U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology

NISTIR 4914

National PDES Testbed
Report Series

Status Report for Second Quarter, FY92

(1 January Through 31 March 1992)

Howard M. Bloom

NATIONAL PDES TESTBED™

October 9, 1992

NIST

NISTIR 4914

National PDES Testbed Report Series

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U.S. Department of Defense

CALS Evaluation and
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The Pentagon
Washington, DC 20301-8000

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Chief, Factory Automation Systems Division
Manufacturing Engineering Laboratory
National Institute of Standards and Technology

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Foreword

As a new century draws near, an emerging information standard will play a key role in making manufactured goods more affordable to develop, buy, and own. Internationally, the standard is known as **STEP** (**ST**andard for the **E**xchange of **P**roduct Model Data). Domestically, the country's collective efforts supporting STEP's development are referred to as **P**roduct **D**ata **E**xchange using STEP, or **PDES**.

Once STEP is in place, manufacturers and governments the world over will share a comprehensive rulebook for describing products digitally and passing these descriptions instantly across a broad range of computer hardware and software platforms. The product model will describe the product's form and function, from conception through consumption.

This standard will be a key by which the defense community will integrate the diverse product information systems used in design, manufacturing, and logistics. Such sweeping integration is the goal of the ambitious U.S. Department of Defense (DoD) initiative, **C**omputer-aided **A**cquisition and **L**ogistic **S**upport (**CALS**).

Since 1988, a number of STEP's components have been tested at the National PDES Testbed (NPT), located in Gaithersburg, Maryland at the National Institute of Standards and Technology. Funded chiefly by DoD's CALS Evaluation and Integration Office (CEIO), the Testbed staff . . .

- **validates** data models, specifications, and draft standards,
- **develops** conformance testing methods and supporting software tools,
- **develops** prototypes of STEP application protocols (APs),
- **distributes** interim STEP specifications, and
- **transfers** technology, through Testbed demonstrations, guest researcher programs, and technical reports.

This status report—the second in a series—summarizes the activities of the Testbed during the second quarter of the U.S. Government's 1992 fiscal year (2Q92). The quarter ran from 01 January through 31 March 1992.

The purpose of this report is to inform the CEIO of the Testbed's 2Q92 accomplishments. For convenience, the technical status sections (2.0 through 5.0) correspond with the Testbed's *FY92 Statement of Work.* While technology transfer is addressed throughout these sections, Section 6.0 ("Education and Technology Transfer") describes how Testbed personnel have conveyed the importance of product data standards to Governmental and industrial decisionmakers. Acronyms and abbreviations used in the report are spelled out—and selected terms clarified—in an appendix. ■

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Executive Summary

IN FEBRUARY the International Organization for Standardization (ISO)'s "STEP subcommittee" (TC184/SC4) voted to issue an Initial Release of STEP (STandard for the Exchange of Product Model Data) at year's end. Recognizing that this would be a critical milestone for STEP's success, the Testbed team agreed to take a leading role in meeting this target. An *Initial Release Plan* was developed by a NIST staff member. The *Plan* outlined critical steps to be performed by several teams.

Application Protocol Methods and Development: The two projects that fall in this domain are developing (1) a structure within which to classify application protocols (APs), define their scope and boundaries, specify required relationships between APs, and prioritize and plan AP projects; and (2) an AP (Shape Tolerance) that is a prerequisite for later Parts of STEP.

The Application Protocols Framework and Methodology (APFM) project delivered two documents: Version 1.0 of *Guidelines for the Development and Approval of STEP Application Protocols*, and *Issues and Recommendations for a STEP Application Protocol Framework*. The APFM project manager presented summary reports and recommended actions to TC184/SC4 and the National Initiative for Product Data Exchange on the issues confronting the planning and management of the development of STEP APs. SC4 adopted these recommendations, including: (1) revise the AP planning process; (2) analyze the requirements for coordinating and qualifying APs developed outside SC4; and (3) define STEP's relationship to the Open Systems Interconnection (OSI) Reference Model and an Open Systems Environment (OSE).

Following an analysis of existing national and international "product classification" systems and relevant information architectures, a prototype AP domain classification system was developed for the AP Framework. This classification system would be used by the National Initiative for coordinating the planning and development of different APs. An initial draft of the *Application Protocol Qualification Manual* was completed and was used for qualifying the first STEP draughting AP. (*For details, see Section 2.1.*)

Recommended changes to the Shape Tolerance Model (Part 47) for completion and harmonization were made by the manager of the Application Protocol for Inspection Planning project. Subsequently, these findings were released, detailing the steps that would need to be taken to harmonize the Shape Tolerance Model with existing tolerancing standards. In Europe, a teaming agreement with German counterparts was finalized. (*For details, see Section 2.2.*)

Technical Support for Standards Bodies: Under these projects, NIST provides management and technical staff to support ISO and IPO (the IGES/PDES Organization) and maintains a central repository of STEP software and documents in their various stages.

NIST staff members were selected to lead the STEP Initial Release Team, the Part Qualification and Validation Project, and the task to compile the EXPRESS portions of the twelve initial Parts. Testbed staff continued to lead a number of ISO Working Groups (WGs), conduct training seminars and workshops, and participate in technical committees and advisory groups. The APFM manager continued his responsibilities as the AP Coordinator for STEP, as the leader of SC4/WG4's (Qualification and Integration)'s AP Guidelines and Framework Project, and as a participant in the work on the STEP Initial Release documents. (*For details, see Section 3.1.1.*)

NIST staff led IPO's review and enhancement of STEP's Shape Tolerance Model, reviewed IPO comments on STEP Part 31 (Conformance Testing Methodology & Framework: General Concepts), and hosted the quarterly meeting of the IPO Steering Committee. NIST staff continued to lead ISO technical efforts, particularly those that contribute to the STEP Implementation Specifications. The draft specification for the STEP Data Access Interface (SDAI—Part 32) was enhanced and presented for comment in Oslo at February's IPO/ISO joint meeting. (*For details, see Sections 3.1.2, 3.1.3, and 3.3.*)

Under NIST funding, a representative from NIST's Electrical and Electronics Engineering Laboratory led an SC4/WG3 project on Product Functionality. That project is specifying an application protocol that will allow engineers to design electronic and electrical products in a way that allows them to be rapidly produced in small quantities. (*For details, see Section 3.3.*)

Technical Coordination With Industry: These efforts provide management and technical support staff for programs and activities of the PDES, Inc. consortium.

At meetings of the STEP Draughting Team, NIST's representative helped resolve longstanding harmonization issues between the two drafting application protocols. At a NIST-hosted meeting, PDES, Inc. participants defined several needs of the AP concerning process planning for automatically machined parts. NIST continued to support PDES, Inc.'s software development efforts by contributing a new version of the NIST EXPRESS compiler, Fed-X. NIST's Electrical & Electronics Engineering Laboratory supported two product data standards for electrical product design: EDIF-PCB and MMACE. (*For details, see Section 4.0.*)

Testing: These projects define the requirements and procedures for the verification, validation, and conformance testing of elements of the emerging STEP standard and the resulting system implementations.

The Validation Testing System (VTS) software tools were updated to the ISO Committee Draft version of Part 21 (Clear Text Encoding of the Exchange Structure). The VTS team continued developing the Data Probe—a software tool that enables AP developers to "populate" and edit STEP-based Parts. The Data Probe entered alpha testing. In conjunction with PDES, Inc., the VTS project evaluated two object-oriented database tools for use in the VTS software. (*For details, see Section 5.1.*)

The Conformance Testing Services project led several initiatives to support SC4's Conformance Testing Procedures working group. A team member visited the U.K.'s STEP testing center to discuss conformance testing for STEP and IGES (Initial

Graphics Exchange Specification). A Cooperative Agreement began with the Industrial Technology Institute, funded by Navy ManTech. (*For details, see Section 5.2.*)

The process of testing the quality and utility of STEP must include implementing STEP-based applications. Fundamental software implementation tools, such as the Fed-X compiler, and specifications, such as the STEP Data Access Interface (SDAI), are specifically identified as part of the STEP Implementation Tools project. These tools, essential for supporting validation testing and conformance testing, will also be useful when industry proceeds to implement STEP-based applications. During this quarter NIST continued to work with PDES, Inc. in developing the specification for the SDAI. In the STEP Implementation Tools project, a report describing considerations for a special class of STEP data translation was released. (*For details, see Section 5.3.*)

Education and Technology Transfer: Tours of the Validation Testing Laboratory were given to a U.S. Senator and to visitors from the Australian Army. Technical reports were published on conformance testing, tolerancing, the AP Framework, and STEP Implementation Tools. (*For details, see Section 6.0.*)

Management and Administrative Support: There were no changes in Testbed management or technical staff. S. Jeane Ford was chosen as the new manager of the National PDES Testbed, with an official starting date of 4 May. (*For an organization chart, see Section 7.0.*)

Travel Coordination and Operational Support: Staff traveled to technical meetings to interface with other members of the STEP community in IPO, ISO, and PDES, Inc. Testbed Support project staff began coordinating with PDES, Inc. to ensure that the configuration, directory structure, and user interface of PDES, Inc.'s STEP testing facilities and NIST's would be as similar as possible so that users could easily alternate between them. Toward this end, the Testbed's Validation Testing Laboratory began supporting another major computer platform. (*For details, see Section 8.0.*) ■

Manager's Message

"WHILE GOVERNMENT may have a relatively small interest in the development of certain product standards, its stake in others, such as interoperability, will be high. . . . In an information-based global economy, where standards . . . serve to interconnect economic activities, inadequate support for the standards setting process will have detrimental effects."

So concluded the U.S. Congress's Office of Technology Assessment (OTA) in a recently issued report, *Global Standards: Building Blocks for the Future* (Government Printing Office: TCT-512, March 1992). Interoperability, says the OTA, will become more problematic, both technologically and administratively. Yet, warns the OTA, while the need for interoperability will become more urgent, achieving it will likely become more difficult.

This growing divergence hardly comes as news to the Department of Defense. It is the reason DoD has consolidated the CALS thrusts of three services under a single program, JCALS—*Joint* Computer-aided Acquisition and Logistic Support.

During the remainder of FY92, the Testbed's technical plan and objectives will be revised to incorporate the requirements and priorities of JCALS. As a significant CALS contributor with interests in commerce and standards, NIST is working to make industry and standards groups aware of the steps JCALS will take to drive procurement strategies and interoperability.

In January, for example, the Department of Commerce launched the National Initiative for Product Data Exchange. Headquartered at NIST, the Initiative is working to ensure that JCALS requirements will be met by the Initiative's roadmap. The Initiative and Testbed staffs coordinate to leverage CALS resources.

Indeed, support of JCALS is a key objective on the Testbed's agenda. For Fiscal Year 1993, we have set six JCALS-driven objectives:

- With the Initial Release of STEP scheduled for January 1993, make testing the top priority. We must maintain a strong link between validation testing and conformance testing, develop a library of STEP test parts, and give industry the tools it needs to develop application protocols (APs).

- Create a **roadmap for developing APs** to support JCALS functions. JCALS requirements must be met by STEP if STEP is to be used effectively as the data-sharing kernel in DoD's Integrated Weapon System Database (IWSDB) and Engineering Workstation.

- Harmonize STEP with the developing standard for communications protocols, **OSI** (Open Systems Interconnection).

- Harmonize STEP with the related CALS business-data standard, **EDI** (Electronic Data Interchange).

- Align STEP's direction with the needs of the **JC-FCIM** (Joint CALS Flexible Computer-Integrated Manufacturing) facilities.

- Recognizing that STEP will help manufacturers design versions of their products for the military *and* commercial markets, assist in forging a stronger partnership between the Departments of Commerce and Defense.

Strategically, the most important goal of FY93 is the Initial Release of STEP. Meeting ISO's self-imposed deadline will require long hours. The task ahead is imposing, but not impossible. When the 12 Parts of the Initial Release are issued, the JCALS community will have a tangible product data standard from which to work.

Development and testing of these and additional Parts are proceeding on schedule. Two application protocols—Explicit Draughting (AP 201) and Associative Draughting (AP 202)—are on schedule. Meanwhile, Configuration Controlled Design (AP 203) is being implemented in a number of PDES, Inc. companies. Both 201 and 203 are included in the Initial Release.

When asked in February to lead STEP's Initial Release Team and Qualification & Validation Project, NIST was pleased to accept. In a sense, these roles formalize the key contributions that NIST staff have made to the international standards community. Testbed members have played key roles in working groups of TC184/SC4—the ISO subcommittee implementing STEP.

In *Global Standards* (p. 91), the OTA authors noted, "If U.S. companies—large and small—are to have access to the European market, the United States must provide greater support for international standards organizations." At NIST, is our belief that in giving an American voice to the international product data standard, we will help CALS-compliant vendors win a greater share of the global market. ■

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Acknowledgments

This quarterly report was compiled from internal monthly status reports and other documents written by the project managers of the National PDES Testbed:

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Mr. James E. Fowler	STEP Implementation Tools
Ms. Cita M. Furlani	Conformance Testing Services; IPO/ISO Support
Ms. Susan Katz	Configuration Management Systems and Services
Mr. Scott Paisley	Testbed Support
Mr. Mark E. Palmer	Application Protocols Framework and Methodology
Mr. Sanford Ressler	Validation Testing Systems

Eleven others contributed materially to this report:

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Ms. Gaylen Rinaudot	Integrated Systems Group, Factory Automation Systems Division
Dr. John R. Rumble	Standard Reference Data Program
Mr. Paul Stregevsky	National PDES Testbed, Factory Automation Systems Division ■

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1.0 Introduction

ACROSS THE WORLD, hundreds of individuals are working to develop an ambitious international standard to describe manufactured goods in digital form. Internationally, the standard is known as **STEP** (**ST**andard for the **E**xchange of **P**roduct Model Data). Domestically, efforts toward STEP are collectively known as **PDES** (**P**roduct **D**ata **E**xchange using **S**TEP).

Within PDES, much of STEP's development, testing, validation, and coordination comes together at the National PDES Testbed (NPT), located at the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland. When the Testbed was created in 1988, its focus was fixed squarely on PDES, which then stood for Product Data Exchange Specification. There were two objectives:

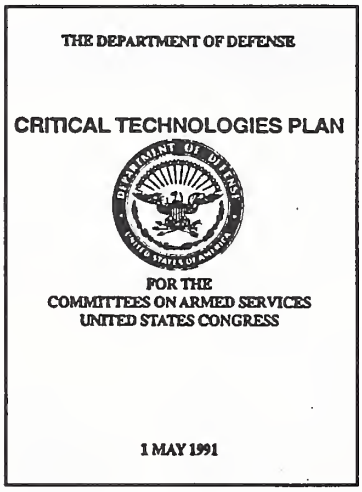
- Test STEP.
- Help develop STEP-compliant software.

