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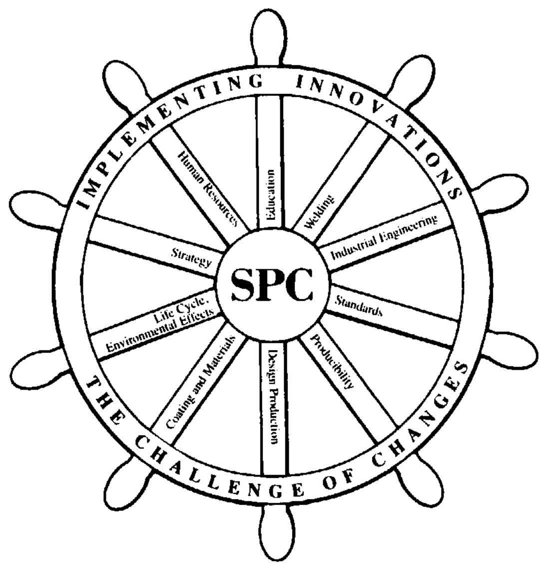

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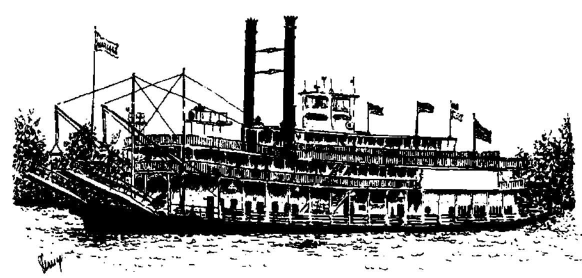

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NIDDESC - IGES Developments -Today's Solution

No. 5B-2

Dr. Burton Gischner, Visitor, and Gregory Morea, Visitor, General Dynamics Corporation, Electric Boat Division

ABSTRACT

Thc Initial Graphics Exchangc Specification (IGES) was first developed in 1980. it has cvolvcd with continual improvcmcnts to the current version 5.1 which was published in October, 1991 (I).

Although IGES has proved to be a very valuable tool, difficulties have been encountered in using it for sophisticatcd transfers, such as for product models or complicated drawings. The primary problems have revolved around the fact that the spccification allows for multiple forms of rcprcscnting the same data, which results in difficultics in transferring that data between varied CAD (Computer Aided Design) systems.

The long range solulion to thcsc difficultics is the cmcrgcncc or STI31' (Standard for the Exchange of Product Model Data). The Navy/industry Digital Data Exchange Standards Committee (NIDDRSC) has been a leading playcr in the dcvclopmcnt of this international standard. However, in the interim, NIDDESC is also spcarchcading the efforts to cnhancc the use of' IGES by dcvcloping application protocols.

Application protocols are required becausc IGES allows for multiple ways of rcprcsenting the same data, and few implcmcntations support all of the IGES Specification. An application protocol dcfincs a logical subschcma of the spccificalion. and dcscribcs the usage of that subschema as well as the ncccssary benchmarks for testing implementations

NIDDESC has led the efforts to develop IGES application protocols for 3D Piping and Engineering Drawings. Thcsc two application protocols arc the first ones to be developcd by the IGES/PDES (Product Data Exchange using STEP) Organization (I.P.O.), and will lcad the way to more productive data transfcr before the development Of STEP'. They will bc referenced by the DOD (United States Department of Defense standard for digital data transfer. MIL-D-28000(2), and should greatly facilitate the occurrence of effective data transfer in these two disciplines. Furthermore, the USe of these IGES application protocols is expected to provide significant guidance in the developmcnt of application protocols for the emerging STEP standard.

This article will focus on the development o; these two application protocols, the involvement of NIDDESC and the shipbuilding industry (a; well as the participation of other industry users and vendors), and the significant benefits to be derived from the adoption of these standards.

