EXTERNAL REPRESENTATION OF PRODUCT DEFINITION DATA

Bradford M. Smith

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards
and Technology
Center for Manufacturing Engineering
Factory Automation Systems Division
Gaithersburg, MD 20899

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A Status Report of ISO Subcommittee TC184 / SC4

Bradford M. Smith
Chairman, TC184/SC4
31 August 1989

In December 1983 the International Organization for Standardization initiated Technical Committee 184 on Industrial Automation Systems. Subcommittee four was formed at that time to work in the area of representation and exchange of digital product data. The term Product Data denotes the totality of data elements which completely define a product for all applications over its expected life cycle. Product data includes the geometry, topology, tolerances, relationships, attributes and features necessary to completely define a component part or an assembly of parts for the purposes of design, analysis, manufacture, test, 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 informationally complete for purposes such as generating manufacturing process instructions, directing quality control testing and performing product support functions. This paper will detail the strategy behind the development of the ISO project, will identify the various technical resources that have been brought together to develop, standardize and use product data technology, will give the status of the effort as of early 1989 and will enumerate project plans for the balance of 1989.

The ability to exchange product data files among a variety of different vendor CAD/CAM systems is critical to both a company's internal plans for integration and its external relationships with contractors and customers. This fact has been recognized by CAD/CAM users throughout the industrialized world and has given impetus to several national projects which are being coordinated through the ISO to develop a single world standard for data exchange. All parties have agreed upon a strategy which makes immediate use of the national standards, but when changes or extensions to these are undertaken, they will be made in conformance with the direction of the ISO work. In this manner, we build the mechanisms for a well defined path for data migration to the new standard.

Whereas the US IGES and the French SET projects have 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 standard envisioned by the SC4 Committee is focused on exchanging product models with sufficient information content as to be interpretable directly by advanced application programs with little need for human interaction. In addition to geometry, the standard will support a wide range of non-geometry data such as features, tolerance specifications, material properties and surface finish specifications. The geometry model will include solid representations for both boundary and constructive solid geometry forms. This coupled with the non-geometric data and the relationship information preserved from the sending system will enable the standard to communicate a complete product model.

MEMBERSHIP

With the official title of External Representation of Product Definition Data, SC4 has as its program of work the standardization of the external representation of product definition data used in computer aided design, analysis, manufacture, test and inspection for obtaining long term retrievability and understandability, completeness and integrity and exchange capability. 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 (P) Members and nine as Observers. In addition, six organizations are participating in a liaison status.

Participating	Observing	Liaisons
Belgium	Australia	AECMA
Brazil	Bulgaria	CAM-I
Canada	China	EWICS
France	Czechoslovakia	JTC1/SC24
Germany, FR	Denmark	TC184/SC5
Japan	Finland	UNECE
Netherlands	Hungary	
Norway	Italy	
Poland	Spain	
Sweden		
Switzerland		
United Kingdom		
United States		
USSR		

GOAL OF SC4 WORK

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 lifecycle of the product. In addition to the standard itself, a series of companion documents are being developed to support implementation, testing and engineering. The committee's work is proceeding along a formal development plan against a set of functional requirements published in document SC4 N30. The Subcommittee effort has been unofficially named Standard for the Exchange of Product Model Data (STEP), although a more formal name will be chosen for the final document.

ORGANIZATION

Recognizing the urgency for an ISO standard in this area and the high cost of international travel, it was decided that SC4 would set design objectives, establish priorities, arbitrate differences, and ensure that objectives are met and that consistency is maintained. With this direction, the majority of the technical work would be accomplished through the creation of a single working group, WG1, set up to:

> Provide technical support and recommendations
> Coordinate national technical developments
> Resolve technical differences
> Collate national contributions to the ISO draft

MEETINGS

The WG1 has organized itself to address the four main topics of (a) design/engineering applications, (b) logical data content, (c) physical file structure and (d) implementation, documentation and validation requirements.

To date, the following meetings have been held:

SC4			WG 1		
July	84	Washington	November	84	Frankfurt
March	85	Paris	March	85	Paris
January	88	Rotterdam	July	85	Madison
November	88	Tokyo	December	85	Leeds
			March	86	Zurich
			July	86	Seattle
			November	86	Frankfurt
			March	87	West Palm Beach
			June	87	London
			October	87	St Louis
			January	88	Rotterdam
			March	88	Washington DC
			July	88	Denver
			September	88	Leeds
			November	88	Tokyo
			April	89	San Antonio
			June	89	Frankfurt

APPROACH

All participants recognize the need for an ISO standard but realize also the rapid pace of change in the field of computer aided design and manufacturing, the existence of national standards for CAD data exchange and the lengthy political considerations in developing international consensus on this issue. The SC4 effort to develop STEP is designed to build upon the existing national efforts in France, Germany, UK and USA rather than simply adopting any one of these.

