

*Project Plan for the Rapid
Response Manufacturing
(RRM) Intramural Project*

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February 1993



Executive Summary

The primary goal of this Advanced Technology Program (ATP) intramural project is to form a collaborative relationship with the National Center for Manufacturing Sciences (NCMS) Rapid Response Manufacturing (RRM) consortium to develop and adopt key technologies that will enable U.S. manufacturers to outperform foreign competitors through the use of advanced, highly integrated systems for manufacturing. The project will focus on leveraging NIST skills and technologies to ensure progress and implementation of the RRM concept from idea to implementation. The project will serve to increase knowledge and skills of NIST personnel and NCMS RRM consortium members by creating a research and development program focused on the technologies that are recognized as important to the NCMS RRM program and the NIST Factory Automation Systems Division (FASD). In addition, an RRM Testbed Laboratory will be established at NIST. This testbed will be used to verify results and identify issues with technology and standards applied to RRM. The project will emphasize technology development, collaboration with industry members of the NCMS RRM consortium, and technology transfer activities. The Testbed Laboratory will be used to integrate system functionality of each software module identified for RRM, to test initial releases of the software components, and to provide an environment for both NIST and NCMS RRM participants to interact and exchange technology.

Technical Approach

INTRODUCTION

The NIST Rapid Response Manufacturing (RRM) Project is sponsored as an intramural project through the NIST Advanced Technology Program (ATP) office¹. This ATP intramural project is managed and executed through the NIST Factory Automation Systems Division (FASD).

The principal objective of the RRM intramural project is to establish collaborations with National Center for Manufacturing Sciences (NCMS) RRM consortium members and to leverage NIST skills and technologies to ensure the advancement of RRM capabilities. With this objective in mind, this project was initiated in order to build expertise and increase awareness of engineering and manufacturing technologies being applied to improve the process of rapid response manufacturing, and to establish an RRM Testbed Laboratory at NIST to be used by both NCMS RRM and NIST researchers to test integration concepts, incorporate standards, and ensure the success of RRM.

The NCMS RRM consortium technical plan for implementing key technologies includes a manufacturing information model that integrates product and process data, an advanced computer-aided engineering environment, knowledge-based software applications for design and process planning, and new production technologies to make products directly from design software. Key to the success of this NCMS program is the use of open systems and object technologies to allow for a seamless integration of the various systems.

1. Advanced Technology Program, U.S. Department of Commerce, Technology Administration, National Institute of Standards and Technology, Administration Building, Room A430, Gaithersburg, MD 20899.

Technical Approach

The NIST RRM intramural project will support each of the NCMS RRM focus areas through the activities defined in this Project Plan document. Primary project activities are grouped into the following major categories: 1) Research and Development, 2) RRM Testbed Laboratory, and 3) Technology Transfer. Each of these categories is discussed below. Further details of specific project activities can be found in a later section of this document.

RESEARCH AND DEVELOPMENT

NIST participates actively in the Computer Integrated Manufacturing (CIM)-related standards community and in such national programs as the Industry-Government National Initiative for Product Data Exchange, Department of Defense (DoD) Computer-aided Acquisition and Logistics Support (CALs) program, and the Navy-sponsored Manufacturing Technology program. Through this unique role, NIST has developed a broad perspective for meeting the requirements for an advanced, highly integrated manufacturing system. With this experience base, NIST is in a position to coordinate the NCMS RRM efforts with other on-going programs in similar areas to leverage these other efforts, thus avoiding the possibility of unnecessary duplication of development efforts. Where there are gaps in the conceptual level technology that are not being addressed by the NCMS RRM consortium, or by other national programs, NIST will undertake efforts to accelerate the development of such technology solutions.

This project will create a Research and Development (R&D) program to support the engineering and manufacturing technologies outlined in the NCMS Rapid Response Manufacturing technical plan. Research efforts will be concentrated around the investigation of product design, mechanical part manufacturing, and computing technologies within the defined scope of RRM. These research efforts will be conducted to better understand the relationship of these technologies to RRM requirements and to understand how the technology will be applied to manufacturing problems. This research will be performed primarily by NIST technical staff, but close collaboration with NCMS RRM industry members will be maintained for a consistent research and development agenda with NCMS RRM participants.

Research topics for the R&D program will be selected so as to fall within the scope of the NCMS RRM effort and the mission of the NIST Factory Automation Systems Division. An RRM needs assessment will be conducted through participation on NCMS RRM committees to identify critical research areas. In addition, a close relationship with internal FASD research projects will be maintained to leverage results into the RRM intramural project. Further details on potential research topics and research methods are discussed in a later section of this document.

