standards Development Environment (SDE)

The objectives of this environment are to assist industry in implementing voluntary consensus standards relevant to computer integrated manufacturing (CIM), facilitate industry efforts to test new applications of advanced manufacturing systems and networks, facilitate efforts to develop and test new data exchange standards utilizing HPCC technology, and accelerate industry deployment of consensus standards. There is a general theme of providing effective support environments for the development of standards as well as facilitating the harmonization across the broad spectrum of standards that compose the range of information and supporting technology required for enterprise integration. Several projects will be involved in coordinating the support mechanisms and information across the various industries.

Testbeds and Technology Transfer Environment (TTTE)

The objectives of this environment are to develop technology transfer infrastructure which can be used to exchange manufacturing information using HPCC technology, to develop prototype information services in collaboration with industry partners which could become commercialized products, to develop services related to document searches and retrieval of government and other research reports, and to establish communication channels for network of researchers and implementors of manufacturing technologies. Testbeds developed under the auspices of TTTE are intended to serve as demonstration sites that industrial technology suppliers and users can utilize, to serve as the interfaces to a network of technology development testbeds across the United States, and to serve as the focal points for information dissemination.

Program Operation

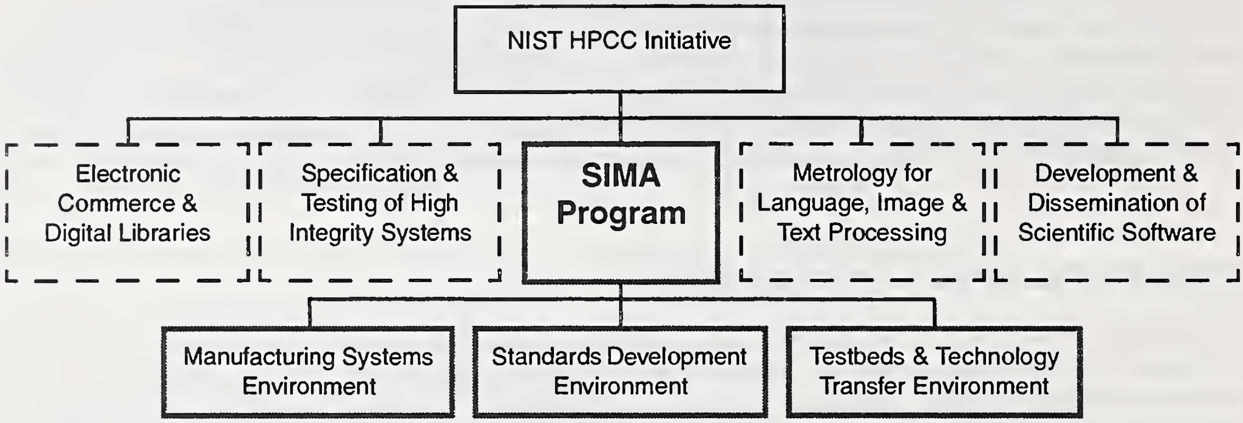


Figure 1. Organization of the NIST HPCC Initiative

The SIMA Program is one of five that has been created at NIST in response to the HPCC initiative (see Figure 1). The SIMA Program is directed by a manager in the Manufacturing Systems Integration Division (MSID) of NIST's Manufacturing Engineering Laboratory (MEL). In addition to overseeing the SIMA Program, the SIMA Program office manages selected external relationships with other agency programs supporting the HPCC initiative, serves as liaison to the HPCC Information Technology committee, and assists with long-range planning and program support for NIST laboratories participating in the program. The program manager is responsible for:

- providing technical and administrative leadership to the program,
- planning and executing collaborative, multi-year technology development and deployment projects,
- ensuring that the program is a focal point for coordinating efforts in response to legislation, and
- identifying related on-going and planned technology development and deployment efforts being undertaken by federal agencies supporting the HPCC/IITA initiative.

Projects within each program environment must satisfy certain criteria. In particular, each project must:

- address well defined industry needs,
- establish collaborations with industry for development and/or validation of results,
- be structured to provide for timely implementation of results, and
- provide a focus on standards or standards-related issues.

Program projects are aimed at providing a "standards solution" for manufacturing systems integration while applying HPCC technology. At the same time, these projects are planned and executed in a manner that utilizes industry collaborators as a mechanism for validating the approach and demonstrating feasibility of results.

Planning is a key aspect of the SIMA Program. The primary purpose of this planning is to help ensure that the program remains responsive to industry needs and applies HPCC technology to support these needs. The SIMA Program uses a planning process to:

- establish appropriate technical direction and standards strategies,
- assure program decisions and execution are supportive of the NIST and IITA goals,
- provide timely reviews to internal and external supporters,
- strengthen the relationship between NIST, industry collaborators, other agencies supporting the IITA initiative, and other technology users and developers; and
- provide opportunities for all laboratory participants to better understand and influence the program's ability to achieve its goals and objectives.

The SIMA Program uses a yearly review process to evaluate the performance of existing projects, bring efforts to a completion stage and then identify new projects to address technology and standard gaps not yet addressed by the program.

Overall guidance for the program is provided by a management council consisting of the program manager and one Division Chief from each participating NIST laboratory. Individual SIMA projects are led by research staff from the participating laboratories and directed by the SIMA Program manager. The following sections briefly summarize the respective missions of each NIST laboratory participating in the SIMA Program[1].

Building and Fire Research Laboratory (BFRL)
BFRL works to enhance the competitiveness of U.S. industry and public safety through performance prediction and measurement technologies and technical advances that improve the lifecycle quality of constructed facilities.

Chemical Science and Technology Laboratory (CSTL)
As the Nation's Reference Laboratory, CSTL performs cutting edge research in measurement science. The Laboratory develops and maintains measurement methods, standards, and reference data; and develops models for chemical, biochemical, and physical properties and processes.

Computing and Applied Mathematics Laboratory (CAML)/ Computing System Laboratory (CSL)
CAML and CSL are in the process of merging into a single Information Technology Laboratory (ITL). The ITL develops, demonstrates, and supplies high quality information technology, metrology, and standards that enable U.S. industry to develop usable, reliable, interoperable products. In doing so, the ITL serves as a neutral agent to accelerate acceptance and use of information technology that will promote economic competitiveness and the public good. The ITL provides leadership and collaborative research to NIST programs in the areas of mathematics, statistics, and information technology use and services to enable NIST to maintain its status as a world class institution.

Electronic and Electrical Engineering Laboratory (EEEL)
EEEL promotes U.S. economic growth through improved international competitiveness, by providing measurement capability of high economic impact focussed primarily on the critical needs of the U.S. electronics and electrical-equipment industries.

Manufacturing Engineering Laboratory (MEL)
MEL works to improve the competitiveness of U.S. manufacturing by working with industry to develop and apply infrastructural technology, measurements, and standards.

1. More information about NIST Laboratories can be found at http://www.nist.gov/labs2.html.

Material Science and Engineering Laboratory (MSEL)
MSEL works to stimulate the more effective production and use of materials by working with materials suppliers and users to assure the development and implementation of the measurements and standards infrastructure for materials.

Physics Laboratory (PL)
PL supports U.S. industry by providing measurement services and research for electronic, optical, and radiation technology.

Technology Services (TS)
TS provides a wide variety of services and programs to help U.S. industry improve its international competitiveness. TS supplies NIST reference materials, data, and calibrations to help industry maintain production quality control. TS also provides information and assistance concerning national and international voluntary and regulatory product standards and certification systems.

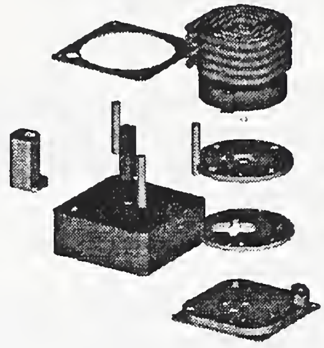
Program Accomplishments

This section summarizes the accomplishments of each SIMA Program technical project. Project summaries are organized by program environment element. Each project summary provides a brief description of objectives, activities, and accomplishments. Further information on any project may be obtained by contacting the project manager listed for that project.

Manufacturing Systems Environment Project Summaries

MSE1: Design Applications

Project Manager: Kevin Lyons
Telephone: (301) 975 - 6550
E-mail: klyons@cme.nist.gov



Assembly model of spray cooling system

This project is addressing integration and information exchange issues associated with design engineering, interoperation, and the modeling of engineering processes. Specifically, the project focuses efforts in the following four areas:

- development of process models to aid in understanding the design process and how design systems aid in product design,
- identification, in the course of developing these models, of functionality and representational requirements for engineering process modeling applications,
- development of data exchange mechanisms between CAD (computer aided design) and design support (e.g., analysis, virtual Reality) systems, and
- extension and enhancement of current design system to demonstrate the impact of incorporating enhanced functionality and support mechanisms for information access and exchange. This prototype system is to help understand how end-users (designers) would apply (or not apply) these technologies to real design and manufacturing problems.

The project is continuing to explore a variety of extended and enhanced data types with the initial effort aimed at the creation of trajectory, component orientation information (process data), swept volumes, and assembly sequencing data that can be merged with position and part representation. The approach for the project is to leverage existing efforts such as the use of existing CAD applications in concert with state-of-the-art virtual reality solutions as a basis for the project's efforts.

FY94 & 95 Accomplishments

- Completed model of NASA's current satellite design and deployment process. This model was developed in conjunction with functional decomposition and behavior relationship models to assist in definition of a new satellite realization process.
- Defined draft specification for virtual assembly design environment (VADE) that supports CAD to virtual reality (VR) information exchange. Prototype system demonstrated information exchange from Pro-Engineer CAD application to OpenInventor-based VR environment.

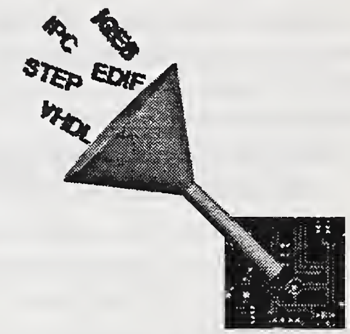
Collaborations

- Black and Decker, for analysis and modeling of the process used to design and engineer new products.
- Caterpillar, for investigation of CAD and virtual reality integration issues.
- Isothermal Systems Research, Inc., for development of integration mechanisms to enable virtual prototyping of mechanical components.
- Perceptronics, for investigation of process modeling requirements and solutions based on their software product.
- Washington State University, for investigation of CAD and virtual reality integration issues.
- George Washington University, for investigation of process modeling methodologies and advanced representations.

MSE2: Electronic Commerce for the Electronics Industry (ECCI)

Project Manager: James St. Pierre
Telephone: (301) 975 - 4124
E-mail: jimstp@eeel.nist.gov

This project is providing mechanisms for access to electronic component design data at various points in the design flow through development of formats and protocols for exchange of product component information. Specifically the project is focussing on:



Standards for electronic product design

- methods for coordinating product information creation, access and maintenance,
- tools and methodologies for conformance and certification testing of software which use electrical product data exchange standards,
- methodologies for incorporating ECCI,
- data dictionaries and common terminology in component descriptions required for ECCI, and
- interoperability between existing standards.

FY94 & 95 Accomplishments

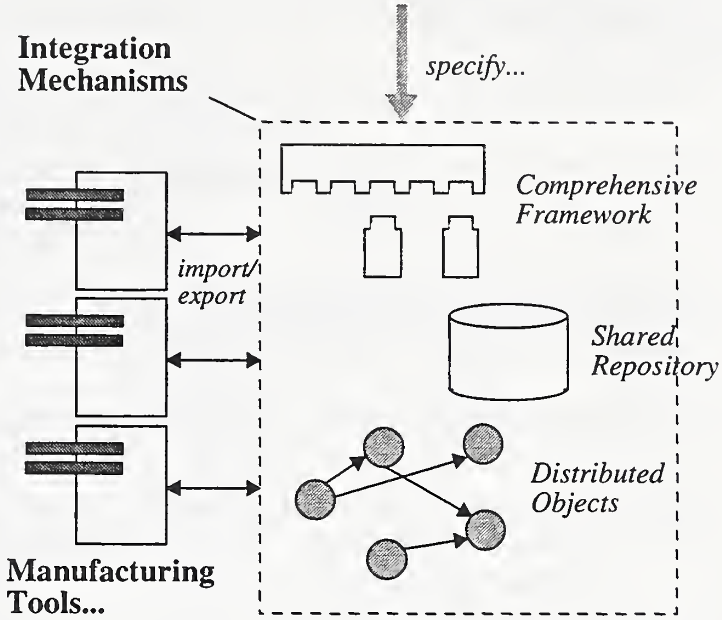
- Elected Chair of the International Electrotechnical Commission (IEC) TC93/WG5 working group on conformance and certification of electrical design automation standards.
- Acquired a complete (computer readable) version of the IEC 1360 Dictionary of Electricity, Electronics and Telecommunications Multilingual Dictionary. This data will be used to develop a prototype object-oriented system to allow on-line access, reference and incorporate dictionary definitions.
- Developed an initial specification for an Internet utility for viewing ECCI related graphical information, and began development of a prototype graphical information browser.
- Delivered year end report describing joint NIST/SEMATECH project which includes recommendations for methodology and technologies to use for conformance and certification of their object-oriented CIM Framework.
- Participated in harmonization meetings of standards organizations producing electronic component-related standards.