These original objectives remain. But as the Department of Defense (DoD) has moved forward in **CALS** (Computer-aided Acquisition and Logistic Support), a second focus has emerged. In that focus, the Testbed recognizes that the STEP product data standard will be the backbone supporting many CALS functions. As such, STEP must be sufficiently robust to meet the multifaceted needs of the U.S. armed forces and their contractors.

Viewed in this light, STEP—and the National PDES Testbed—are CALS cornerstones. Yet, the same might be said of scores of other CALS projects. Recognizing the need to set priorities, in 1991 DoD established the CALS Evaluation and Integration Office (CEIO). In so doing, DoD underscored that the CALS projects must yield maximum benefit, with minimum redundancy.

Subsequently, NIST refocused the Testbed's strategy to strengthen its support of three CALS strategic objectives:

- **Reduce lead time,** by using a shared data environment.
- **Reduce cost,** by eliminating duplicate data and providing accurate digital technical information.
- **Improve quality,** by ensuring data consistency to support the application of powerful tools of computer-aided design (CAD) and computer-aided engineering (CAE).


THE DEPARTMENT OF DEFENSE

CRITICAL TECHNOLOGIES PLAN

FOR THE
COMMITTEES ON ARMED SERVICES
UNITED STATES CONGRESS

1 MAY 1991

STEP will play a critical role in meeting these objectives. STEP also will be a key standard for meeting the Flexible Manufacturing milestones set forth in DoD's *Critical Technologies Plan* (1 May 1991). According to those milestones, by 1996 DoD is to have in place a STEP-based provisioning system that will rapidly make-to-order machined mechanical parts, as diagrammed in **Figure 1-1**.

But before this scenario can take shape, certain pieces of CALS must fall in place. That was the conclusion of the *CALS Architecture Study* (June 1991), which cited two technological concerns:

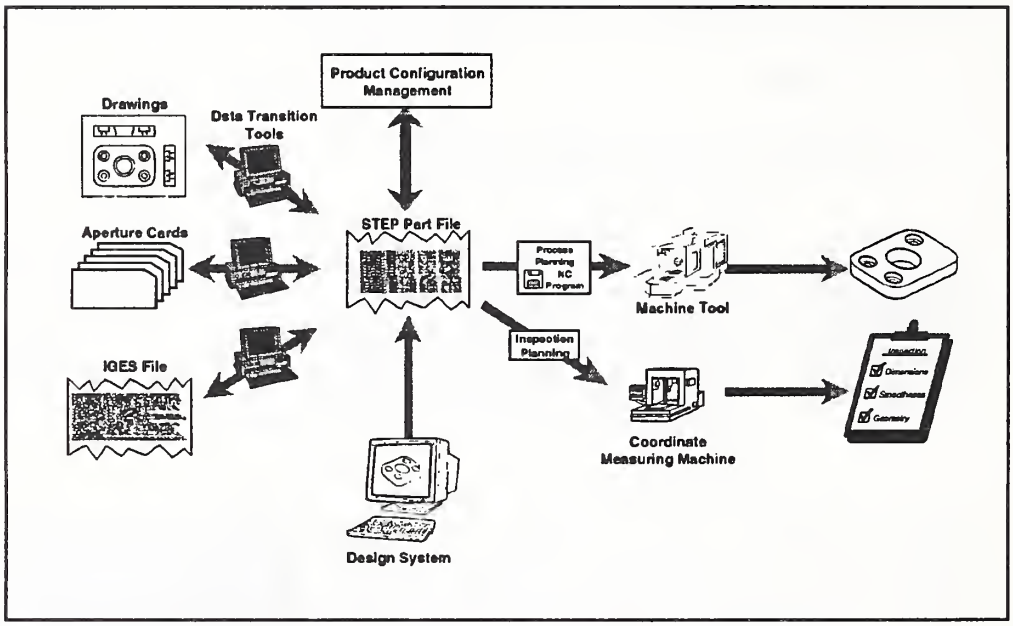


Figure 1-1. DoD's *Critical Technologies Plan* calls for STEP-based mechanical-parts product data systems by 1996.

- Testing methodologies are inadequate.
- Standards critical to CALS (particularly, STEP) are not yet fully developed.

and made four recommendations:

- Develop a full set of product data user requirements.
- Develop standards as a harmonized package, interfacing with existing and emerging information technology standards, as appropriate.

- Provide **conformance testing** to validate vendor claims.
- Develop **data models**, for these are critical to standardization.

Anticipating these concerns, the National PDES Testbed has been working closely with key parties participating in the development of STEP. The coordination has four thrusts:

- **Work with DoD and other Government agencies** to ensure that requirements are developed to meet the nation's needs.
- **Work with industry**—through memoranda of understanding (MOUs) and Cooperative Research and Development Agreements (CRADAs)—to ensure that STEP is accepted and implemented.
- **Work with national and international standards organizations** to ensure that STEP standards are adopted in a timely and useful manner and meet DoD requirements.
- **Take the lead** in developing the testing methodologies and services to support the development of STEP.

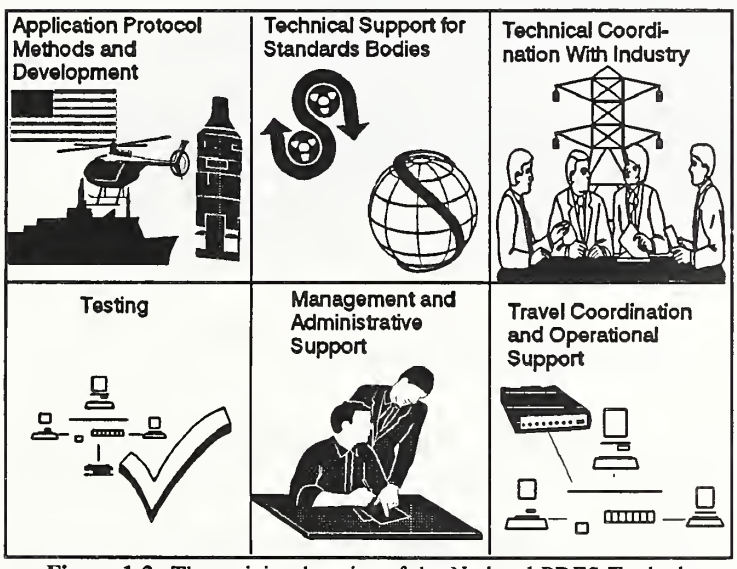


Figure 1-2. The activity domains of the National PDES Testbed.

The organization shown in **Figure 1-2** supports these four thrusts while ensuring that the Testbed receives adequate coordination and technical support.

The Testbed has six overall goals:

- Develop a proven **methodology** for delivering effective STEP application protocols (APs).
- Develop a set of quality **APs** to meet the roadmap of the DoD *Critical Technologies Plan.*
- Put in place **procedures for testing** whether vendor software conforms with STEP.
- Ensure that STEP APs support the JCALS data model and the IWSDB (Integrated Weapon System Database).

- Provide for **legacy data**—data that predates the STEP standard.
- Build a **network of DoD facilities** developing experience with STEP.

Brief Overview of the STEP Technology and Standards

Figure 1-3 illustrates the building blocks that represent the STEP methodology. End-user community requirements are converted into **application protocols**, referred to as APs, that define an application's scope (such as process planning for machined mechanical parts), the information to be exchanged between the application and a

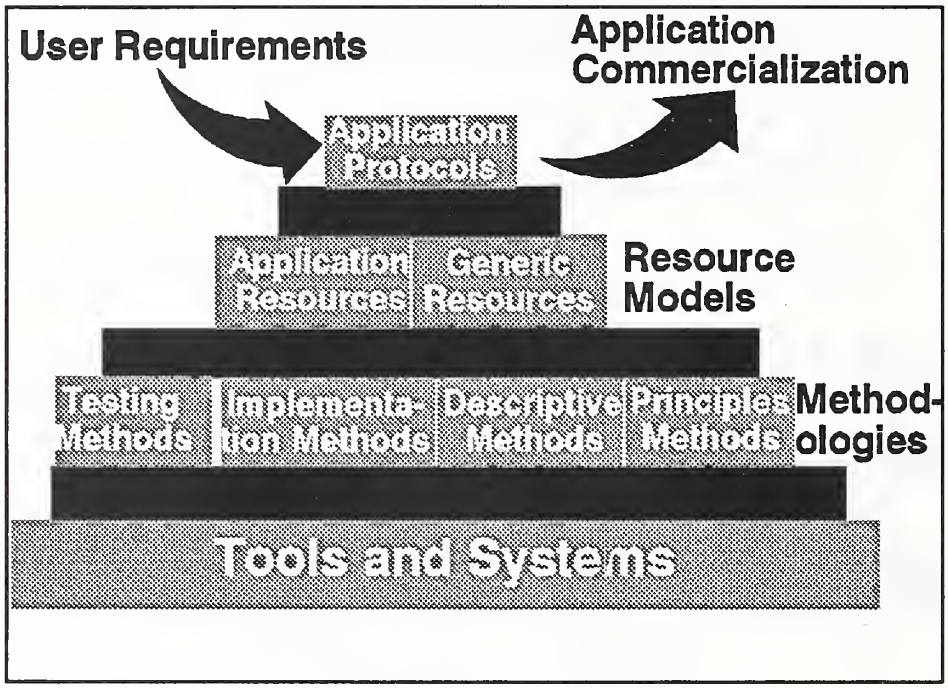


Figure 1-3. STEP Building Blocks.

data repository (such as a file or shared database), and conformance specifications to help the STEP developers implement the AP correctly.

The APs become Parts of STEP that systematically increase its capability. They are built upon **resource models** that define a generic set of basic product information entities across a specified set of resources (such as tolerance and geometry) and applications (such as drafting). The APs (and, in turn, the resource models) are being developed according to a set of rules that are specified within four methodology categories:

- **Testing methods** define the requirements and procedures for the verification, validation, and conformance testing of the emerging standards and the resulting system implementations.
- **Implementation methods** define the means in which the information expressed through the standard is actually managed when implemented in an application.

- **Descriptive methods** define the manner in which the standard is specified. Information modeling is the key method, and a special information modeling language, EXPRESS, is to become a standard itself (as Part 11).

- **Principles methods** are the basic set of techniques for the development of the entire set of STEP Parts.

For each method, there is a corresponding set of Parts. The collection of APs, resource models, and methods makes up the evolving STEP standard.

The bottom building block, "Tools and Systems," is not part of the actual standard, but instead provides support functions for standards activities. Included in this category are items such as configuration management systems; software tools, such as editors and compilers; and computer support systems.

The STEP strategy is to define a framework for classifying application protocols so that a "roadmap" for implementing STEP can be published that describes levels of functionality (in terms of the product life cycle, product type, and other criteria). The Initial Release of STEP will have, as a minimum capability, file exchange for drafting information (where tolerancing and dimensioning are considered symbols rather than variables associated with the product geometry), and configuration control of design data.

After this Initial Release, strong consideration will be given to producing a collection of APs that replaces all the functionality of IGES (Initial Graphics Exchange Specification). Over FY92, the STEP community is creating a modular approach for STEP's release that will allow manufacturers to implement STEP incrementally. Development of this approach is being coordinated through the National Initiative for Product Data Exchange. ■

2.0 Application Protocol Methods and Development

Summary

The Application Protocols Framework and Methodology (APFM) project delivered two documents: Version 1.0 of Guidelines for the Development and Approval of STEP Application Protocols and Issues and Recommendations for a STEP Application Protocol Framework. Related Air Force projects were reviewed and the findings shared with industry. National and international projects on digital product data were reviewed for ideas useful to the AP Framework. Based on analysis of existing national and international "product classification" systems and relevant information architectures, a prototype AP domain classification system was developed for the AP Framework.

A draft of the Shape Tolerance Model (Part 47) was completed and reviewed by IPO and ISO. In Europe, a teaming agreement with German counterparts was finalized for the Inspection Planning AP. Findings on the need to harmonize the Shape Tolerance Model with existing tolerancing standards were released.

THE TWO PROJECTS that fall in this domain are developing (1) a structure within which to classify application protocols, define their scopes, specify how specific APs must relate to others, and prioritize and plan AP development projects; and (2) a tolerance AP that will be needed to complete key Parts of STEP.

2.1 Application Protocols Framework and Methodology

Note: A detailed explanation of the AP methodology is provided in *Guidelines* document discussed below.

During the quarter, Version 1.0 of the *Guidelines for the Development and Approval of STEP Application Protocols* was released by this project. It is available on the STEP On-Line Information Service (SOLIS) in the "ap-guide" directory as WG4 document N34; by calling the IGES/PDES Organization (IPO) at (301) 975-3982; by contacting the IPO office on Internet at andrews@cme.nist.gov; or by writing to:

IPO Office
National Institute of Standards and Technology
Metrology Building, Room A127
Gaithersburg, MD 20899.

Task 1: Develop STEP Application Protocols Framework

Related programs reviewed—During the first quarter, project members finished analyzing the technical issues that face the planning and management of the development of STEP application protocols. These results were documented in NISTIR 4755, *Issues and Recommendations for a STEP Application Protocol Framework*, and in a summary report for Subcommittee 4 (SC4—Industrial Data and Global Manufacturing Programming Languages) of Technical Committee 184 (TC184—Industrial Automation and Integration) of the International Organization for Standardization (ISO). This summary report was presented at the February meetings of SC4. The subcommittee went on to adopt the report's recommendations.

Two other documents were reviewed:

- the new Committee Draft of ISO/IEC 7498-1, *Information Technology—Open Systems Interconnection Reference Model*
- the new draft amendment for ISO/IEC 9545, *Information Technology—Open Systems Interconnection Application Layer Structure, Amendment 1: Extended Application Layer Structure.*

One conclusion from this study was that there is a need to define how STEP relates to the Open Systems Interconnection (OSI) Reference Model and to an Open Systems Environment (OSE). The results of this investigation were presented to the NIST-wide Product Data Exchange Task Group and to representatives of SC4's Working Group 7 (Implementation Specifications).

Starting in 1Q92, a number of related projects were studied for ideas relevant to the AP Framework; these projects are listed in **Table 2-1.** In 2Q92, the project team collected documents on the DoD CALS Architecture, DoD technical standards for command and control information systems, and TC184's Subcommittee 5 (Framework for CIM System Integration). Initial reviews of these documents were completed. Project staff met with the Air Force PAS-C program (PDES Application Protocol Suite for Composites) and the PDES, Inc. Electrical Project to analyze requirements, relevant ideas, and methods for the AP Framework.