Research results will be transferred to the RRM community through publication of a series of journal articles and other technical reports. The information gathered through this R&D program should accelerate the unification and integration of key RRM technologies. This research will also assess the relevance of various standardization activities, identify technical gaps in current standards, and identify integration issues for commercial applications in the RRM engineering environment.

An additional FASD focus in the RRM R&D program will be to identify and address division deficiencies. This program will strive for compatibility between individual research topics (i.e., along a common theme). A long-term division objective is to develop a strategic plan for a continuing division program along this common theme

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that focuses on critical manufacturing technologies. It is anticipated that this strategic plan will be developed during FY94.

RRM TESTBED LABORATORY

The R&D efforts of this project will be combined with the development of an RRM Testbed Laboratory at NIST which emulates the system architecture proposed for the NCMS RRM integrated engineering environment. Development of this facility will draw upon experience gained through the NIST Automated Manufacturing Research Facility (AMRF) research program, the National PDES Testbed, and related FASD research activities. The RRM Testbed Laboratory will be established to serve as a neutral arena for the comparison, integration, and testing of software and hardware components for engineering and manufacturing systems designed for the RRM environment.

The RRM Testbed Laboratory will serve as a conduit of information on issues and advancements in RRM-related technologies and as a mechanism for bringing internal FASD projects together to produce a division-wide testbed resource for factory automation research. The NIST RRM Testbed will enable the following functions:

- Support direct interaction between NIST and NCMS RRM technical staff
- Provide facility for testing and integrating RRM software and hardware components
- Demonstrate RRM system functionality
- Provide facility for testing and integrating computer standards related to RRM
- Evaluate architecture design and interface specifications for the integrated engineering environment

The NIST RRM Testbed Laboratory will be developed through close interaction with the NCMS RRM committees, specifically the Engineering Environment, Reference Architecture, and Direct Manufacturing committees. The Testbed Laboratory will be based upon an open engineering environment and an integrating framework as defined by the NCMS reference architecture. The NIST RRM Testbed will be implemented in a phased approach in order to provide an initial capability as early as possible in the overall RRM program, with the ability to update testbed functionality as technologies and applications mature.

The RRM Testbed Laboratory will interact with several commercial and experimental product lines being implemented by the NCMS RRM consortium to measure the progress of the program against real-life benchmarks. Various combinations of design and manufacturing systems will be implemented in the Testbed Laboratory. It is anticipated that the NIST RRM Testbed Laboratory facility will include a mix of academic, industrial, and commercial systems. The need for an integrating framework arises because applications to support RRM must utilize information exchange standards to achieve integration. In order to integrate these various applications, a number of standard approaches will be required, in terms of data models, interfaces, protocols, and methodology.

TECHNOLOGY TRANSFER

The third major focus area of the NIST RRM intramural project is Technology Transfer. Technology Transfer activities are one of the primary missions of NIST and will play a significant role in this RRM intramural project. Several project activities are included in this area as outlined below.

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1. Cooperative Research and Development Agreement (CRDA) with NCMS
The RRM intramural project will develop a CRDA with NCMS to outline expectations, technical activities, and interactions with the NCMS RRM consortium. Once the umbrella CRDA is established with NCMS, additional opportunities for collaborative research will be pursued through CRDAs with industrial participants and commercial software suppliers within the NCMS RRM consortium to further enhance the technical direction of the RRM intramural project.
2. RRM Workshop with NCMS
An RRM Workshop will be held with NCMS RRM participants to highlight the current RRM-related research needs and to identify the key technologies and technological barriers to RRM. An expected outcome from this workshop is recommendations on how to address these technological barriers.
3. NCMS RRM committee participation
NIST RRM intramural project staff will participate in selected NCMS RRM committees as appropriate and deemed beneficial to the RRM effort. Currently, participation in the following NCMS RRM committees is expected during FY93:
 - Reference Architecture
 - Integrated Product and Process Model (IPPM)
 - Engineering Environment
 - Integration Test Group (Phase I Prototype)
 - Knowledge-Based Applications
 - Direct Manufacturing
4. National PDES Testbed (NPT) assistance
The RRM intramural project will provide assistance to NCMS RRM consortium members in the training and use of the National PDES Testbed facility and software tools for working with STEP (Standard for the Exchange of Product Model Data) models and product data. This assistance will also include consultation activities for STEP resource models, model integration aspects, the NCMS RRM Integrated Product and Process Model (IPPM) data model, and the STEP Data Access Interface (SDAI). This assistance will be provided primarily during the Phase I prototype efforts of the NCMS RRM Integration Test Group and during NCMS RRM development of the IPPM.
5. Consultation with other FASD research efforts
The RRM intramural project will facilitate access by NCMS RRM consortium members to consultation with other FASD research efforts. Several current FASD projects are involved with technologies within the scope of RRM, including engineering design, manufacturing process planning, shop floor scheduling, persistent object database systems, and system architectures.
6. Research Associate and Guest Worker arrangements
NIST has a long history of performing collaborative research and providing technology transfer through Research Associate or Guest Worker arrangements. Through these programs, participants establish an office area on-site at NIST to take advantage of NIST facilities and NIST staff interaction. The RRM intramural project will offer these arrangements to NCMS RRM consortium members as appropriate and desired by NCMS RRM. These arrangements are typically established for a