Collaborations

- SEMATECH, for validation of the CIM Framework.
- Viewlogic Systems Inc., for analysis of electronic component data requirements in electronic engineering and design software.

MSE3: Integration Mechanisms

Project Manager: Neil Christopher
Telephone: (301) 975 - 3888
E-mail: neilc@cme.nist.gov



Mechanisms for integrating manufacturing applications

The U.S. manufacturing industry is strengthening customer-supplier relationships at the systems level and is supporting these relationships by integrating distributed manufacturing systems. The SIMA Integration project is working with three national consortia as well as with other NIST projects to develop integration standards for distributed manufacturing software systems. The basis for these standards are models of manufacturing-related information and corresponding protocols for exchange. These models and protocols are critical to defining and designing the interfaces between software applications. Well defined interfaces are critical to reducing the cost of creating distributed manufacturing software systems. These models, protocols, and standards will be of particular use to system integrators and software providers building systems that support product design, manufacturing engineering, and production engineering activities.

FY94 & 95 Accomplishments

- Systems: Evaluated the pragmatics of using Common Object Request Broker Architecture (CORBA) based Object Request Brokers to build distributed manufacturing software systems by collaborating with the Software Engineering Institute to build a distributed engineering analysis system based on Sandia National Laboratory developed software components.
- Models: Completed the SIMA Reference Architecture: Part One - Activity Model. Completed formal information representations relating to the Manufacturing Systems Integration (MSI) scheduler code. Generated database schema for the MSI models. Updated the MSI schemas to the international standard (IS) version of EXPRESS.
- Standards: Delivered ISO/IEC 11404:1995, Information Technology --Programming Languages -- Language-Independent Datatypes. Delivered Technical Corrigendum for Part 21 of ISO 10303. Worked with members of the Object Management Group to re-establish the Manufacturing Special Interest Group (MfgSIG). Evaluated ISO TC184/SC4 proposed new work item for Interface Definition Language (IDL) binding to ISO 10303 Part 22. Hosted meetings of ISO/IEC JTC1/SC22/WG11.
- Technology Transfer: Hosted the “Architects Roundtable” -- a meeting of leading architects from national programs in manufacturing information technology. The purpose of the meeting was to work towards maximizing the national impact of these programs. The programs represented were: NIIIP, TEAM, SEMATECH, and SIMA.

Collaborations

- SEMATECH, for investigation of integration methodologies and frameworks.
- NIIIP (National Industrial Information Infrastructure Protocols), for analysis of manufacturing integration architectural approaches.
- Technologies Enabling Agile Manufacturing (TEAM), for analysis of integration solutions.
- Software Engineering Institute, for validation of CORBA-based software implementation.

MSE4: Modeling of Manufacturing Resource (MR) Information

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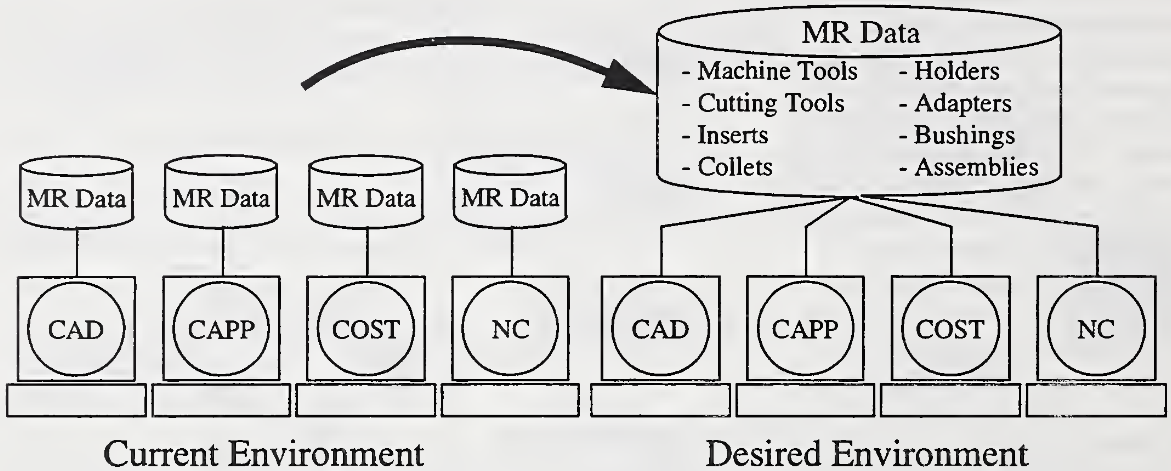

Transitioning from multiple manufacturing resource stores to a common database

This project is developing and validating a proposed common representation for manufacturing resource (MR) data. Specifically, a limited scope of MR data is addressed, including milling and turning machine tools; cutting tools appropriate to the processes of milling, drilling, boring, reaming, tapping, and turning; cutting tool inserts; and the tool holding and assembly components required to mount the cutting tools to the machines. Electronic representations of manufacturing resources are used within a variety of software applications, including manufacturing process planning, manufacturing simulation, tool selection, and machine tool programming systems. Each software system typically represents this data using different formats, which results in a manufacturing facility storing and maintaining MR data multiple times. This situation causes much duplicate work for maintaining the information, redundant stores of MR data which may or may not contain the most recent and accurate information, and longer lead times for implementing new systems which require this data. System integration or sharing of resource data between systems or engineering functions is not possible without information loss in the current environment. The work of this project addresses these concerns by developing a publicly available representation for MR data that is common to a variety of software applications and engineering functions and attempts to satisfy the various perspectives and requirements from MR vendors, manufacturing software vendors, and mechanical parts manufacturers. The solution proposed by this project is based upon a thorough analysis of current representations from the various perspectives. The project intends to evaluate the completeness and usability of the proposed data structure through prototype implementation in a shared database environment to support multiple CAE applications. The project results are expected to provide a catalyst for a standardized MR data structure by providing proven results and a working strawman to appropriate standards organizations.

FY94 & 95 Accomplishments

- Completed state-of-the-art assessments of various technology areas (e.g., rapid prototyping, variant design, process capability representation, visualization applications, etc.) initiated during prior years. Published NISTIR for each assessment.
- Analyzed existing manufacturing resource data representations from several perspectives (e.g., tooling vendor, CAE software developer, manufacturing facility, standards organization).
- Developed a detailed requirements specification (NISTIR 5707) to describe the proposed MR data representation (i.e., categories, attributes, and relationships).
- Developed EXPRESS and EXPRESS-G (graphical) information models based upon the MR requirements document.
- Distributed MR requirements document for widespread review by industry, tooling vendors, standards bodies, etc.
- Submitted MR requirements document as strawman proposal to ISO TC29 (small tools) WG34 (computerized machining data exchange).
- Obtained and installed database and CAE application system components for the MR data test environment for evaluation of the resulting MR data structure.

Collaborations

- Rapid Response Manufacturing (RRM) consortium, for development of an integrated product and process model (IPPM).
- Technologies Enabling Agile Manufacturing (TEAM) consortium, for development of a manufacturing resource database.
- Allied-Signal Aerospace, for analysis of data representations for cutting tools and inserts.
- Texas Instruments, for development of machining cost models during integration of the Cognition Cost Advantage software with the MR database.
- Institute of Advanced Manufacturing Sciences (IAMS), for integration of the MetCapp process planning application with the MR database.
- SGS Tool and Sandvik Coromant, for review of MR data structure from a cutting tool vendor perspective.

MSE5: Operator Interfaces for Virtual and Distributed Manufacturing

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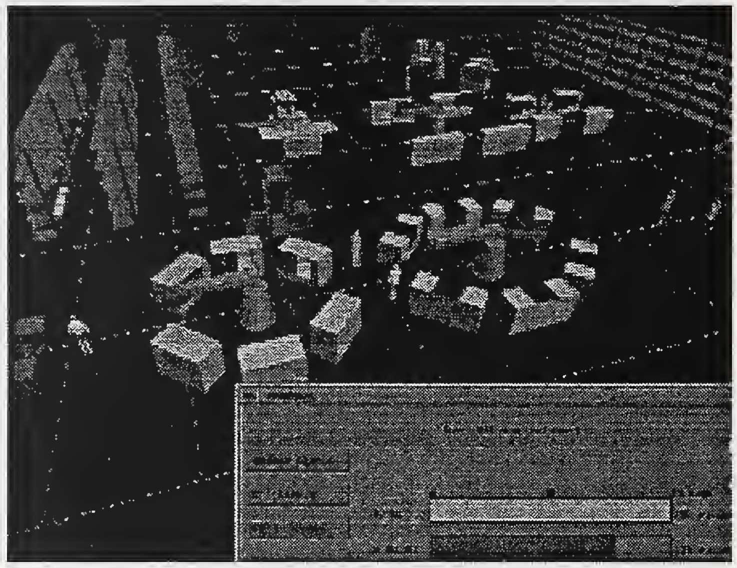

Simulated gear factory

The objective of this project is to understand and address standards issues in human interfaces for virtual and distributed manufacturing systems employing HPCC technology. The project is developing methods to collect and present relevant manufacturing information at an appropriate level of abstraction for interactively examining remote operations and representations, and cooperatively controlling remote systems.

The issue addressed is that of human interfaces for control of distributed and simulated manufacturing systems, as developed in a laboratory setting for the SIMA AMSANT facility. The focus is not only on remote interaction with shop-floor equipment, but also on interfaces for development, management and control of plant, operations, processes, and design at a variety of levels such as shop-floor supervisor, production foreman, plant manager, production executives, facility designers, product designers, process designers, and consultants. The general problem is to collect and present the relevant information, at the appropriate level of detail, and in the most efficient possible format, to a variety of remote decision-makers and allow them to examine interactively remote situations and cooperatively control the remote environments. Issues with which the project is concerned are:

- the definition of the information needs of end-users that must flow across the interface between manufacturing databases and display systems appropriate for presenting the information to human operators,
- the development of standard interfaces between operating manufacturing databases and user-display systems appropriate for presentation to human operators,
- the understanding of human factors issues determining the most effective way to present information in context,
- the development of interface standards for the man-machine display interface,
- the exploration of advanced technologies for presenting the information in real-time to enable identification of interface standards issues. Two current technologies being investigated are graphics-based virtual reality techniques oriented towards real-time, single user displays, and text-based multi-user shared environments orient.

FY94 & 95 Accomplishments

- Established an operator interface visualization laboratory in AMSANT providing an initial version of a multi-user virtual factory environment.
- Demonstrated a graphical interface into the real-time database of a simulated gear-manufacturing operation.
- Established an operational text-based multi-user environment.

Collaborations

- University of Illinois, to construct an Immersadesk and develop interfaces to "CAVE" software.
- San Francisco State University, to construct a text-based virtual environment.
- Advanced Technology Research Corporation, to construct gear-factory simulation.
- West Virginia High Technology Consortium, to conduct a study of user interface requirements for manufacturing.

MSE6: Process Planning Applications

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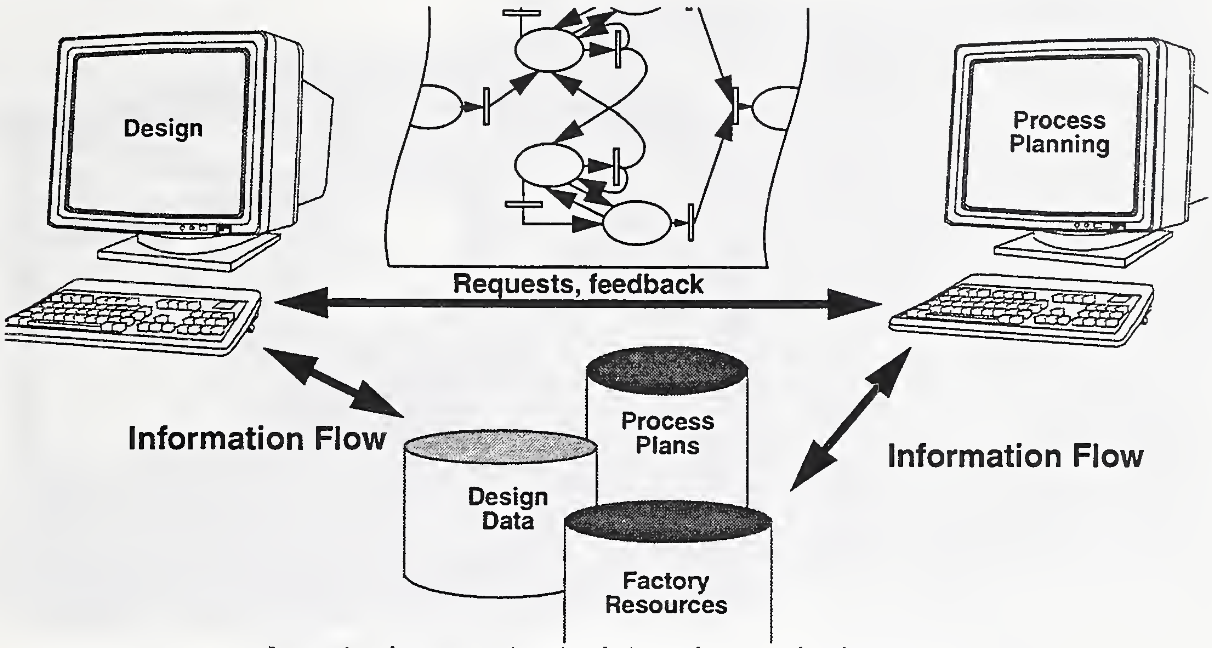

Interactions between engineering design and process planning systems

The objective of this project is to improve the capabilities and integration of manufacturing planning applications. This is being addressed in three ways: (1) specifying a series of information and process models and communications protocols needed by manufacturing planning systems, (2) implementing these specifications as part of an integration activity using commercial planning system software, and (3) developing a repository of information supporting the research, development, and integration of future planning system applications. The information shared between the planning functions and other engineering functions such as design, scheduling, and production is being identified, formally modeled, and implemented as a series of databases. Access to these databases will be via accepted or emerging standard mechanisms.