A strategy for classifying AP domains was developed. It is based on an analysis of four existing national and international "product classification" systems and relevant information architectures. The prototype AP classification system is being tested by staff of the National Initiative for Product Data Exchange (NIPDE) as a basis for their project coordination activities.

Project manager Mark Palmer continued to fulfill the responsibilities of the AP Coordinator for the ISO STEP project. He participated in the meeting of the Project Management Advisory Group (PMAG) to SC4. During the February meeting, Palmer proposed a two-stage planning process for planning and approving AP projects, along with the criteria for their approval. The PMAG ratified the two-stage process and used it to formally establish seven AP planning projects.

Table 2-1. R&D Projects Studied for *Application Protocols Framework and Methodology* in 2Q92.

Program/Sponsor	Project/Document
U.S. Department of Defense	
CALS	· *CALS Architecture Study* · CALS Data Classification Team · *Harmonizing CALS Product Data Description Standards* (Electronic Industries Association) · *A Survey of Technical Standards for Command and Control Information Systems* (IDA P-2457)
Navy	NIDDESC (Navy-Industry Digital Data Exchange Standards Committee)
Air Force	· EIP (Enterprise Integration Program) · EIS (Engineering Information System) · ICAM (Integrated Computer-Aided Manufacturing): ENG0, MFG0 · IDS (Integrated Data Strategy) · PAP-E (PDES Application Protocols for Electronics) · PAS-C (PDES Application Protocol Suite for Composites)
U.S. Private Sector	
General Motors	C4 (CAD/CAM/CAE/CIM) Program
PDES, Inc.	· Application Protocol Development and Test · Electrical/Electronics · Sheet Metal
International	
ESPRIT (European Strategic Programme for Research and Development in Information Technology)	· CIM-OSA (Computer Integrated Manufacturing—Open Systems Architecture) · COMBINE (Computer Models for the Building Industry in Europe) · IMPPACT (Integrated Modeling of Products and Processes using Advanced Computer Technology)
ISO	TC184/SC5 (Framework for CIM System Integration)
ISO/IEC	JTC1: ISO/IEC 10032—*Reference Model of Data Management*

Task 2: Test and Refine AP Methodology

Version 1.0 of the *Guidelines for the Development and Approval of STEP Application Protocols* was completed and distributed for review by IPO and ISO. Comments on Version 1.0 were received during March; a summary of the comments was prepared for the April ISO/IPO meeting. An initial draft of the *Application Protocol Qualification Manual* was completed and was used for qualifying the first STEP Draughting AP (Part 201).

The project manager continued serving as leader for the AP Guidelines and Framework Project of SC4's Working Group 4 (Qualification and Integration). He also participated in work on the STEP Initial Release documents.

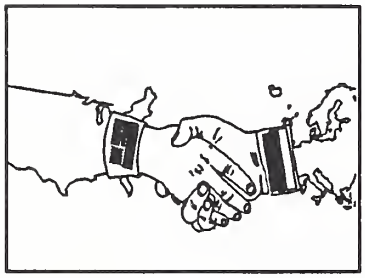
2.2 Application Protocol for Inspection Planning *(NIST-Funded)*

In 2Q92—this project's second quarter—the project team modified and enhanced the Shape Tolerance Model.

Shape Tolerance Model draft completed—The Shape Tolerance Model (STEP Part 47) captures the tolerance information in the existing ANSI (American National Standards Institute) and ISO standards. Project Leader Shaw Feng finished drafting the revision to this Part. At the January meeting of IPO/ISO, Feng presented his recommendations to the leaders of Tolerances Team (Working Group 3, Team 3) of SC4 and the leaders of the IPO Technical Committee on Tolerancing.

Feng will present the resulting consensus recommendations at the April meeting for approval by the ISO Committee. At quarter's end, these recommendations were being reviewed by ISO's Tolerances Team.

As a result of Feng's effort, the Shape Tolerance Model now embodies the information of virtually all existing ANSI and ISO tolerancing standards. Accordingly, it can be used to exchange data from drawings that are based on either or both of these tolerancing standards.



Trans-Atlantic worksharing agreement finalized—In 1Q92, at the IPO/ISO meeting in Houston, Feng had informally agreed to exchange information with his counterparts in ESPRIT (European Strategic Programme for Research and Development in Information Technology). In 2Q92, that agreement was formalized. Feng's team members at NIST, and their counterparts at the RPK Institute at Germany's University of Karlsruhe, will collaborate to develop the AP for Inspection Planning for STEP.

Part 47 EXPRESS enhanced—Most of the model's EXPRESS language was updated from version N439 to the new version, N14.

Harmonization report issued—Feng completed his investigation into the differences and similarities among existing tolerancing standards. His findings are documented in *Comparison of the ISO 10303 Part 47 Draft with ANSI and ISO Tolerancing Standards for Completion and Harmonization of Part 47* (NISTIR 4744). The report is available by requesting a copy on the Internet network at trager@cme.nist.gov, or write to:

CALS/PDES Office
National Institute of Standards and Technology
Metrology Building, Room A127
Gaithersburg, MD 20899 ■

3.0 Technical Support for Standards Bodies

Summary

When the ISO subcommittee developing STEP voted to schedule the Initial Release of STEP by January 1993, NIST staff were selected to lead the Initial Release Team, the Part Qualification and Validation Project, and the task to compile the STEP information modeling language, EXPRESS.

Testbed staff continued to lead a number of ISO working groups, conduct training seminars and workshops, and participate in technical committees and advisory groups.

NIST staff led IPO's review and enhancement of STEP's Shape Tolerance Model (Part 47) and reviewed comments on STEP Part 31 (Conformance Testing Methodology and Framework: General Concepts).

Under NIST funding, a NIST representative led an ISO Working Group 3 project on Product Functionality, which seeks to develop an application protocol by which engineers can design electronic and electrical military products for which spares could be rapidly produced.

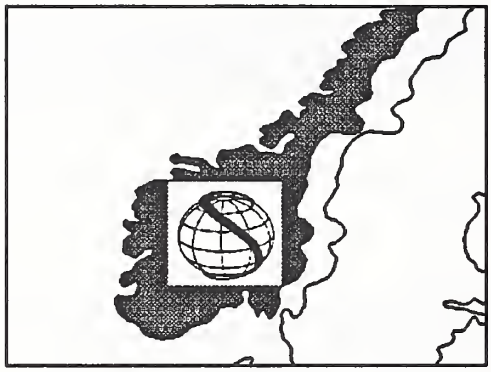
IPO/ISO SUPPORT AND Configuration Management play critical value-added roles for the entire PDES and STEP development efforts. Under these projects, NIST provides management and technical staff to support ISO and IPO and maintains a central repository of STEP software and documents in their various stages.

3.1 IPO/ISO Support (IIS)

With February's decision by ISO to make STEP a Draft International Standard (DIS) at year's end (discussed below in Section 3.1.1), IIS activity increased. Coordination responsibilities became especially heavy for the six Testbed members who chair committees of ISO or IPO.

3.1.1 NIST Leads Team Effort to Field STEP Initial Release

In February, NIST participated in the quarterly meeting in Oslo, Norway, of ISO Technical Committee 184, SC4. In Oslo, SC4's PMAG gave top priority to coordi-



nating changes to STEP's twelve Initial Release Parts. The goal of this effort, which began immediately, is to produce a high-quality DIS of STEP in the shortest time possible.

In Oslo, the STEP Initial Release Team was formed to oversee the release of DIS 10303—STEP's formal title—by 1 January 1993. Under the guidance of John R. Rumble of NIST's Standard Reference Data Program, the team identified three needs:

- Review all issues relating to **integration**—how the twelve initial Parts work together.
- Complete the **qualification**—the process of certifying that the Parts have been soundly written, as measured against an established set of criteria.
- Edit the Parts for uniform style and readability.

The response to these needs is diagrammed in **Figure 3-1.**

To guide participants, an eight-task draft *STEP Initial Release Plan* was released by the STEP PMAG. Under the *Plan*, the STEP standards community is coordinating more closely with subgroups and meeting frequently to ensure that the Initial Release is composed of a coherent, compatible set of twelve Parts (described in **Table 3-1**). As shown in Figure 3-1, two SC4 groups play key roles in the Initial Release effort: Qualification & Integration (Working Group 4) and the Editing Committee.

Testbed staff supported by the IIS project play critical roles in the Initial Release Team's success. NIST is coordinating the effort to compile the Initial Release of the STEP Parts. Representatives from the U.K., France, Germany, Japan, and the U.S. were instructed to identify errors, make temporary corrections only to allow for full compilation, and report on the results. In March, results were being returned to NIST for distribution to Integration and Part Editors.

The Testbed assumed responsibility for Task A25, "Compile EXPRESS." The role of Task Leader was accepted by Cita Furlani, manager of the IIS project and Product Data Engineering Group Leader in NIST's Factory Automation Systems Division.

The goal of Task A25 is to test whether the EXPRESS portions of the Initial Release can be computer-processed. By the end of the quarter, the Testbed had received results from four STEP Test Centers: NIST, STEP Tools, Inc. (Rochester, N.Y.); Association GOSET (France), and ProSTEP (Germany).

Two subtasks of A25 require Testbed support:

- Provide the correct EXPRESS models to the STEP testing

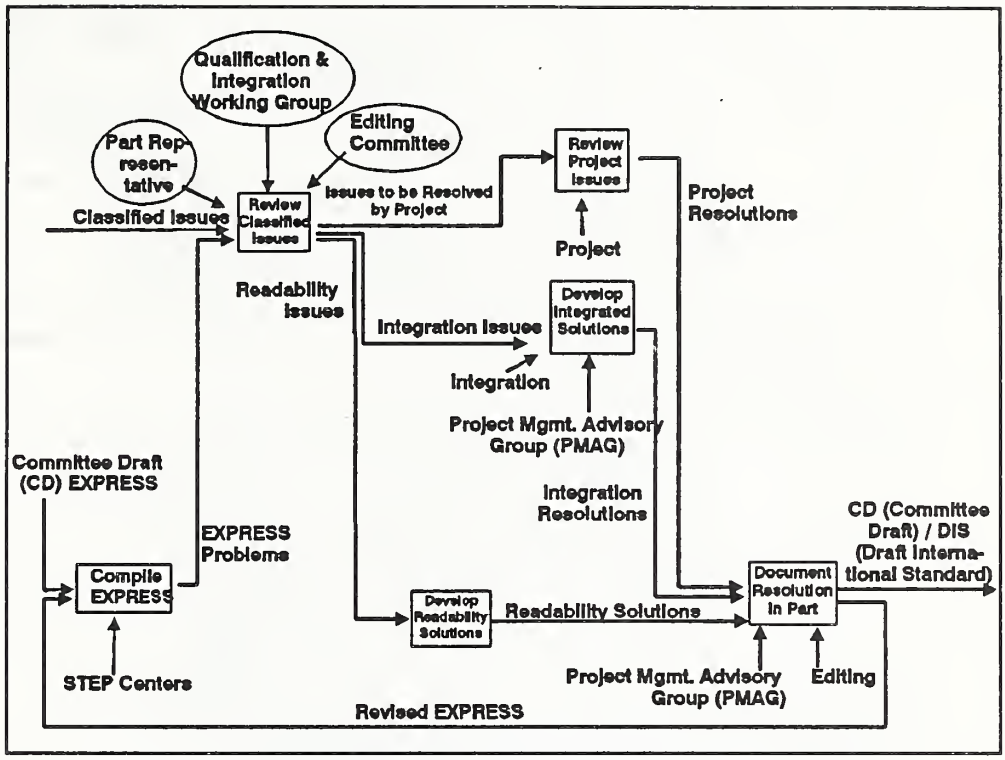


Figure 3-1. How the Initial Release of STEP will be integrated, qualified, and edited.

centers. Leading this subtask are Susan Katz, manager of the Testbed's Configuration Management Systems and Services project, and Selden Stewart, Integrated Systems Group Leader in NIST's Factory Automation Systems Division.

- Compile the models, using Fed-X, the National PDES Testbed's EXPRESS compiler.

Initial Release Team resolves ballot comments—On 24-28 February, WG4 met in Long Beach, California. NIST's Mary Mitchell led WG4's Part Qualification and Validation project, while NIST's Bill Danner helped WG4 members resolve ballot comments dealing with integration issues surrounding three 40-series Parts.

Later WG4 met at Leeds, U.K., resolving ballot comments for all remaining 40-, 100-, and 200-series Parts of the Initial Release.

NIST members were asked to contribute to other tasks, as well. The main contributors were John Rumble, Mary Mitchell, Cita Furlani, Bill Danner, and Mark Palmer.

Table 3-1. STEP Parts That Will Appear in the Initial Release.

No.	Name	What It Does
1	Overview and Fundamental Principles	Gives an overview of the Parts of the ISO 10303 (Industrial Automation Systems—Product Data Representation and Exchange) series of standards. Outlines the role of each Part class and the relationships between them. It is relevant to those who write ISO 10303 documents and provides introductory material and information to ISO 10303's implementers and users.
11	Description Methods: The EXPRESS Language Ref. Manual	Introduces the information modeling language to be used when defining models. Explains the elements of the EXPRESS language, presenting each element in its own context with examples. Defines the complete syntax of EXPRESS.
21	Clear Text Encoding of the Exchange Structure	Provides for mappings from EXPRESS schemas to a file-exchange implementation form.
31	Conformance Testing Methodology & Framework: General Concepts	Provides a foundation for the subsequent Parts in this class which establish conformance testing services.Conformance testing gives confidence that an implementation has the required capabilities and that its behavior conforms consistently. The standardization of *abstract test suites* requires international definition and acceptance of a common test methodology, together with appropriate test methods and procedures. It is the purpose of this class to define the methodology, provide a framework for specifying abstract test suites, and define the procedures to be followed during conformance testing.
41	Integrated Generic Resources: Fundamentals of Product Description and Support	Provides general-purpose resources that are available for use by APs, as well as sharable utility resources that are available for use by resource developers. Also, provides the overall organization for the integrated generic resources documented in other Parts. Specifies the high-level structure for the integrated resources.
42	Integrated Generic Resources: Geometric & Topological Representation	Specifies the integrated resources used to explicitly represent the shape or geometric form of a product model. The geometry section is concerned primarily with curves and surfaces; the topology section, with connectivity relationships rather than with an object's precise geometric form. The geometric shape models completely represent the shape; often, these shapes will include topological data. Also found are numerous geometric and topological functions and special enumerated data types needed for the geometric and topological entity definitions.
43	Integrated Generic Resources: Representation Structures	Specifies the integrated resources used for structuring representation into collections of geometric representation that can be distinguished from each other, providing a basis for distinguishing which elements of geometric representation are geometrically related from those that are not. Also, provides a mechanism for distinguishing the logical components of a swept solid as referenceable geometric elements.
44	Integrated Generic Resources: Product Structure Configuration	Maintains the information needed to manage a product's structure and the configuration of that structure. Captures information concerning the hierarchical structure of a product and interchangeability of similar parts. Supports all product categories, such as *mechanical*, *electrical*, *architectural*, and *software*. Allows vendors to maintain multiple design versions, bills of material, and parts lists through successive stages of product development.
46	Integrated Generic Resources: Visual Presentation	Specifies the generic resources used for the description, presentation definition, presentation appearance, and presentation resource definition.
101	Integrated Application Resources: Draughting	Establishes the resource structures, entities, and relationships necessary to accommodate, preserve, and exchange product definition data supporting the draughting function, as semantically defined in a Draughting application protocol.
201	Application Protocol: Explicit Draughting	Specifies the information requirements for two-dimensional, geometrically explicit computer-aided-design (CAD) drawings that contain explicit annotation.
203	Application Protocol: Configuration-Controlled Design	Specifies the structure for exchanging configuration-controlled three-dimensional product-design data. The focus is on mechanical parts and assemblies between an enterprise's application systems. In this context, *configuration* comprises only data and processes that control the 3D product-design data. Included are data pertaining to the shape representation, configuration control, and description of the bill-of-material structure of a product within its design phase.