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predetermined length of time and with specific objectives. The NIST RRM Testbed Laboratory is the intended facility for these Research Associate or Guest Worker arrangements.

Project Activities

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During the first year of the RRM intramural project, the primary focus will be on establishing a formal relationship with the NCMS RRM consortium, researching key technologies within the RRM scope, establishing a NIST RRM Testbed Laboratory, and providing National PDES Testbed assistance for the NCMS RRM Phase I prototype effort. Detailed activities and project tasks for the RRM intramural project are provided below for the three major activity categories.

Research & Development Program Activities

The primary objective of the R&D program is to support and accelerate development of the engineering and manufacturing technologies required by the NCMS RRM consortium. Technical staff members of the RRM Intramural Project will perform research in RRM-related topics in order to achieve this objective. Project activities for the R&D program will include:

- Conduct RRM needs assessment through participation on NCMS RRM committees
- Submit proposals for research topics and methods
- Perform research in approved RRM-related technology
- Provide periodic status reviews
- Document research results in journal-submission quality technical report
- Submit research results for journal publication

R&D program research areas will be selected based upon several criteria. The research must be within the scope of the NCMS RRM effort. This scope is defined in the NCMS RRM technical plan and is outlined below from the perspective of the NIST RRM staff. Secondly, the research topics must be within the scope and mission of the NIST Factory Automation Systems Division. This mission can be stated as the “application of information technology and manufacturing knowledge to promote multi-enterprise concurrent engineering in the manufacturing of discrete parts.”² Critical research needs within these scopes will also be identified through participation on NCMS RRM technical committees. Research required in critical areas or for key technologies will be given top priority. Lastly, the R&D program will attempt to form some compatibility between individual research topics to address the long-term FASD objective of developing a continuing program that focuses on critical manufacturing technologies.

2. Bloom, Howard M. and Masters, Larry W., “The Technical Program of the Factory Automation Systems Division 1992”, National Institute of Standards and Technology, Internal Report, NISTIR 4856, May 1992.

Project Activities

NIST RRM staff will submit proposals for R&D topics to RRM project management prior to research initiation. Proposals will include a brief description of the topic, research goals and objectives, planned deliverables, and the methods of research to be employed. R&D topics will be approved by NIST RRM project management prior to research initiation. The R&D topics will be evaluated based upon applicability to the established selection criteria.

A preliminary brain-storming session was conducted by NIST RRM staff to identify the engineering and manufacturing technologies that are within the scope of RRM. These factors will be used for scoping of the RRM intramural project research subjects. Results of this brain-storming session are provided below.

RRM Scoping Factors for R&D Research Areas

- Manufacturing Process
 - Mechanical Parts Production
 - Metal Fabrication Processes
 - Numerical Control (NC) Machining
- Applied Technology (as applied to RRM)
 - Concurrent Engineering
 - Computer Integrated Manufacturing (CIM) Architectures
 - STEP Standard for the Exchange of Product Model Data
 - Objected-Oriented Methodologies
 - Artificial Intelligence (Knowledge-Based/Expert Systems)
 - Feature-Based Design/Manufacturing
 - Information Modeling
 - Integration Technology
- Commercial Application Assessment
 - Computer Aided Design (Mechanical)
 - Analysis (Finite Element Analysis, Simulation, etc.)
 - Computer Aided Manufacturing (Process Planning, NC code, etc.)
 - Object Database Systems
 - Schema Repository / Schema Management
 - Test Case Library

All R&D program research topics will fall within one or more of these scoping factors. One method suggested for incorporating multiple scoping factors into a single research focus would be to perform research on the “use of an [applied technology] for a selected [commercial application] within the scope of a [manufacturing process]”. Note the use of the three major scoping factor categories within the brackets. Specific research areas could be inserted into each of the bracketed items to form research topics within the RRM scope. One example of this method might be “Use of [Concurrent Engineering] for [Finite Element Analysis] within the scope of [Mechanical Part Production]” (brackets used to illustrate example). This suggestion for incorporating multiple scoping factors will not be a requirement for selection of a research topic, however.