FY94 & 95 Accomplishments

- Defined and documented process planning activity model.
- Analyzed two commercial process planning systems with respect to their process plan representations, as a precursor to pilot standards implementations.
- Created repository of sample product and process data for testing of engineering applications.
- Completed and documented a preliminary modular, composable process planning architecture.

Collaborations

- International Technegroup, Inc., for development of open interfaces to their process planning system, MultiCAPP.
- Advanced Databases, Inc., for implementation of mechanisms enabling data sharing among applications.
- Institute for Advanced Manufacturing Sciences (IAMS), for work on a pilot implementation of STEP AP213 (Process Plans for NC machining.)
- Cimplex Corporation, for investigation of STEP AP213 and AP224 as open interfaces to their software product.
- Technologies Enabling Agile Manufacturing (TEAM), for definition of requirements for integrated process planning.
- Florida State University, for definition of a modular, composable process planning architecture.

MSE7: Process Plant Engineering and Construction

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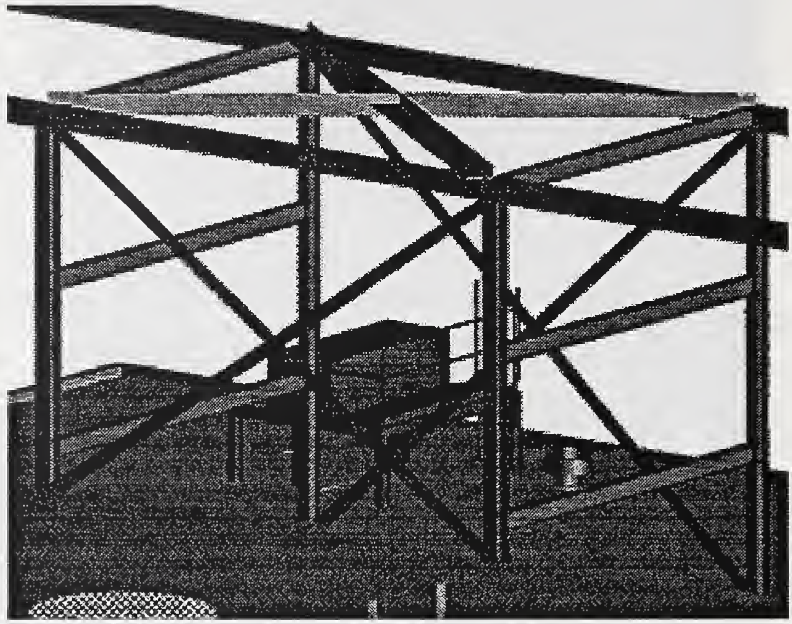
The object of this project is to work with U.S. industry to develop its technical capability to represent and exchange information supporting the design and construction of structural systems using internationally accepted protocols. ISO TC 184/SC 4 has recently embarked on a STEP application protocol project that addresses structural steelwork, based on European input from the Eureka CIMSteel project. NIST is working with U.S. industry members and the cognizant professional society, the American Institute of Steel Construction (AISC), to ensure that this STEP project properly addresses U.S. requirements. NIST is exploring the potential use of STEP application protocols to create virtual construction environments that allow engineers and constructors to visualize and manipulate a common process plant model from widely disparate viewpoints.



Structural steel frame model

FY94 & 95 Accomplishments

- Reviewed and critiqued the available CIMSteel documentation and the STEP AP project proposal.
- Developed a detailed example of structural steelwork design of a process plant as baseline industrial practice to critique the proposed application reference model and to explore STEP usage scenarios.
- Worked with Director of Building Design and Software for the American Institute of Steel Construction to establish a technical task force for structural steelwork activities in STEP.

Collaborations

- American Institute of Steel Construction, for establishing a technical task group and serving as its government liaison member.

MSE8: Production Applications

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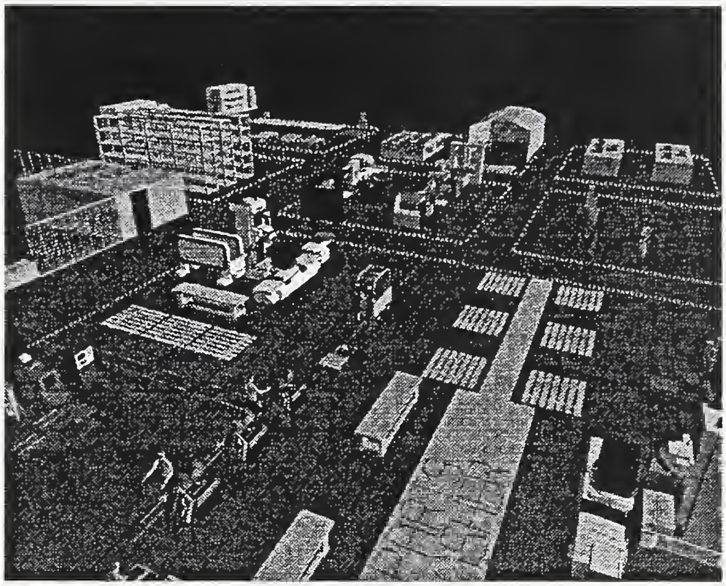

Simulated production facility

This project is addressing integration problems associated with production engineering, scheduling, and simulation systems. The project is developing process models, information models, and interface specifications, databases, and extensions to commercial production software that resolve or facilitate system integration. After assessing industry needs, this project has selected and installed software applications that are used to engineer a production system, perform production scheduling, and simulate production. Prototype integrated systems are being constructed from commercial products and industry provided data. The principal elements of the technical approach are to:

- identify and address critical industrial needs through collaboration,
- develop solutions to production software integration problems,
- construct prototype environments using commercial products,
- validate results through industrial testing of system implementations, and
- specify and promote needed industry standards, and facilitate rapid commercialization of new technology.

FY94 & 95 Accomplishments

- Developed process model for production system engineering and a model for scheduling information.
- Developed initial simulated production facility in AMSANT representing machine tools, tool crib, shipping and receiving, cleaning and deburring, painting area and other support processes.
- Developed extensive reference bibliography on production system engineering.
- Held production system engineering kick-off meeting at Black and Decker Fayetteville plant with industry and university collaborators.

Collaborations

- Black and Decker, to provide test parts, product design models, CAD files and process flow diagrams for evaluating integration of production applications.
- CIM Technologies, for installation of plant layout software (Factory CAD/FLOW).
- Framework Technologies, for installation and testing of manufacturing system design software (FM/ASPECT).
- Litton AMECOM, to provide test parts, product design models, CAD files and process flow diagrams for evaluating integration of production applications.
- McDonnell-Douglas, to partner in Joint Advanced Strike Technology (JAST) Program Support and process capability workshops for purpose of sharing integration related to integrating production applications.
- Pritsker Corporation, for developing and demonstrating integration of scheduling and shop floor data collection.
- AutoSimulation, Inc., for developing and demonstrating integration of scheduling and shop floor data collection.
- DLOG Corp., for demonstrating integration of scheduling and shop floor data collection.
- AMP, Inc., for demonstrating integration of scheduling and shop floor data collection.
- Ohio University, for demonstrating integration of generic algorithm scheduler into commercial simulation scheduling package.
- Purdue University, for demonstrating integration of neural net scheduler into commercial simulation-based packages.

MSE9: Reference Model Architecture

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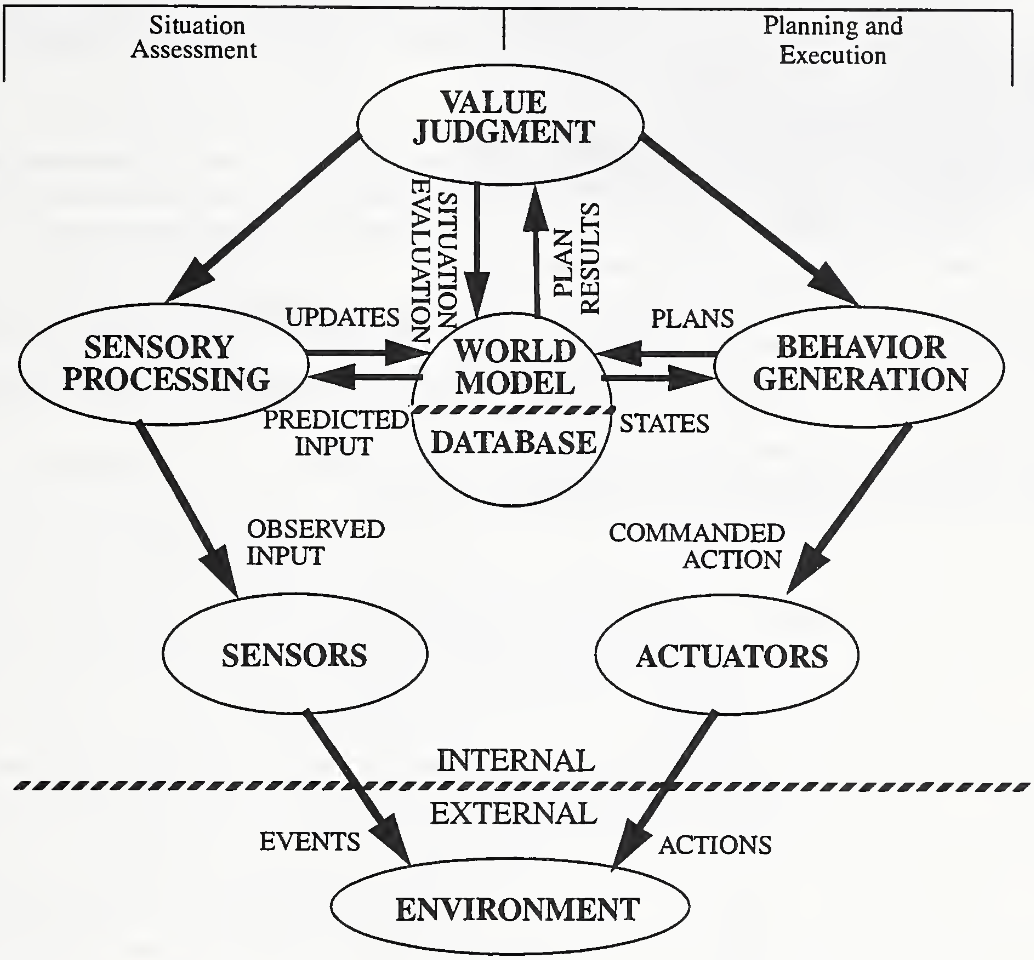

Abstract model of the architecture

The objective of this project is to develop a detailed design of a reference model architecture for intelligent control of manufacturing processes and to demonstrate, validate and evaluate the NIST Reference Model Architecture through analysis and performance measurements of a simulated and prototype implementation. The approach includes leveraging the work of other programs, such as the NIST Enhanced Machine Controller, in developing interface specifications among the architectural components, and working with industry in developing tools to support development of Reference Model Architecture based system implementations. The goals of this work are to provide U.S. industry with state-of-the-art manufacturing architectures and models, foster the development and implementation of advanced manufacturing systems, and anticipate and address the needs of the U.S. manufacturing industry for the next generation of advanced systems and standards.

FY94 & 95 Accomplishments

- Designed hardware/software computing infrastructure for first Reference Model Architecture-based system for the Next Generation Inspection System (NGIS) facility.
- Developed and documented operational scenario for first implementation and held design review on the task frame conceptual design.
- Produced draft design of Reference Model Architecture incorporating architectural concepts developed in previous NIST work on robot control systems, manufacturing systems integration, and quality industrial automation.

Collaborations

- Technologies Enabling Agile Manufacturing (TEAM) Consortium, for development of message interfaces as part of the Intelligent Closed Loop Processing effort and for development of an enhanced machine controller (EMC).
- National Center for Manufacturing Sciences (NCMS), for development of the NGIS control system.
- NIIIP Consortium, for use of real-world manufacturing scenarios.
- ISO TC 184/SC4 Industrial Data, for participation in standardization areas related to manufacturing technology, mechanical products, and parametric representations.
- Advanced Technology and Research, Co., for development of real-time control system software and supporting tools.
- Drexel University, for development of experimental planners and schedulers.
- Catholic University, for development of inspection-related software.