NOMENCLATURE

AEC =Architecture, Engineering, and Construction Committee
- Committee of the IGES/PDES Organization through which NIDDESC efforts are submitted

AP = Application Protocol
A specification for representing product model data from an application area in the format of a given data exchange standard

AVM = Application Validation Methodology Committee
- Committee of the IGES/PDES ORGANIZATION which sets criterion for and approves format of application protocols

CAD = Computer Aided ***Design***
Describes computer methods and symbols used in the design process

CALS = Computer--aided Acquisition and Logistic-Support
Program of the Office of the Secretary of Defense
Objective is to establish an integratcd set of standards and specifications for the creation, management, and exchange of product development and logistic data by computer

DoD = United States Department of *Defense*
Issuing organization for MIL-D-28000 to specify standards for digital data exchange

DoE' = United States Department of Energy
- Developcd an IGES based plan for exchanging drawings among its own sites

DOEDEF = Department of Energy Data Exchange Format
Project to establish rules and guidelines to enable production drawing exchange within the DoE

IGES = Initial Graphics Exchange Specfication
First developed in 1980
Currently in widespread USC in American industry
- Primarily designed to transfer graphics betwcen existing CAD systems

I. P. 0. = IGESIPDES Organization
- United States committee that publishes IGES Specification and is coordinating U.S. effort toward development of STEP

I. S. 0. = International Standards Organization
Parent organization of committee that is developing STEP Standard

MIL-D-28000 = DoD Specification for Digital Data Exchange
- References the 3D Piping IGES Application ProtocoI as Class V
Eventually plans to supplement Class II with the Engineering Drawings IGES Application Protocol

NIDDESC=Navy lndustry Digital Data Exchange Standards Committee
- Joint, cooperative effort of Navy and industry to develop data exchange standards and procedures for use in the shipbuilding industry

PDES = Product Data Exchange using STEP
- Unilcs States effort in support of development of STEP Standard

SEA WOLF = SSN2 I
New Class of submarine being developed for the United States Navy by Newpon News Shipbuilding and General Dynnamics/Electric Boa1 Division. whose design and construction have pioneered in the production USC of electronic data cxchange

STEP = Standard for the Exchange of Product Model Data
- Proposed international standard for the exchange of product models
Version 1 is currently in I.S.O. balloting process
Current version is very restrictcd in scope and will be of limited USC in man;, application areas
- It will be years before STEP is in widespread production use

INTRODUCTION

General use of IGES

The importance and benefits of electronic data exchange have long been recognizcd, and the difficulty of developing and maintaining direct translators betwcen CAD systems led to the concept of a neutral filc transfer, and the subsequent development of the Initial Graphics Exchange Specification (I) with Version I being published in 1980.

In the last decade, IGES has been expanded and improved greatly with Version 5.1 being published in October, 1991. Despite the expansion in the scope of IGES (for instance, it now includes solid geometry and attribute table representations), and its vast improvement in recent years, there arc still many organization.. that have had difficulties in using the specification to successfully accomplish digital data transfer.

One problem frequently encountered, is that because of the breadth of the IGES Specification, thcrc may be several correct ways to represent certain entities from a CAD system, and an exchange will only be successful if both systems choose to USC the same implementations. Documents such as the "IGES 5.1 Recommendcd Practices Guide " (3) have helped reduce these problems by giving guidelines for the best way IO implement the specification in certain instances. However, to insure the best possible transfer between diverse CAD systems, the IGES processors must be written IO conform to a much more rigid set of requirements. It is this lightly controlled environment (which will lead to successful and productive digital data transfers) that the development of application protocols is designed to create.

Specific Projects

Aside from the general attempts to usc IGES successfu1ly. Severall organizations or projects have developed task forces or working groups to use IGES to implement their specific data cxchange requirements.

The Navy/Industry Digital Data Exchange Standards Committee (NIDDESC) was formed in 1986 as a joint cooperative effort between the Navy and corporate participants from the shipbuilding industry because of the realization as to how valuable effective electronic data exchange could be to the marine industry. It is largely because of the efforts of NIDDESC and its member companies that the application protocol development projects discussed in this article wcrc Undertaken

The SEAWOLF Digital Data Exchange project provides another example of the successful usc of IGES for exchanging data. This project was a joint effort of NAVSEA, General Dynamics/Electric Boat Division, and Newport News Shipbuilding and used IGBS successfully to transfe- engineering drawings as well as structural and piping models. In fact, the SEAWOLF piping Product Model transfer provided the basis for the development of the 3D Piping IGES Application Protocol (4). A more detailed description of the SEAWOLF Digital Data Exchange Project is available in Reference 5.