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Once the RRM scope was obtained, NIST RRM intramural project staff conducted a second brain-storming session to identify potential research topics. These potential research topics were then grouped into higher-level categories. Results of this session are provided below. These research topics should be considered examples or potential research topics, and may not reflect actual R&D program research subjects.

Sample Research Topics

- Concurrent Engineering Environment
 - Survey use of concurrent engineering techniques in manufacturing facilities
 - Identify types, purposes, and interface formats of information that is shared in manufacturing environments for mechanical parts
- Data Modeling and Representation in Manufacturing
 - Survey CASE tools for ability to generate object-oriented prototypes from data models
 - Analyze methods for applying application-specific constraints (e.g., RRM mechanical parts manufacturing) to an integrated data model for data sharing purposes
- Automation Tools for Mechanical Parts Production
 - Investigate techniques for process simulation for mechanical parts manufacturing systems
 - Research the state-of-the-art for NC program generation for machining of mechanical parts
- Design Feature Representation
 - Assess availability and functionality of feature-based commercial systems for manufacturing
 - Investigate conceptual design features and representations for mechanical parts
- Conceptual Design
 - Survey commercial and research systems used for conceptual design of hard goods
 - Research tools and techniques to aid in assessing aesthetic quality of conceptual design

Several methods for conducting research are available to RRM intramural project staff. The common element in all research topics will most likely be a literature review of technical journals and textbooks. In addition, contacts will be made through industrial, academic, and government users and/or developers of the specific technology or application. Information on research subjects can also be obtained through attendance at industry meetings, workshops, technical conferences, and/or training courses. Project staff can also sponsor and conduct workshops at NIST with a specific technology focus to obtain industry feedback.

Research results of each R&D program research effort will be transferred to the RRM community through publication of technical journal articles and other technical reports. The primary first-year deliverable of each research effort will be a final draft of the research report in journal-submission quality. This report will, at a minimum, describe the research results, goals, methods, references, technical gaps in relevant standards,

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integration issues for commercial applications, and recommendations for methods of further technology research, development, and/or implementation. The focus of the final reports for the research efforts will be to directly assist the NCMS RRM consortium and to accelerate development and integration of technology solutions required by the NCMS RRM effort. Actual publication of the journal articles is not expected as a first-year deliverable due to time constraints by journal publishers, but will be included as a second-year deliverable.

Other first-year deliverables of the R&D program include the R&D topic proposal and intermediate status reviews. Intermediate status reviews will be used to show progress of research activities and to demonstrate assurance that the final research report will be delivered on schedule. The intermediate status reviews will consist of both formal and informal presentations during RRM intramural project meetings that include a summary of the research methods, activities, results, and plans.

RRM Testbed Laboratory Activities

One of the major focus areas for the first year of the RRM intramural project will be to establish an RRM Testbed Laboratory at NIST. This RRM Testbed Laboratory will serve as a facility where collaborators can investigate interoperability between systems, experiment with the use of standards, and perform exploratory integration studies. The RRM Testbed Laboratory will also allow collaborators to address information technology barriers to RRM. Project activities for establishing the NIST RRM Testbed Laboratory will include:

- Coordinate with appropriate NCMS RRM technical committees
- Analyze existing NIST testbed capabilities
- Define requirements for establishing an RRM Testbed Laboratory
- Develop Implementation Plan for RRM Testbed Laboratory
- Pursue additional funding for RRM Testbed equipment, software, furniture, and facility modifications
- Procure RRM Testbed equipment, software, furniture, and facility modifications
- Establish communications network in RRM Testbed facility
- Install RRM Testbed systems, software, and equipment
- Design and create RRM informative posters for Testbed demonstration purposes
- Identify and obtain RRM-related technical books, standards, and journal articles to form a library of information
- Develop RRM Testbed documentation
- Demonstrate operational RRM Testbed Laboratory (initial implementation)

Initial activities for establishing the RRM Testbed Laboratory will center around defining the testbed requirements. A thorough analysis will be performed to identify RRM Testbed requirements for computer hardware and software platforms, software applications, communications capabilities, software development and integration tools, facilities, staff resources, and other considerations. Results of this requirements analysis will be transformed into an Implementation Plan for the RRM Testbed Laboratory. The Implementation Plan will include descriptions of each activity necessary to establish the

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RRM Testbed, identification of staff resources, and an implementation schedule.