MSE10: STEP for the Process Plant Industries

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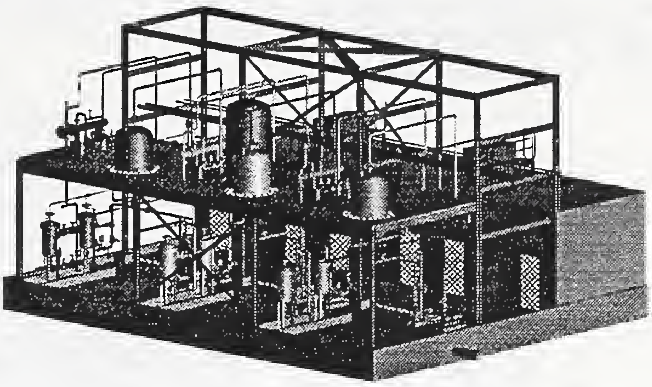

Process plant model

This project is working with industry to develop, test and demonstrate the STEP application protocols needed for exchanging and sharing information during the design, construction, operations, and maintenance of process plants. The objectives of this project are:

- analyze the information exchange problems and needs of the process plant industries,
- define a strategy for the collaborative development of the STEP application protocols (APs) that meet the industries' requirements,
- work with industry to develop and validate the highest priority APs, and
- demonstrate prototypes and support the industrial implementation of these APs as international standards.

FY94 & 95 Accomplishments

- Held workshops with the process plant and information technology industries to define requirements and priorities for information exchange standards
- Worked with industry to establish the PlantSTEP, Inc. Consortium
- With PlantSTEP, defined the scope and project plan for the Plant Spatial Configuration STEP AP project. Advanced the project proposal through the U.S. and ISO approval process
- Published NISTIR 5675, Group 1 for the Plant Spatial Configuration STEP Application Protocol
- Hosted Industry Review Board Workshop on the AP 227 Group 1 document.
- Distributed for international review, the combined CDC (Committee Draft for Comment) packet of the Group 1 documents for the first two STEP APs for the process plant industries, AP 221 and AP 227.
- Developed "Control Engineering Data Models and Glossaries" document.
- With pdXi, defined the scope and project plan for the Process Engineering STEP AP project. Advanced the project proposal through the U.S. and ISO approval process.
- Established initial test case library for the validation testing of the STEP APs for the process plant industries.

Collaborations

- PlantSTEP, Inc., for development and testing of draft data exchange standards and interoperability testing of trial implementations.
- Process Data eXchange Institute of AIChE (pdXi), for development and testing of draft standards for exchanging process engineering data.
- Established research plan with CSTL and the University of Missouri-Rolla to develop components of the Process Engineering AP.
- Worked in the U.S. Chemical Industry Technology and Manufacturing Competitiveness Task Group. Produced industry roadmap for implementing information technology, "Computers in the Chemical Industry"
- Working with ISA (International Society of Measurement and Control) to educate their members on the strategic importance of participating in the development of STEP APs for the process and power industries. Working on the ISA STEP Committee to develop the ISA STEP implementation plan.
- Construction Industry Institute, for promotion of STEP developments relating to process industry practices.

MSE11: Virtual Enterprise Frameworks for Small Manufacturers

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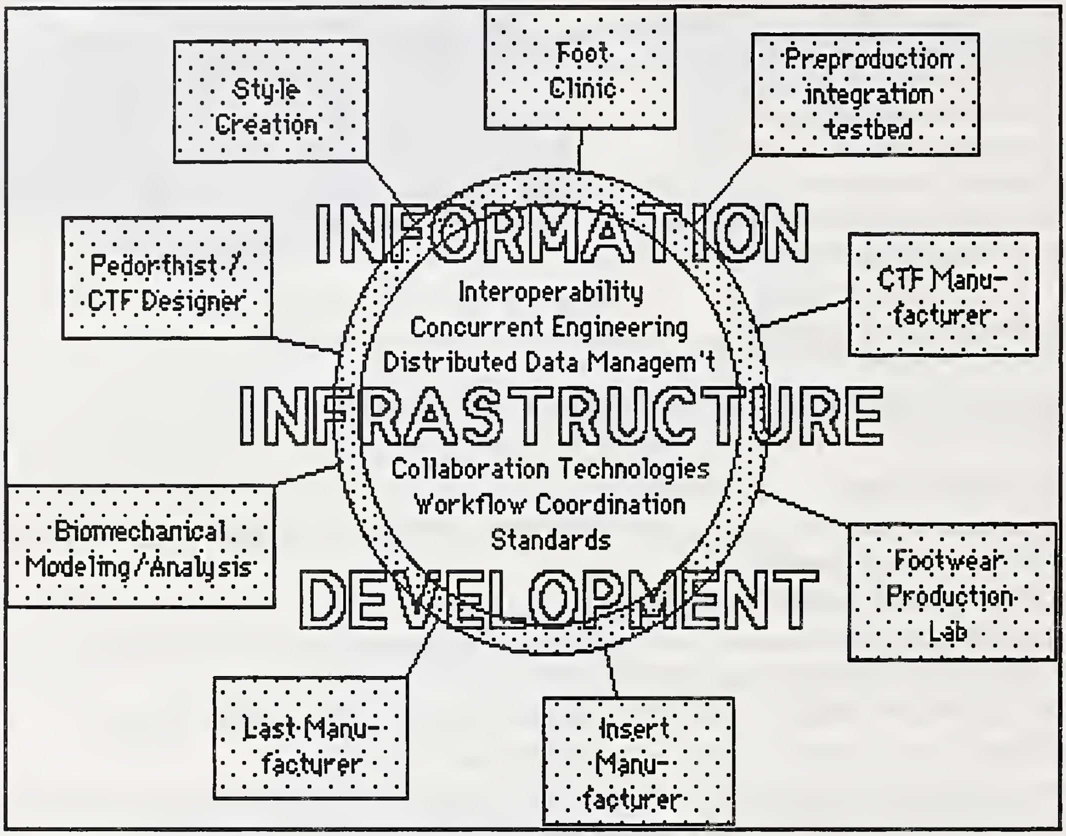

Virtual enterprise for custom therapeutic footwear manufacturers

In this project, NIST researchers are developing a virtual enterprise framework in collaboration with the custom therapeutic footwear (CTF) industry. The framework will be used to develop interoperability standards needed by the industry to integrate the manufacturing processes required. The effort will enable the CTF industry to enjoy the benefits from open, modular, and reconfigurable integration of commercial software applications that support the design, planning, and production of products within the SIMA vision of a virtual manufacturing enterprise. Project collaborators comprise a broad set of domain experts, including medical researchers who are studying foot problems and treatment with CTF, manufacturing technologists who are developing new manufacturing technologies (e.g., automated foot measurement devices, new CTF CAD systems, etc.), and the CTF manufacturers themselves to deploy and test the new technologies in an actual business scenario.

FY94 & 95 Accomplishments

- Determined the industry technology needs and priorities, and received industry endorsement of the CTF project.
- Created a “top-level” enterprise model and vision for the CTF industry. Included is an example of a manufacturing scenario utilizing the new CTF manufacturing technologies.
- Catalyzed the initiation of an industry activity for establishing a committee to develop interoperability standards and to secure support for creating a CTF pilot project.

Collaborations

- Footwear Industries of America (FIA), to produce interoperability standards for the footwear industry.
- Pedorthic Footwear Association (PFA), to produce interoperability standards for the footwear industry.

MSE12: Virtual Reality for Manufacturing

Project Manager: Sandy Ressler
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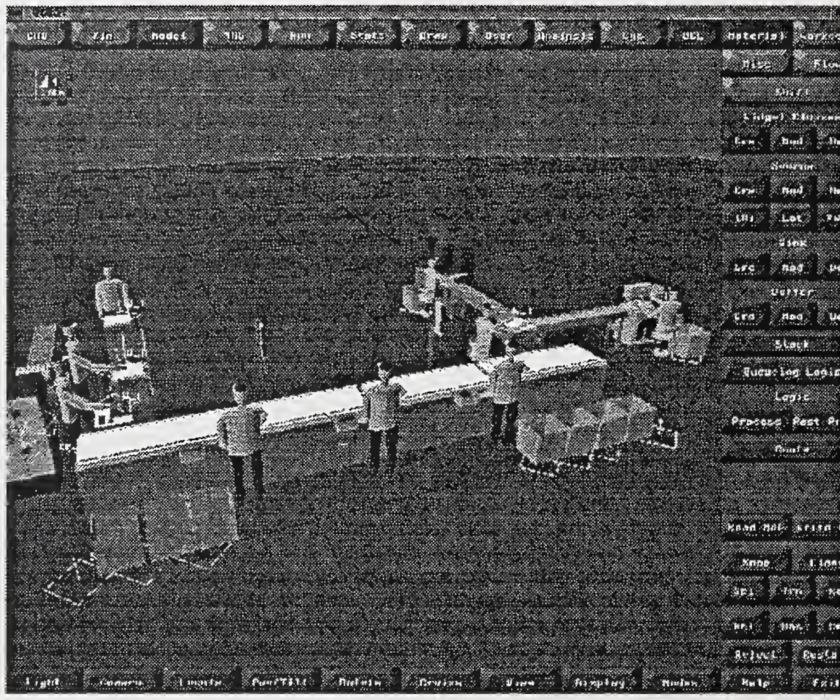
The objective of this project is to explore the use of virtual reality (VR) technology to assist the manufacturing industry in achieving systems integration of manufacturing applications. This is being done by enhancing several SIMA applications through VR technology. Current limitations of VR technology are being scrutinized, different ways to make the technology more efficient are being explored, and VR standards which will enhance the manufacturing process are being investigated. VR is usually defined as a computer-generated simulation of a three dimensional environment, in which the user is both able to view and manipulate the contents of that environment, gather information, and effectively solve problems.



Simulation model of product assembly line

FY94 & 95 Accomplishments

- Developed the first phase of a prototype VR application that simulates a Black and Decker product assembly line.
- Created an initial proof-of-concept of an image-based factory floor based on the same Black and Decker assembly line.
- Developed initial functionality of an immersive VR environment, integrating HMD (Head Mounted Display), Glove and Position Trackers.
- Created initial VRML (Virtual Reality Modeling Language) version of a Black & Decker product.

Collaborations

- Black and Decker, for visualization of shop floor operations in the manufacture of circular saws.
- Army Research Institute, for basic research in image-based virtual environments.

Standards Development Environment Project Summaries

SDE1: Application Protocol Development Environment (APDE)

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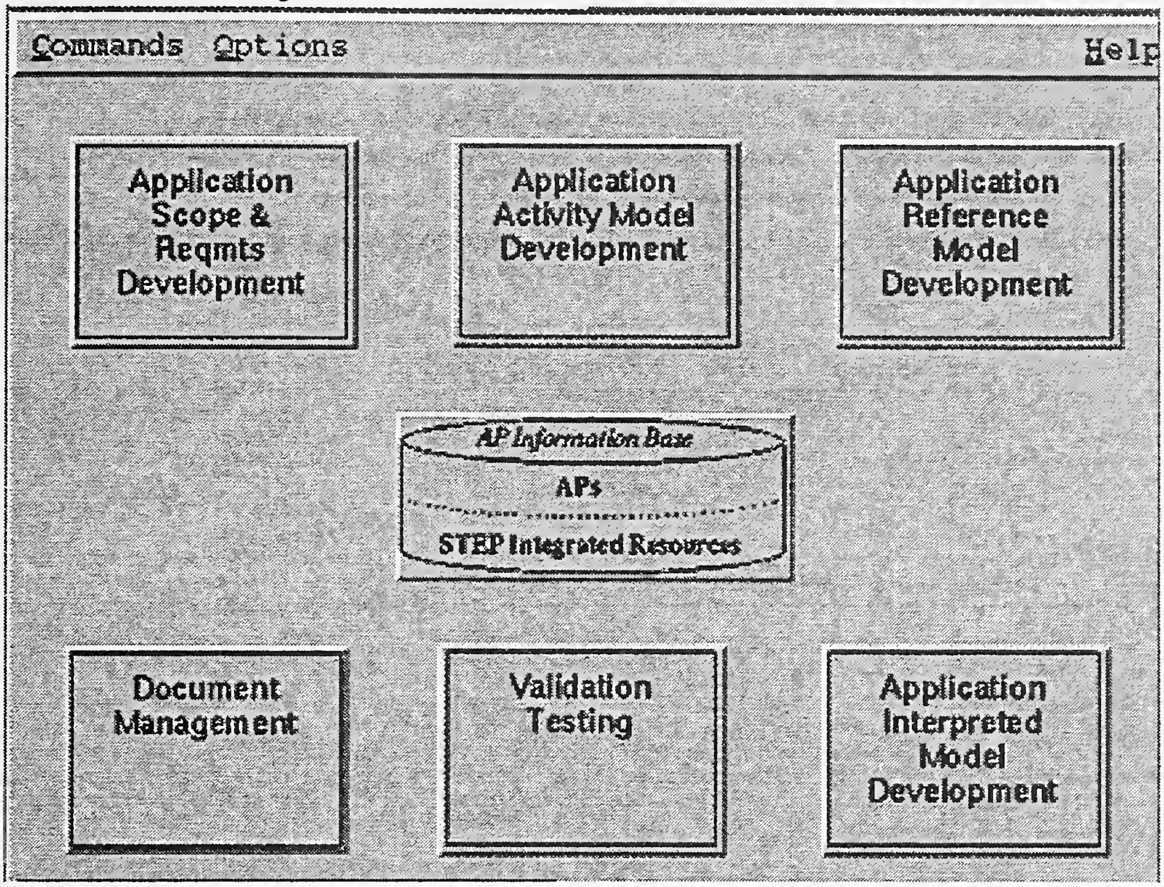

User interface to the APDE software

The APDE project is accelerating the development of STEP and aiding application protocol (AP) developers in creating STEP specifications more efficiently, with high quality and at a lower cost, by establishing an integrated suite of software tools. Application protocols submitted to ISO must meet specified criteria for standardization and usually require extensive rework before they are allowed to progress through the standards process. Current practices used for AP development require extraordinary labor expenditures on behalf of AP developers to define AP documents. While AP developers may use some software tools to help them accomplish their AP development tasks, the tools work independently, are not integrated, and have not been customized specifically for the purpose of AP development.

