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PRODUCT DATA EXCHANGE: THE PDES PROJECT – STATUS AND OBJECTIVES

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Chairman, IGES/PDES Organization

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Throughout industrialized countries of the world, companies are using an increasingly larger number of computing systems in all phases of design, analysis, manufacture, test and long term support of their products. While system vendor, software design and engineering application vary widely, a common factor among these systems is that each computing application has its own internal mathematical model of the product. This is called a digital product model, and elements of information in the product model that describe the product are called product data. The term product data denotes the totality of data elements which completely define the product for all applications over its expected life cycle. Product data includes the geometry, topology, relationships, tolerances, attributes and features necessary to completely define a component part or an assembly of parts for the purposes of design, analysis, manufacture, inspection and product support. Very little if any process data is included, with the exception of aspects such as a heat treat specification. The product model is expected to be sufficiently complete as to enable the generation of all downstream process data.

Well over a hundred vendors offer computer aided design (CAD) systems, each with its own internal product model form. And it is natural that different companies or different groups within the same company would choose different CAD systems to meet their varying needs. Hence, in the normal course of business, there is a natural requirement to be able to exchange the digital part models that are developed on one system and used on another system. The importance of such a CAD data exchange capability cannot be overemphasized. Estimated now at $ 5.3 billion in gross sales for 1988[1], the CAD industry is expanding quickly, and the capabilities of CAD systems have changed much over the decade of the 1980's. But the need for part model exchange among these systems has not diminished. Rather, with over 10,000 new CAD systems being sold each month, portability of data is even more important to world industry today than ever before.

The Initial Graphics Exchange Specification (IGES) was developed in 1979 to address just this problem. IGES enables the exchange of product data models in the form of 2D and 3D wireframe representations, fully surfaced representations and solid model representations. Applications supported by IGES include the traditional engineering drawing, 3D mechanical part models for analysis or for numerical control machining and electronic part models for printed wiring boards and cabling and wiring systems. The technology embodied by IGES is the same as that which is in the internal product models of present generation CAD systems.

While many are quite content with this level of technology, others point out that it is inadequate to meet some of our present design needs and is overwhelmed by those envisioned for the 1990's. Here in particular we see the need to allow shared access to product databases, and we see engineering problems which presently require large amounts of highly skilled labor to provide manual analysis of the product data. Representative of these would be to ascertain whether a building design meets handicapped access code or the problem of economically producing the control data to manufacture a part in an automated factory. The

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[1]. Daratech Inc., Charlestown, MA., Feb 1989.

IGES technology assumes that a person is available on the receiving end to interpret the meaning of the product model data. For instance, a person is needed to determine how many holes are in the part because a hole itself is not defined. It is represented in IGES technology by its component geometry, for instance by two circles, and is thus indistinguishable from the circular edges of a rod.

Clearly, a more sophisticated representation and exchange form is needed to support the product data model needs of the coming decade. The Product Data Exchange Specification (PDES) project is focused on the development of a sophisticated approach to product data representation that is intended to support both shared databases and physical file exchange. Considerable resources are being placed on this effort both in terms of the volunteer effort to develop and standardize the specification and in the large company and government funded programs to implement software embodying the technology.

This paper will detail the strategy behind the development of the PDES project, will identify the various technical resources that have been brought together to develop, standardize and use PDES technology, will give the status of the effort and will enumerate project plans for the balance of 1989.

THE PDES PROJECT

Whereas IGES has addressed the need for data exchange where the received product model is interpreted by a human either as a display or as a generated plot, the PDES project is focused on exchanging product models with sufficient information content as to be interpretable directly by advanced CAD/CAM application programs. In addition to geometry, PDES will support a wide range of non-geometry data such as manufacturing features, tolerance specifications, material properties and surface finish specifications. The geometry model in PDES will include solid representations. This coupled with the non-geometric data and the relationship information preserved from the original database will enable PDES to communicate a complete product model.

It is the intent of the PDES project to fully support the needs for a complete product model as required by sophisticated applications programs in many areas of use. For instance, in the area of manufacturing, these application programs would include generative process planning systems, CAD-directed inspection and automated NC data generation projects already underway. In the area of maintenance planning the applications programs may enable analyses of assembly/disassembly.

The initiation activities of the PDES project were designed to prove the methodology and to more rigorously establish PDES information content to serve as a baseline for future development. The methodology is based upon a three-layer architecture and the use of reference models and formal languages. The three layers include an applications layer, a logical layer, and a physical layer. Formal data and information modeling methodologies are used to document requirements of the applications layer. The data models produced are then analyzed to identify commonalities, resolve conflicts and synthesize a consistent and cohesive information model for PDES called the logical layer or conceptual schema. Finally, this model is translated into EXPRESS for communication to the physical layer. At the physical layer the conceptual schema is either used to create a database structure or is embedded into a language-based ASCII file format for physical exchange.