3.1.2 Task 1: Support ISO Development Activities

During this quarter, Testbed staff supported by this project have . . .

- **continued serving as Convener of SC4's WG5, "STEP Development Methods," and Co-Chair of IPO's "PDES Development Methods" Committee**—In Oslo, NIST's Bill Danner submitted and resolved ballot comments against the EXPRESS Language Reference Manual (Part 11). His comments dealt with the schema interface constructs needed when developing STEP APs. Danner is the convener of WG5 and leader for that group's Project 2 (Integration and Interpretation Methods).

  Danner also presented to WG5 the draft of a document describing how STEP specifies semantic rules for allowing information to be shared among diverse information systems.

  Danner submitted a draft of a document describing how the STEP Integrated Resources and Application Interpreted Models (AIMs) are to be developed. AIMs are needed to implement APs.

  Finally, Danner advised national delegations on how to develop STEP Parts in a way that would allow these Parts to interoperate. For Parts facing DIS review in 1993, he stressed, development would have to proceed in a highly integrated fashion. This recommendation, tendered at the Subcommittee 4 level, led to the decision to form the Initial Release Team to ensure integration across all STEP Parts.

- **prepared and led a training session on Resource Qualification and Integration for WG4 Project 4 (STEP Integration Technology Training)**—The training session was led by Mary Mitchell, who chairs the Part Qualification and Validation project.

  Following the Oslo meeting, additional technical staff were trained and applied to the effort to "qualify" the Initial Release Parts. Mitchell provided leadership for this effort. She led the technical work, trained the new qualifiers, and effectively managed the project's activities. Under her guidance, the WG4 staff stabilized the *Application Protocol Qualification Manual*.

- **supported Working Group 3 (Product Modeling), Project 3 (Part 47: Shape Tolerances):** NIST's Jesse Crusey continued to chair this project. On 23 January, he met with the leaders of ANSI Y14.5.1 (Mathematical Definitions of Y14.5 Tolerancing Principles) to forge closer working ties between the tolerancing committees of ANSI (American National Standards Institute) and IPO. As a result, Crusey and his fellow chair in ANSI agreed to collaborate on shared goals.

  Later in the quarter, Crusey reviewed all CD ballot issues for Part 41, then advised the NIST representative to the U.S. Technical Advisory Group (TAG) whether to approve the Part's DIS status. He also reviewed Part 1. (Summaries of both Parts can be found in Table 3-1.)

- **supported WG3 Project 4, STEP Materials Model (Part 45)**—NIST's John Rumble continued to lead this project and "own" Part 45. In response to comments received at Oslo and elsewhere, the EXPRESS for this part was revised. Under Rumble's direction, the project prepared a detailed breakdown of properties and the parameters affecting those properties. The breakdown was scheduled to be reviewed in April, when the project would reconvene in Seattle.

- **supported the STEP Technical Advisory Group (TAG)**—Kent Reed, the NIST representative to the U.S. TAG for SC4, participated in a TAG meeting in Salt Lake City. He collated and distributed NIST comments on six Parts and presented the NIST vote.

- **supported Working Group 7 (Implementation Specifications)**—NIST was the focal point for accelerated efforts to develop the SDAI specification. In his role as chair of the IPO Implementation Specifications Committee, Jim Fowler coordinated the contributions of IPO and ISO committee members as well as those of PDES, Inc. team members to the draft specification. The draft document was scheduled for review the following month, in Seattle.

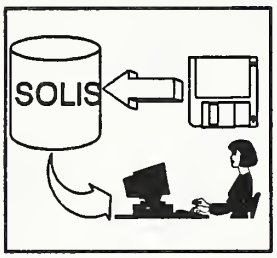
3.1.3 Task 2: Support IGES/PDES Organization (IPO) Technical Activities

In 1Q92, Jesse Crusey accepted the roles of Chair of the IPO Tolerance Committee and Owner of STEP Part 47. In 2Q92 this Part was reviewed and improved. (The status of Part 47 is discussed further in Section 2.2, "Application Protocol for Inspection Planning.")

At IPO's quarterly meeting in Salt Lake City, Jim Fowler chaired the meeting of the STEP Implementation Specifications Committee. Fowler is the Testbed's project manager for STEP Implementation Tools (Section 5.3).

In January, NIST's Kent Reed reviewed comments on Part 41 at IPO's meeting.

3.2 Configuration Management Systems and Services (CMS&S)



Throughout STEP's development, thousands of documents and computer programs are created and must be managed. It is critical that the developers who use and test these resources have access to the up-to-date versions. The STEP On-Line Information Service (SOLIS), maintained by CMS&S, lets users download the latest STEP materials by modem, network, or electronic mail.

CMS&S Support for Initial Release Team

Member of this project supported the STEP Initial Release Team (Section 3.1.1) by creating and distributing EXPRESS-only versions of STEP Parts. Of the twelve STEP Parts slated to appear in the Initial Release, eight were distributed for compilation:

Part 41	Integrated Generic Resources: Fundamentals of Product Description and Support
Part 42	Integrated Generic Resources: Geometric and Topological Representation
Part 43	Integrated Generic Resources: Representation Structures
Part 44	Integrated Generic Resources: Product Structure Configuration
Part 46	Integrated Generic Resources: Visual Presentation
Part 101	Integrated Application Resources: Draughting
Part 201	Application Protocol: Explicit Draughting
Part 203	Application Protocol: Configuration-Controlled Design

Project members extracted the EXPRESS portions from each of these Parts. Files containing the extracted EXPRESS from each CD Part were sent to the STEP centers in France, Germany, Japan, and the United Kingdom, and, domestically, to STEP Tools, Inc. (Rochester, N.Y.); PDES, Inc. (Charleston, S.C.); and NIST's National PDES Testbed (**Figure 3-2**). The EXPRESS extracts of these Parts were also stored in an Initial Release directory in SOLIS.

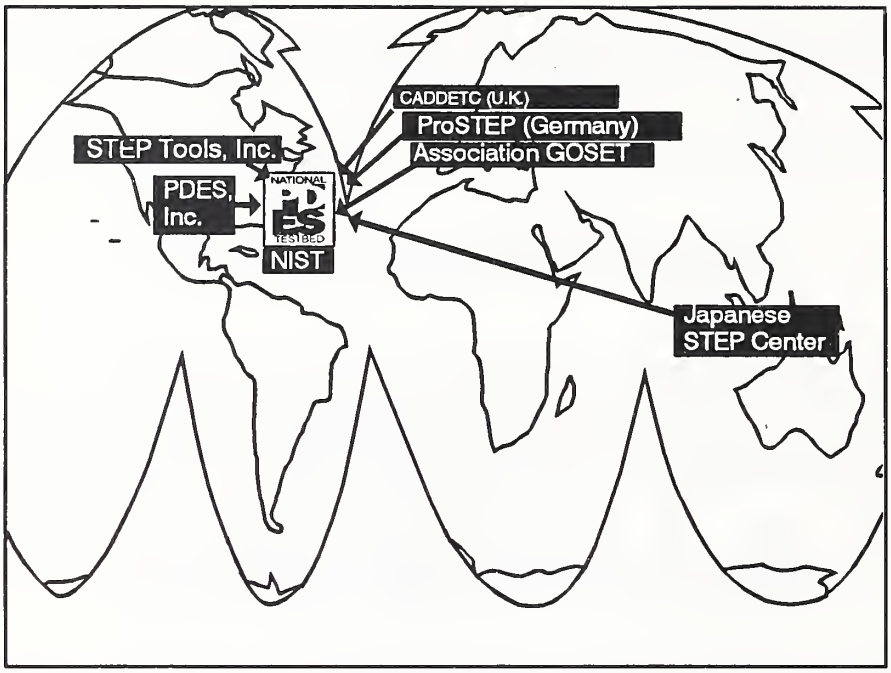


Figure 3-2. NIST began coordinating findings about EXPRESS submitted by STEP Test Centers.

Enhance STEP On-Line Information Service (SOLIS)

Support for the STEP bulletin board system (BBS) ended at the close of the quarter. Kermit—the broadly used, public-domain file-transfer mechanism—was installed to replace the BBS on 1 April. The installation of Kermit completed the first of two prerequisites for accomplishing an important Configuration Management project goal: expanding SOLIS's directory structure. The next step will be to locate and/or modify a mail server that can support the expanded directory structure.

The new structure will give SOLIS users the ability to identify, store, and organize successive versions of each STEP Part. It will also make it a simple matter to organize the storage of software tools into matched sets—for example, a STEP parser and EXPRESS compiler, each based on the same version of EXPRESS. Furthermore, the new directory structure will group the contents of SOLIS so that new users will find it easier to locate the information they need.

Administer and Maintain Established Services

More than 1,000 SOLIS files and indexes were downloaded by more than 100 users each month. At quarter's end, more than 580 files were available for downloading in SOLIS, in 41 main directories. The 41 directories are listed in **Table 3-2.**

Table 3-2. Main Directories in the STEP On-Line Information Service (SOLIS) as of 31 March 1992.

Name	Date	Description
Note: For STEP Part directories, the date denotes the version of the Part stored. For other directories, the date denotes the file most recently added.		
a25exp	03-04-92	EXPRESS extractions of STEP Initial Release Parts, for STEP Initial Release Task A25, "Compile EXPRESS"
ap-guide	02-20-92	*Guidelines for the Development of STEP Application Protocols*
docs	07-29-91	ISO TC184/SC4 information, including Part editors and ballot schedule
latex	10-11-91	LaTeX style files used in some of the STEP Parts
listings	10-11-91	listings of directories' contents (downloadable version of Bulletin Board System screens)
nptdocs	10-08-91	National PDES Testbed (NPT) documents
npttools	08-26-91	National PDES Testbed (NPT) tools
old1	10-10-91	previous version of STEP Part 1 (Overview and Fundamental Principles)
old21	03-12-91	previous version of STEP Part 21 (Clear Text Encoding of the Exchange Structure)
old41	06-07-91	previous version of STEP Part 41 (Integrated Generic Resources: Fundamentals of Product Description and Support)
old44	11-02-90	previous version of STEP Part 44 (Integrated Generic Resources: Product Structure Configuration)
old47	01-29-91	previous version of STEP Part 47 (Integrated Generic Resources: Shape Tolerances)
old48	02-07-91	previous version of STEP Part 48 (Integrated Generic Resources: Form Features)
old101	06-26-91	previous version of STEP Part 101 (Integrated Application Resources: Draughting)
old104	01-03-91	previous version of STEP Part 104 (Integrated Application Resources: Finite Element Analysis)
old203	04-05-91	previous version of STEP Part 203 (Application Protocol: Configuration-Controlled Design)
old204	11-29-90	previous version of STEP Part 204 (Application Protocol: Mechanical Design Using Boundary Representation)
part1	12-29-91	STEP Part 1 (Overview and Fundamental Principles), Version 9, N50
part11	04-29-91	STEP Part 11 (Description Methods: The EXPRESS Language Reference Manual, Version N14)
part21	03-12-91	STEP Part 21 (Clear Text Encoding of the Exchange Structure)
part31	01-02-92	STEP Part 31 (Conformance Testing Methodology & Framework: General Concepts), Version 10, N29
part41	09-06-91	STEP Part 41 (Integrated Generic Resources: Fundamentals of Product Description and Support), Version 6, N105, Committee Draft of 11 Oct '91
part42	02-03-91	STEP Part 42 (Integrated Generic Resources: Geometric & Topological Representation), First Edition, Subcommittee 4, N87, Committee Draft of 21 June '91
part43	07-26-91	STEP Part 43 (Integrated Generic Resources: Representation Structures), Subcomm. 4, N93, Committee Draft of 8 August '91

Table 3-2. Main Directories in the STEP On-Line Information Service (SOLIS) as of 31 March 1992.

Name	Date	Description
Note: For STEP Part directories, the date denotes the version of the Part stored. For other directories, the date denotes the file most recently added.		
part44	07-22-91	STEP Part 44 (Integrated Generic Resources: Product Structure Configuration), Version 1, Working Group 3, N52
part45	12-11-91	STEP Part 45 (Integrated Generic Resources: Materials), First Edition
part46	07-25-91	STEP Part 46 (Integrated Generic Resources: Visual Presentation), First Edition
part47	12-15-90	STEP Part 47 (Integrated Generic Resources: Shape Tolerances)
part48	02-10-92	STEP Part 48 (Integrated Generic Resources: Form Features), Second Edition, First Release
part49	10-17-90	STEP Part 49 (Integrated Generic Resources: Product Life Cycle Support)
part101	07-11-91	STEP Part 101 (Integrated Application Resources: Draughting), Version 2.7, Subcomm. 4, N97, Committee Draft of August '91
part102	12-19-90	STEP Part 102 (Integrated Application Resources: Ship Structures), Version 4.0
part104	01-03-91	STEP Part 104 (Integrated Application Resources: Finite Element Analysis), Version 1.0
part105	01-27-92	STEP Part 105 (Integrated Application Resources: Kinematics), Version "Sapporo '91"
part201	Not yet in SOLIS; expected in fourth quarter of 1992	
part202	07-18-91	STEP Part 202 (Associative Draughting), Working Group 3, N62
part203	08-21-91	STEP Part 203 (Application Protocol: Configuration-Controlled Design), Version 7
part204	10-10-91	STEP Part 204 (Application Protocol: Mechanical Design Using Boundary Representation), Version 2.0
part205	11-11-90	STEP Part 205 (Application Protocol: Explicit Draughting), Version 1.1
phase1	08-26-91	PDES, Inc. Phase I Deliverables
wg4docs	01-08-92	documents from Technical Committee 184, Subcommittee 4, Working Group 4 (Qualification and Integration)
wg7docs	11-01-91	documents from Technical Committee 184, Subcommittee 4, Working Group 7 (Implementation Specifications)

3.3 Other Support

National Initiative begun ***(NIST's participation is DoC-funded)***—On 6 January, the Department of Commerce formally launched the National Initiative for Product Data Exchange (NIPDE). The first workshop was held 29-30 January at NIST. Testbed staff participated.