The DOEDEF Project of the U. S. Department of Energy (DOE) successfully set Up rules and standard format **for** the transfer of' drawings via IGBS among many **DoE** sites using different CAD systems.

The success of these project specific implementations demonstrates that digital data exchange using IGES can be productive in today's environment when the scope, formats, and implementation of the transfers arc rigidly controlled. These experiences have led to creation of the concept of IGES application protocols. and their development and implementation through efforts led by NIDDESC.

Throughout this article mcntion is made of several 0rganizations and Specification. Thc IGES/PDES Organization (I.P.O.) is a body composed of volunteers from industry and government agencies (primarily in the United States) who have developed the IGES Specification and are participating in the development of STEP' under the auspices of the International Standards Organization (I.S.O.). IGES has been primarily used to transfer graphics data between existing CAD systems. STEP is being developed to provide an international standard for the exchange of product models.

NIDDESC is a joint cooperative effort of the U. S. Navy and the marine industry to develop data exchange standards and procedures for usc in the shipbuilding industry. NIDDESC participates actively in the I.P.O. and is making major contributions to both the IGES and STEP standards.

All of these activities fall under the umbrella of the Computer-aided Acquisition and Logist;: Support (CALS) Program of the United States Department of defense, and arc heavily supported and enthusiastically endorsed by the government .

APPLICATION PROTOCOLS - CONCEPT AND IMPLEMENTATION

Background

The Initial Graphics Exchange Specification (IGES) was first developed in 1980 as a neutral file format to facilitate digital data transfer between CAD systems existing at that time. Despite the extensive efforts that went into developing the specification, many attempted data transfers wer unsuccessful or encountered problems, especially in the first few years of the standard.

Some of the problems were caused by the IGIB Specification not having an adequate representation for all constructs within a CAD system. Thcsc were addrcsscd in later versions 01 the standard, and ongoing enhancements arc still underway

More difficulties, however, were caused by opposite problems: that IGES allowed multiple correct representations of thc same information. and that vendors would each implemcnt a unique subset of the specification. Additional complications were caused by the lack of validations procedures for translators and the translation process.

It is the above class of problems that the concept of an application protocol was designed to solve.

Structure of an Application Protocol (Ap

Thc basic problem in digital information exchanges can bc exprcsscd as agreeing on the meaning and purpose of exchange data. The resolution of this problem is achieved by providing the methods for developing, testing, and implementing information models that define unambiguous sets of data elements.

Application protocols are the means to this solution. They provide a method to achieve consistent and reliable exchange of product data within a specified application area. The key concept is to explicitly link the application's information content to the entities and data structures to be exchanged. An AP defines the context for the use of product data, and specifics the use of the standard (i.c. IGES) in that context to satisfy an industrial need.

There arc four key components to an application protocol:

1) Application Scope and Requirements - defines the realm and applicability of the type of data to be exchanged;
2) Application Reference Model (ARM) - defines the supported information and application domain in an information modelling language that is independent of the specific transfer specification being used;
3) Application Interpreted Model(AIM) - specifies the data constructs used fog rprcsenting the application information defined in the ARM in the selected neutral file format (i.c. IGES); and
4) Conformance Criteria and Test Purposes - specifies conformance testing to increase the confidence that different implementations of the AP will be able to exchange information successful1y.

A more detailed description of the structure and requirements for an IGES application protocol is available in the "Guidelines for tl:1[8] Specification and Validation of IGES Application Protocols". by R. Harrison and M. Palmer (6).

Implementation Efforts

The STEP Standard, which is being developed as an international specification for the exchange of product model data, will depend heavily upon application protocols basis for its successful implementations. However, in the interim period until STEP is an approved international standard with production translators to support it it. there is a need for IGES application protocols.

The urgent need for application protocols and the extensive time required for STEP to become a workable standard has caused NIDDESC lo lead development efforts for two IGES application protocols: one for three dimensional (31)) Piping, and the other for Engineering Drawings. Along with the extensive marine industry participation, the AP 'efforts have received significant help lion: CAD vendors and members of process plant and other industries. This voluntary participation demonstrations the wide spread need for these documents.

