Barnard A.F., Clark, S.N., and **Fowler, J.E., "Requirements for an Application Protocol Development Environment,"** NISTIR 5197, May 1993.

The National PDES project at NIST is focused on the development and implementation of the emerging international Standard for the Exchange of Product model data (STEP). One subproject within the Testbed is the effort to establish an Application Protocol Development Environment (APDE). This report documents the requirements for an APDE. The requirements provide guidance as to what capabilities and APDE should provide. The requirements described were derived from the experiences of current Application Protocol developers.

Bloom, H.M., "Strategic Plan for the Factory Automation Systems Division," NISTIR 5148, March 1993.

The objective of this report is to present the strategic plan for the Factory Automation Systems Division. The explosion of new information technologies and new manufacturing methods such as concurrent engineering, with the corresponding requirements for data interface standards, has made it clear that the Division must reevaluate its present status and develop a strategy that will bering the Division's research and development activities in line with the future needs of U.S. industry.

A vision of 21st century manufacturing is presented in terms of the implementation of the "virtual Enterprise" and the use of Multi-Enterprise Concurrent Engineering. The vision is based on reports published by the National critical Technologies Panel, the Agile Manufacturing Forum, and the new government Advanced Manufacturing Initiative.

Clark, S.N., Feeney, A.B., and **Fowler, "Specifications for an Application Protocol Development Environment,"** NISTIR 5248, August 1993.

The National PDES Testbed project at NIST is focused on the development and implementation of the emerging international Standards for the Exchange of Product model data (STEP). One subproject within the Testbed is the effort to establish an Applications Protocol Development Environment (APDE). This report documents the specifications for an APDE. The specifications describe were derived from the requirements described in an earlier report.

Clark, S.N. and **Feeney, A.B., "APDE Demonstration System Architecture,"** NISTIR 5318, December 1993.

The National PDES Testbed project at NIST is focused on the development and implementation of the emerging international Standard for the Exchange of Product Model data (STEP). One sub-project within the Testbed is the effort to establish an Application Protocol Development Environment (APDE). This report describes the architecture of a prototype system which will be built at NIST to demonstrate some of the features needed in an APDE and some approaches to providing these features. This demonstration system will focus on a specific step in the AP development process, namely ARM interpretation. The functionality demonstrated is based on specifications documented in an earlier report.

Diaz, C., "User's Guide for the Algorithm Testing System/Version 1.1," NISTIR 5137, February 1993.

The NIST Algorithm Testing System (ATS) is a software package for evaluating the performance of geometric fitting software. This report is a user's guide to the ATS. This user's guide documents the detailed description of the system operation.

Feng, S.C., Dimensional Inspection Planning Based on STEP and DMIS," NISTIR 5183, April 1993.

An international standard on product data representation and exchange for dimensional inspection planning is being developed. This paper provides a review of fundamental technology enabling the standard development and describes the current status of an activity model. The model defines functional requirements of the standard. An IDEFO diagram has been generated to represent the activity and its sub-activities, inputs, outputs, controls and planning, and information modeling.

Fowler, J.E., "Variant Design for Mechanical Artifacts - A State of the Art Survey," NISTIR ??????

Variant design refers to the techniques of adapting existing design specifications to satisfy new design goals and constraints. A survey of approaches supporting variant design is presented. Capabilities used in current commercial computer aided design systems are discussed along with approaches used in recent research efforts. Information standards applicable to variant design are identified as well. Barriers to variant design in current systems are identified and ideas are presented for augmentation of current systems to support variant design.

Hopp, T.H., "The Language of Tolerances," published in the proceedings of Indo-U.S.-Japanese Conference on Quality through Engineering Design, January 11-14, 1993, Bangalore, India.