Disciplines in the applications layer have been modeled by three techniques: the US Air Force developed IDEF1x methodology; by the Nijssen Information Analysis data modeling technique, NIAM, and by EXPRESS - a data specification language developed internally by the project.

Application disciplines addressed to date include mechanical piece parts, mechanical assemblies, AEC models, FEM models, manufacturing applications, drafting applications and electrical printed wiring board products including both schematic and physical designs. Supporting technical areas are also provided in PDES for tolerances, solids modeling, curve and surface modeling and presentation data.

ORGANIZATIONS CONTRIBUTING TO PDES DEVELOPMENT

The IGES/PDES Organization: Led by the National Institute of Standards and Technology, the IGES/PDES Organization promotes and facilitates the development of the IGES and PDES Specifications and works with other standards making bodies, both foreign and domestic, for the purpose of achieving their formal standardization. The Organization provides an efficient structure to manage and execute the program of work which is accomplished by a voluntary membership numbering over 900. A formal Long Range Plan has been developed, a set of bylaws define the organization and procedures, and detailed tasks and schedules are in place for both IGES Version 5.0 and PDES Version 1.0 Data exchange specifications developed by the Organization are submitted for American National Standards Institute approval via the ANSI approved Y14.26 Subcommittee of ASME and for international standards approval via the ISO TC184/SC4 Committee. Hence, the IGES/PDES Organization supports a focused national program of standards development for this vital area of data exchange.

PDES, Incorporated: In April 1988, several major technology companies joined together under the name PDES, Incorporated with the specific goal of accelerating the development and implementation of PDES. Eighteen companies now participate, and each has pledged considerable resources. A Class I member must commit $100 K per year and two technical experts for a minimum of three years. Phase I of the PDES, Inc. program, covering the first eighteen months, will focus on validation and implementation of a subset of the Draft Proposal. Emphasis will be placed on a data exchange implementation of mechanical parts and rigid assemblies. Phase II will focus on a database implementation and will broaden the scope to include such areas as electronic components and assemblies.

The National PDES Testbed: The National PDES Testbed was established at the National Institute of Standards and Technology over the summer of 1988. The testbed intends to perform five major functions: (1) ensure standards compliance, (2) demonstrate applications of PDES technology, (3) integrate a national network of testbeds, (4) identify unsolved problems and leading edge research required for PDES implementations, and (5) establish a program for technology transfer, testbed information consolidation and dissemination. Close working relationships and a formal Memorandum of Agreement link the Testbed with PDES, Inc.

ISO Committee TC184/SC4: In December 1983 the International Organization for Standardization (ISO) initiated Technical Committee 184 (TC184) on Industrial Automation Systems. Subcommittee 4 (SC4) was formed at that time to work in the area of representation and exchange of digital product data. One hundred forty-five experts from twenty-three countries are involved with the work of the SC4 committee. Fourteen of these countries are classified as Participating members and nine as Observers. In addition, six organizations are participating in a liaison status. The Subcommittee's effort has been unofficially named Standard for the Exchange of Product Model Data (STEP), although a more formal name was chosen for the draft which was formally registered for ballot. STEP has been based primarily on the PDES project but has benefitted from many contributions from international efforts in Europe.

Unanimous agreement exists on the need for creating a single ISO standard which enables the capture of information to represent a computerized product model in a neutral form without loss of completeness and integrity, throughout the life cycle of the product. In addition to the standard itself, a series of companion documents are being developed to support implementation, testing and engineering use of the technology. The Subcommittee's work is proceeding along a formal development plan against a set of published functional requirements.

THE RELATIONSHIP BETWEEN PDES AND STEP

To some participants the PDES and STEP projects are the same, but to others they are different. Indeed there are elements present of each view. Both projects have the same technical goals and have coordinated their schedules. They also share the same chairman and many of the same individual experts. For these reasons PDES and STEP are seen by many as simply two elements of an internationally coordinated effort.

But to some of the individual experts working on the project, there are some differences. PDES is seen as a cooperative R&D project which has produced a first draft of its specification, and STEP is seen as a standardization project to move the PDES draft forward into a formal ISO standard. While this is a useful concept to place the two projects into perspective, it does not give proper recognition to the many technical contributions being made to the effort by the experts in the ISO SC4/WG1 committee.

It is important to note that PDES is not being pursued separately as a US national standard through the ASME Y14.26 Committee as is usually done with IGES versions. The strategy here is to gain consensus internationally first through the STEP project and then to adopt this work under ANSI procedures. This supports the SC4 Committee's development plan to have one standard for use worldwide.