THE 3D PIPING IGES API'LICATION PROTOCOL

Background of the Piping AP

The 3D Piping IGES Application Protocol represents an attempt to use IGES in ways that arc beyond the original scope of the specification) Whereas IGES was primarily designed to enable the transfer of graphical data as it is captured oil current CAD systems, the Piping AP is using IGES to transfer product model information. To facilitate this use of IGES, several enhancements were required to the specification in order to support the piping model transfer. enhancements were approved by theI.P.O.. and arc included in Version 5.1 of the IGES specifications(1)

The scope of the 3D Piping IGES Application Protocol is discussed in the abstract of the. document itself (4). As explaincd there:

> "The 3D Piping IGES Application Protoco! (Al') specifies the mechanisms for declining and exchanging 3D piping system models in IGES format. The AP defines three-dimensional arrangement data of piping systems which includes definition data types of geometry (shape and location), connectivity, and material characteristics. The scope of this Al' includes only piping System and 1101 drawings or

internal details of equipment. The specified piping model is sufficiently detailed to supper: the fabrication and final assembly of a piping system.

IGES is designed to support a broad range of applications and information, and it is recognized that few implementations wil! support all of the specification. An application protocol defines a logical subschcma of the IGES Specification, the usage of the subschema, and the necessary benchmarks for testing implementations.
The 3D Piping IGES Application Protocol is the first IGES AP to be delivered to industry and is an important example for the development of STEP (Standard for the Exchange of Product Model Data) application protocols."

Historical Perspective on Development Efforts in Pining Data Transfer

Discussions about using IGES to transfer piping product model data began in the IGES/PDES Organization's AEC Committee in the mid-1980s. These led to the incorporation of a 3D Piping Example as an appendix to IGES Version 4.0. The AEC Committee also participated in development of a Distribution Systems Model. The IGES example was a forerunner of the SEAWOLF Piping Data Exchange Procedure and the 3D Piping IGES Application Protocol, while the Distribution Systems Model was a pre-cursor to the STEP Piping Application Protocol (being developed by NIDDESC) as well as the ARM used in the 31) Piping IGES AP.

The real impetus for a 3D Piping IGES Application Protocol, however, came from the SEAWOLF Digital Data Exchange Project. This new class of submarine is being jointly designed for the U. S. Navy at Newport News Shipbuilding and General Dynamics/Electric Boat Division with the potential for construction at both shipyards. The SEAWOLF Piping Data Exchange Procedure was developed in a cooperative effort between Newport News Shipbuilding, Electric Boat Division and NAVSEA, and was designed to use an IGES neutral file format to transfer piping product model information between Newport News' VIVID' system, and Electric Boat Division's PIPER system. Both of these were. in-house developed CAD systems that were being used to support SEAWOLF piping design and fabrication. Most of the IGES constructs that were later used in the 31) Piping IGES AI' were first implemented in translators developed for SEAWOLF Piping Data Exchange.

The formal project to develop the 3D Piping IGES Application Protocol was sponsored by NIDDESC, although it also had significant participation from members of the process plant industry as well as the vendor community.

Version 1 .O was published in October, 1990 and underwent extensive review within the IGES community. Version 1 .l was formally published in March, 1992 and incorporates changes designcd to resolve the comments against Version I .O. The March, 1992 version of the document is the one being referenced by MIL-D-28000, and the one that is being submitted to the I. P. 0. for approval and inclusion in the next version of the IGES Specification.

This extensive review process has insured that the 3D Piping IGES Application Protocol is not I shipbuilding or NIDDESC solution, but instead represents a consensus agreement among several industries of a viable way to transfer piping product model data in today's environment.

Version 1.1 of the Pining AP

The scope of the 3D Piping IGES AP is the exchange of 3D piping models at a Ievcl of detai' sufficient to support fabrication and assembly of piping systems. In this case, a 3D model consist, only of piping system data. Specifically excluded are other types of systems that arc similarly modelled, i.e. structural steel and concrete. I IVAC (heating, ventilation, and air conditioning), art' electrical cable tray and conduit systems.

This application protocol defines a core 01 required data which supports a corresponding set of piping-related activities. These activities include:

I) interference analyses
2) connectivity checks,
3) basic parts lists,
4) graphic presentations
5) basic piping isometrics.
6) pipe bending instructions, and
7) limited piping redesign.

VIVID® is a registered trademark of **Newport** News Shipbuilding.