Requirements for the NIST RRM Testbed Laboratory will be developed in coordination with the NCMS RRM consortium. It will be necessary for NIST RRM staff to participate on NCMS RRM committees, specifically the Engineering Environment, Reference Architecture, and Direct Manufacturing committees. The Testbed Laboratory will be based upon an open engineering environment and an integrating framework as defined by the NCMS reference architecture. Further definition of these requirements will come from the NCMS RRM committees.

Additional RRM Testbed Laboratory requirements will be formed based upon an analysis of existing NIST testbed capabilities. Testbed facilities, including the National PDES Testbed, Engineering Design Laboratory, and the planned Process Planning Testbed, will be analyzed to determine available capabilities and functionality, and to assess typical customer expectations of a testbed operation. The RRM Testbed Laboratory will leverage available capabilities whenever possible and will strive for no overlap between existing testbeds.

The current RRM intramural project budget does not include sufficient funding for fully outfitting the RRM Testbed with the necessary computer hardware, software, equipment, and other components for a usable working environment. Established guidelines must be followed pertaining to the use of project funds as provided by the ATP office project sponsor. Additional funding for the purpose of procuring RRM Testbed components will be pursued through the NIST Depreciable Equipment allocations and other sources (both internal and external to NIST) as appropriate. This project issue represents a major risk in the overall success of the NIST RRM Testbed Laboratory.

Implementation of RRM Testbed components will be performed as they become available and according to the Implementation Plan. Computer workstations, software packages, and network communication capabilities will be installed in the Testbed Laboratory. Technical books, journal articles, and standards on RRM-related technologies will be identified and obtained to form a small resource library for RRM researchers. Information posters will be designed and created to illustrate the concepts of RRM and the activities of the RRM Testbed. These posters will be displayed on both the inside and outside walls of the testbed facility and will be used primarily during demonstrations and to publicize the existence of the RRM Testbed. Testbed documentation, including a testbed overview, user instructions, and software documentation, will also be developed and/or obtained.

The NIST RRM Testbed will be implemented in a phased approach in order to provide an initial capability as early as possible in the overall RRM program, with the ability to update testbed functionality as technologies and applications mature. The primary deliverable for this effort during the first year of the RRM intramural project is a demonstration of an operational initial implementation of the RRM Testbed Laboratory. This deliverable will be measured based upon the capability for NCMS RRM consortium members and NIST RRM staff to use the testbed facility, either on-site or remotely, for the research and development activities intended for the testbed. Other first-year deliverables for the Testbed Laboratory effort include the Implementation Plan and the testbed documentation.

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The planned facility to be used for the NIST RRM Testbed Laboratory is Room B107 of NIST Building 220 (Metrology). A preliminary analysis of the requirements and room modifications necessary to transform this room into an RRM Testbed includes the following items:

Preliminary RRM Testbed Requirements

- Equipment
 - Sun Sparcstation workstations (3-5 based on needs and funding)
 - other computers/workstations (defined by NCMS RRM consortium needs)
 - laser printer with printer table
 - network communications
 - CD-ROM drives for Sun Sparcstations
 - desktop manufacturing machines (e.g., mill, turning center, CMM)
- RRM software and information
 - RRM software applications with documentation (e.g., ProEngineer, ICAD, object-oriented database, others as identified by NCMS RRM consortium)
 - development and/or integration software tools
 - RRM Testbed Laboratory documentation
 - library with books, journals, and standards relating to RRM technology
 - RRM posters with overview information
- Furniture:
 - ergonomic workstation desks and chairs (1 for each workstation)
 - fold-up conference table with additional chairs
 - work tables, book shelves, and file cabinets
- Office equipment and potential room modifications
 - overhead projector in roll-around cart
 - combination white board/chalk board/overhead projector screen
 - telephones (2 separate numbers)
 - additional/upgraded room lighting

A proposed layout for the RRM Testbed Laboratory is illustrated in Figure 1.

Technology Transfer Activities

The third major activity category for the RRM intramural project is Technology Transfer. Details of the project tasks for each of the Technology Transfer activities as identified in the Technical Approach section are provided below.