IPO Steering Committee hosted ***(NIST-funded)***—On 25 and 26 March, the IGES/PDES Steering Committee met at NIST for its Spring meeting (**Figures 3-3** and **-4**). Several key topics were covered. The new chairman, Jim Nell, reported on the new ANSI CIM (Computer-Integrated Manufacturing) Standards Board; this board will be coordinating all ANSI standards organizations that fall under CIM. For example, an important interaction had been created between the IPO and the Data Interchange Standards Association (DISA) to work toward making STEP compatible with EDI (Electronic Data Interchange).[1]

Figure 3-3. At NIST, the IPO Steering Committee discussed how to meet the challenge of completing the STEP Initial Release in 1992.

Figure 3-4. Acting Testbed Manager Howard Bloom describes STEP testing issues to IPO members.

Meeting participants heard a report on the first Board of Directors meeting for IPO's parent organization, US PRO[2].

NIST's Bill Conroy reported on NIPDE's first workshop. NIPDE members presented materials on their efforts in product data exchange.

The Steering Committee recommended that IPO expand its scope to include all the Manufacturing Management Data covered under SC4's WG8 (Industrial

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[1] Electronic Data Interchange refers to the electronic transfer of structured data via standard messaging protocols. The two internationally accepted EDI standards are ANSI's X.12 and United Nations' EDIFACT. Typically, EDI uses X.400 as the standard messaging and forwarding protocol.

[2] United States PROduct Data Association—the parent organization set up in Spring 1992 to manage the development, testing, and implementation of product data exchange technology. A nonprofit membership corporation, US PRO provides management, guidance, and leadership for its subsidiary organizations, including IPO, the National IGES Users Group (NIUG), and the U.S. TAG to SC4.

NIST's Bill Conroy reported on NIPDE's first workshop. NIPDE members presented materials on their efforts in product data exchange.

The Steering Committee recommended that IPO expand its scope to include all the Manufacturing Management Data covered under SC4's WG8 (Industrial Manufacturing Management Data). NIST's *National PDES Testbed Status Report for First Quarter, FY92* was distributed at the meeting. Acting Testbed Manager Howard Bloom gave a presentation on the NIST plans to implement the CALS strategy for PDES/STEP.

Support for electrical design standards ***(NIST-funded)***—In 1990 SC4's WG3 launched the Product Functionality project (Project 17). The project is chaired by Jim Mays of Naval Logistic Command; Mays is assisted by Curtis Parks of NIST's Electronics & Electrical Engineering Laboratory. In Oslo, Parks led the P17 meeting.

The long-range goal of this project is to produce an AP for systems engineering that will allow its users to model the behavior requirements for product design. The objective is to design electrical and electronic products that can be rapidly produced in the small quantities typical of spares orders.

While in Oslo, Parks participated in meetings of ISO's Joint Electrical Working Group (JWG9). Representing 14 nations, this working group was created to harmonize ISO's electrical STEP standards with product data standards being developed by the International Electrotechnical Commission (IEC). ■

4.0 Technical Coordination With Industry

Summary

At meetings of the STEP Draughting Team, NIST's representative helped resolve longstanding harmonization issues between two drafting application protocols. At a NIST-hosted meeting, PDES, Inc. participants defined several needs of the Numerical-Control Process Planning for Machined Parts application protocol. NIST continued to support PDES, Inc.'s software development efforts by contributing a new version of the NIST EXPRESS compiler. The new release of PDES, Inc. software that had been updated to the new version of EXPRESS was tested on two widely used workstation platforms in the Validation Testing Laboratory. Two electrical-standards efforts were assisted by NIST's Electrical & Electronics Engineering Laboratory.

THE PROJECTS in this domain provide management and technical support for programs and activities of the PDES, Inc. consortium. Institute staff continued to work with PDES, Inc. to expedite the goals of that industrial consortium. Originally, the Testbed's focus was on supporting PDES, Inc. programs that targeted structural and mechanical parts. The quarter, however, saw the focus broaden to encompass efforts pertaining to electrical and electronic components.

4.1 PDES, Inc. Technical Program Support

Members of the Testbed technical staff continued to devote significant portions of their time supporting the efforts of PDES, Inc. in key areas.

4.1.1 STEP Draughting Team

Allison Barnard, of NIST's Factory Automation Systems Division, continued to represent the Testbed on this team to establish consensus on harmonization points between, and review validation plans for, two STEP application protocols: Parts 201 (Explicit Draughting) and 202 (Associative Draughting). Barnard also continued to serve as editor of two documents for the Part 202 Testing Team: The *Part 202 Testing Plan* and *Project Plan*.

In ISO's CD ballot that ended mid-January, seven countries submitted comments against Part 101. At the SC4 meeting in Oslo, Norway, Barnard and the other PDES members of WG3/Team 6—known as the STEP Draughting Team—reviewed these issues; classified, cross-referenced, and catalogued them; and determined their priority. Part 101 is an Integrated Application Resource for draughting that is heavily referenced by the two above-mentioned application protocols.

Oslo provided the AP 201 and 202 development teams their first opportunity to meet jointly to discuss harmonization issues. A fundamental issue had to be resolved: The boundaries between the two APs needed to be clearly delineated to control overlap of functionality and to ensure that all known user requirements were satisfied by at least one of the APs. A major point had to be decided: Would the Explicit Draughting AP allow for association between the shape and dimensions? Or, alternatively, would 2D systems supporting dimension associativity be forced to use the Associative Draughting AP?

This issue was brought before the PMAG. As a result of the PMAG's counsel, the Draughting Team decided *not* to expand the scope of Part 201 to include dimensional associativity. Instead, the team decided that 201 would be a complete subset of 202 and would not support associative dimensions. Had 201's scope been expanded, the STEP Initial Release would have had to include at least portions of Part 47.

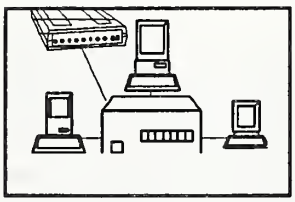
Later in the quarter, Barnard and the other team members met in Los Angeles with Bill Burkett of WG5's Qualification Methods Project for a "prequalification" meeting. Burkett explained the qualification procedure, then walked through the committee's *Part 202* document, commenting on the content, the structure, and other attributes of the Part. This exercise proved very informative and promised to allow the team to develop Part documentation that would pass qualification with a minimum of problems.

4.1.2 Numerical-Control Process Plans Application Protocol

Figure 4-1. The needs of a CNC process planning AP were discussed by representatives from Watervliet Arsenal, Pratt & Whitney, Newport News Shipbuilding, and GM-Hughes at a Testbed-hosted meeting.

Jesse Crusey, of NIST's Factory Automation Systems Division, continued to help develop several machined-part applications that require the accurate "vertical" transfer of product data. During the quarter, NIST hosted a meeting of the CDIM B4 team Context-Driven Integrated Model (**Figure 4-1**). Under Crusey's guidance, the team members focused on product data transfers for process planning, tool design, and computer-numerically-controlled (CNC) tools. The resulting AP will be a 200-series STEP Part.

4.2 Testbed Readiness



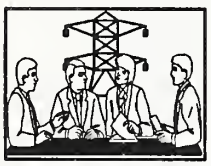
Task 1: Software Acceptance Testing—The Testbed Readiness project completed Phase I testing of PDES, Inc. Block Point Release (BPR) 3.1 on the Digital Computer Corporation (DEC) and Sun SPARCstation 2 workstations in the Validation Testing Laboratory. At quarter's end, the Testbed Readiness project was awaiting the results of Phase II testing (to be performed by an ancillary PDES, Inc. team) and the documentation before installing BPR 3.1 as the default ToolKit.

Task 2: Database Administration—Testbed database instances reside on two different platforms (DEC and SPARCstation), on a total of four computers. These database instances were maintained as required.

Task 3: UNIX Environment Maintenance—Minor corrections were made to the window-management environment so that Sun workstation users can more effectively use their pointing devices (typically, a mouse) to manipulate windows. Also, changes were made to the generic environment to reflect the fact that the Testbed's Sun 3 workstations had been upgraded to SPARCstation 4s.

Task 4: PDES Testbed Hotline—Local and remote users called on the Testbed Hotline for help eight times. Questions and requests for help were received on the use of software, documentation, communications, and accounts.

4.3 PDES, Inc. Electrical/Electronics Team *(NIST-Funded)*



Under funding from NIST's Electronics & Electrical Engineering Laboratory (EEEL), Institute employees are helping to guide the development of product data electrical standards. In January, Michael McLay—on loan to EEEL from NIST's Manufacturing Engineering Laboratory—participated in the monthly meeting of the PDES, Inc. Electrical/Electronics (PIEE) Team.

McLay, together with a colleague from industry, is responsible for defining the tools to support the team's modeling and testing objectives, then furnishing the tools with which to create the modeling and testing software.

The team decided that the first system would demonstrate information exchange between the electrical *design* and *layout* of a printed-circuit assembly. The information exchange would use an object-oriented database; however, simple file-storage would also be supported.

McLay also attended part of the session on creating a data planning model, where the team reviewed the EDIF (Electronic Data Interchange Format) data model for printed circuit boards (PCBs). EDIF-PCB is the first of about 25 existing standards that will be considered when developing the STEP data model.

4.4 Support for a High-Power-Tube Standard *(NIST- and Navy-Funded)*

In late February, NIST's Mike McLay visited California to tour the manufacturing facilities of three **power transmission tube** manufacturers participating in **MMACE** (Microwave and Millimeter-Wave Advanced Computational Environments). He also visited Cimflex Teknowledge (Palo Alto), a firm that develops electronic CAD (ECAD) software.

The Naval Research Laboratory (NRL) has been cosponsoring NIST's participation in MMACE to provide technical guidance on issues involving standards. If power-transmission tubes are to comply with CALS standards, all product life-cycle information must be captured in a digital electronic format. MMACE's mission—to develop an advanced computational environment for designing and manufacturing power transmission tubes—would meet the CALS requirements if the environment is developed as a STEP application protocol, complete with provisions for conformance testing of commercial applications.

McLay's three tours—at Hughes Electron Dynamics Division, Varian Associates, and Litton Electron Devices—gave him a first-hand look at the design, fabrication, and test process for *traveling wave tubes* (TWTs) and *klystrons*. (See sidebar, "No mass market.")

In March, McLay returned to California to participate in an

No mass market

TRAVELING WAVE TUBES and Klystrons are among the most rarefied of electrical devices. These high-power tubes are essential components of several key DoD weapons and satellites.

While DoD must rely on these tubes into the next century, no mass market has emerged to drive down their cost. The tubes range in length from a few centimeters to more than a meter; their cavities range from a single millimeter to 200 millimeters across. Production orders seldom reach 100 tubes, and the fabrication and assembly sequence is uncommonly complex. With solid-state device makers developing diodes, thyristors, and other power devices of ever-higher power densities, tube-makers know they must continually improve the way they design and manufacture their wares if they are to find a place on tomorrow's products.

Tube design remains arcane and poorly documented. Yet mechanical parts must be modeled to establish their resistance to vibration and heat, as well as their strength and stiffness. Electrical properties must be calculated in three dimensions. Modeled together, these calculations require tremendous computational horsepower. Not surprisingly, rather than fully develop and test a design on a CAD screen, designers historically have ordered up a rough prototype and measured its electrical properties.

As supercomputer power trickles down to the desktop, simulation promises to replace this hit-or-miss prototyping. But first, tube-design software must be improved and standardized. ■

MMACE Program meeting. There, the participants' differing software needs began to be consolidated into a requirements document for a single pool of "codes"—the industry's term for analysis and design software.

Originally the pool was envisioned as simply a publicly accessible software depot that would hold codes donated to MMACE. In 2Q92, however, participants voted to expand the pool to include other, more general, software, which MMACE participants will use for development software. Several software tools from the National PDES Testbed, including Fed-X and Expect, will be installed in the pool for use in the project. Expect allows developers to automate interactive computer programs that run on UNIX workstations. It was designed by NIST's Don Libes under NIST funding. Expect is described in several references[1]; further information is available by contacting Libes on Internet at libes@cme.nist.gov. ■

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[1] Expect: Curing those uncontrollable fits of interaction. *Proceedings of the Summer 1990 USENIX Conference;* June 11-15, 1990; Anaheim, California.

Libes, Don. Using Expect to automate system administrations tasks. *Proceedings of the Fourth USENIX Large Installation Systems Administration Conference;* October 17-19, 1990; Colorado Springs.

____. Expect. *The C Users Journal* 9(1); January 1991.

____. Expect: Scripts for controlling interactive programs. *Computing Systems* 4(2); University of California Press Journals; November 1991.

McNutt, Dinah. System administration: Expect. *SunExpert Magazine* 2(1); January 1991.

5.0 Testing

Summary

The Validation Testing System (VTS) software tools were updated to the ISO Committee Draft version of Part 21 (Clear Text Encoding of the Exchange Structure) to keep pace with the evolving STEP standard. Specifically, the tool Fed-X Plus, which translates EXPRESS into C++, was updated along with the C++ class libraries, which read information from the STEP physical file. In support of the PDES, Inc. Block Point Release (BPR) team, the VTS team participated in an evaluation of several object-oriented database tools. Most of the team's work went toward developing the Data Probe—a STEP-based editing tool that entered alpha testing during the quarter.

The Conformance Testing Services project led several initiatives to support SC4's Conformance Testing Procedures working group (WG6). A project member visited the U.K.'s STEP testing center to discuss conformance testing for STEP and IGES. A Cooperative Agreement began with the Industrial Technology Institute under funding from Navy ManTech.

The process of testing STEP must include implementing STEP-based applications if the standard is to be useful. Fundamental software tools, such as the Fed-X EXPRESS compiler, are specifically identified as part of the STEP Implementation Tools project. These tools, which are needed to support validation testing and conformance testing, will also be useful when industry implements STEP-based applications. NIST continued to work with PDES, Inc. to develop the specification for the STEP Data Access Interface. Also, a report on STEP data translation was released.