Dimensional tolerancing is a language used to communicate product specifications. Effective communication using this language relies on there being a common, shared meaning for tolerances. By this measure, the language relies on there being a common, shared meaning for tolerances. By this measure, the language of tolerances defined in modern standards does not support good communication. Some reasons for this are: the evolution of technology; the lack of research on tolerances prior to the last two decades; and a greater need for rigorous product specifications in a computer environment. I discuss the weaknesses of the language of tolerances and suggest a three-part program of research and standards development to improve it.

Hopp, T.H., "Computational Metrology," published in *Manufacturing Review*, Volume 6, Number 4, 1993.

Coordinate measuring systems (CMSs) assess length-based characteristics of mechanical parts by measuring points on the part surface and analyzing the point data. Data analysis software can contribute significantly to the total measurement error of a CMS. Factors affecting software performance include the choice of analysis method, the quality of the software, and characteristics of the specific measurement task. By computational metrology we mean the study of how data analysis factors affect the measurement uncertainty of a CMS.

This paper describes research at NIST on computational metrology. Metrological questions fall into two categories: 1) the proper choice of data analysis objective for a particular application and 2) the performance of the implementation. Our research goal is to develop the basis for a national standard in the U.S. for CMS software performance evaluation. we are implementing a Special Test service to be offered through the NIST Measurement Services Program. The service is based on a black-box model of software, in which the internal structure of the software and the choice of solution methods are assumed to be unknown. The model identifies a number of error sources for data analysis software. We are designing test methods for identifying the various components of the model and how those components relate to measurement uncertainty in inspection applications.

Jurrens, K.K, and **Luce, M.E., "Project Plan for the Rapid Response Manufacturing (RRM) Intramural Project,** NISTIR 5174, April 1993.

This Project Plan documents the objectives, activities, and deliverables, and schedule for the NIST Rapid Response Manufacturing (RRM) Project. This project is sponsored as an intramural project through he NIST Advanced Technology Program (ATP) office. The RRM Intramural Project is managed and executed through he Factory Automation Systems Division (FASD). The primary goal of this 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. This project will focus on leveraging NIST skills and technologies to ensure progress and implementation of the RRM concept from idea to implementation. the three primary focus areas of the RRM Intramural Project include 1) Research and Development, 2) RRM Testbed Laboratory, and 3) Technology Transfer.

Jurrens, K.K., "An Assessment of the State-of-the-Art in Rapid Prototyping Systems for Mechanical Parts," NISTIR ????????

This report documents an assessment of the State-of-the-Art in Rapid Prototyping (RP) systems for mechanical parts. This technology area has been identified as one of the key focus areas of the National Center for Manufacturing Sciences (NCMS) Rapid

Response Manufacturing (RRM) industry consortium. Several commercial systems for Rapid Prototyping are discussed, along with current research development work in new prototyping methodologies. The vast majority of Rapid Prototyping systems used in industry today are based upon the Stereolithography process, initially developed by 3D Systems, Inc. Other systems and prototyping technologies have more recently been commercialized. Applications for RP technology within a manufacturing facility can be quiet diverse. Industrial uses of this technology have progressed from product visualization and verification, through design integration and optimization, to rapid fabrication techniques for cast parts. This report also discusses several technology issues associated with the development and implementation of RP systems. In addition, a view into the future is provided with a comparison of the current State-of-the-Practice to the Sate-of-the-Art and a discussion on expected advanced in RP technology. Finally this assessment addresses standardization activities and provides recommendations for continued research to support the needs of the RRM program.

Kramer, T.R., and **Senehi, M.K., "Feasibility Study: Reference Architecture for Machine Control Systems Integration,"** NISTIR 5297, November 1993.