1. Cooperative Research and Development Agreement (CRDA) with NCMS

The RRM intramural project will develop a CRDA with NCMS to outline expectations, technical activities, and interactions with the NCMS RRM consortium. Once the umbrella CRDA is established with NCMS, additional opportunities for collaborative research will be pursued through CRDAs with industrial participants and commercial software suppliers within the NCMS RRM consortium to further enhance the technical direction of the RRM intramural project.

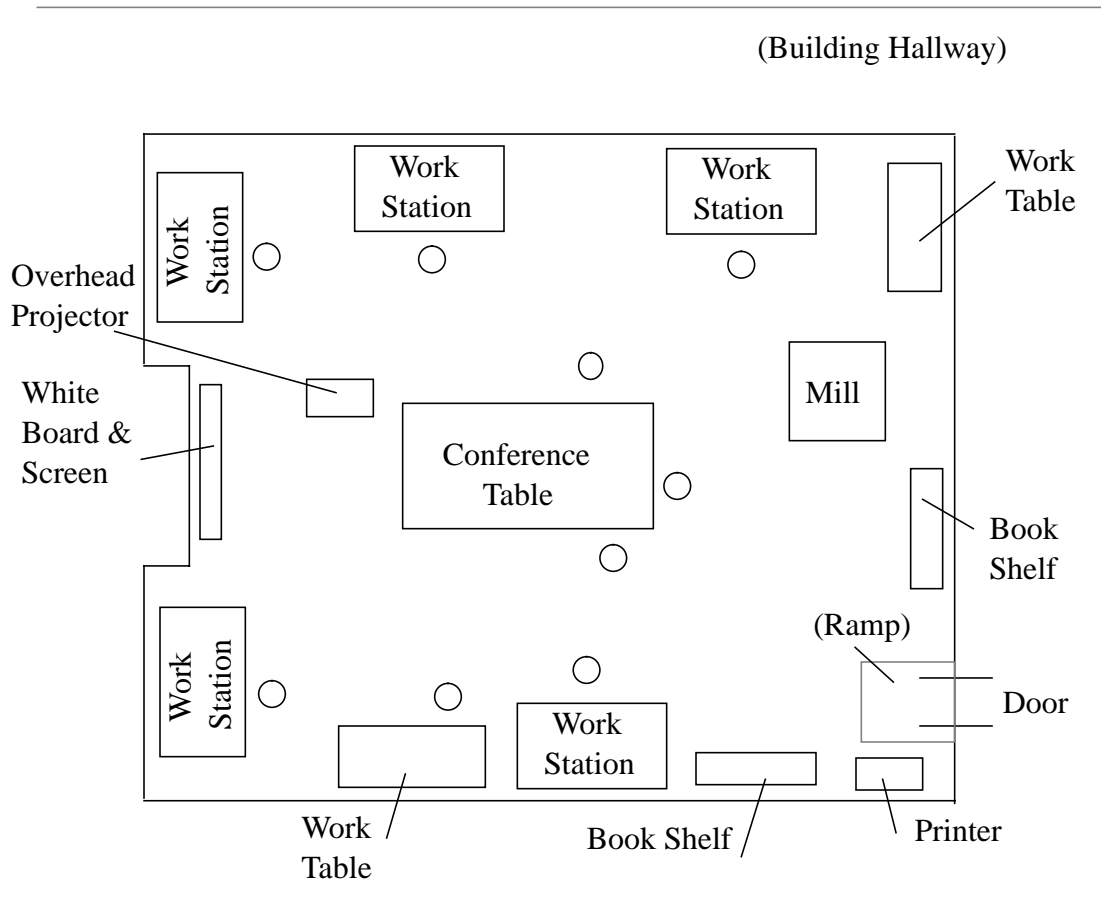


Figure 1: Proposed NIST RRM Testbed Layout
NIST Building 220, Room B107

Project activities required to develop this CRDA include:

- Meet with NIST ATP Office and NCMS RRM participants to review technical and administrative plans
- Develop Statement of Work
- Establish formal agreement between NIST and NCMS on CRDA contents
- Finalize CRDA through NIST and NCMS administrative and legal personnel

2. RRM Workshop with NCMS

An RRM Workshop will be held with NCMS RRM participants to highlight the current RRM-related research needs and to identify the key technologies and technological barriers to RRM. An expected outcome from this workshop is recommendations on how to address these technological barriers.