TESTING METHODS define the requirements and procedures—and provide prototype software tools—for the verification, validation, and conformance testing of elements of the emerging STEP standard and the resulting system implementations.

5.1 Validation Testing System (VTS)

Task 1: Validation Testing System Software Design

Work continued on this document.

Task 2: Committee Draft (CD) Ballot Version of VTS Tools

This task was completed. The update of the VTS tools was carried out in two subtasks:

- The tools were updated to the Part 21 specification. An exception report was written, specifying which portions were not compliant.
- Fed-X Plus was updated.

Task 3: Data Probe and STEP Library Enhancement

Development of the editing tool, Data Probe, continued to be the major VTS task, as called for in the *FY92 Statement of Work*. In early February, a functionally useful version of the Data Probe was placed into the Revision Control System and made available to a few select internal users. This version is now undergoing test and is known as the Alpha version. In addition the Data Probe has been given to PDES, Inc. to obtain some preliminary feedback.

Task 4: STEP AP Validation Workshop

This workshop will be held in April, during the joint quarterly meeting of IPO and ISO. The VTS team began preparing a half-year in advance, during October's joint IPO/ISO meeting. During 2Q92, Mary Mitchell and Sandy Ressler brought the workshop materials into final form and lined up five participants to speak on various facets of application protocols and validation testing.

Object-Based Database Integration *(NIST-Funded)*

In conjunction with PDES, Inc., NIST's Validation Testing System project hosted on-site evaluations of two object-oriented databases (OODBs) to examine in detail the functionality of these databases. The initial work of NIST and PDES, Inc. developers with the Validation Testing System and supporting software tools indicates that an object-oriented database will be needed to properly support the full functionality of STEP data. Experience by both PDES, Inc. and NIST points to a number of problems with current standards and implementation of the prevailing relational-database approach. By evaluating commercial OODBs, the two organizations seek to take advantage of newer, more appropriate technology. (See sidebar, "Move toward commercial software.")

On 14 February, members of the Testbed and NIST's Computer Systems Laboratory hosted a presentation by Objectivity, Inc. (OI; **Figure 5-1**). Earlier, in a joint project with Mentor Graphics, OI had developed a software toolkit for the CAD Framework

Initiative—an industrial consortium working to develop product data standards for electrical CAD.

5.2 Conformance Testing Services (CTS) *(Navy ManTech-Funded)*

Mary Mitchell of this project contributed to SC4's Working Group 6 (Conformance Testing Procedures), helping clear the way toward an agreed-upon approach for defining the tests for each AP. WG6 is the ISO committee working on the STEP 30-series Parts. The WG6 members dealt with several conformance testing issues:

- When an Implementation Under Test (IUT) has demonstrated that portions of it conform to STEP, should it be granted provisional conformance?
- Should different levels of conformance be allowed within APs? What guidance should be provided to AP developers on defining these levels?
- What role do usage tests play in conformance testing?
- What test notation language should be used to define the standardized sets of tests for APs?

Move toward commercial software

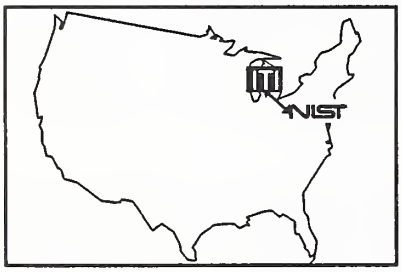
The PDES, Inc. consortium began evaluating commercial STEP toolkits to be the foundation of its next-generation set of software tools, commonly known as the PDES ToolKit. With the current ToolKit, developers can test emerging STEP models and prototype the exchange of STEP physical files. With the next generation, they will be able to prototype a STEP data-sharing environment, using the emerging SDAI (STEP Data Access Interface) specification (STEP Part 22).

By drawing on commercial products, the PDES ToolKit offers users some of the latest advances in software engineering, database management systems (DBMSs), and STEP technology itself. Indeed, when NIST and PDES, Inc. created the current ToolKit, they availed themselves of commercial database products that were on the market in 1989.

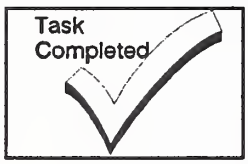
In 2Q92, PDES, Inc., in conjunction with NIST, began evaluating commercial STEP vendor toolkit products. In object-oriented databases, the evaluators considered how well the product supported query languages and browsing. They looked for data-management features, such as versioning, security, and transactions. Importantly, the selected technology would have to be able to be ported to the variety of computer platforms needed by PDES, Inc. member companies. ■

Figure 5-1. Dave Hentchel of Objectivity, Inc. explains how OI's object-oriented database technology can meet the challenges of STEP.

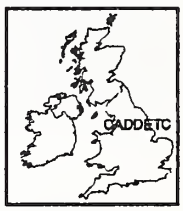
The latter issue was viewed as especially critical. Accordingly, WG6 asked NIST and the Industrial Technology Institute (ITI—Ann Arbor, Mich.) to evaluate test notation languages by SC4's April meeting in Seattle. EXPRESS-I is a prime candidate because it is intended to be compatible with the STEP information-modeling language, EXPRESS. NIST and ITI also contributed additional requirements for a test notation language.



Agreement set with ITI—A Cooperative Agreement with ITI took effect on 01 February. Under the agreement, NIST and ITI will be contributing to the development of standards to enable STEP to be conformance tested. The two institutes also will develop a conformance testing system for STEP.



Report issued—In February, a contract deliverable from ITI was released for distribution. The report had been prepared under ITI's FY91 contract to the CTS project. Titled *Requirements and Recommendations for STEP Conformance Testing* (NISTIR 4743), the report was edited by Sharon Kemmerer of NIST's Computer Systems Laboratory, with significant input from Mary Mitchell, Cita Furlani, and Gary Carver of the Factory Automation Systems Division.



CTS team member visits U.K. STEP Test Center—Mary Mitchell visited the University of Leeds and CADDETC, or CAD-CAM Data Exchange Technical Centre—the U.K.'s center of excellence in Product Data Exchange. There she met with Dr. Susan Bloor, Deputy Director; members of CADDETC's IGES Testing Lab; and researchers. The focus was on conformance testing for both IGES and STEP. They looked at the conformance testing methods and systems being used for IGES and discussed how to leverage this work—performed by CADDETC under the conformance testing project sponsored by the Commission of the European Communities (CEC)—as well as the conformance testing work being done for STEP by NIST and ITI. The researchers showed Mitchell the Leeds STEP Editor, a structure editor sporting an improved graphical interface.

In February and March, a number of activities were undertaken in addition to normal start-up activities for a large project. They included:

- ITI team members visited both NIST and PDES, Inc. to begin evaluating existing STEP tools for potential contributions to a STEP conformance testing system. The tools will soon be installed at ITI for further evaluation.

- ITI and PDES, Inc. developed a draft Memorandum of Understanding (MOU) that will cement ties and support interchange of ideas, tools, and information between the two organizations. This will close the triangle of NIST, ITI, and PDES, Inc. Two additional MOUs are being developed: between ITI and the IPO Testing Project and between NIST, ITI, and the CEC-sponsored Conformance Testing Services (CTS) project No. 15, "CAD/CAM Systems Data Exchange Interfaces."

- The NIST CTS project began developing a repository of information on activities related to STEP conformance testing in the U.S. and abroad. The goal was to capture as much of what is going on as possible. The repository will be updated throughout the life of the project.

- ITI developed a position paper on test notations appropriate to STEP conformance testing. This paper will be submitted to WG6 at SC4's April meeting in Seattle.

- ITI and NIST began holding discussions with the developers of AP 203 (Configuration-Controlled Design) to enable ITI to work with the AP 203 team (primarily PDES, Inc. personnel). As members of this team, ITI personnel will assist in developing the Abstract Test Suite required for conformance testing. They also will use the experience as a basis for contributing to the STEP guidelines for developing and using Abstract Test Suites.

5.3 STEP Implementation Tools (SIT)

This project develops software and specifications that support implementations of STEP. The process of testing the quality and utility of STEP must include implementing STEP-based applications.

- **Fed-X compiler completed**—The SIT team completed the improved version of Fed-X. This version—N14—supports the Committee Draft version of the EXPRESS language. The new compiler will be released to the public on the STEP On-Line Information Service (SOLIS) as soon as the updated documentation is approved by NIST.

- **Updated SDAI spec presented to IPO/ISO**—In January, Jim Fowler hosted an SDAI meeting attended by PDES, Inc. team members and other industry participants, including representatives from heavy-equipment manufacturer Deere & Co. and CAD vendor Auto-trol Technology. The purpose of the meeting was to review a strawman SDAI specification written by Jim Fowler and Chia-Hui Shih, a PDES, Inc. member from CAD vendor SDRC.

A substantial number of technical issues were considered at the meeting. The meeting catalyzed a great deal of effort by contributors from Auto-trol, DEC, Deere, NIST, and PDES, Inc. to develop a revised strawman specification. At the IPO STEP Implementation Specifications committee meeting in Salt Lake City, the new specification was reviewed. As a result of that review, yet another version was prepared for submission in February to SC4's WG7 (Implementation Specifications) in Oslo. Working Group 7 accepted that version as the new baseline draft SDAI specification (Part 22). For the remainder of the quarter, improvements to Part 22 continued for consideration at the joint IPO/ISO meeting in Seattle.

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Report issued—*Considerations for the Transformation of STEP Physical Files* (R. Kohout; S.N. Clark, ed.) was released as NISTIR 4793. It is available on SOLIS. The report discusses the issues arising from the need to translate STEP data files in accordance with versions of the corresponding data model (schema).

- **Data translation software continued**—NIST's Steve Clark continued to implement his design for software that translates STEP exchange files between related versions of the same "schema," or data model. ■

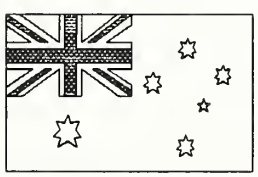
6.0 Education and Technology Transfer

Summary

Tours of the Validation Testing Laboratory were given to a U.S. Senator and visitors from the Australian Army. Five technical reports were published.

EDUCATING decisionmakers about the importance of STEP, and the role of PDES in making STEP a national reality, remained a priority.

6.1 U.S., Foreign Officials Visit Testbed



On 13 February, a delegation from the Australian Army was given a tour of the Validation Testing Laboratory by Jim Fowler, manager of the STEP Implementation Tools project. Later in the month, the Testbed was visited by U.S. Senator Barbara Mikulski (D-MD) as part of a tour to see how NIST research relates to jobs and competitiveness.

Figure 6-1. Dr. John Simpson, Director of NIST's Manufacturing Engineering Laboratory, explains the Testbed's competitive importance to Senator Barbara Mikulski (D-MD).

6.2 Reports Issued

Five reports were completed and distributed (**Table 6-1**). Additional copies are available by contacting the CALS/PDES Office on Internet at trager@cme.nist.gov, or by writing to:

CALS/PDES Office
National Institute of Standards of Technology
Building 220, Room A127
Gaithersburg, MD 20899. ■

Table 6-1. Documents Published by the National PDES Testbed, 2Q92.

Month Issued	NISTIR Report Number	Title	Author(s)	Discussed in Section ...
January	4743	Requirements and Recommendations for STEP Conformance Testing	S.J. Kemmerer, ed.	7.2 of 1Q92 Status Report
January	4744	Comparison of the ISO 10303 Part 47 Draft with ANSI and ISO Tolerancing Standards for Completion and Harmonization of Part 47	S.C. Feng	2.2
January	4755	Issues and Recommendations for a STEP Application Protocol Framework	T.R. Kramer, M.E. Palmer, and A.B. Feeney	2.1
March	4787	National PDES Testbed: Status Report for First Quarter, FY92	H.M. Bloom	N/A
March	4793	Considerations for the Transformation of STEP Physical Files	R. Kohout; S. Clark, ed.	5.3

7.0 Management and Administrative Support

Summary

There were no changes in Testbed management, support staff, or technical staff.

THERE WERE NO CHANGES in Testbed management or technical staff. S. Jeane Ford was chosen as the new manager of the National PDES Testbed with an official starting date of 4 May. (During the preceding quarter, the PDES, Inc. Liaison left the program to work on the National Initiative for Product Data Exchange.) **Figure 7-1** shows the Testbed projects, project managers, and program-office staff. ■

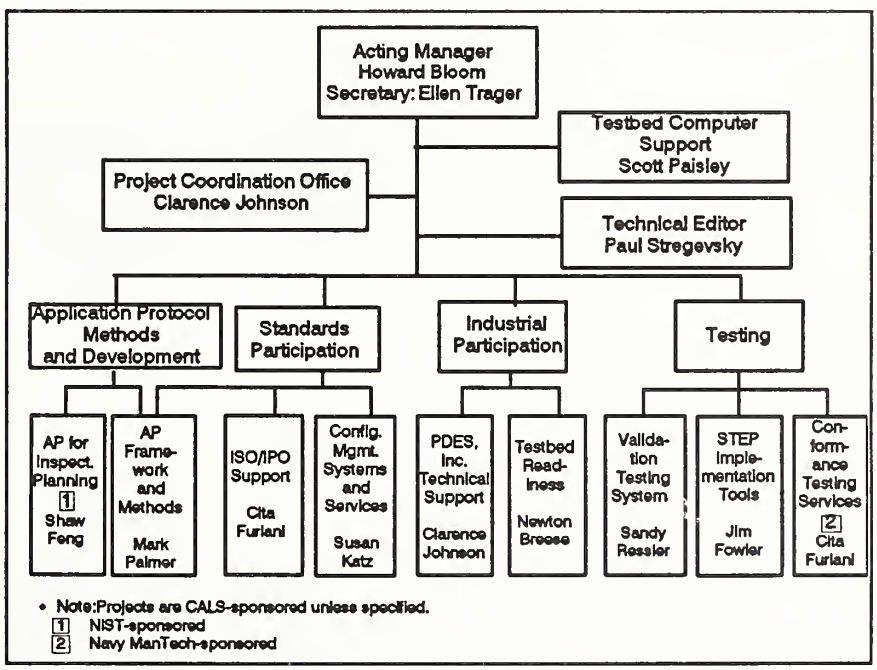


Figure 7-1. Organization Chart for National PDES Testbed as of 31 March 1992.

8.0 Travel Coordination & Operational Support

Summary

Trips were taken chiefly to support IPO, ISO, and PDES, Inc. Staff began coordinating with PDES, Inc. to ensure that the configuration and user interface of that consortium's testbed are as similar as possible to those of the National PDES Testbed. Toward this end, NIST's Validation Testing Laboratory began supporting another major brand of engineering workstation.