The Manufacturing Engineering Laboratory (MEL) at the National Institute of Standards and Technology (NIST), has been conducting research on control of mechanical systems for more than sixteen years. The Robot Systems Division has developed an architecture, the Real-time Control System (RCS) which focuses on providing real-time control of equipment. The Factory Automated Systems Division has developed the Manufacturing System Integration (MSI) architecture which focuses on providing information integration with factory production systems. While the architectures share some common features such as the use of hierarchical control and task decomposition, there are also differences. This report documents the work performed in assessing the feasibility of combining the RCS and MIST architectures into a single reference architecture. The report is written primarily for the team of researchers charged with developing the joint architecture. It includes a literature survey, a framework for developing the joint architecture, a detailed set of issues about architectures and control architectures, and a preliminary sketch of the joint architecture.

Lee, Y.T., and **Moncarz, H.T., "A Prototype Application Protocol for Ready-to-Wear Pattern Making**, NISTIR 5115, January 1993.

A Ready-to-Wear Pattern Making Information Model is introduced for extending the emerging international Standard for the Exchange of Product Model Data (STEP) to include the exchange of apparel pattern data. This model focuses on a representation of two-dimensional (flat) patterns generated by the traditional ready-to-wear pattern making and grading method. A testing methodology of the information model is also described in this paper.

Libes, D., The NIST STEP Part 21 Exchange File Toolkit: An Update," NISTIR 5187, May 1993.

The NIST STEP Part 21 Exchange File toolkit is a software library for building tools that manipulate files in the format described by Part 21 of STEP. Part 21 is also known as "Clear Text Encoding of the Exchange Structure". The toolkit was released to the public in 1990. This paper describes the changes that have been made to the toolkit since then.

Libes, D., "The NIST EXPRESS Toolkit: Obtaining and Installing," NISTIR 5204, May 1993.

The NIST EXPRESS Toolkit is a software library for building EXPRESS-related tools. The NIST Part 21 Exchange File toolkit is a software library for building Part 21-related tools. This paper describes how to obtain the toolkits and install them.

Libes, D., "The NIST EXPRESS Toolkit: Updating Existing Applications," NISTIR 5205. June 1993.

The NIST EXPRESS Toolkit is a software library for building EXPRESS-related tools. The toolkit was previously released in 1991, based on EXPRESS N14. The current release is based on N151 and while the philosophical underpinnings are similar, much of the interfaces have changed significantly. This paper describes changes that must be made to extant applications so that they can work with the new toolkit.

This paper should be read by anyone maintaining software based upon the NIST EXPRESS toolkit. This paper will also provide insight to people interested in the internals of EXPRESS implementations and some of the ways they have changed over time due to experience and the different EXPRESS specifications.

Libes, D., "The NIST EXPRESS Toolkit: Using Applications," NISTIR 5206, June 1993.

The NIST EXPRESS Toolkit is a software library for building EXPRESS-related tools. The NIST Part 21 Exchange File Toolkit is a software library for building Part-21 related tools. This paper describes how to use applications such as "fedex" and "p21", which are stand-alone programs that read and report errors in EXPRESS schemas and Part 21 exchange files. Readers of this document need no knowledge of the internals of the toolkits.

Libes, D., A Debugger for Tcl Applications," published in the proceedings of the 1993 Tcl/Tk, June 10-11, 1993 in Berkely, CA.

Tcl is a language specifically intended for generic application control. By suing it, application programmers escape the dilemma of whether to design sophisticated application-specific languages or whether to build tools more quickly but that are limited in flexibility. Tcl is easy for application programmers to use, however, up to now, there has been no general-purpose debugger for application users.

This paper describes an implementation of a debugger for Tcl applications The debugger has a typical front end but with some extremely unusual commands, in part because of the features and limitations of Tcl. The debugger is modeless, allowing users to issue Tcl and application commands along with debugger commands. Each type of command may invoke the other, allowing debugging to be programmed, dynamically or in advance.

debugger is written in C and is very fast. When linked in but not used, it does not show applications at all. The debugger requires no modifications to the Tcl core,a nd can be plugged into applications with little effort.

Libes, D., "The NIST EXPRESS Toolkit: Design and Implementation," published in the 7th Annual Engineering Database Symposium - ASME Computers in Engineering Conference, San Diego, CA, August 9-11, 1993.