The Subcommittee concedes that these national standards will continue to be used in parallel until an ISO solution is developed and implemented. But it is felt that these standards are all based upon technology that will be inadequate to meet industry needs in the decade of the 1990's when an ISO standard could be expected to be ready for production use. All are based upon wireframe and surface geometry with limited if any capability for expressing tolerances, features, data relationships and part attributes. Such capabilities have been shown to be essential for producing control data for advanced automation systems and for providing life cycle control over the product configuration.

It was agreed by members of SC4 that whenever existing national standards are enhanced, development should be undertaken in parallel with the corresponding STEP effort to ensure that compatible concepts are used. This will cause the various national standards to converge towards STEP and will simplify the eventual migration of data from the current standards to STEP.

It is intended that STEP Version 1.0 offer capabilities for geometry, topology, tolerances, and

features and will support applications in drafting, electrical, AEC, mechanical design, product configuration management and FEM analysis. Formal information models have been prepared for several topical areas as well as for specific Version 1.0 application areas. Twelve separate information models are incorporated into the Draft Proposal. Some such as tolerance or shape-size are further broken down into more detailed functional components.

Many problems exist with this process. No one modeling technique is totally adequate for the information requirements in product data. Conversion from one representation format to another is an intellectual exercise requiring detailed expertise. Software tools to support the modeling work are scarce and still evolving. And finally, experts in product data modeling are few in number making review by separate peer groups nearly impossible. The work in WG 1 to develop the technical content of STEP has already generated around 300 documents to date. The sheer size and complexity of the evolving standard present major challenges for gaining the necessary technical review and for tracking all technical changes that are made.

PROGRESS TO DATE

Excellent international cooperation has produced good progress toward the goals set by SC4. Few if any of the original experts understood the enormity of the scope or realized the extent of the tasks. But the work effort has come a long way over four and a half years. The committee has become the world focus for the development of a new technology for the digital representation of product data. It has attracted a capable team of international experts. It has developed new techniques for information expression and new software utilities to check for consistency. The work has progressed to the stage of a first draft of the specification, and early experimentation has shown successful prototype implementations.

Work has proceeded in two distinct areas, project management and specification development. In the area of project planning, WG 1 started with the development of a firm set of functional requirements, a table of contents for STEP Version 1.0, and an extensive plan for documentation and testing. A preliminary design specification and a basic concepts document were prepared, and briefings for management and technical personnel were begun.

In the second area of developing the standard itself, a Working Draft of STEP Version 1.0 was finalized by WG1 at its November 28-29, 1988 meeting and submitted to the SC4 meeting on November 30. SC4 review and discussion centered upon whether the Working Draft should be sent to ISO Central Secretariat for registration as an ISO Draft Proposal (DP). The DP status is given to a Working Draft under ISO rules when all main elements of the technical content of the intended standard are present and the style and form of the document are suitable as an international standard.

All members of SC4 felt that much work still remained to achieve completeness and integration of the Working Draft. However, most also felt that the document was ready for widespread technical review and should be placed under strict configuration control. Hence, by a majority vote, SC4 agreed to send the document to ISO for registration as an ISO Draft Proposal. Annex D detailing the information models, Annex E and Clause 6 were felt to be valuable contributions but not of sufficient maturity to be included in the Draft Proposal. However, they were circulated with the ballot, and experts were asked to decide which portions should be moved into the DP. The Draft Proposal and its annexes comprise over 2100 pages of technical information. Balloting commenced in February 1989 with responses due in June.

Of the fourteen 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 SC4/WG1 to begin the technical review task.

Two other significant actions taken by the SC4 at the November 1988 meeting were decisions to set up an Editing Committee and to break the one large DP into parts. The Editing Committee was established under SC4 to coordinate and process the DP through the ISO ballot process and to maintain strict configuration management over the document. The UK chairs the committee which consists of members from France, Germany, Japan, Netherlands and USA.