Few worry about according which credit to which committee for the PDES/STEP development. Most are concerned that the ultimate standard has the coverage and the quality needed by users and that PDES and STEP do not begin to diverge from each other in scope of work or printed specifications. While we cannot foresee the results that international consensus building will have on the PDES submission and while we must realize that each country has only one vote, we are confident that the large overlap in experts on each committee will help to ensure that a single standard of good technical quality will result.

PROGRESS TO DATE

Through good international cooperation, a firm set of functional requirements and an extensive plan for documentation have been generated. As the various components of the PDES document have been developed by individual expert groups, they have been integrated into a series of testing drafts, each adding increasingly more complex data structures to the PDES/STEP development. Several testing drafts were published in 1987 and several more in 1988. Additional material necessary to complete the full content of a Version 1.0 document was generated in the third quarter of 1988. This was published as a first Working Draft of PDES Version 1.0 in October and was submitted to the ISO standards group for consideration at their next meeting.

At their meeting on 30 November, the majority of members of ISO TC184/SC4 and its Working Group 1 voted to register the Working Draft as an ISO Draft Proposal for a new standard (STEP Version 1.0) on the representation and exchange of digital product model data. This major milestone was reached during meetings on November 28 through December 2 in Tokyo, Japan. Delegations from nine ISO countries attended including France, Germany (Federal Republic), Japan, Netherlands, Norway, Switzerland, United Kingdom, United States, and the USSR. This work has been achieved through excellent international collaboration over a four year period and comprises over two thousand pages of technical material.

Balloting for the approval of the Draft Proposal (DP) of STEP Version 1.0 began in February 1989 with comments due in June. Few experts expected that this first ballot would result in approval, however. The document has known deficiencies that will take much committee work to resolve.

An Editing Committee was established by TC184/SC4 to process the DP through to an International Standard and to maintain strict configuration management over the document. Strong and active liaisons are being established with finite element modelling, architecture-engineering-construction, electrical and electronic communities to ensure coordination of future development support for these application areas.

The work this year is divided into two main projects; providing a thorough technical review of the ISO DP, and developing new models and concepts for incorporation into a future version of PDES. In the first project, the technical work is focused on the STEP DP, on the balloting process and on fixing known deficiencies within the scope of STEP Version 1.0 The second project continues the committee's development of new capabilities for PDES which extend the range of applications that are possible. When finished, PDES Version 2.0 will be submitted to the ISO committee to begin the standardization consensus process again.

ISO BALLOTING RESULTS

Of the fourteen ISO SC4 P Member countries, ballots were received from nine. All countries found serious flaws in the document, and all but one voted for disapproval. But the review was successful in the enumeration of deficiencies which must be fixed for the next ballot. In total, 1584 comments were received from the nine voting countries. These comments have been given to the SC4/WG1 in order to begin the technical review task. Each committee is asked to analyze the comments, come to consensus on a solution and modify the text of the Draft Proposal to reflect the change. The IGES/PDES Organization committees are pursuing solutions to these same problems and are contributing them to the collective international effort. The details of this process are further described below.

Draft Proposal Technical Review

GOAL: The goal of this effort is to complete the technical development work on the DP and advance it through the full ISO ballot process. It is important to note that the vote by SC4 at the November 1988 meeting did not imply approval of the content of the DP. Rather, it is simply the first action which begins the official international voting process that ultimately will produce consensus approval.

PRIORITY: This work effort will be given top priority among PDES activities.

WORK ELEMENTS: ISO procedures require that the format of the DP be editorially correct according to ISO style and that the content be considered correct, complete and well integrated. The SC4 Editing Committee is charged with accomplishing this first work element, and it is agreed that all changes made by the SC4 Editing Committee will be reviewed for technical accuracy by the SC4/WG1 Committee. The second work element presents a major challenge. Completing all models and accomplishing integration of the models will require much work from our technical committees.

CHANGE CONTROL: The Draft Proposal is a document owned by the SC4 Committee and is under strict configuration control by them. It can only be changed as a result of an official ISO SC4 ballot process. It must be remembered that the US has only one vote.

ASSUMPTIONS:

The Working Draft of PDES Version 1.0 is of historical reference only - all future improvements will be made to the ISO document through the ballot process.

Balloting will not be able to enlarge the scope of the document through the addition of models not already represented in the DP.

Balloting may reduce the scope of the document by eliminating certain models from the DP.

If any models are removed as a result of the ISO balloting process, this will reduce the scope of STEP Version 1.0 If this occurs, the reduction in scope must be discussed at the IGES/PDES Organization Steering Committee to decide if the models should be pursued by the US only, be deferred for a future version or be dropped permanently. If the decision is to continue work, the models will be entered into the scope of work for PDES 2.0

Ballot comments will be used to generate a series of issue notices identifying required technical changes.