The implication is that the model transferred will include enough information to support each of these applications on the receiving system, not that the end products are exchanged. For instance. "basic piping isometrics" means that the receiving system has enough information to generate an isometric drawing in its own format, not that the actual drawing is transferred.

The Attribute Table Entity in the IGES Specification was expanded to support the core attributes in the piping AP, as well as to include many other properties that are not required by the application protocol. This allows the functionality of the core data to be extended by agreements between the sender and receiver of the data.

The unique feature of this protocol is its attempt to use IGES to transfer data describing a complete product model, rather than just the graphical data associated with that model. It thus requires the sending and receiving systems to make specific interpretations of IGES entities. For instance, a pipe is not represented by a solid model of cylinders and toroids, but instead has its 'centerline represented by an IGES Composite Curve Entity. The pipe diameter (and other properties) are referenced in the IGES file by a pointer to an Attribute Table Instance Entity.

In a similar manner, the Piping AP identifies many piping occurrences by special interpretations of various IGES entities. For example, a piping joint is represented by a null composite curve consisting of only two Connect Point Entities. The Composite Curve Entity will, in turn, point to an Attribute Table Instance Entit! to specify the properties of that joint.

The fact that this AP requires specific interpretations of IGES entities means that a general purpose IGES translator may not support this protocol. A company may need to modify its translator or write a new one in order to comply with the AP. However, the use of the 3D Piping IGES Application Protocol will enable the transfer of a far richer set of piping product model data than merely using IGES as a graphical transfer mechanism.

Version 1.1 of the 3D Piping IGES AP was formally issued in March, 1992. It has been extensively reviewed within the IGES/PDES Organization, and has been approved by the I. P. O's ABC and AVM Committees.

Validation testing of the application protocol is currently underway at the David Taylor Research Center. Upon completion of this testing, the AP' will be submitted to the IGES Project Committee and then the I. P. 0. Genera! Assembly for approval and inclusion in the next version of the IGES Specification. This will be the first IGES application protocol to be submitted to the I. I'. 0. formal approval and is also the version referenced in MIL-D-28000.

Version 2 of the Piping AP

The one issue that was not resolved ver:l successfully during the development of Version 1.1 of the 3D Piping IGES AP was how to handle the passing of models for components, especial!y standard library representations or cataIogs.

In the SEAWOLF Piping Data Exchange efforts, both the participating shipyards agreed to exchange material catalogs on a regular (monthly) basis, and to cross-reference each other's part numbers. Thus, the IGES files exchanged for piping merely referenced a part number for each component, and provided a transformation matrix to orient it correctly in space. It was assumed that the receiving system would recognize the part number in its catalog, have the component's geometry already loaded, and be able to orient the fitting correctly by applying the transformation matrix to a standard set of rules agreed upon for the origin and orientation of all components.

This approach was not deemed practical by the: developers of the 3D Piping IGES AP because one could not rely on a transfer only being successful if entire catalogs were exchanged between competitive CAD systems. Furthermore, discussions among the participants about catalog exchanges, often bogged down with issues about proprietary internal representations, or using configurations that were much more easily implemented on one CAD system than on another.

The eventual solution agreed upon for Version 1 .I was to not pass catalogs, but instead to pass ;I CSG (Constructive Solid Geometry) representation for each component whenever it occurred in the piping model. Although this method was inefficient, it at Icast provided an interim solution that would enable developmcnt and implementation of the AP to continue.

A working group, headed by NIDDESC, is currently developing a second version of the 3D Piping IGES Application Protocol which will address the catalog issue. The decision was mad,: to Classify all fittings as eithcr "specialty" or "commodity" components. "Specialty" items will be transferred individually with CSG solid IGES representations, as in the Version 1.1 solution.

Most standard components will be classed as "commodity" items. The working group in determining a neutral representations as far as origin and orientation for these fittings. The geometry will be passed as a parameterized list of key dimensions which will enable the component to be modelled on the receiving system in whatever form that CAD system uses for the given type of fitting. This solution will greatly simplify the processing of component data, and should make Version 2 of the 3D Piping IGES AP a much more easily implemented and valuable specification.

Several other enhancements will also be included in this version of the Piping AP. The attribute lists will be expanded to permit transfer of further information, which will support additional downstream applications.