Project activities required to conduct the RRM Workshop include:

- Establish workshop location and date

Project Activities

- Define workshop agenda
 - Define expectations for workshop participants and attendee contributions
 - Identify workshop participants and attendees through publications, contacts, related standards efforts, known researchers in a given field, etc.
 - Invite workshop participants and attendees
 - Conduct workshop
 - Document workshop proceedings
3. NCMS RRM committee participation

NIST RRM intramural project staff will participate in selected NCMS RRM committees as appropriate and deemed beneficial to the RRM effort. Currently, participation in the following NCMS RRM committees is expected during FY93:

Reference Architecture
Integrated Product and Process Model (IPPM)
Engineering Environment
Integration Test Group (Phase I Prototype)
Knowledge-Based Applications
Direct Manufacturing

The RRM intramural project anticipates that NCMS RRM Steering Committee representation will be provided by the NIST ATP office.

The primary project task for this activity is to attend and contribute to NCMS RRM committee meetings and work sessions. In addition, NIST personnel assigned to a specific NCMS RRM committee will remain knowledgeable about committee activities through the email mailing lists established by NCMS.

The need to keep the rest of the RRM intramural project staff informed on the progress of other committees has been recognized. This requirement will be satisfied through various reporting mechanisms, including meeting minutes, trip reports, and status updates (both formal and informal) during internal RRM intramural project meetings. NIST contributions to and technical recommendations for the NCMS RRM committees will also be assessed and documented through the status update reports. These reporting mechanisms will be required deliverables for this project activity.

4. National PDES Testbed (NPT) assistance

The RRM intramural project will provide assistance to NCMS RRM consortium members in the training and use of the National PDES Testbed facility and software tools for working with STEP models and product data. This assistance will also include consultation activities for STEP resource models, model integration aspects, the NCMS RRM Integrated Product and Process Model (IPPM) data model, and the STEP Data Access Interface (SDAI). This assistance will be provided primarily during the Phase I prototype efforts of the NCMS RRM Integration Test Group and during NCMS RRM development of the IPPM.

Project activities required to provide NPT assistance include:

- Provide tools and environment training, usage assistance, and readiness preparation
- Maintain computer accounts and privileges (computer system support staff)

Project Activities

- Provide facility use and coordination for testing and integration of data exchange standards and RRM-related applications
- Provide STEP model consultation, including integration aspects
- Evaluate quality aspects of NCMS RRM IPPM data model

Periodic progress reports on completed and in-process NPT assistance activities will be provided to RRM intramural project management. The frequency of these status updates will be determined based upon amount of NPT assistance requested by NCMS RRM and project management need. For assistance requests by NCMS RRM that require a significant amount of resources, time and personnel estimates will be submitted to project management prior to initiation of the activity.

Primary deliverables from this project activity will include the following items:

- Approved Training Materials for NPT tools and environment training classes
- Assessment Reports for STEP model and IPPM consultation and evaluation (specifically noting what was done and results found, including deficiencies and recommendations)

5. Consultation with other FASD research efforts

The RRM intramural project will facilitate access by NCMS RRM consortium members to consultation with other FASD research efforts. Several current FASD projects are involved with technologies within the scope of RRM, including engineering design, manufacturing process planning, shop floor scheduling, persistent object database systems, and system architectures. Some of the FASD projects expected to provide consultation include:

- Manufacturing Systems Integration (MSI) architecture
- Process Planning Testbed
- Engineering Design Laboratory
- National PDES Testbed
- Persistent Object Base Testbed

6. Research Associate and Guest Worker arrangements

NIST has a long history of performing collaborative research and providing technology transfer through Research Associate or Guest Worker arrangements. Through these programs, participants establish an office area on-site at NIST to take advantage of NIST facilities and NIST staff interaction. The RRM intramural project will offer these arrangements to NCMS RRM consortium members as appropriate and desired by NCMS RRM. These arrangements are typically established for a predetermined length of time and with specific objectives. The NIST RRM Testbed Laboratory is the intended facility for these Research Associate or Guest Worker arrangements.

YEAR 2

During the second and follow-on years of the NCMS RRM program, the RRM Intramural Project will continue its support activities. All three of the major activities from the first year of the project will continue. The Research and Development Program will expand into additional topics related to RRM and initiate development of a continuing FASD program along a common theme. Research results from the R&D program will be published as technical journal articles to facilitate development of RRM-related technologies.

First Year Deliverables (FY93)

The NIST RRM Testbed Laboratory will continue to evolve as new capabilities become available. This facility will become fully functional during this timeframe and it is expected at this point that participation in the RRM Testbed Laboratory will blossom. Efforts made during FY93 to arrange for Research Associate and Guest Worker appointments should result in a fruitful interaction between NCMS RRM and NIST researchers in the Testbed Laboratory.