The software tools being developed in the APDE project are integrated and they interact with a central information repository at NIST. The repository consists of STEP-related documents and data, much of it represented in Standard Generalized Markup Language (SGML). As the project matures, collaboration with various software suppliers will be established. The APDE goal is 40% reduction of the AP development cycle time, currently estimated at 2-4 years with 4-6 full time equivalent staff.

FY94 & 95 Accomplishments

- Collected and prioritized APDE requirements at standards meetings through workshops and through use of an electronic questionnaire.
- Planned and published the APDE architecture.
- Designed and implemented components of an SGML environment for STEP.
- Provided SGML and STEP training to collaborators and STEP participants.

Collaborations

- Concurrent Technologies Corporation, for joint development of AP development tools and methods.
- SoftQuad, Inc., for customization of SGML editing tools for the STEP community.
- DiK, Corp., for development of software automating the creation of AP documents.
- Bernier and Associates, for development of tools to gather and analyze information requirements addressed within an AP.

SDE2: STEP Conformance Testing

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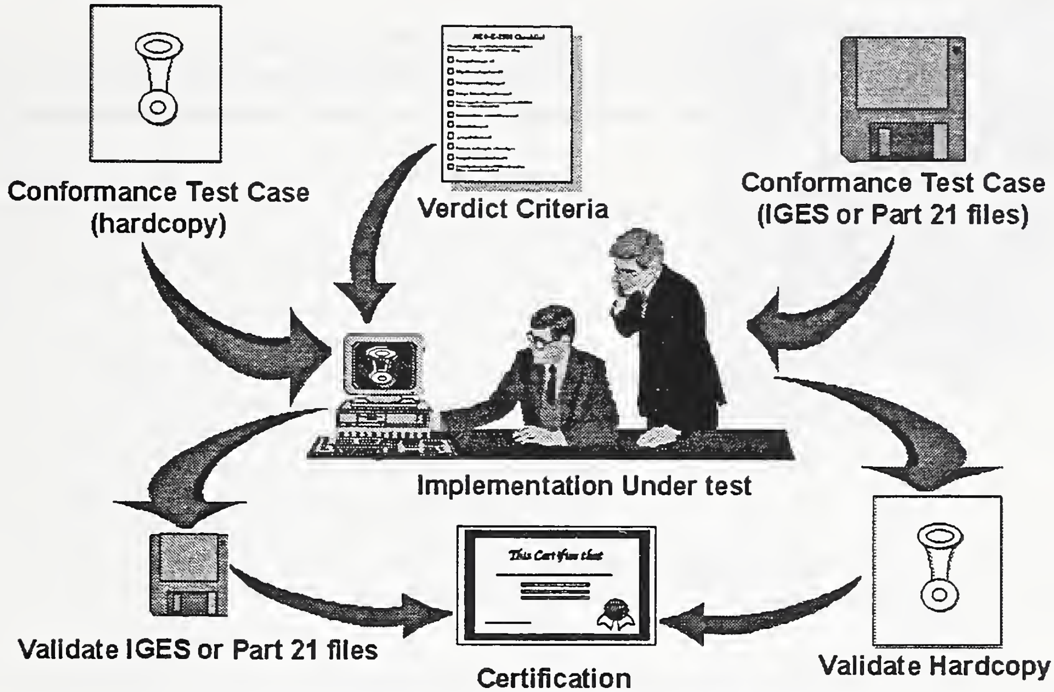

Conformance testing process

This project is providing the means by which vendor's software products will be measured for conformance to the STEP standard, through development of a set of value added software tools that will be made available for vendors to use during their product development process. Under this approach, vendors gain confidence that their products can successfully pass testing, vendors have access to tools that improve the quality of their products and reduce the costs of software testing, and vendors gain in the expanded market that user confidence in testing brings.

FY94 & 95 Accomplishments

- Supported the STEPNet Interoperability Activity to isolate CAD system problems with exchange of AP203 data. Twelve systems were evaluated. Of the files exchanged: 12,420 instance violations were detected and resolved; 28% of all constraints in the standard were violated at least once; 114 vendor-unique constraint violations were detected and resolved; and 57 vendor pair issue resolution interactions were avoided. The CAD systems showed very measurable improvements over previous results: one third were able to pass validation for advanced boundary representation solids and the average coverage of configuration management concepts increased to 42 percent.
- Licensed the test system and test suite for STEP "Application protocol - Configuration Controlled 3D Mechanical Design" (ISO 10303-302) to several vendors.
- Developed a Federal Information Processing Standard for STEP to be used by government agencies when procuring STEP compliant systems.
- Defined STEP conformance test methods and requirements for test laboratories and client; ISO 10303-34 (Methods) and ISO 10303-32 (Testing Requirements) received international review and acceptance.
- Established collaboration with Boeing towards work on a geometry analyzer tool, obtained an export license for the technology based upon Boeing software, and produced initial design document.

- Made NIST/Industrial Technology Institute Testing Service (NITS) available on the World Wide Web. Most of the testing system tools are now available for remote use. This strategy is aimed at making the tools more widely available while eliminating the expense of porting the tools to multiple software platforms.

Collaborations

- Industrial Technology Institute, for development of STEP test systems and methods.
- PDES, Inc., for validation of conformance testing systems through pilot implementation projects.
- Boeing, for evaluation of conformance testing services and for investigation of geometric representation analysis techniques and software.

SDE3: STEP Implementations

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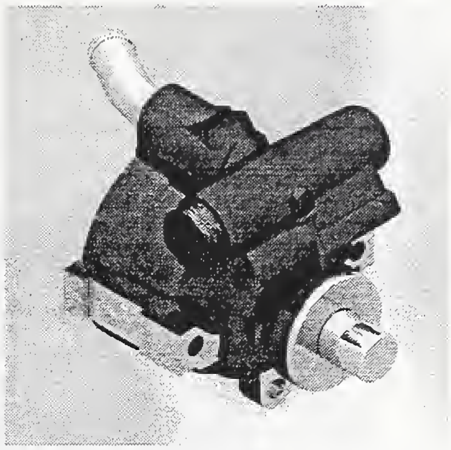

Model of supercharger used for testing STEP translators

This project is accelerating the adoption of STEP by promoting development of industry consensus on implementation and facilitating implementation of production-ready STEP applications. NIST is working with industry to identify requirements for interoperable systems by providing guidance on implementing STEP within a well defined scope, by developing test methodologies and data exchange metrics, and by testing STEP translators within the context of industrial pilots. NIST is working to ensure implementation experience is fed back into the standards process. The goal is to achieve the introduction of STEP into production environments. The project is collaborating with the AutoSTEP pilot which includes participants from Ford, General Motors, Chrysler and their suppliers. NIST has interviewed industry collaborators to obtain information on requirements and infrastructure data. This project has established and will maintain an on-line database of STEP translator problems. Project collaborators will log the results of each STEP data transfer. CAD system vendors will use this data to identify and fix problems in subsequent software releases. The project aims to ensure that STEP is responsive to the product data needs of U.S. industry.

FY94 & 95 Accomplishments

- Established a process for identifying STEP discrepancies and enhancements to rapidly obtain resolution so that implementation can proceed.
- Established on-line database for STEP translator problem reporting.
- Led an effort to establish a STEP Implementors Forum, organizing a number of workshops and drafting an initial operating procedure.

Collaborations

- Automotive Industry Action Group (AIAG), for work in the AutoSTEP Supply Chain Integration project.
- Industrial Technology Institute (ITI), for development of STEP conformance testing software.
- PDES, Inc., for development of software tools, standards coordination, issues reporting, and training.
- U.S. Army Tank Automotive Command, for work in the Defense Systems Supply Chain Integration project on implementation of STEP AP209 (Design to Analysis).

Testbeds and Technology Transfer Environment Project Summaries

TTTE1: Advanced Manufacturing Systems and Networking Testbed

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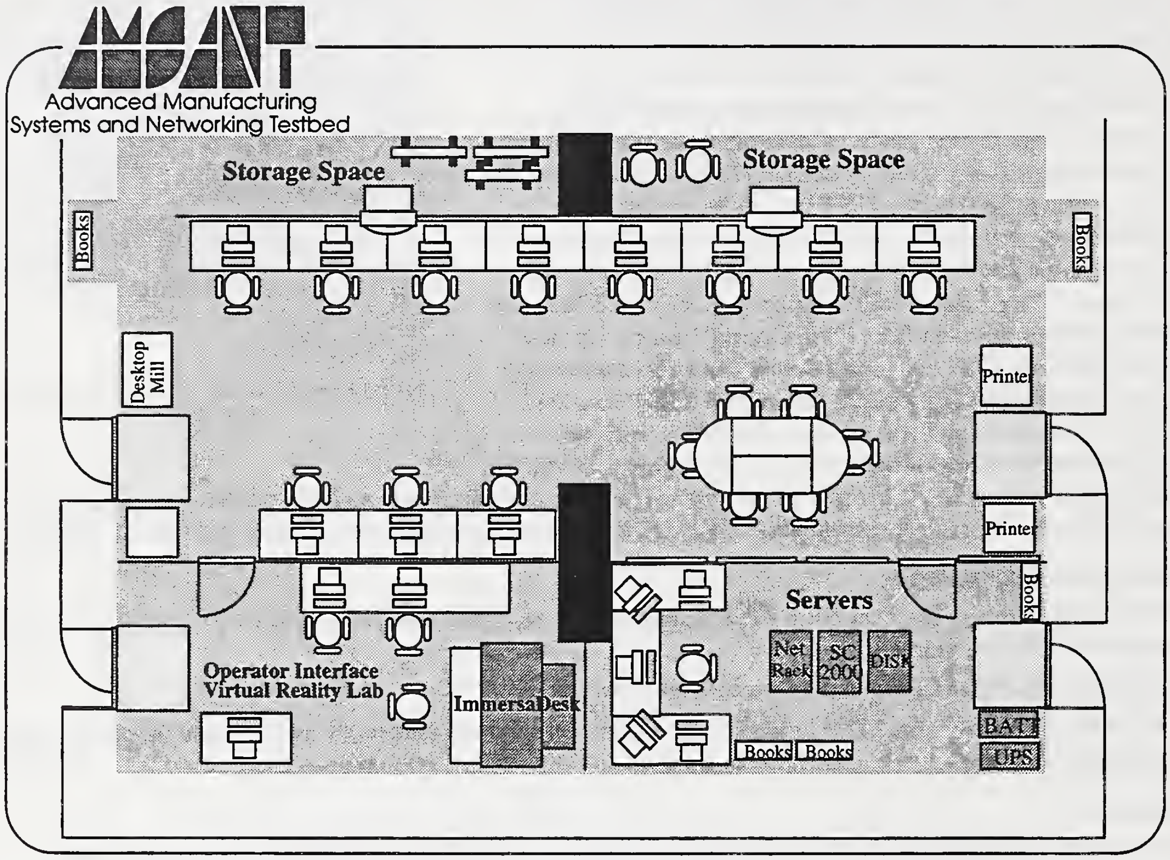

The Advanced Manufacturing Systems and Networking Testbed (AMSANT) facility houses special purpose, high-performance computers equipped with high speed networking (Asynchronous Transfer Mode - ATM) capabilities that are being used by NIST researchers and external collaborators to develop new manufacturing technologies and standards, as well as demonstrate proof-of-concept solutions to manufacturing systems integration problems. MEL is teamed with NIST's Computing and Applied Mathematics Laboratory and Computer Systems Laboratory to pioneer an ATM backbone network at NIST and to connect NIST to the ATDnet. The ATDnet is a Washington area ATM test network that connects several government agencies performing research on the NII.