A new IGES entity, called Piping Flow Associativity, has been approved by the IGES/PDES Organization, and will be incorporated in Version 2 of the AP as a better way to indicate groupings and properties of piping collections such as: Pipe **Runs,** Pipelines, Piping Assemblies, or Piping Systems.

It is also hoped that during implementation of Version 1.1 problems or difficulties may be revealed so that the developers of Version 2 will be able to find improved solutions.

The proposed schedule is to complete a draft of Version 2 of the 3D Piping IGES AP by the end of 1992, and then submit it to the I. I'. 0. for approval and incorporation into the IGES Specification.[2]

Conclusions from Piping AP Efforts

The 3D Piping IGES Application Protocol is providing a workable method for transferring piping product model data in today's environment. Version 2 will be available shortly, and this will greatly simplify the problem of passing catalogucd components, and thus enhance the implementability of the document. Eventually. the 3D Piping IGES Al' will be supplanted by a STEP application protocol for the transfer of piping product models (which NIDDESC is also developing), but in the interim, the IGES AP is providing industry with a valuable **tool.**

THE ENGINEERING DRAWINGS IGES APPLICATION PROTOCOL

Background of the Drawing

To convey knowledge about a product's design or fabrication, engineering drawings arc the most commonly used tools. **One** of the principal uses ! most Computer Aided Design (CAD) systems is the creation and production of these drawing:. The use of a CAD system can significantly increase the quality of drawings produced while reducing the time spent on their generation Because of this double benefit, drawings produced on CAD are becoming a necessary part of today's business environment, including shipbuilding.

Since drawings are used at various stages in the life-cycle of a product, and specific stages of the life-cycle are usually handled by different organizations, it is likely that an electronic drawing will be represented on several diffcrcnt CAD systems throughout its existence. This is due to the multitude of systems available, and their unique uses during the design, fabrication and support of a product. Assuming one wants a particular drawing resident on each of the CAD systems involved, one must either load the drawing from scratch on each system or find some Way of electronically transferring the drawing data from one system to another.

Loading the drawing from scratch is a time consuming process, and it is prone to error since a considerable amount of manual work is involved Therefore, electronic transfer is a much preferrcd alternative. For drawing data, the transfer can either be in rastor or vector form. Rastor transfer is best likened ıo faxing a document, in that the image is broken up into a series of dots which produce a picture of the drawing. This method **is** purely a two dimensional transfer, and the receiver cannot easily modify the drawing. Rasto- transfer, however, may be useful where the receiving system need not modify the data, such a.: plan file or manufacturing activity.

When modification of the received drawing, or **the** transfer of an associated model. is required then a vector transfer is called for. A vccı

2 Development of the 3D Piping IGES Application Protocol is being led by Dr. Burton Gischncr of General Dynamics/Electric Boa: Division, and he can be contacted at: **(203) 433-3948.**

transfer preserves specific entity types as well as spataial releationship Thus a three dimensional ellipse in the sending system should result in a three dimensional ellipse in the receiving system. A perfect vector transfer would result in exactly identical copies of the drawing, and any associatcd model, on both the sending and receiving systems. This lofty goal is seldom reached, although. perfectly acceptable results are achieved using the methods outlined in this paper.

Assuming a vector transfer is required, the next consideration is whether to use a direct translator or a neutral file specification. The direct translator takes the constructs of the sending system and converts them to the constructs of the receiving system. Such an approach may be useful when the translation is to be a singular event involving two specific CAD systems with no changes to software revisions during the process. If these conditions are not met, then the number of direct translators required increases rapidly, thereby losing any potential savings. In this case. which is more common, then a neutral file transfer is called for.

In a neutral file transfer, the drawing data on the sending system is converted to a neutral representation which is then read into the receiving system. The file can be transferred between systems using magnetic tape or telecommunications lines. Both the sending and receiving systems must have converters capable of understanding both the neutral file and the native CAD database. Perhaps the most common neutral file transfer for engineering drawings is IGES. The remainder of this paper deals with how IGES is being successively refined to enable the successful transfer of engineering drawings.

Drawing Exchange Using Straight IGES

Under continual development for the past twelve years, IGES is a collection of neutral representations for geometric, annotation and organizational entities needed to make up drawings with some product model data. These entities are grouped together in a fixed-format text file which a sending processor creates from the native CAD database. The file is then transferred to the receiving processor which reads the file and converts the IGES entities to native database entities and constructs. Specific information about the actual IGES file may be found in "Reference 1."