The NIST EXPRESS toolkit is a software library for building EXPRESS-related tools. EXPRESS is an ISO language for describing information models. EXPRESS descriptions are neutral to different data storage paradigms and systems on different hardware platforms and networks.

This paper describes the design and implementation of the toolkit including its important interfaces, data structures, and algorithms. This paper is recommended for anyone wishing to modify the toolkit or anyone wishing to build their own EXPRESS implementation. The reader is assumed to be familiar with the EXPRESS language, the basics of traditional language implementations, and C - the language with which the toolkit is implemented.

As a tested against which to benchmark the evolving EXPRESS language, conformance to the standard (currently Draft International Standard) is the highest priority in the toolkit. Nonetheless, time/space efficiency, accurate and helpful diagnostic, and ease-of-use are also critical to the success of the toolkit. The paper describes how these concerns are addressed even though EXPRESS is a complex and sophisticated language. The toolkit is available from the National Institute of Standards and Technology. The toolkit is just one of a number of tools for data management in STEP, a family of ISO standards currently in development. All of the NIST tools, including the NIST EXPRESS toolkit, are in the public domain.

Libes, D.,"Shtolo - Converting STEP Short Listings to Annotated Listings," NISTIR 5291, November 1993 .

A STEP Application Protocols includes an AIM Express Annotated Listing. An annotated Listing is created by combining the Short Listing and any objects from STEP Integrated Resource Parts that are referenced from the Short Listing either directly or indirectly. A number of transformations are performed on the resulting model, which is them formatted and printed.

In the past, this process has been carried out by hand. This document describes Shtolo, a tool to automated this process. Shtolo conforms to EXPRESS Part 11 and the Supplementary Directives for the Drafting and Presentation of ISO 10303 allowing direct inclusion of the result into an Application Protocol specification.

Shtolo relies on the NIST EXPRESS toolkit and the NIST EXPRESS Pretty Printer.

Libes, D., "Expp - An EXPRESS Pretty Printer," NISTIR ????????, .

EXPRESS is a data modeling language. EXPRESS is relatively new having only been standardized in 1993. Today, few tools exist that automatically generate EXPRESS and correspondingly most EXPRESS is hand-written. In the future, we predict that all but a tiny fraction of EXPRESS will be computer generated or computer read. While perhaps only during debugging, much of it will be read by humans so it is important that it "appear" as easy to read as possible.

The Supplementary Directives for the Drafting and Presentation of ISO 10303 state rules and guidelines for layout of EXPRESS. These rules and guidelines are incomplete and inadequate for humans, no less for the purposes of writing software to perform such presentation. Instead they appear to be an attempt to codify how people write EXPRESS now, with an eye towards making this easy for humans.

We provide improvements on their rules. These new rules are aimed at what we believe will be the biggest producers of EXPRESS in the future - programs. We have encoded these rules into a software library that can be incorporated into other tools. It has been used successfully in tools produced at NIST.

McLean, Charles R., "Computer-Aided Manufacturing System Engineering," published in the proceedings of the IFIP TC5/WG5.7 International Conference on Advances in Production Management Systems, APMS '93, Athens, Greece, September 28-30, 1993.

A new type of computer-aided engineering environment is envisioned which will improve the productivity of manufacturing/industrial engineers. This environment would be used by engineers to design and implement future manufacturing systems and subsystems. the work which is currently underway at the United States National Institute of Standards and Technology (NIST) on computer-aided manufacturing system engineering environments is described. The NIST project aims to advance the development of software environments and tools for the design and engineering of manufacturing systems. The paper presents an overall vision of the proposed environment, identifies technical issues which must be addressed, and describes work on a current prototype computer-aided manufacturing system engineering environment.

Mitchell, M. J., "AP Validation Workshop," NISTIR 5107, January 1993.

