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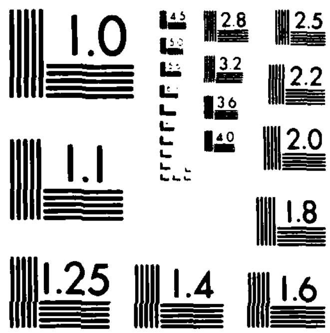
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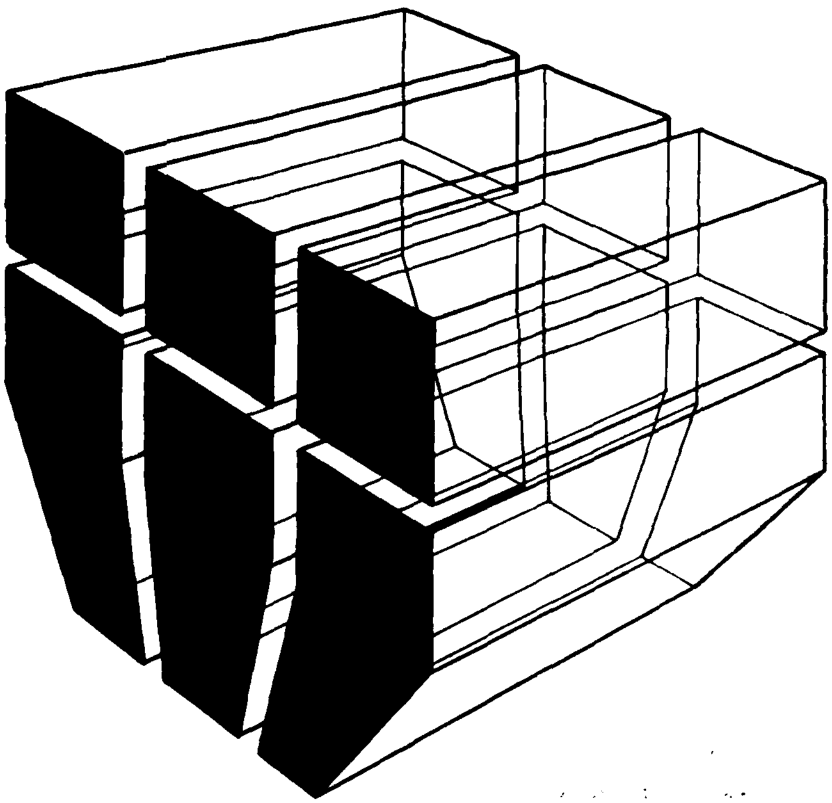
US Army Corps
of Engineers
Construction Engineering
Research Laboratory

TECHNICAL REPORT P-85/03
November 1984
Concept CAEADS—ADS Integration

GRAPHICS TRANSLATORS FOR COMPUTER-AIDED DRAFTING AND DESIGN: INTERFACE ALTERNATIVES FOR THE A/E COMMUNITY



by
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Increased development and competition in the computer-aided graphics industry has produced many advanced systems for architecture and engineering (A/E). However, this growth in technology has come without standardization, making it difficult or impossible to transfer data between dissimilar systems.

Graphics translators are studied for potential in transferring A/E information from one system to another. Two types of translators are considered--

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direct and neutral--with neutral formats showing more promise industry-wide. Progress by professional organizations in standardizing a neutral graphics translator is discussed.

FOREWORD

This investigation was performed for the Directorate of Engineering and Construction, Office of the Chief of Engineers (OCE), under Project 4A162731AT41, "Military Facilities Engineering Technology"; Technical Area A, "Facility Planning and Design"; Work Unit 060, "Concept CAEADS--ADS Integration."

The work was performed by the Facility Systems Division (FS) of the U.S. Army Construction Engineering Research Laboratory (USA-CERL). The OCE Technical Monitor was Mr. T. Kenney, DAEN-ECE-A.