FY94 & 95 Accomplishments

- Collected AMSANT requirements from all SIMA Projects
- Designed and constructed first AMSANT node in Metrology building
- Installed high-performance workstations and servers in AMSANT facility to support computing requirements of SIMA projects
- Designed and installed high-speed ATM LAN to support communications requirements of SIMA projects

Collaborations

- Sandia National Labs, to provide communications capabilities for NIST/Sandia "Virtual Collaborative Environments" project

TTTE2: AMSANT for Process Plant Industries

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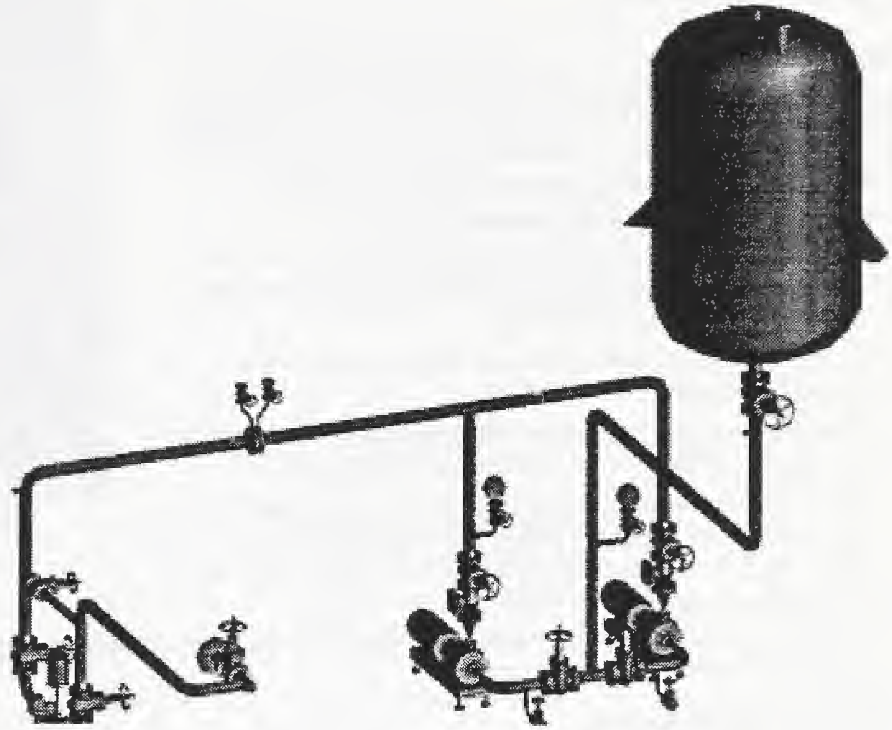
The objective of this project is to establish an experimental computing and communication facility to:

- provide a baseline of industrial practice in process plant engineering and construction,
- support the companion projects -- "STEP for the Process Plant Industries" and "Process Plant Engineering and Construction,"
- serve as an open testbed for integration activities of industrial partners, and
- serve as a communications hub for all U.S. participants. This facility is a distributed component of the NIST-wide Advanced Manufacturing Systems and Networking Testbed (AMSANT).



Piping model for process plant

FY94 & 95 Accomplishments

- Created a laboratory equipped with 5 representative computer graphics workstations connected via the NIST backbone network to the companion AMSANT for Manufactured Parts and to the Internet.
- Established electronic mail list service to more than 200 participants in the STEP-Architectural, Engineering, and Construction (AEC) activities, including the Process Plant subgroup.
- Brought up anonymous file transfer protocol and World Wide Web Services for the STEP-AEC activities and specialized services for the PlantSTEP, Inc., participants.
- Installed three commercial computerized systems for creating and reviewing process plant designs, trained staff, and created representative design models using those systems.
- Validated the application protocol schemas being developed in the companion "STEP for the Process Plant Industries" project, and constructed and partially populated relational databases from the schemas.
- Created dataProbes for STEP AP 227-- Plant Spatial Configuration -- and STEP AP 225 -- Building Elements using Explicit Shape Representation -- and worked with PlantSTEP, Inc., participants to begin populating STEP exchange structures with test-case data.

Collaborations

- PlantSTEP, Inc., for development and testing of draft data exchange standards and interoperability testing of trial implementations.
- Industry Alliance for Interoperability, as a member of its Research Advisory Committee.

TTTE3: Analysis Tools for Assessment and Optimization of Process and Product Design

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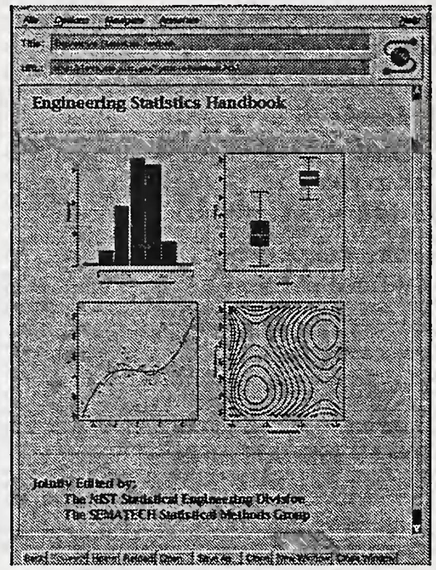
The objective of this project is to develop an integrated computer environment which provides a design/manufacturing engineer immediate on-line access to those statistical analysis tools necessary for characterizing, modeling, monitoring, and optimizing a process or product. This is achieved by creating an engineering-friendly, integrated system with the following capabilities:

- ready access to an on-line "statistics for engineering" handbook with state-of-the-art discussion/exposition of statistical solutions for everyday engineering problems;
- an on-line translator which maps engineering problems into appropriate statistical counterparts;
- an on-line solver which identifies via its structure what the optimal statistical methodology is for a given engineering problem;
- an on-line environment which has seamless and simultaneous access to both the engineer's data and to an appropriate analysis engine so as to automatically and immediately apply the correct methodology to the engineer's data.
- an on-line interpreter which translates the output of the statistical methodology tools into conclusions which are significant and meaningful to the engineer.



Web interface to handbook

FY94 & 95 Accomplishments

- Analyzed & enumerated barriers to present software systems in choosing, using, and interpreting optimal statistical solutions for specific manufacturing problems.
- Designed (within the Dataplot analysis engine) a self-directed menu-file system to serve as a portable core component in the Graphical User Interface (GUI) environment.
- Designed a multi-purpose GUI link to interface with handbook chapters, a citation index for the statistics literature, and with user data sets.
- Implemented the GUI for PC/DOS, UNIX, and interfaced the GUI to Mosaic.
- Designed a problem road-mapping translation window available as part of the GUI.
- Connected to the GUI a database of categorized 300 + reference data sets.
- Connected to the GUI a database of categorized 50 + commonly-employed experimental designs.
- Connected to the GUI a bibliographic database of reliability terms/definitions.

Collaborations

- SEMATECH, to co-author an Engineering Statistics Handbook.

TTTE4: Manufacturing Information Technology Transfer

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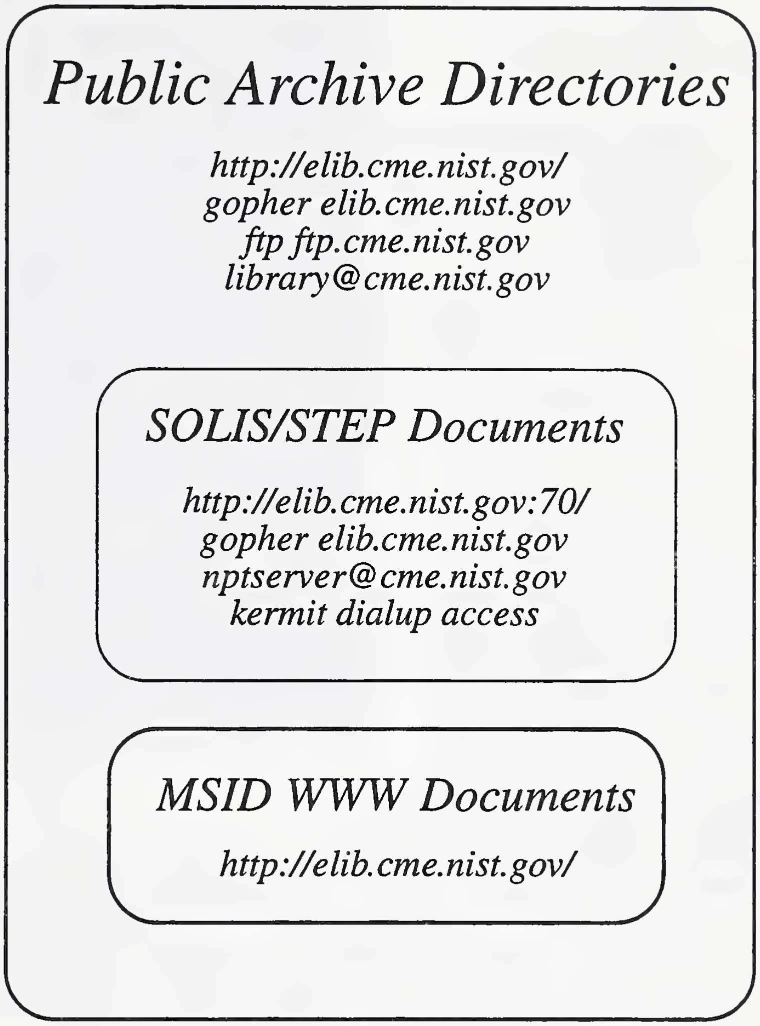
This project is providing a coordinated and focused infrastructure of the emerging tools, technologies and growing electronic networks that have resulted from the information exchange revolution currently underway across the NII. These systems will enable American industry to have access to readily-available information bases containing up-to-date manufacturing research developments and practices and to facilitate information sharing and collaboration opportunities. To date, MITT's efforts have concentrated on building an infrastructure of available tools and servers for information dissemination and populating a manufacturing resource repository. In FY94 MITT efforts included the development of an on-line prototype suite of authoring, searching and retrieval tools and a core set of selected information bases on-line, that were identified in a needs analysis conducted in FY94. In the second year the project has focussed on teaming with other SIMA projects to apply these tools and services to improve communication and technology transfer of results to the manufacturing standards communities.



Access mechanisms to on-line information archives

FY94 & 95 Accomplishments

- Deployed servers and tools as described in NISTIR 5656, "The MITT Electronic Library: An Implementation Description."
- Conducted in-house training courses on internet-based information services (i.e., document retrieval and information dissemination) for SIMA staff.
- Established web presence for the SIMA Program, for MSID, and MEL.

Collaborations

- NSF/NCSA World-Wide Web Federal Consortium, for development of Web software tools.
- Montgomery Blair High School, for development of Web prototypes.

TTTE5: Standard Reference Data Delivery and Use

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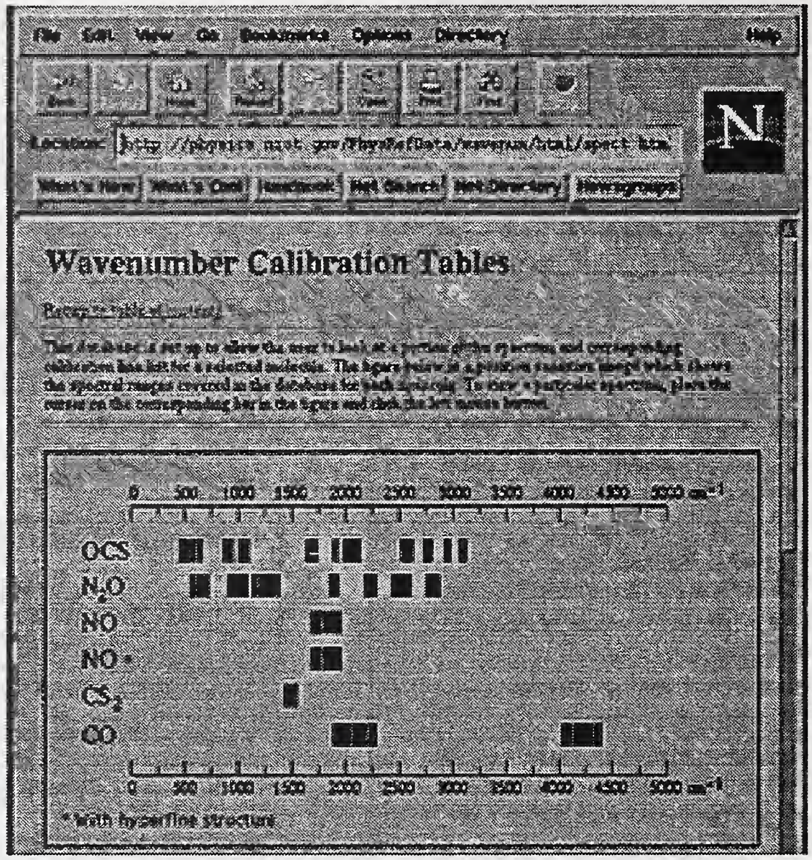

Web interface to physics reference data

Critical decisions in manufacturing and engineering depend on reliable data. The NIST Standard Reference Data Program (SRDP) provides numeric data critically evaluated in data centers throughout the NIST laboratories. The thrust of this project is to make that data more readily available to engineers and scientists in U.S. industry. The breadth of the NIST data program and the diverse expectations of the industrial community require that NIST provide tools to help users find the data they need. Much of the NIST data is available today with responsive interfaces for individuals to use on their local computers. Project participants are creating ways to reuse the existing structures and algorithms, generating new algorithms where necessary, in order to deliver the existing and future NIST data, so that the data are both accessible on-line to individuals and freely exchangeable among instruments. SIMA efforts are taking place in two NIST laboratories, the Chemical Science and Technology Laboratory and the Physics Laboratory, with coordination and supporting activities performed by SRDP. The chemistry projects began in FY94. The physics lab began participating in FY95.

FY94 & 95 Accomplishments

- Developed tools allowing specification of chemical substances as a framework for on-line searching for chemical data.
- Develop software to generate indices necessary for searching all NIST chemical databases by Chemical Abstract Series number or simple chemical formula.
- Developed a prototype data model for analytical instrumentation including application activity and application reference models.
- Developed a graphical interface scientifically appropriate for web access to wavelength data for the NIST Wavelength Calibration Tables from Heterodyne Frequency Measurements.
- Provided on-line access to the fundamental physical constants.