During the course of the ISO/IPO meeting held in Seattle, Washington, in April of 1992, a one-day workshop was held on AP validation requirements and procedures. Included in this workshop were representatives from all approved AP projects and planning projects. the goal of this workshop was to reach consensus on AP validation and conformance testing requirements. The objectives were to establish qualifications criteria for AP validation reports; to discuss lessons learned from initial AP validation activities (i.e. AP requirements validation, ARM validation, and AIM validation); to discuss the proposed improvements to the AP Development and Approval Guidelines; to examine completeness requirements for AP conformance testing; and to discuss the relationships between the components of the AP documents.

This document is an informal record of the proceedings, including the call for participation; the objectives, expectations,a nd agenda for the workshop; transcripts of presentations; a workshop summary and resulting recommendations,a nd a list of attendees. Presentations included:

Guidelines on Writing Standards Within STEP, Nigel Shaw, British Aerospace
Status for AP Methods and Documentation, Mark Palmer, NIST
Model Quality Criteria and Metrics Status, Roger Stumps, Boeing
Deploying the Voice of the Customer, Kurudi Muralidhar, ITI
What Information is Required in APs to Ensure Compatible Information Exchange, Jon Aas, FEGS Ltd.
Common Methods for PDES, Inc., Steve Ryan, PDES, Inc.
Developing and Validation Marine Industry Application Protocols , Kent Reed, NIST
The Roles of Mapping Tables and Conformance Test Purposes in STEP Application Protocols, Julian Fowler, CADDETC

Mitchell, M. J.,"STEP Quality System: Action Plan and assessment of Practices," NISTIR 5300, November 1993.

This describes a plan for establishing a quality systems throughout ISO TC184/SC4. SC4 is responsible for the development of ISO 10303 - Product Data Representation and Exchange. The goal of the proposed quality systems is to ensure the high-quality draft standard are developed to meet industry needs. This paper also provides and assessment by the existing quality practices within SC4 with the objectives of defining a baseline for the quality inspection system in which all draft specifications are reviewed against documented quality criteria. A plan for extending the defined quality criteria to address all aspects of STEP is also presented.

Moncarz, H.T., and **Lee, Y.T., "Report of Scoping the Apparel Manufacturing Enterprise,"** NISTIR 5106 and also published in the *Journal of Clothing Science Technologies*, issue 4/5, 1993.

This paper identifies a set of manufacturing data interfaces that could be standardized for the effective computer integration of the information required to operate an apparel manufacturing enterprise. The interfaces are called Application Protocols. A method is described to use pieces of information, referred to as Unites of Functionality, as building blocks for designing Applications Protocols.

Morris, K.C., "Data Probe: A Tool for EXPRESS-based Data," published in the proceedings of the 7th Annual Engineering Database Symposium - ASME Computers in Engineering Conference - San Diego, CA, August 1993.

The problem of sharing data has many facets. The need to share data across multiple enterprises, different hardware platforms, different data storage paradigms and systems, and a variety of network architectures is growing. The emerging Standard for the Exchange for Product Model Data (STEP), being developed in the International Organization for Standardization (ISO), addresses this need by providing information models, called application protocols, which clearly and unambiguously describe data. The validity of these information models is essential for success in sharing data in a highly automated engineering environment.

This paper describes the Data Probe: a tool for examining, editing, and managing EXPRESS-based data. The Data Probe tool supports the validation of STEP application protocols. The paper includes a description of the software architecture, the initial implementation, and plans for future enhancements. The software is designed as independent components which can be incorporated into other STEP-related systems or software requiring general purpose editing tools for structured information.

Morris, K.C., Mitchell, M.J., and **Feeney, A.B., "Validating STEP Application Models at the National PDES Testbed,"** NISTIR 5196, May 1993.