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GRAPHICS TRANSLATORS FOR COMPUTER-AIDED DRAFTING AND DESIGN: INTERFACE ALTERNATIVES FOR THE A/E COMMUNITY

1 INTRODUCTION

Background

The Corps of Engineers is among many architectural/engineering (A/E) agencies making greater use of computer-aided drafting and design (CADD). The CADD industry has grown significantly in the past 2 years, with further growth expected in the areas of design and analysis. However, this surge in the industry has come without standardization among manufacturers. Moreover, in efforts to gain a competitive edge, CADD manufacturers have developed new software offering unique capabilities, but the data structures are protected as trade secrets and are therefore unavailable to clients and other vendors.

This unbridled development and competition has given the A/E community many quality drafting systems, but it has effectively prevented the systems from communicating with each other. Thus, the Corps is unable to take advantage of the graphics information becoming increasingly available as A/E professionals make wider use of CADD tools.

Related to the lack of communication between CADD systems is the Corps' need to alter and archive design and drafting graphics through electronic means. Maintaining project information in paper form throughout the design and life cycle has been very expensive due to storage requirements, revision inconsistencies, and unnecessary drafting.

Most problems associated with electronic media communication and storage of graphics could be reduced or eliminated by an acceptable method for information transfer among CADD systems. One promising method uses graphics translators for this transfer. Several types of graphics translators are available, each with advantages and drawbacks. These methods should be evaluated for possible use with the Corps of Engineers Computer-Aided Engineering and Architectural Design System (CAEADS)[1] and any future CADD equipment. CAEADS is an integrated system of computer aids to the design process for military construction, supporting the design and review activities of Corps District offices and the review of private A/E firms under contract with the Corps.

[1]Daniel, Mann, Johnson, and Mendenhall, Computer-Aided Engineering and Architectural Design System, Vol 1, Technical Report P-97/ADA067719 (U.S. Army Construction Engineering Research Laboratory, January 1979).

Objective

The objective of this study was to evaluate alternative graphics translators for transferring architectural data (drawings, geometry, and nongraphics) between different CADD systems.

Approach

The state of the art in graphics translators was assessed through attendance at numerous conferences on that topic. Proposed standards for these programs were obtained for study from the issuing agencies. Recent results from field use of graphics translators were considered.

Scope

This evaluation is limited to the Corps of Engineers' projected needs in military construction. The work considers all phases of building design and documentation. Other Corps activities such as heavy civil design or mapping functions are not considered.

Mode of Technology Transfer

It is recommended that the results of this study be used to develop an Initial Graphics Exchange Specification translator for CAEADS to evaluate potential as a "front end" for commercial drafting systems and as a "review tool" for design layouts prepared on other CADD systems.

2 GRAPHICS TRANSLATOR ROLE IN COMMUNICATION

Military design often involves several architectural contractors and subcontractors, each of whom may use a different CADD system. In principle, a graphics translator could tie together the many systems used by the Corps and contractors by providing the ability to communicate between different systems.

How Could the Corps Use a Graphics Translator?

A graphics translator can allow districts to transfer graphic libraries and nongraphic information (e.g., building criteria) in an electronic format to Districts or A/E firms rather than with the current paper documents. This information can then be culled quickly to provide the A/E firm with information applicable only to the building in question, eliminating extraneous data that may confuse and slow the designer. Such information given at the project's beginning could aid in providing a complete, consistent design.

Another way a translator could benefit the Corps is as an interface to CAEADS review modules. The Corps will most likely continue to have at least 80 percent of its military workload done by outside A/E firms. Many of these firms have CADD systems and recent technology in optical scanners promises to bring non-CADD users on-line. The most efficient way to review A/E contractor projects may be automatically through the CAEADS review modules. With this system, many mundane activities necessary to insure that designs comply with applicable criteria can be done accurately and quickly without human intervention. This leaves the reviewer more time to evaluate the concept and quality of the design without the burden of minor details that are often easily missed.

Finally, after the project is designed, it can be archived or passed to the facility engineer (who may have yet a different system) for facility maintenance. The district can also archive a copy of the project for future reference. However, if the building later requires remodeling or additions, there is a danger that the current CADD equipment will not be compatible--an important consideration in light of the rapid rate of change in systems.

What Information Will Be Translated?

The scope of information to be translated will grow as the Corps learns to use CADD more effectively and as the technology for systems and translators matures.