8.1 Travel Coordination

At off-site conferences and meetings of working groups, members exchanged findings and expertise, negotiated criteria and goals, and helped ensure that STEP will meet DoD's needs. The purpose of each trip is summarized in **Table 8-1**.

Note: Six Testbed members chair committees or working groups for IPO or ISO. To reduce costs, interim meetings are often held at NIST.

Table 8-1. 2Q92 Trips Funded by the National PDES Testbed.

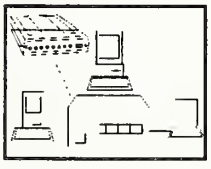
When?	Where?	Who?	Why?
12-17 Jan.	IPO Meeting, Salt Lake City, Utah	Allison Barnard	to help the STEP Draughting Team harmonize AP 201 (Explicit Draughting) with AP 202 (Associative Draughting), review the latest version of the AP 202 Application Resource Model, attend the meeting of the Integration Committee, and review testing plans for AP 201 and 202.
		Jesse Crusey	to chair the Shape Tolerance Project and attend two committee meetings (Manufacturing Technology and Mechanical Products) supporting PDES, Inc.'s Manufacturing AP and the Inspection AP
		Jim Fowler	to chair the STEP Implementation Specifications Committee on development of the STEP Data Access Interface (SDAI)
		Cita Furlani	to participate in the Testing Project Committee, the PDES, Inc. Systems Integration Board (SIB), and Conformance Testing and related meetings
		Mary Mitchell	to participate in the Integration and Interpretation Methods Committee, the Qualification Committee, and the Integration and Training Committee

Table 8-1. 2Q92 Trips Funded by the National PDES Testbed.

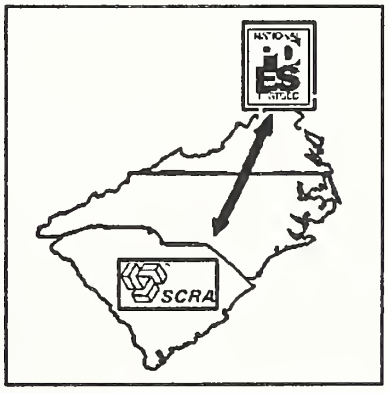
When?	Where?	Who?	Why?
30 Jan. -6 Feb.	Meeting of ISO Technical Committee 184 (Industrial Automation and Integration), Subcommittee 4 (Industrial Data and Global Manufacturing Programming Languages) in Oslo, Norway	Allison Barnard	to resolve harmonization issues between APs 201 (Explicit Draughting) and 202 (Associative Draughting) in Working Group 3 (Product Modeling)
		Steve Clark	to participate in the meetings of Working Group 5 (STEP Development Methods) and Working Group 7 (Implementation Specifications); and to participate in the advancement of SDAI and EXPRESS
		Jim Fowler	to present the results of the U.S. efforts toward development of the SDAI specification and participate in SDAI's advancement
		Mary Mitchell	• For Working Group 4 (Qualification & Integration)/Project 1 (Part Qualification and Validation), to conduct a Qualification Workshop on AP 201 (Explicit Draughting) and evaluate AP qualification criteria • For Working Group 4, Project 4 (STEP Integration Technology Training), to present a training session on Resource Qualification and Integration • for Working Group 6 (Conformance Testing Procedures), to participate in the development of the 30-series (Testing) STEP Parts
		Mark Palmer	• to chair the meetings of the AP Guidelines and Framework Project of WG4 (Qualification & Integration) • to present Version 1.0 of the *Guidelines for the Development and Approval of STEP Application Protocols* • to present initial recommendations on developing an AP Framework for STEP (NISTIR 4755) • to perform the responsibilities of the AP Coordinator for SC4's Project Management Advisory Group • to participate in the meetings of WG4's AP Integration Project, WG5's Part Qualification Methods Project, and WG6
6-8 Feb.	CADDETC (STEP Test Center), Leeds, U.K.	Mary Mitchell	to view tools and test methods that could prove useful for STEP conformance testing and to discuss possible collaborations
14 Feb.	SCRA, Charleston, S.C.	Cita Furlani	to participate in the meeting of the PDES, Inc. Systems Integration Board (SIB)
		Mark Palmer	to chair a meeting with PDES Inc. representatives on the requirements and development of a Framework for STEP APs

Table 8-1. 2Q92 Trips Funded by the National PDES Testbed.			
When?	**Where?**	**Who?**	**Why?**
25-28 Feb.	Objectivity, Inc. & Digital Equipment Corp.'s CAD/CAM Technology Center (Mass.)	K.C. Morris	to attend training courses at both companies as part of her participation in the PDES, Inc. ToolKit evaluation-and-planning project; and to discuss possible CRADAs (Cooperative Research and Development Agreements)
2-6 March	Team Meeting for CDIM A2, Los Angeles	Allison Barnard	to help plan work, review the Project 6 glossary, and develop the Application Resource Model (ARM) validation questionnaire for CDIM A2 (the precursor to AP 203, Configuration-Controlled Design)
30 March to 2 April	PDES, Inc. Off-Site Meeting, St. Simons, Georgia	Allison Barnard	to be briefed on the technical progress of other teams; review the dimension section of the AP 202 model; and discuss model harmonization, schedule, and priorities
		Jesse Crusey	to represent NIST at the SIB meetings and to participate in the Prototype Implementation Team meetings
		Jim Fowler	to represent the Testbed at the PDES, Inc. SIB meetings and to contribute toward PDES, Inc. efforts on SDAI development
		Mary Mitchell	to coordinate the Initial Release Team's qualification and editing efforts, which included: baseline from integration activity, strategy, working procedures and requirements for the C&E team, and resource/scheduling issues; and to conduct the Part 1 Qualification workshop and review APQM Group 1 criteria
		K.C. Morris	to participate in technical meetings involving the future development of software tools for developing STEP and SDAI; and to demonstrate the Validation Testing Systems software to the PDES, Inc. testing teams that would be using it

8.2 Testbed Support

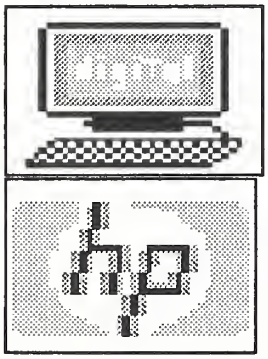


Two domestic testbeds coordinated—Like NIST, the South Carolina Research Authority (SCRA) in Charleston maintains a STEP testbed. Testbed Support staff began coordinating with SCRA systems managers to ensure that, to the greatest extent possible, the two testbeds will share a common configuration and user interface. The advantages of this similarity will be twofold:



- Should a problem arise in either testbed, the conditions that gave rise to it can be replicated in the other, and its source and solution more quickly determined.

- Anyone trained to use either set of computer facilities will be able to use the other with little or no retraining.



DEC demo supported—In January, staff from Testbed Support provided substantial support to Digital Equipment Corporation when DEC demonstrated its PDES ToolKit in the Validation Testing Laboratory.

HP workstation support added—The Testbed began supporting a new workstation: Hewlett-Packard 400. Supporting the HP platform is an important step because HP workstations are widely used by U.S. commercial and defense engineers, both in mechanical and electrical CAD. Like most of the other equipment in the Validation Testing Laboratory, the HP workstation was donated by the manufacturer.

Demonstration held for contractor—During an open house sponsored by NIST's Automated Manufacturing Research Facility (AMRF), the Testbed Support project set up a demonstration of STEP for the Industrial Technology Institute (ITI), a not-for-profit institute in Ann Arbor, Michigan. Later in the quarter, ITI opened an account on the Testbed and began working with the Conformance Testing Systems project under a Cooperative Agreement (as discussed in Section 5.2, "Conformance Testing Services"). ■

Appendix: Abbreviations, Acronyms, & Terms

AFSC	Air Force Systems Command
AFWAL	Air Force Wright Aeronautical Laboratories (now Air Force Wright Research and Development Center)—Dayton, OH
AIM	Application Interpreted Model (in **STEP**). AIMs are elements of **APs**.
ANSI	American National Standards Institute (New York City). ANSI is the U.S. member body in **IEC** and **ISO**; it has certified more than 1,400 standards. A private, nonprofit federation of standards organizations that has no official charter, ANSI is the self-designated national coordinating body for U.S. standards development organizations.
ANSI Y14.5.1	Mathematical Definition of Y14.5 Tolerancing Principles
AP	application protocol (in **STEP**). Some APs are part of **ISO 10303**; others are being developed by organizations, companies, and other groups on their own, using the STEP methodology. As of 1 April 1992, STEP had 12 official APs under development (201-209, plus Electronic Printed Circuit Assembly, Design, and Manufacture; Electronics Test, Diagnostics, and Remanufacture; and Electrotechnical Plants.). For specific APs, see the numerical listing under **Part**.
ARM	Application Resource Model
ASD	Aeronautical Systems Division (of **AFSC**)
Association GOSET	the **STEP** test center of France
BBS	bulletin board system
BPR	Block Point Release (of software)
C4	**CAD/CAE/CAM/CIM** (a General Motors program)
CAD	computer-aided design; see also **CAE, CAM**
CADDETC	**CAD-CAM** Data Exchange Technical Centre—the **U.K.** center of excellence in product data exchange; a **STEP** test center. CADDETC (pronounced `kuh-`det-see`) was formed at Leeds University to support industry's need to exchange product data in electronic form. It opened in 1986 under funding from the U.K. Department of Trade and Industry. CADDETC conducts conformance testing and is accredited by **NAMAS**.
CAE	computer-aided engineering

CALS	Computer-aided Acquisition and Logistic Support (of the **DoD**)
CAM	computer-aided manufacturing
CCITT	Comite Consultatif International Telegraphique et Telephonique (translated *Consultative Committee for International Telephony and Telegraphy*)
CD	committee draft; see **IS**.
CDIM	context-driven integrated model (in **STEP**; ensures that applications can be supported by Resource Parts [the 40- and 100-series])
CDIM A1	the **CDIM** that is the precursor to **AP 203**
CDIM A2	the **CDIM** that is the precursor to **AP 202**
CDIM B4	the **CDIM** for numerical-control process planning for machined parts; precursor to an as-yet-unnumbered 200-series Part
CEC	Commission of the European Communities (sponsors a **CADDETC** conformance testing project)
CEIO	**CALS** Evaluation and Integration Office
CEN	Comite' Europeen de Normalisation (translated *European Committee for Standardization*). Established 1965; nonprofit, international. CEN's 16 member nations have pledged to adopt international standards rather than national.
CIM	computer-integrated manufacturing
CIM-OSA	Computer-Integrated Manufacturing—Open Systems Architecture (a program of **ESPRIT**)
CM	Configuration Management
CMS&S	Configuration Management Systems and Services (an **NPT** project)
COMBINE	COmputer Models for the Building INdustry in Europe
convener	the leader of any **SC4** working group. The convener usually serves as a project leader but also is responsible for coordinating the working group's other project leaders.
CRADA	Cooperative Research and Development Agreement; created by the 1986 Federal Technology Transfer Act (P.L. 99-502)
CTS	Conformance Testing Services (an **NPT** project)
DBMS	database management system
DEC	Digital Equipment Corporation (a member of PDES, Inc. and developer of STEP software tools and prototypes)

DIS	Draft International Standard (of ISO); see IS. A DIS is complete and stable, requiring only a final editing to become an IS. A DIS can therefore be the basis for an implementation. The Initial Release of STEP will be a DIS.
DISA	Data Interchange Standards Association
DoC	[U.S.] Department of Commerce
DoD	[U.S.] Department of Defense
EDI	Electronic Data Interchange—the electronic transfer of structured data via standard messaging protocols; also describes how the information or business document is formatted. The two internationally accepted EDI standards are ANSI's X.12 and EDIFACT. Typically, EDI uses X.400 as the standard messaging and forwarding protocol.
EDIF	Electronic Data Interchange Format. Developed by the U.S. electronics industry under sponsorship of EIA to transfer gate array and standard cell designs. Used extensively in the electronics design automation industry to exchange data between CAE and CAD systems. Now handles integrated-circuit transfers; new versions can translate PCB features.
EDIFACT	Electronic Data Interchange for Administration, Commerce, and Transport—a United Nations-sponsored standard for EDI
EDIF-PCB	an EDIF-based standard for PCBs—being considered by PIEE as it develops STEP-based electrical standards
Editing Committee	one of three advisory groups to SC4; reviews STEP documents for internal consistency, compliance with ISO Directives, and technical coherence
EEEL	Electronics & Electrical Engineering Laboratory (at NIST)
EIA	Electronic Industries Association (Washington); had 600 standards in 1991
EIP	Enterprise Integration Program (Air Force)
EIS	Engineering Information System (a CALS program sponsored by AFSC/ASD/AFWAL)
ESPRIT	European Strategic Programme for Research and development in Information Technology (a multinational umbrella program)
Expect	a NIST-developed software tool that allows developers to automate interactive computer programs that run on UNIX-based workstations
EXPRESS	the formal information-modeling language used for STEP. EXPRESS Version 1 is now a DIS. As a general information-modeling language, EXPRESS (STEP Part 11) is becoming widely used for non-STEP

	data, often in conjunction with **IDEF**. EXPRESS information models enable database interfaces to be generated automatically, using code generators.
FASD	Factory Automation Systems Division (of **NIST**'s Manufacturing Engineering Laboratory; host to the **NPT**)
Fed-X	[Federal] EXPRESS Translator—the **STEP** compiler developed by the **NPT**. It is a public-domain software tool for manipulating information models written in EXPRESS. Fed-X is a three-pass translator. The first two passes are the standard parsing and symbol-table resolution passes of a traditional compiler. The third pass can be tailored to specific applications, producing output in a specified format.
Fed-X Plus	an implementation of **Fed-X** that translates **EXPRESS** into C++
FY	fiscal year
GOSET	—See **Association GOSET.**
HP	Hewlett-Packard (a member of **PDES, Inc.**)
ICAM	Integrated Computer-Aided Manufacturing—an Air Force program conducted in the early 80s.
IDA	Institute for Defense Analyses (a Federally Funded Research & Development Center in Alexandria, VA)
IDEF	Integrated Computer-Aided Manufacturing **DEF**inition [Language]. In June 1992, IDEF was to become the first set of modeling techniques to be selected as a Federal Information Processing Standard (FIPS).
IDS	Integrated Design Strategy (a U.S. Air Force program)
IEC	International Electrotechnical Commission (sponsors **JTC**s and **JWG**s with **ISO**)
IGES	Initial Graphics Exchange Specification—the most widely used neutral data-exchange format; includes simple geometry (lines, arcs, points) and constructive solid geometry and finite-element data. MIL-D-28000A is the **CALS** standard for IGES application subsets; it contains five classes of IGES "application" subsets: technical publications, mechanical engineering drawings, electrical, NC machine tools, and piping.
IIS	**IPO/ISO** Support (an **NPT** project)
IMPPACT	Integrated Modeling of Products and Processes using Advanced Computer Technology (an **ESPRIT** program)
IPO	**IGES/PDES** Organization—managed by **NIST**; created to help industry replace IGES with **STEP**, avoiding conflicts during the transition

IS International Standard (of **ISO**). The sequence of development of ISO standards documents is **WD**, **CD**, **DIS**, and finally IS.