The problem of sharing data has many facets. The need to share data across multiple enterprises, different hardware platforms, different data storage paradigms and systems, and a variety of network architectures is growing. The emerging Standard for the Exchange of Product Model Data (STEP), a project of the International Organization for Standardization (ISO), addresses this need by providing information models which clearly and unambiguously describe data. These models are organized into application protocols. An application protocol addresses the data sharing needs for a particular application area. STEP integrates the information requirements from all the application protocols. the validity of these information models is essential for success in sharing data in a highly automated environment.

This paper describes how information models will be validated in the National PDES Testbed at the National Institute of Standards and Technology, (PDES, Product Data Exchange using STEP, is the U.S. effort in support of the international standard.) Application model development and testing is a complex process which involves synthesizing, analyzing, and manipulating large amounts of diverse information. Most of the process relies exclusively on human capabilities for analysis s, judgment, and interaction; however, part of this process can and should be automated. A strategy for automation is based on an analysis of the flow of information in the model development and testing process and initial experiences with automation for validation testing at the National PDES Testbed.

Morris, K.C., "Position paper for "Workshop on Application Integration Architectures," Published in the proceedings of ???????????

This paper summarizes:

- The work that is currently being done within ISO 10303
  (a.k.a. STEP- ISO/TC184/SC4)

- The needs for data access and sharing in manufacturing and engineering
  environment, and

- the role of the STEP Standard Data Access Interface for sharing data.

Particular emphasis is given to the STEP Standard Data Access Interface since coordination with other standards is especially important for applications using this interface. The paper is intended to describe these topics as a basis for discussion at the Workshop on Application Integration Architectures at Texas Instruments.

Ray, S.R., "A National Testbed for Process Planning Research," NISTIR 5169, April 1993.

The National Institute of Standards and Technology is in the process of establishing a testbed which will serve the research and information needs of the process planning community. This testbed is building up four primary services designed to facilitate process planning research: information services, workshops, a testing and integration laboratory, and a collaborative research program. Each of these services is described, along with their motivation and expected impact.

Ray, S.R., "Proceedings of the 1993 Industrial Process Planning Workshop," NISTIR 5284, October 1993.

On June 17-18, 1993, the National Institute of Standards and Technology (NIST) sponsored an information-gathering workshop focused on identifying the principal challenges and opportunities in manufacturing process planning from the perspective of today's discrete parts manufactures. There were a total of twenty-three attendees at the workshop, with six attendees representing software/system vendors, fourteen representing manufacture/contractors, and three from government organizations. Additional NIST employees also attended the workshop.

The workshop focused on three major themes related to process: functionality of process planning systems, the integration of these systems into the larger manufacturing system environment, and the obstacles to and opportunities for the introduction of new technologies for process planning.

Sauder, D.A., "Data Probe Users Guide," NISTIR 5141, March 1993.

Data Probes are software tools build using the emerging international Standard for the Exchange of Product Model Data -- commonly referred to at STEP. A Data Probe is created, edit, or view data that conforms to the specification found in the information model from which it is created. It is also used to conveniently view information model.

Data Probe was built at the National Institute of Standards and Technology to assist in the development of STEP. A Data Probe may, however, be used by anyone that wishes to create and edit data corresponding to an information model. Data Probe is available as public domain software.

This document explains what Data Probes are, discusses what is involved in creating a Data Probe, explains how to run a Data Probe, and provides a detailed explanation of the commands needed to use a Data Probe.

Wallace, S.E., Senehi, M.K., Barkemyer, E., Ray, S.E., and **Wallace, E.K., "Manufacturing Systems Integration Control Entity Interface Specification,"** IR 5272, September 1993.

The major activity of the National Institute of Standards and Technology (NIST) Manufacturing Systems Integration (MSI) project is the development of an open architecture that incorporates an integrated production planning and control environment with provisions for the detection and recovery from anomalous situations. This document defines the details of the interfaces for control entities (schedulers and controllers) which are incorporated into an integrated system that conforms to the NIST MSI architectural model as revised in 1992.