The first kinds of information to be translated will reflect the lowest common denominator in the industry. For example, basic drafting documentation that mimics the manual contract preparation process will be translated. The information will include basic geometric entities, their related parameters such as line type and line weight, and probably their drawing level. Associated annotation and dimensioning will be included as well as general notes. Potential problems will be with standardization of drafting levels and font types and with the ability to retain the association of entities into groups often called "cells" or subfigures.

As the Corps builds libraries of drafting information, the A/E will be provided basic, standard drafting data such as sheet layouts, symbols, and possibly details as they become available. As drafting systems become more intelligent, additional nongraphic information may also be translated. This may include the ability to associate graphic entities into related groups (cells) and to provide some definition of what the related groups mean. Two examples are (1) associating furniture groups into a workstation definition with catalog numbers and (2) defining the office or organization. Another potential use for this ability is to automatically reference detail numbers both from the plan to the detail and back to every instance of the detail cut.

Design systems eventually will provide much better integration of graphic and nongraphic information, effectively replacing many drafting system functions. Functional requirements (e.g., area, relations, fire-code, and handicap criteria) will be tied directly to the graphics for automated analysis of a building design. To do this, a building "model" must be translated; annotated drawings will no longer be acceptable without the model. As a result, the translated information will have meaning to the computer, not just the operator.

What Else Is Needed?

Although the current experience with translators is somewhat limited, it is known that a translator alone cannot prepare contract documents consistently. The translator provides only the ability to communicate between systems. It neither supplies a specific building data format nor dictates the content of what is provided. To standardize the contract documents, an office procedure should be developed to provide consistent format and content between projects and between districts. This could reduce the common complaint by A/E firms that no two districts require the same information in the same format.

Districts also will be able to transfer additional information, such as standard symbols and details, in a form that would provide A/E firms with useful drafting aids. Such libraries would require a major effort to develop and maintain, but they could have tremendous impact on the speed of contract development and, if properly used, could reduce errors in the documents as well.

3 ALTERNATIVE TRANSLATOR FORMATS

Direct Translators

A direct translator is a program that will convert a project's database from one computer directly to another. It is the most efficient way to pass information between machines since the software developer has the advantage of knowing which machines will be interfaced and, more importantly, the specific capabilities and limitations of each system (Figure 1).

With these advantages, why not use direct translators for passing information between Corps systems? The reason for not doing so is based on economics and practicality rather than technical aspects. When only two systems are involved, the direct translator certainly is the most efficient way to pass data. Only two translators are required--one for each direction.

When direct translators must be written for several systems, the number required grows exponentially. For example, when three systems are involved, six translators are needed; four systems require twelve translators to be written and maintained.

The problem can become further complicated as multiple versions of the systems are developed. When the hardware remains the same, the systems usually are upwardly compatible. But when new hardware is introduced, as is currently happening in the industry, vendors often must support multiple versions of the programs and their translators.

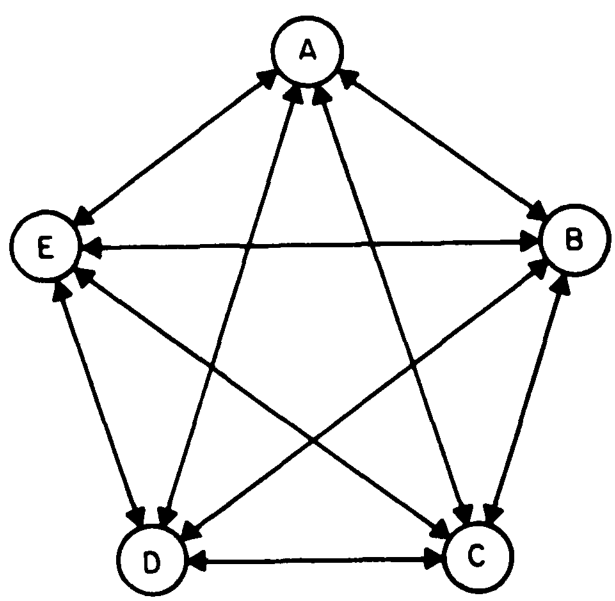

Figure 1. Direct translator concept.