ISO International Organization for Standardization (sic). Headquartered in Geneva, Switzerland, ISO is composed of some 100 member countries. The U.S. member body is **ANSI**. ISO maintains standards in 39 areas; each area, in turn, comprises 3 to 32 subareas, each of which contains one or more standards. ISO's objective is to promote the development of standards in the world, with a view toward facilitating the international exchange of goods and services and developing cooperation in the sphere of intellectual, scientific, technological, and economic activity.

ISO 10303 Industrial Automation Systems—Product Data Representation and Exchange (the **STEP** standard)

ITI Industrial Technology Institute (Ann Arbor, MI)—an independent, not-for-profit institute dedicated to promoting the renewal and continuing vitality of North American manufacturing; also: International TechneGroup Incorporated (Milford, Ohio). **PDES** conformance-testing tools will be developed by the Ann Arbor-based ITI; the Milford ITI—a contractor to **PDES**, Inc.—performed **IGES** work and is developing product-data exchange techniques using standards.

IUT Implementation Under Test (in **STEP**)

IWSDB Integrated Weapon System Database (of **JCALS**)

JCALS Joint Computer-aided Acquisition and Logistic Support (formerly **ACALS**)—a DoD-infrastructure information management system that supports uniform logistic, acquisition, engineering, and other weapon system life-cycle functional applications through the use of a multi-weapon-system **IWSDB** and its Global Dictionary/Directory Services

JC-FCIM Joint **CALS** Flexible Computer-Integrated Manufacturing

JTC Joint Technical Committee (of **ISO** and **IEC**)

JTC1 Joint Technical Committee 1—an information technology standards committee that resulted from a merger between two technical committees of **ISO** and **IEC**. Developed the ISO/IEC 10032 Reference Model of Data Management.

JWG joint working group (of **ISO** and **IEC**)

JWG9 (of **SC4/IEC**) Electrical and Electronic Applications. Formed to develop resource models and **APs** using **STEP** methodologies, taking into account documented efforts such as **EDIF** and **IGES**.

MEL Manufacturing Engineering Laboratory (of **NIST**; home to **FASD** and, in turn, the **NPT**)

MMACE Microwave and Millimeter-Wave Advanced Computational Environments

MOU	memorandum of understanding
N14	the **CD** ballot version of **EXPRESS**; so called because N14 is the document number of **ISO**'s **TC184/SC5/WG5**
NAMAS	National Measurement Accreditation Service (of the U.K); provides external assessment of a laboratory, confirming that testing is carried out in a competent manner
NIDDESC	Navy-Industry Digital Data Exchange Standards Committee
NIST	National Institute of Standards and Technology (Gaithersburg, MD)
NISTIR	—prefix for report numbers of **NIST** Interagency/Internal Reports
NIUG	National **IGES** Users Group
NPT	National **PDES** Testbed (NIST-Gaithersburg)
NRL	Naval Research Laboratory (Washington, DC)—cosponsor of **NIST**'s participation in MMACE
OI	Objectivity, Inc. (a developer of **OODB** tools)
OODB	object-oriented database
OSE	Open Systems Environment
OSI	Open Systems Interconnection [reference model]—a set of international open-systems communications standards being promoted by the Corporation for Open Systems (COS)
OTA	Office of Technology Assessment (of the U.S. Congress)
Part	any of more than 30 **STEP** standards, each to be produced as an **IS** in multiple volumes. Parts 1-39 each define methods. Parts 40-199 document the integrated generic product data model and application resource models of STEP. Parts 200-299 are reserved for specific **APs**. For a partial listing, see the numerical series immediately below; for descriptions of the 12 Parts of STEP's Initial Release, see Table 3-1.
Part 11	Description Methods: *The EXPRESS Language Reference Manual*
Part 21	Clear Text Encoding of the Exchange Structure
Part 22	**STEP** Data Access Interface (**SDAI**)
Part 31	Conformance Testing Methodology and Framework: General Concepts
Part 41	Integrated Generic Resources: Fundamentals of Product Description and Support (*Note:* Parts 41-44, 101, 201, and 203 are closely related; changes in one potentially affect others.)

Part 42 Integrated Generic Resources: Geometric and Topological Representation (*Note:* Parts 41-44, 101, 201, and 203 are closely related; changes in one potentially affect others.)

Part 43 Integrated Generic Resources: Representation Structures (*Note:* Parts 41-44, 101, 201, and 203 are closely related; changes in one potentially affect others.)

Part 44 Integrated Generic Resources: Product Structure Configuration (*Note:* Parts 41-44, 101, 201, and 203 are closely related; changes in one potentially affect others.)

Part 45 Integrated Generic Resources: Materials

Part 46 Integrated Generic Resources: Visual Presentation

Part 47 Integrated Generic Resources: Shape Tolerances

Part 101 Integrated Application Resources: Draughting (*Note:* Parts 41-44, 101, 201, and 203 are closely related; changes in one potentially affect others.)

Part 201 Application Protocol: Explicit Draughting—considered complete but undergoing international balloting for elevation to **DIS** status. The title means 2D drawings with explicit annotation. (*Note:* Parts 41-44, 101, 201, and 203 are closely related; changes in one potentially affect others.)

Part 202 Application Protocol: Associative Draughting (will be created from **CDIM A2**)

Part 203 Configuration-Controlled Design—will be created from **CDIM A1**. Considered complete but undergoing international balloting for elevation to **DIS** status. (*Note:* Parts 41-44, 101, 201, and 203 are closely related; changes in one potentially affect others.)

PAS-C **PDES** Application Protocol Suite for Composites. Awarded by U.S. Air Force in 1991 to **SCRA** to develop and demonstrate APs for structures made of composite materials (polymer-, metal-, and ceramic-matrix). PAS-C will define a neutral data format for composite structures so that the composite product data can be transferred digitally for design, analysis, test, production, quality assurance, and repair of typical aircraft structural parts.

PCB printed circuit boards

PDES Product Data Exchange using **STEP**. (PDES stood for *Product Data Exchange Specification* from July 1984 until March 1990.)

PDES, Inc. the industrial consortium managed by **SCRA** to speed the development and acceptance of **STEP** among U.S. manufacturers

PIEE **PDES, Inc.** Electrical/Electronics Team

PMAG	Project Management Advisory Group—one of three advisory groups to SC4. The PMAG documents and supports a general understanding of STEP requirements, functional goals, and priorities.
Project 1 (of WG4)	Part Qualification and Validation
Project 2 (of WG5)	Integration and Interpretation Methods
Project 3 (of WG3)	Shape Tolerance Model (Part 47)
Project 4 (of WG3)	STEP Materials Model (Part 45)
Project 4 (of WG4)	STEP Integration Technology Training
Project 5 (of WG4)	Application Protocol Guidelines and Framework
Project 17 (of WG3)	Product Functionality (for electrical and electronic products)
R&D	research and development
RAMP	Rapid Acquisition of Manufactured Parts (a Navy CALS system; SCRA is prime)
SC	subcommittee; as an ISO prefix (e.g., *SC4*), one of 654 subcommittees (of 172 TCs); the organizational unit below TC and above WG
SC4 (of TC184)	Industrial Data and Global Manufacturing Programming Languages. SC4 was established December 1983 to develop standards for digitally representing and exchanging product data. Commonly known as the STEP Subcommittee, SC4 also addresses industrial manufacturing management data. SC4 is the parent subcommittee of STEP's six working groups, as well as two that are developing companion standards to STEP: MANDATE and Part Libraries.
SC5 (of TC184)	Framework for CIM System Integration
SCRA	South Carolina Research Authority (Charleston)—manager of PDES, Inc. and RAMP
SDAI	STEP Data Access Interface (Part 22)—the emerging ISO standard application programming interface that will provide a common "plug and play" link for product data applications. C++ and C language bindings and OODB implementations are the initial focus.
SIB	Systems Integration Board (of PDES, Inc.)
SIT	STEP Implementation Tools (an NPT project)
SOLIS	STEP On-Line Information Service (maintained by the NPT's CMS&S project)
SPARCstation	a series of UNIX-based engineering workstations made by Sun Microsystems; uses Sun Microsystems' Scalable Process ARChitecture

STEP	STandard for the Exchange of Product model data (ISO 10303). Initiated by SC4 in 1983, STEP will be published as a series of documents: the standard is technically a suite of standards, with each document an individual IS. STEP is a neutral mechanism capable of completely representing product data throughout the life cycle of product. The essential completeness of this representation makes STEP suitable not only for neutral file exchange, but also as a basis for implementing and sharing databases and archiving. With STEP, data becomes a neutral factor; no translators are needed.
STEP Draughting Team	Team 6 of SC4/WG3. It is responsible for developing Parts 101, 201, and 202.
TAG	Technical Advisory Group (of ANSI; generally, for ISO's TC184)
Task A25	(of the STEP Initial Release): Compile EXPRESS to test whether the EXPRESS portions of the Initial Release can be computer-processed.
TC	technical committee—the highest organizational level in ISO, just above subcommittee (SC)
TC184	Technical Committee 184 (of ISO): Industrial Automation Systems and Integration. Founded December 1983, TC184 is the parent TC of SC4.
TC184/SC4	See SC4
TC184/SC5	See SC5
TWT	traveling wave tube (a non-solid-state class of high-power devices)
U.K.	United Kingdom
UNIX	the predominant operating system used in engineering workstations
US PRO	United States PROduct Data Association—the parent organization set up in Spring 1992 to manage the development, testing, and implementation of product data exchange technology; it is a nonprofit membership corporation providing management, guidance, and leadership for its subsidiary organizations, including IPO, NIUG, and the U.S. TAG to SC4.
Validation Testing Laboratory	the assemblage of engineering workstations at NPT configured to allow local and remote users to test STEP. Predominantly located in Room 6 of Building 304 at NIST.
VTS	Validation Testing Systems (an NPT project)
WD	Working Draft; see IS.
WG	working group (of an ISO subcommittee)

WG3 (of SC4)	Product Modeling. As of 1 April 1992, Working Group 3 had 18 teams. Each team is responsible for developing one or more resource models, including all **AP** models. The results are qualified and integrated information models. See also **STEP Draughting Team.**
WG4 (of SC4)	Qualification & Integration
WG5 (of SC4)	**STEP** Development Methods. Provides the methods necessary for developing STEP. This includes specification of all methods used internally by **IPO** in the development of technical contributions to STEP.
WG6 (of SC4)	Conformance Testing Procedures (the **WG** that addresses 30-series **STEP** Parts)
WG7 (of SC4)	Implementation Specifications
WG8 (of SC4)	Industrial Manufacturing Management Data
X.12	—ANSI's **EDI** standard
X.400	an electronic mail specification that enables the transfer of messages between users and applications. Widely supported in Europe; ratified as an international standard; a new 1988 version was approved by **CCITT**. X.400 supports multiple information streams, including data, **EDI** documents, fax, voice, and audio.
Y14	Standards for Drawing and Drafting Practices Committee (of **ANSI**)
Y14.26	Subcommittee on the Digital Communication of Product Definition Data (of **ANSI** Committee **Y14**)
Y14.26M	—ANSI's standard for **IGES**
Y14.5M-1982	Dimension and Tolerancing Standard (of **ANSI**)
Y14.5.1	[ANSI] Mathematical Definitions of Y14.5 Tolerancing Principles

NIST-114A
(REV. 3-90)

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

BIBLIOGRAPHIC DATA SHEET

1. PUBLICATION OR REPORT NUMBER
NISTIR 4914

2. PERFORMING ORGANIZATION REPORT NUMBER

3. PUBLICATION DATE
August 1992

4. TITLE AND SUBTITLE
Status Report for Second Quarter, FY92
(1 January Through 31 March 1992)

5. AUTHOR(S)
Howard M. Bloom

6. PERFORMING ORGANIZATION (IF JOINT OR OTHER THAN NIST, SEE INSTRUCTIONS)
U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
GAITHERSBURG, MD 20899

7. CONTRACT/GRANT NUMBER

8. TYPE OF REPORT AND PERIOD COVERED
Status Report (01/01 - 03/31/92)

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (STREET, CITY, STATE, ZIP)
U.S. Department of Defense
CALS Evaluation and Integration Office
The Pentagon
Washington, DC 20301-8000

10. SUPPLEMENTARY NOTES

11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

An emerging information standard will make products more affordable to develop, manufacture, and maintain. The standard is STEP (STandard for the Exchange of Product Model Data). U.S. development efforts are collectively called PDES (Product Data Exchange using STEP). Much of STEP is being tested at NIST, in the National PDES Testbed.

The International Organization for Standardization (ISO) voted to issue a STEP Initial Release at year's end. NIST members were selected to lead STEP's Initial Release Qualification Team and compile the EXPRESS information-modeling portions. ISO adopted Testbed recommendations for planning and managing STEP Application Protocol (AP) development. A system for classifying APs was prototyped. An Application Protocol Qualification Manual draft was completed and used to qualify the first drafting AP. Findings were released on harmonizing STEP's tolerancing model with existing tolerancing standards. The draft specification for the STEP Data Access Interface was enhanced. The STEP Bulletin Board System was replaced by a file server that allows users to locate information more quickly. The Data Probe editor entered alpha testing. Two object-oriented database tools were evaluated. Technical reports were published on conformance testing, tolerancing, the AP Framework, and STEP Implementation Tools.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)
AP; Application Protocols; CALS; configuration management; conformance testing; National PDES Testbed; SDAI; STEP; STEP Data Access Interface; testing; validation.

13. AVAILABILITY

XX	UNLIMITED
	FOR OFFICIAL DISTRIBUTION. DO NOT RELEASE TO NATIONAL TECHNICAL INFORMATION SERVICE (NTIS).
	ORDER FROM SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, DC 20402.
X	ORDER FROM NATIONAL TECHNICAL INFORMATION SERVICE (NTIS), SPRINGFIELD, VA 22161.

14. NUMBER OF PRINTED PAGES
58

15. PRICE
A04

ELECTRONIC FORM