Technology Transfer activities will also continue into follow-on years. NIST will continue to participate in NCMS RRM committees as appropriate. Other Technology Transfer activities will be identified based on project needs at that time. Support assistance from National PDES Testbed staff will most likely decrease over time, whereas requirements for consultation from other NIST research projects may increase. Additional workshops will also be convened, as part of the continuing effort to facilitate communication between NIST and the NCMS RRM participants, and to ensure that the technologies being applied satisfy the needs of the NCMS RRM effort.

First Year Deliverables (FY93)

- RRM Intramural Project Plan (i.e., this document)
- Cooperative Research and Development Agreement (CRDA) with NCMS
- Workshop between NIST & NCMS RRM to address technology barriers
- RRM Workshop Proceedings
- RRM Testbed Laboratory Implementation Plan
- Demonstration of operational RRM Testbed Laboratory (initial implementation)
- RRM Testbed Laboratory Documentation
- Proposals for R&D topics
- Final draft of RRM research reports in journal-submission quality
- Status Reports for NCMS RRM committee participation
- Approved Training Materials for NPT tools and environment training classes
- Assessment Reports for STEP model and IPPM consultation and evaluation

Expected Second Year Deliverables (FY94)

- Published journal articles based on NIST RRM research topics
- RRM research proposals and final reports for additional RRM-related topics
- Technology transfer of NIST RRM research to NCMS and FASD projects
- Enhanced NIST RRM Testbed Laboratory
- Research Associate/Guest Worker appointments to NIST RRM Testbed
- Additional RRM Workshops and Workshop Proceedings
- Status Reports for FY94 NCMS RRM committee participation
- Strategic Plan for a FASD continuing program related to the RRM Intramural Project R&D Program

Project Personnel

Project staffing for the technical positions defined below will be selected from all FASD groups. Computer support services will be provide by Global Support and contracted when necessary. National PDES Testbed personnel will be utilized during the prototype development phase outlined in the NCMS RRM technical plan. Management support for the RRM project will be provided by the FASD Production Management Systems (PMS) group leader, and any additional management support will be provided by other members of division management. The following project positions have been identified and personnel will be appointed by FASD management to fullfil staffing requirements for FY93.

- **PROJECT MANAGER:** Responsible for overall management of the project and administration of project budget, also responsible for reporting progress to FASD and ATP management. Shall have previous project management experience.
- **TECHNICAL MANAGER:** Responsible for overall technical direction and management of research and development assignments to project staff. Responsible for designing and developing the Testbed Laboratory and will participate in selected NCMS RRM committees. Shall have the capability to effectively lead project teams, experience in product design, manufacturing, and computing systems, and ability to assess research results from a variety of RRM-related technology topics.
- **MECHANICAL ENGINEER:** Will participate in selected NCMS RRM committees and research state-of-the-art in technology related to RRM. Shall have a background in product design and manufacturing and have the ability to apply research results to RRM-related concerns in mechanical part design and production.
- **MANUFACTURING ENGINEER:** Will participate in selected NCMS RRM committees and research state-of-the-art in manufacturing technologies related to RRM. Shall have a background in manufacturing processes for mechanical parts and have the ability to apply research results to RRM-related concerns in manufacturing and concurrent engineering environments.
- **GENERAL ENGINEER:** Will participate in selected NCMS RRM committees and research state-of-the-art in technology related to RRM. Shall have experience in product design, including knowledge about feature-based concepts, and have the ability to apply research results to RRM-related concerns.
- **COMPUTER SCIENTIST (3):** Will support testbed development, participate in selected NCMS RRM committees, and perform research related to RRM technology. Shall have a background in computer databases, data modeling (specifically as related to product and process data representation - e.g., STEP), and application of computer technologies to develop software solutions for RRM-related concerns. Knowledge of object-oriented computing concepts is also beneficial.
- **COMPUTER SUPPORT STAFF:** Will assist the technical manager with the implementation of the Testbed Laboratory.
- **NATIONAL PDES TESTBED (NPT) STAFF:** Will provide training and operational support of any NPT software tools used by the NCMS RRM Integration Test Group committee during the twelve-month prototype development phase.
- **ADMINISTRATIVE SUPPORT STAFF:** Will provide NIST RRM Project administrative and secretarial support for the RRM project team, including typing, travel arrangements, photocopying, etc.

Project Timeline

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