Conclusion

The SIMA Program is managed to ensure that the technical activities of the program address the requirements of U.S. industry, are appropriate to the mission of the NIST Laboratories, and are consistent with the overall HPCC/IITA goals. This report documents how those objectives are supported by the program's structure and the technical activities of the SIMA projects. NIST is satisfying HPCC/IITA goals through:

- development and testing of protocols for exchange of engineering and manufacturing data enabling manufacturing systems integration,
- application of information infrastructure technologies providing efficient access to scientific and engineering reference data enabling development and refinement of products and processes, and
- research in advanced simulation and modeling techniques for engineering and manufacturing processes to identify how these techniques mesh with and enhance existing applications and practices.

Up-to-date information about the SIMA Program is maintained on the Web homepage -- http://elib.cme.nist.gov/msid/projs/sima-pm/sima.htm. Information about the government's overall activities in HPCC can be found at http://www.hpcc.gov/.

Future plans

NIST's unique focus on working with industry to develop voluntary, consensus standards will be a key feature of SIMA projects as their technology developments mature. A significant challenge that industry representatives have identified to the program is that of decreasing the development time for standards formally sanctioned by national and international standards bodies. Given the rapid pace of technological change, and the commitment in time and money U.S. industry makes to voluntarily participate in the formal standards process, it is easy to understand the need for more rapid standardization.

In response to this need, in FY96 the SIMA Program will develop a structured process for technical projects to follow in their development of protocols for data exchange. These protocols, which will be known as Initial Manufacturing Exchange Specifications (IMES), will cover interfaces between manufacturing applications, interfaces between manufacturing applications and manufacturing data repositories, and interfaces between users and the applications themselves. The overall IMES development process will be a phased approach, with the expectation that the timeframe from start to finish would be 2 to 3 years. Phases for IMES development will include industry requirements analysis, specification development, prototype implementation and validation, and initiation of the standardization process. Industry participation throughout the IMES development process is expected to ensure that the IMES satisfies the intended needs with a viable solution. This formal IMES development process should ensure that the resulting specifications are high quality, industry-tested solutions ready for the voluntary standardization process.

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[1] "High Performance Computing and Communications: Toward a National Information Infrastructure," Report by the Committee on Physical, Mathematical, and Engineering Sciences, Federal Coordinating Council for Science, Engineering, and Technology, Office of Science and Technology Policy, published by the National Coordination Office for HPCC, 1994.

[2] "Information Infrastructure Technology and Applications," Report of the IITA Task Group, High Performance Computing, Communications and Information Technology Subcommittee, Federal Coordinating Council for Science, Engineering, and Technology, Office of Science and Technology Policy, published by the National Coordination Office for HPCC, February 1994.

[3] "HPCC FY95 Implementation Plan," Office of Science and Technology Policy, published by the National Coordination Office for HPCC, April 1994.

[4] "Technical Program Description Systems Integration for Manufacturing," Bloom, H., NISTIR 5476, NIST, Gaithersburg, MD, July 1994.

[5] ISO 10303-1, "Industrial automation systems and integration - Product data representation and exchange - Part 1: Overview and fundamental principles," International Organization for Standardization, Geneva, Switzerland.

[6] "Systems Integration Needs of U.S. Manufacturers, Conference Report," Stewart, S. and Pinholster, G., Journal of Research of the National Institute of Standards and Technology, Vol. 99, No. 5, October 1994.

[7] "The NIST SIMA Interactive Management Workshop," Johnson, C., et al., NISTIR 5717, NIST, Gaithersburg, MD, September 1995.

[8] "Background Study - Requisite Elements, Rationale, and Technology Overview for the Systems Integration for Manufacturing Applications (SIMA) Program," Barkmeyer, E., et al., NISTIR 5662, NIST, Gaithersburg, MD, September 1995.

Appendix A: Collaborators

Consortia, National Programs, and Trade Associations			
Name	**Location**	**Description**	**Collaborating Project**
American Institute of Steel Construction	Chicago, IL	The American Institute of Steel Construction is a non-profit trade organization that represents the fabricated steel industry of the United States. The Institute's objectives are to improve and advance the use of fabricated structural steel through research and engineering studies to develop the most efficient and economical design of structures. It also conducts programs to improve product quality.	Process Plant Engineering and Construction (p. 18).
Automotive Industry Action Group (AIAG)	Detroit, MI	The AIAG is an automotive trade association to address industry issues in supply, manufacturing, engineering, quality, and finance. The association has over 1000 member companies and includes Chrysler, Ford, and General Motors.	STEP Implementations (p. 31).
Construction Industry Institute	Austin, TX	The CII is a national industry organization focussing on development of industry standards and voluntary recommended practices for design and construction of manufacturing facilities. Members include Amoco, ARCO, Bechtel, Chevron, Monsanto, and others.	STEP for the Process Plant Industries (p. 23).
Footwear Industries of America (FIA)	Washington, DC	The FIA is a trade association working to make the American footwear industry more competitive in the global market and to serve as an information resource for the industry. It has over 150 members including most of the large shoe manufacturers and suppliers to the industry.	Virtual Enterprise Frameworks for Small Manufacturers (p. 24).
Industry Alliance for Interoperability (IAI)	N/A	The IAI is an architectural, engineering, and construction (AEC) industrial association formed to develop and maintain the Industry Foundation Classes specification which provides customizable objects that encapsulate information about building elements as well as design, construction, and management objects. IAI members include AEC/CAD vendors, AEC/CAD users, and government agencies.	AMSANT for Process Plant Industries (p. 33).
National Industrial Information Infrastructure Protocols (NIIIP)	Stamford, CT	The NIIIP consortium's objective is to develop open industry software protocols that will make it possible for manufacturers and their suppliers to effectively interoperate as if they were part of the same enterprise. The consortium includes IBM, Digital Equipment Corporation, Enterprise Integration Technologies, General Dynamics, Lockheed Aeronautical Systems, Magnavox, Texas Instruments, and other participants.	Integration Mechanisms (p. 13). Reference Model Architecture (p. 21).

Consortia, National Programs, and Trade Associations			
Name	**Location**	**Description**	**Collaborating Project**
NSF/NCSA World-Wide Web Federal Consortium	Urbana, IL	The NSF/NCSA WWW Federal Consortium works to advance member agency goals by supporting continued development of NCSA Mosaic and related technology through funding agreements between the agencies and NSF, and to foster collaborative research and development and the exchange of information between NCSA and member agencies, and among member agencies.	Manufacturing Information Technology Transfer (p. 35).
Next Generation Inspection System Program	Ann Arbor, MI	NGIS is a program of the National Center for Manufacturing Sciences, Production Equipment and Systems Special Interest Group. The objective is to develop next generation inspection capabilities on coordinate measuring machines and machine tools.	Reference Model Architecture (p. 21).
PDES, Inc.	Charleston, SC	The PDES, Inc. consortium's objective is to accelerate the development and implementation of STEP. The consortium includes the South Carolina Research Authority, Boeing, Ford, General Motors, Hughes, Lockheed Martin, Northrop Grumman, and other participants.	STEP Conformance Testing (p. 29). STEP Implementations (p. 31).
Process Data eXchange Institute of AIChE (pdXi)	New York, NY	pDXI is an industry trade group working to develop and maintain open approaches to electronic data exchange and management of process engineering data. Members include DuPont, Exxon, and Simulation Sciences, Union Carbide, and others.	STEP for the Process Plant Industries (p. 23).
Pedorthic Footwear Association (PFA)	Columbia, MD	The PFA represents both retail and manufacturing segments of the pedorthic profession. Members share interest in pedorthic management of the foot from practice and treatment to education and research.	Virtual Enterprise Frameworks for Small Manufacturers (p. 24).
PlantSTEP, Inc.	Wilmington, DE	PlantSTEP, Inc. is a consortium working to support the development of information exchange standards to advance the capabilities of process plant and construction industries. Members include DuPont, Merck, Black & Veach, Bechtel, Intergraph, Computervision, and CAD Centre.	STEP for the Process Plant Industries (p. 23). AMSANT for Process Plant Industries (p. 33).
Rapid Response Manufacturing	Ann Arbor, MI	The RRM consortium's objective is to increase first product quality while decreasing design to manufacturing cycle time. The RRM consortium includes the National Center for Manufacturing Sciences (NCMS), General Motors, Ford Motor, Texas Instruments, United Technologies, Lockheed Martin Energy Systems, and other participants.	Modeling of Manufacturing Resource (MR) Information (p. 14).

Consortia, National Programs, and Trade Associations			
Name	**Location**	**Description**	**Collaborating Project**
SEMATECH	Austin, TX	The SEMATECH consortium's objective is to sponsor and conduct research aimed at assuring leadership in semiconductor manufacturing technology for the U.S. semiconductor industry. The consortium includes Advanced Micro Devices, Digital Equipment Corporation, Hewlett-Packard, Intel, IBM, Lucent Technologies, Motorola, National Semiconductor Corporation, Rockwell International, and Texas Instruments.	Electronic Commerce for the Electronics Industry (ECCI) (p. 12). Integration Mechanisms (p. 13). Analysis Tools for Assessment and Optimization of Process and Product Design (p. 34).
Technologies Enabling Agile Manufacturing (TEAM)	Oak Ridge, TN	The TEAM consortium's objective is to enhance national industrial competitiveness by advancing and deploying manufacturing technologies that promote agility. The consortium includes American firms and consortia representing many industrial sectors including aerospace, automotive, consumer electronics, and software along with multiple federal agencies and facilities.	Integration Mechanisms (p. 13). Modeling of Manufacturing Resource (MR) Information (p. 14). Process Planning Applications (p. 17). Reference Model Architecture (p. 21).
U.S. Chemical Industry Technology and Manufacturing Competitiveness Task Group	N/A	The TMCTG is a task group consisting of more than 200 technical leaders from the chemical industry formed under the auspices of several professional societies and trade groups. The task group's goal is to identify factors affecting the competitiveness of the industry, identify technical needs, and make recommendations for cooperative efforts.	STEP for the Process Plant Industries (p. 23).
West Virginia High Technology Consortium	W. VA	The WVHTC is a non-profit organization dedicated to growing information-technology companies in the Mountain State. The foundation is a research and educational corporation dedicated to accelerating the state's economic growth through research, development, and education.	Operator Interfaces for Virtual and Distributed Manufacturing (p. 16).

Individual Companies			
Name	**Location**	**Description**	**Collaborating Project**
Advanced Databases, Inc.	Redwood Shores, CA	Vendor of the MATISSE object-oriented databases.	Process Planning Applications (p. 17).
Advanced Technology and Research Corporation	Burtonsville, MD	Consultants specializing in research and development of intelligent control systems, automation, robotics, simulation, engineering analysis, and computer science.	Operator Interfaces for Virtual and Distributed Manufacturing (p. 16). Reference Model Architecture (p. 21).
Allied-Signal Aerospace	Kansas City, MO	The Kansas City Division of Allied-Signal Aerospace is a Department of Energy contractor producing electrical and mechanical components for weapon systems.	Modeling of Manufacturing Resource (MR) Information (p. 14).
AMP, Incorporated	Harrisburg, PA	Manufacturer of electronic connectors.	Production Applications (p. 19).
AutoSimulation, Incorporated	Bountiful, UT	Vendor of simulation and scheduling software.	Production Applications (p. 19).
Bernier and Associates, Inc.	Topsfield, MA	Software consultants specializing in data collection and analysis	Application Protocol Development Environment (APDE) (p. 27).
Black and Decker	Towson, MD	Manufacturer of portable power tools and household appliances.	Design Applications (p. 11). Production Applications (p. 19). Virtual Reality for Manufacturing (p. 26).
Boeing Commercial Airplane Group	Seattle, WA	Manufacturer of commercial airplanes.	STEP Conformance Testing (p. 29).
Caterpillar	Peoria, IL	Manufacturer of earth-moving equipment.	Design Applications (p. 11).
Cimplex Corporation	San Jose, CA	Vendor of computer-aided manufacturing software.	Process Planning Applications (p. 17).

Individual Companies			
Name	**Location**	**Description**	**Collaborating Project**
CIM Technologies	Ames, IA	Vendor of plant layout software.	Production Applications (p. 19).
Concurrent Technologies Corporation	Johnstown, PA	A non-profit company chartered to take technology from research labs to the commercial workplace.	Application Protocol Development Environment (APDE) (p. 27).
DiK Corporation	Darmstadt, Germany	A university-based corporation specializing in automotive design and analysis.	Application Protocol Development Environment (APDE) (p. 27).
DLOG Corporation	Chicago, IL	Vendor of shop floor data collection software.	Production Applications (p. 19).
Framework Technologies	Milwaukee, WI	Vendor of production simulation software.	Production Applications (p. 19).
Industrial Technology Institute	Ann Arbor, MI	Provider of services and applied research supporting manufacturers.	STEP Conformance Testing (p. 29). STEP Implementations (p. 31).
Institute of Advanced Manufacturing Sciences (IAMS)	Cincinnati, OH	Vendor of computer-aided process planning software.	Modeling of Manufacturing Resource (MR) Information (p. 14). Process Planning Applications (p. 17).
International Technegroup, Inc.	Milford, OH	Vendor of computer-aided process planning software.	Process Planning Applications (p. 17).
Isothermal Systems Research, Inc.	Colton, WA	Developer of thermal management systems for electronic systems.	Design Applications (p. 11).
Litton AMECOM	College Park, MD	Software developers specializing in manufacturing applications.	Production Applications (p. 19).
McDonnell-Douglas	St. Louis, MO	Manufacturer of aerospace products.	Production Applications (p. 19).
Perceptronics	Woodland Hills, CA	Vendor of engineering process modeling software and technology.	Design Applications (p. 11).