All of the constructs necessary to build an electronic engineering drawing are present in IGES. This includes not only geometry and annotation, but also itcms such as views. coordinate systems, line styles and subfigures. The problem with IGES, in fact, is that many of the necessary constructs may be represented several ways. As an example, there are two distinct ways to represent splints in an IGES file. parametric or rational b-splinc. This leads to problems when the sending system outputs one type, and the receiving system is set to receive the other. Both systems are correct, yet the data will not be transferred.

After organizations spent several years attempting to transfer data with the mismatches described above, a consensus was reached among IGES users that some refinement of the process was necessary for successful data exchange to take place. Since all of the IGES constructs were necessary lo some users, condensing the actua, Specification was not practical. Thus, some projects placed limits on how IGES could be used for a given transfer. Three of these are described below, for these should be considered the forerunners of the application protocol.

Project Peculiar Uses Of IGES

One of the largest driving forces behind IGES has been the U.S. Department of Defense (DoD). As many weapons systems have been designed and fabricated with IGES transfers as part of the process, DoD has a vested interest in establishing successful IGES transfers. To promote this goal, DoD has issued a military specification, MIL-D-28000 (2), which requires the use of subsets of IGES for various applications. One of these is the transfer of engineering drawings, which is the Class II subset. A subset restricts the type of IGES entities that may be used for a particular application, with the entities coming from the entire specification. No guidance is given as to how the entities will be used, which leads to problems when them are multiple ways to use the same entity. Because of this, the subset is not used in production, and the goal of the project team developing the AP is lo replace Class II with the AP.

Since a combination of entity restrictions and usage guidelines is required to successfully implement an IGES transfer, it would be a great advantage if both the sending and receiving systems were known before the transfer capability is developed. Such was the case for the representatives of the Navy, the Electric Boat Division of General Dynamics and Newport News Shipbuilding who implemented the SEAWOLF

Digital Data Exchange. The SEAWOLF submarine is a joint design project between the three organizations, and, from the outset, an electronic drawing exchange capability was desired to support the project. IGES was chosen as the transfer mechanism, and Computervision and Cadam were the CAD systems involved.

Because the SEAWOLF exchange was bounded as described above, intensive testing was conducted to establish an acceptable transfer capability. This involved considerable rework to both IGES processors, identification of specific entities and constructs to be used, and the generation of a set of specific procedures to be used for the exchange. The exchange is based on functional equivalence between sending and receiving systems, so while transmitted drawings may not look exactly alike, they will still be completely usable. An example of this is that block letters may be filled on one system, and in outline form on the other. The letters arc still readable on both systems. This exchange is currently in production; the key to this was the establishment of a set of specific project information to use for the exchange. For more information on the SEAWOLF program, please see "Reference 5."

The U.S. Department of Energy (DOE) took the idea of project specific exchange documents one step further. For their sites involved in nuclear work, DoE developed a plan for the exchange of drawing data amongst the CAD systems involved. Again this plan was IGES based, and the exchange was bounded by the involved systems. This project, known as the DOEDEF (Department of Energy Data Exchange Format) was planned around an agreed to level of exchange capability, which was tested before actual production exchanges. Also, key to this program was the development of project specific instructions, including what entities and constructs could be used. This project involved more than two CAD systems, so the testing and documentation was even more involved than that required for SEAWOLF.

What the three projects described above all point to is that for IGES exchange to work both entity constructs and specific usage instructions are required. Although the problem is simplified if the sending and receiving systems are known, this is not always the cast. Therefore, a more comprehensive document is required to guarantee an acceptable level of IGES drawing exchange. The answer to this need is ant application protocol, AP, which defines how IGES can be used for « specific discipline exchange, in this case engineering drawings. By having CAD systems. and their users, agree to produce and receive IGES files in a certain way. an acceptable transfer can be assured. Thus, an AP is a project specific document applying to the entire class of IGES drawing exchange. The rest of this paper traces the development of an AP for engineering drawings.