Anticipating the large volume of comments on DP 10303 and the need to categorize and summarize these comments in a short period of time before the June WG1 meeting in Frankfurt, a database system was developed to organize the information. DBASE 4 was used to create a stand-alone applications program which was called the SC4 Ballot Manager. Basic capabilities of the program included entering individual comments in the form requested by SC4 and WG1, editing the comments as needed, merging comments from several sources, and importing ASCII text comment files into Ballot Manager memo fields.

The database program was distributed to all SC4 P Members on a floppy disk. The content of each Ballot Manager record was set up to include the information requested by SC4 in the 10 February ballot mailing. Even though the use of the database by P Members was optional, a majority of ballots were received in that form. Six of the nine P Members responding submitted Ballot Manager databases, and two other countries sent ASCII files which were quickly imported into the database.

Several comments and considerable discussion at the June WG1 meeting in Frankfurt indicated the need to break the DP into parts with each part to be submitted as a separate document for ISO approval. Thus the ultimate ISO standard will be given one number but be published in a series of parts as the work on each volume is approved. WG1 established an ad hoc group to define this breakup. A strategy was developed which called for fifteen parts encompassing the overview, description methods, conformance, general resources, application resources and application protocols.

The initial version of each part will be generated by the Editing Committee by dividing the contents of the Tokyo DP. The WG1 subgroup responsible for that part will have to add all required introductory information to make the part a stand alone ISO document and to ensure that all parts are integrated with each other. Each part, when created, will revert to Working Draft stage of document approval within WG1. The schedule is to have several of the new documents ready for distribution by the October 1989. This may enable some of the new Working Drafts to be made ready for consideration at the next SC4 meeting in January 1990.

PLANS

Our work in STEP for 1989 can be divided into two main projects: a thorough technical review of the ISO Draft Proposal and new models and concepts development for incorporation into future versions. Understanding the differing goals, milestones, timescales, priorities and configuration management procedures of these two projects will help to organize our work for 1989.

STEP Version 1.0 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 30 meeting did not constitute approval of the content of the Draft Proposal. 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 STEP activities.

WORK ELEMENTS: ISO requires that the format of the DP be editorially correct according to ISO style and that the content be considered complete and well integrated. A special working group called the Editing Committee has been established within the ISO SC4 Committee to provide for the first work element. All changes made by the Editing Committee will be submitted for approval to the SC4/WG1 Committee. The second work element presents a major challenge. Completing all models and ensuring 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 each P Member has only one vote.

ASSUMPTIONS:

Balloting will not be able to enlarge the scope of STEP Version 1.0 through the addition of models not already represented in the DP.

Balloting may reduce the scope of Version 1.0 by eliminating certain models from the DP.

Any models removed from Version 1.0 will be discussed at the SC4 level to decide whether they should be included in the scope of the next version of STEP or should be dropped permanently from the work of SC4.

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

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

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

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 STEP. This effort lends a focus to the new committee work in progress concerning AEC, electrical and drafting models. In addition, it provides the target for the new activities approved by SC4 which expand our scope, e.g. into kinematics, logistics and materials.

PRIORITY: This effort should take second priority to the technical completion of Version 1.0

WORK ELEMENTS: Most technical committees have work already in progress that will expand the scope of STEP. These work elements must be identified by name, described by a brief statement of scope and approved by SC4.

CHANGE CONTROL: The new models being prepared by technical committees for incorporation into the next version of STEP 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:

Scope of STEP Version 2.0 includes all modeling efforts underway as of November 88.

Scope will be augmented by actions adopted by SC4 at its November 88 meeting.

If any models are removed from Version 1.0 as it moves through the ballot process, the SC4 Committee should consider whether to include them in the scope of Version 2.0

SUMMARY

The work of SC4 to develop a single international standard for product data exchange is proceeding along a well defined plan of action. Progress to date has been good, but major technical and much editorial review lies ahead as the Draft Proposal begins the long process of ISO consensus building. Despite the seemingly large number of people involved, the task is large and the milestone schedule is optimistic. Yet there is among those involved a tremendous personal commitment and a keen sense of international teamwork towards a common goal.

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5. AUTHOR(S)   Bradford M. Smith

10. SUPPLEMENTARY NOTES

☐ 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 used in the development of the ISO project, identifies the various technical resources brought together to develop, standardize and use product data technology, and gives the status of this 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)

Computer Aided Design; data exchange; ISO;PDES; product data; standards; STEP

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