Individual Companies			
Name	**Location**	**Description**	**Collaborating Project**
Pritsker Corporation	West Lafayette, IN	Vendor of simulation and scheduling software.	Production Applications (p. 19).
Sandvik Coromant	Fair Lawn, NJ	Manufacturer of cutting tools and accessories.	Modeling of Manufacturing Resource (MR) Information (p. 14).
SGS Tool Company	Munroe Falls, OH	Manufacturer of solid carbide cutting tools.	Modeling of Manufacturing Resource (MR) Information (p. 14).
SoftQuad, Inc.	Toronto, Canada	Vendor of Standard Generalized Markup Language (SGML) software tools.	Application Protocol Development Environment (APDE) (p. 27).
Texas Instruments Defense Systems Electronics Group	Dallas, TX	Manufacturer of electronic components and systems.	Modeling of Manufacturing Resource (MR) Information (p. 14).
Viewlogic Systems Incorporated	Marlborough, MA	Vendor of electronic product design and engineering software.	Electronic Commerce for the Electronics Industry (ECCI) (p. 12).

Government Agencies			
Name	**Location**	**Description**	**Collaborating Project**
Army Research Institute	Alexandria, VA	ARI conducts basic, exploratory, and advanced research and engineering development to increase readiness and effectiveness of Army personnel.	Virtual Reality for Manufacturing (p. 26).
Sandia National Laboratory	Albuquerque, NM	A multi-program national laboratory under the Department of Energy with objectives in national defense, energy security, environmental integrity, and economic security.	Advanced Manufacturing Systems and Networking Testbed (p. 32).
U.S. Army Tank Automotive Command (TACOM)	Warren, MI	TACOM works to shorten lead-times and improve quality for military vehicle manufacturing.	STEP Implementations (p. 31).

Academic Institutions			
Name	**Location**	**Department**	**Collaborating Project**
Carnegie Mellon University	Pittsburgh, PA	Software Engineering Institute (A federally funded research and development center operated by CMU to provide leadership in software engineering and in the transition of new software engineering technology into practice.)	Integration Mechanisms (p. 13).
Catholic University	Washington, DC	Department of Mechanical Engineering	Reference Model Architecture (p. 21).
Drexel University	Philadelphia, PA	Department of Electrical and Computer Engineering	Reference Model Architecture (p. 21).
Florida State University	Tallahassee, FL	Department of Industrial Engineering	Process Planning Applications (p. 17).
George Washington University	Washington, DC	Department of Engineering Management	Design Applications (p. 11).
Montgomery Blair High School	Silver Spring, MD	Science, Mathematics, Computer Science Magnet Program	Manufacturing Information Technology Transfer (p. 35).
Ohio University	Athens, OH	Department of Industrial and Systems Engineering	Production Applications (p. 19).
Purdue University	West Lafayette, IN	Department of Industrial Engineering	Production Applications (p. 19).
San Francisco State University	San Francisco, CA	School of Humanities	Operator Interfaces for Virtual and Distributed Manufacturing (p. 16).
University of Illinois	Chicago, IL	Department of Computer Science	Operator Interfaces for Virtual and Distributed Manufacturing (p. 16).
University of Missouri-Rolla	Rolla, Mo.	Department of Chemical Engineering	STEP for the Process Plant Industries (p. 23).
Washington State University	Pullman, WA	School of Mechanical and Materials Engineering	Design Applications (p. 11).

Standards Committees			
Committee	**Organization**	**Description**	**Collaborating Project**
IEC/TC93/WG5	International Electrotechnical Commission (IEC)	The role of IEC/TC93/WG5 is to define methodologies and/or guidelines for the conformance and certification testing of any product which implements a TC93 standard. Its goal is to gather consensus among the member countries as to the acceptance procedures used for conformance and certification testing of products.	Electronic Commerce for the Electronics Industry (ECCI) (p. 12).
TC29/WG34	International Organization for Standardization (ISO)	To develop standard digital representations for "computerized machining data exchange" of cutting tool information.	Modeling of Manufacturing Resource (MR) Information (p. 14).
TC184/SC4/ WG3/ Ad Hoc Committee on Parametrics	International Organization for Standardization (ISO)	The role of the Parametrics Committee is to determine the need for parametric representations in STEP and related standards, and propose how techniques and models may be changed to meet those needs.	Reference Model Architecture (p. 21).
TC184/SC4/ WG3/T7	International Organization for Standardization (ISO)	The role of the Mechanical Product Definition Committee is to analyze, document, and model information and data about mechanical products.	Reference Model Architecture (p. 21).
TC184/SC4/ WG3/T11	International Organization for Standardization (ISO)	The role of the Process Plant AP Planning Project is to identify and define the information necessary to manufacture or facilitate the manufacture of a component.	Reference Model Architecture (p. 21).
TC184/SC4/ WG3/T12	International Organization for Standardization (ISO)	The role of the Manufacturing Technology Committee is to work with industry to define the scope and coordinate the development of application protocols for the process plant industries.	STEP for the Process Plant Industries (p. 23).
STEP	International Society of Measurement and Control (ISA)	To develop standards and recommended practices for the measurement, instrumentation, and control industry.	STEP for the Process Plant Industries (p. 23).

Appendix B: FY94 and FY95 Project Publications

MSE1: Design Applications, (p. 11)

[1] Lyons, K., and Duffy, M. R., "Requirements, Methods and Research Issues for Modeling the Product Realization Process," in IFIP - Working Group 5.7, Reengineering the Enterprise Workshop Proceedings, Galway, Ireland, April 1995.

[2] Lyons, K., and Duffy, M., "Modeling The Product Realization Process: Requirements, Method and Research Issues for Computer Support Tools," in FAIM 95 (Flexible Automation and Intelligent Manufacturing) Conference Proceedings, Stuttgart, Germany, June 1995.

[3] Lyons, K., Duffy, M.R., Anderson, R. C., "Product Realization Process Modeling: A Study of Requirements, Methods and Research Issues," NISTIR 5745, NIST, Gaithersburg, MD, June 1995.

[4] Lyons, K., "Collaborative Design for Assembly of Complex Electro-mechanical Products," in National Center for Manufacturing Sciences (NCMS) Manufacturing Technology Conference Proceedings, Orlando, FL, May 1995.

[5] Lyons, K., Connacher, H., Jayman, S., "Virtual Assembly Design Environment," in the 15th ASME International Computers in Engineering (CIE95) Conference Proceedings, Boston, MA, September 1995.

[6] Pratt, M., "IFIP WG5.10 Conference: Virtual Prototypes and Product Models in Mechanical Engineering," NISTIR 5650, NIST, Gaithersburg, MD, May 1995.

MSE2: Electronic Commerce for the Electronics Industry (ECCI), (p. 12)

[7] Stewart. S.L., St. Pierre, James A., "Roadmap for the Computer Integrated Manufacturing Application Framework," NISTIR 5679, NIST, Gaithersburg, MD, June 1995.

[8] Stewart. S.L., St. Pierre, James A., "Roadmap for the Computer Integrated Manufacturing (CIM) Application Framework," Technology Transfer #95052825A-ENG, SEMATECH, Austin, TX, May 1995.

MSE4: Modeling of Manufacturing Resource (MR) Information, (p. 14)

[9] Algeo, M., Feng, S., and Ray, S., "A State-of-the-Art Survey on Product Design and Process Planning Integration Mechanisms," NISTIR 5548, NIST, Gaithersburg, MD, December 1994.

[10] Algeo, M., "A State-of-the-Art Survey of Methodologies for Representing Manufacturing Process Capabilities," NISTIR 5391, NIST, Gaithersburg, MD, March 1994.

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[13] Jurrens, K., Fowler, J., and Algeo, M., "Modeling of Manufacturing Resource Information, Requirements Specification," NISTIR 5707, NIST, Gaithersburg, MD, July 1995.

[14] Moncarz, H., "Visualization Applications for Manufacturing: A State-of-the-Art Survey, Final Report," NISTIR 5427, NIST, Gaithersburg, MD, May 1994.

[15] Ressler, S., "Applying Virtual Environments to Manufacturing," NISTIR 5343, NIST, Gaithersburg, MD, January 1994.

MSE5: Operator Interfaces for Virtual and Distributed Manufacturing, (p. 16)

[16] Kent, E., "Final Report: A Workshop on the Application of Virtual Reality to Manufacturing," NISTIR 5543, NIST, Gaithersburg, MD, December 1995.

MSE6: Process Planning Applications, (p. 17)

[17] Feng, S., Yang, Y., "A Dimension and Tolerance Data Model for Concurrent Design and Systems Integration," SME Journal of Manufacturing, May 95.

[18] Pratt, M., "Towards Optimality in Automated Feature Recognition," Computing, 10 (Supplement), pp. 253-174. Geometric Modelling - Dagstuhl 1993, G. Farin, H. Hagen & H. Noltemeir, ed., Springer-Verlag, 1995.

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[20] Regli, W., "Automated Manufacturability Analysis: A Survey," NISTIR 5713, NIST, Gaithersburg, MD, September 1995.

[21] Subrahmanyam, S., DeVries, W., and Pratt, M.J., "Feature Attributes and their Role in Product Modeling," in Proc. 3rd ACM Symposium on Solid Modeling and applications, Salt Lake City, UT, May 1995.

MSE8: Production Applications, (p. 19)

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[29] "Group 1 for the Plant Spatial Configuration STEP Applications Protocol," NISTIR 5675, NIST, Gaithersburg, MD, July 1995.

MSE11: Virtual Enterprise Frameworks for Small Manufacturers, (p. 24)

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SDE1: Application Protocol Development Environment (APDE), (p. 27)

[32] Phillips, L., Lubell, J., "An SGML Environment for STEP," NISTIR 5515, NIST, Gaithersburg, MD, June 1994.

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SDE2: STEP Conformance Testing, (p. 29)

[34] Mitchell, M., "Initial NIST Testing Policy for STEP - Beta Testing Program for AP 203 Implementation," NISTIR 5535, NIST, Gaithersburg, MD, November 1994.

TTTE4: Manufacturing Information Technology Transfer, (p. 35)

[35] Potts, M., "The MITT Project Electronic Library: An Implementation Description," NISTIR 5656, NIST, Gaithersburg, MD, April 1995.

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Appendix C: Program Products Available

Standard Reference Databases[1]

[1] The 1986 CODATA Recommended Values of the Fundamental Physical Constants, by E.Richard Cohen and Barry N. Taylor:

Values of the basic constants and conversion factors of physics and chemistry resulting from the 1986 least-squares adjustment of the fundamental physical constants as published by the CODATA Task Group on Fundamental Constants and recommended for international use by CODATA.

[2] Recent and Current Program of the NIST Atomic Data Centers, by W. L. Wiese and W. C.Martin.

Critically evaluated data and bibliographies on atomic spectra --energy levels, wavelengths, transition probabilities, and line shapes.

[3] Bibliographic Database on Atomic Transition Probabilities, by J. R. Fuhr and H. R. Felrice.

An interactive database with references on atomic transition probabilities (oscillator strengths, line strengths, and radiative lifetimes). Both theoretical and experimental papers are listed.

[4] Atomic Spectroscopic Database, by A. Musgrove, G. R. Dalton, W. C. Martin, E. B. Saloman (NIST), and C. Stern Grant and G. Eichhorn (Harvard-Smithsonian Center for Astrophysics).

Includes most of the existing critically evaluated NIST data on atomic energy levels, transition probabilities, and wavelengths that are reasonably up-to-date. This interactive database has energy level data for over 500 spectra, transition probabilities for Sc through Ni, and wavelength data for spectra of several elements.

[5] Atlas of the Spectrum of a Platinum/Neon Hollow-Cathode Reference Lamp in the Region 1130-4330, by J. E. Sansonetti, J. Reader, C. J. Sansonetti, and N. Acquista.

An atlas of the spectrum is given, with the spectral lines marked and their intensities, wavelengths, and classifications listed. Graphical figures of the spectrum are included.

[6] Wavenumber Calibration Tables From Heterodyne Frequency Measurements, by Arthur G. Maki and Joseph S. Wells.

An atlas of molecular spectra and associated tables of wavenumbers for the calibration of infrared spectrometers.

1. Information on obtaining and accessing these databases can be found at http://www.nist.gov/srd/.

Appendix D: AMSANT Software Systems Available

The following software applications are installed in the AMSANT facility. These packages are used by SIMA researchers and their collaborators.

Computer aided design computer aided engineering/ computer aided manufacturing Software	*Integration Software*	*Simulation Software*
AutoCAD	Design IDEF	ARENA
Bentley Microstation Modeler	FirstSTEP XG	AutoMOD
Cimplex Manufacturing Analyst & NC Verify	Matrix Product Data Manager	AutoSched
Cognition Mechanical Advantage & Cost Advantage	ObjectStore OODBMS	Deneb QUEST, IGRIP, and VNC
IAMS MetCAPP	Orbix Object Request Broker	Pritsker (FACTOR)
ICEM/Part	SEMATECH CIM Framework	
InterCIM	STEP Tools, Inc. EXPRESS Toolkit	
Multi-CAPP		
Parametric Technology Corp. Pro/Engineer, Pro/Manufacture, and Mechanica		
SDRC I-DEAS		
SmartCAM Free Form Machining		