Results of a ballot will include a new DP, a list of issue notices accommodated in the new DP and a list of unresolved issue notices.

All models in the final DP should be complete and well integrated.

It may not be possible to finish work on all models in time for a second ballot round.

DEVELOPING FUTURE VERSIONS OF PDES

The ISO balloting is expected to result in the publication of a STEP Version 1.0 document. The scope of Version 1.0 was intentionally limited to certain common resources such as geometry, features and tolerances plus preliminary applications capability which could be accomplished with the available manpower. Now that Version 1.0 is progressing within the ISO committee, it is possible for the IGES/PDES Organization to begin planning for a future version with an expanded scope.

New information models are underway in applications of AEC, composites, electrical, materials and product life cycle. Certain resource requirements shared by several application areas are also being considered for component libraries, kinematics and the functional or behavioral specification of the product. In addition to these new areas, a next version of PDES may also contain some of the models which the ballot process removes from STEP Version 1.0

The additional capability that we can now envision for PDES must be slated for a Version 2.0 of STEP because no new work which extends the scope of the Version 1.0 STEP document can be added. Therefore, our work to develop a future version of PDES has as its objective the publication of a Working Draft of PDES Version 2.0 which will then be submitted to ISO for use as a base document on which a STEP Version 2.0 can be developed. This is further described below.

Developing a Working Draft of PDES Version 2.0

GOAL: The goal of this effort is to extend the scope of the current effort in several topical and applications areas in order to produce a draft of the next version of PDES. Contributions from the international community are expected and welcomed. This document would then be submitted to the ISO SC4/WG1 community as a base document from which STEP 2.0 could evolve. This effort lends a focus to the new committee work already in progress concerning logistics, AEC, electrical and materials models. In addition, it provides the target for the new activities approved by SC4 which expand the scope, e.g. into kinematics.

PRIORITY: This effort should be of second priority.

WORK ELEMENTS: Most technical committees have work already in progress that will expand the scope of PDES. These work elements must be identified by name and described by a brief statement of scope.

CHANGE CONTROL: The new models being prepared by technical committees for incorporation into the next version of PDES are owned by their respective committee until they are approved by committee ballot and are submitted for integration. Changes to individual committee models are at the discretion of the originating committee. Generally, committees have found that model version control and a model custodian are useful and workable techniques for organizing their work. No additional procedures are thought to be necessary within a committee.

ASSUMPTIONS:

Version 2.0 will not differ from but only extend upon the ISO STEP Version 1.0

Scope of Version 2.0 is extended by modeling efforts underway as of November 88.

All other extensions to the scope of PDES Version 2.0 must be approved by the Steering Committee.

All new work started for Version 2.0 should be submitted to SC4 so that it is authorized as new work for STEP Version 2.0

Scope may be extended by Steering Committee consideration of new work proposed by SC4 at its November 88 meeting.

If any models are removed from the ISO document as it moves through the ballot process, the Steering Committee should consider whether to continue US development efforts towards their inclusion in a future version.

SUMMARY

The exchange of digital product models is expected to become as commonplace in the 1990's as the exchange of paper-based engineering drawings is today. Aside from our basic systems for written communication, for monetary valuation and for weights and measures, no technology seems as important to our future commerce and trade as the ability to exchange in digital form the definition of the product being purchased or sold.

The PDES project cleared a major milestone in 1988 with the publication of the Working Draft of PDES Version 1.0 and its acceptance by ISO as a First Draft Proposal of STEP. While the current document has many flaws and will require considerable technical work to give it the quality that is necessary, the resources have been identified, organized and committed to the task. Through excellent cooperation nationally and internationally, the PDES project is expected to mature quickly from research concept to production capability. This last year has seen the establishment of PDES, Inc. bringing needed industry support and the National PDES Testbed offering integration testing and demonstration capability.

All are committed to PDES, to its evolution as an international standard under the STEP project and to its adoption throughout industry as a major contribution to the field of industrial automation.

NOTE: The First Working Draft of PDES Version 1.0 is available from:

National Technical Information Service	
Springfield, Va	703 487-4650
Order Number	PB 89-144-794
Price	$ 169.95

*Reference: Status Report of ISO Committee TC184/SC4, 31 August 1989.

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☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

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)

This paper details the strategy behind the development of the PDES project, identifies the various technical resources that have been brought together to develop, standardize and use PDES technology, gives the status of the effort as of early 1989 and enumerates project plans for the balance of the year.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

CAD Data Exchange; PDES; product data; standards; STEP

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