<u>Engineering Drawing IGES AP Development</u>

As stated above, an AP for engineering drawings covers an IGES exchange between any combination of users and systems that state they produce AP compliant files. Therefore, the logical group to develop such a document is a combination of CAD vendors and users. The IGES/PDES Organization recognized such a need and directed the I.P.O. Drafting Committee to put together such a group and produce an AP.

Early efforts centered around an AP to govern the exchange of drawings that arc purely two dimensional, with no associated product model. As development proceeded on this protocol, it became evident that this class of exchange was really a subset of the broader category of exchange of drawings with an associated model. Therefore, this project was rolled into the comprehensive protocol which is under activ development.

To efficiently produce the protocol, the L.P.O. Drafting Committee formed a specific project devoted to this document. The project is chaired by Mr. G. Morea, who is sponsored by NIDDESC The Navy actively endorses the IGES protocol concept, and NIDDESC expects this protocol to replace the Class II subset in MIL-D-28000 (2). The I.P.O. project includes members of both the vendor and user communities. Representatives from Caterpillar and Sandia National Laboratories have been especially active from the user community. Likewise, representatives form Computervision and Autodesk have been active from the vendor community. Both the users and vendors realize that a successful protocol implementation will require input from both parties. Working under the Drafting Committee. the project group meets regularly to develop the document.[3]

[3] Development of the Engineerings Drawing IGES Application Protocol is being led by Mr. Gregory Morea of General Dynamics/Electric Boat Division, and he can be contacted at: **(203) 433-3403.**

Again. there are several different combinations of drawings and models that need to be exchanged. depending on specific project needs. To accommodate this, the protocol has established a taxonomy of engineering drawing creation and exchange parameters. As examples, there may or not be an associated model, and the dimensions may or may not be associated with features of the model. Depending on how these parameters arc set, certain levels of exchange functionality are defined. These range from the exchange of two dimensional sketches to the exchange of a model alone from which a drawing is automatically produced on the receiving system.

To support each of the defined levels of functionality, a set of application requirements is defined. 'These specify the constructs that both the users and vendors must use to produce compliant files. A reference model organizes this data from a logical standpoint, and an interpreted model provides the specific IGES entities and constructs to be used in file creation. This protocol uses the same reference model as STEP AP 202, Associative Draughting. **As** STEP is the logical progression from IGES, this protocol provides a bridge between the two. In addition, data generated from this protocol will be used to further validate AP 202 as it is developed.

Accompanying the protocol itself is a large body of test data. This data serves two specific purposes. The first is to validate the ideas and constructs specified in the protocol itself. The second is to provide a baseline for users and vendors to use when assessing compliance to the protocol. The test data is a combination of specially developed, protocol specific cases and actual user drawings.

To obtain the support that the protocol needs for effective implementation, it will go through a number of formal approval cycles before being published. The I.P.O. Drafting Committee, Application Validation Methodology Committee and IGES Project Committee all need to approve the document before the entire I.P.O. approves it. Once this is accomplished, the document will be published both as part of the IGES Specification (1) and as part of MIL-D-28000 (2). At this point. the protocol can be used to successfully transfer engineering drawing data within the IGES community.

Conclusions from Drawing AP Efforts

In summary, the protocol establishes a level of exchange capability that can be guaranteed independent of specific vendor user combinations by specifying a protocol compliant file.

This climates the need for rounds of testing now required each time a project seeks to use IGES for drawing transfer. In addition, this reduces the errors associated with attempts to use the entire specification. The document also provides an ideal transition to STEP.

SUMMARY

The eventual goal for data transfer is to use a neutral file solution incorporating STEP, the international standard for product model exchange, but the reality of this is several years away. Thus, NIDDESC has led the development of two IGES application protocols to provide an interim method for transfering piping product models and engineering drawings via IGES before the completion of STEP.

These application protocols provide valuable data exchange tools now, and will provide a baseline and guideline for the development of STEP application protocols. They will be the first application protocols submitted to the I. P. 0. for approval, and are setting a precedent for future developments.

The IGES/PDES Organization has agreed to include all approved application protocols as part of the IGES Specification, and MIL-D-28000 will reference these documents so they can be invoked on DoD contracts. Thus, by guiding development of the 3D Piping IGES Application Protocol and the Engineering Drawings IGES Application Protocol, NIDDESC has taken the lead in providing national standards to enable production exchange of this data in today's environment.

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