At last count, more than 16 systems with greater than 1 percent market share had been designed specifically for the A/E community. Multiple versions of these systems plus those developed for other industries have made it impractical for vendors to maintain direct translators for their customers. Therefore, most direct translators in use today are maintained by users or third party software houses for individual customers who have received access to each system's internal data structure. Although direct translators can become very expensive, there are times when they may be a better alternative because the data can be translated more efficiently. For the most part, however, neither vendors nor the Government can afford to maintain a direct translator for every possible combination of equipment.

The Corps experience with Direct Translators seems to bear this out. Huntsville Division has maintained both neutral translators such as SIF and a direct translator over the last few years. The direct translator was developed under contract to a New Jersey firm to tie on Applicon and Intergraph together. The original contract to develop a one-way interface was expected to take approximately 6 months to develop. However, during the contract period, one of the CAD vendors upgraded their system, effectively making obsolete much of the previous work. As a result, the contract was extended to a year with the cost rising accordingly. Once developed, the translator was not maintained due to the cost and quickly became obsolete. Huntsville found that it was just impractical to maintain a direct translator as a custom implementation and has resorted to using a more economical SIF translator that is maintained by the CAD vendor.

Neutral Translators

An alternative type of translator would use a neutral or intermediate file format. This concept would allow individual vendors to support only two translators: one for passing information from the system to the neutral format, and one for passing information from the neutral format to another system (Figure 2).

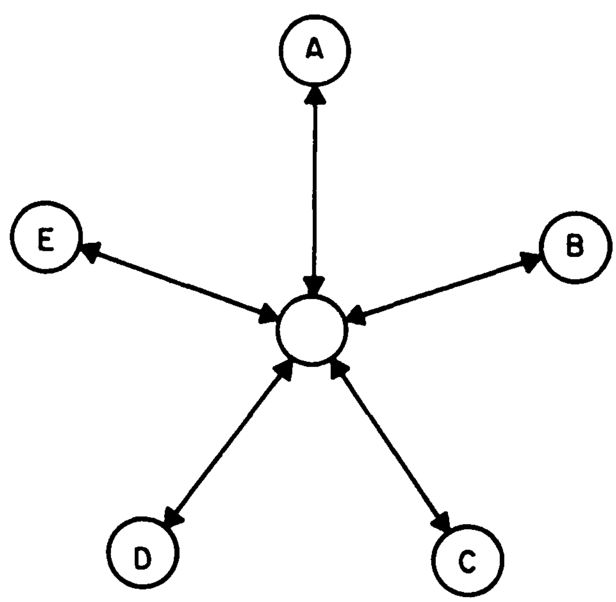

Figure 2. Neutral translator concept.

For a neutral format to be successful, it must (1) anticipate every data element that might be used or be flexible enough to accommodate future extensions that might be required, and (2) be a generally accepted standard by vendors and users. To be complete, the format would need to have an equivalent entity for each proprietary data element that might be developed. That is, unless all data elements could be converted to a neutral format, data would be lost.

Since it is unreasonable for any standard to anticipate future system capabilities, the format must be flexible to allow for unforeseen enhancements. That is, the format must allow changes in the system without negating earlier defined entities. Although this task is complex, it can be done with careful definition and involvement by as many vendors and users as possible. Such effort would result in a concensus standard.

In contrast, a format may be technically competent and yet not provide a practical solution to the problem. A true test of the format's acceptance is the number of vendors who are willing to write translators in that format. It seems many vendors have little desire to write translators at all. Many feel they lose a marketing advantage, particularly with large companies, when other systems can be made compatible with the companies' existing ones. This tends to force the company to buy all its systems from a single vendor to maintain compatibility. Only recently have system owners begun to demand translators to allow communication with other machines.

Standard Interchange Format (SIF)

The first neutral format to receive general acceptance by the A/E community was the SIF, developed by the Intergraph Corporation in 1979. Before that, the CAMRAS, Siggraph's CORE, and CALCOMP neutral formats existed but were not recognized by the industry as general interface media. After developing several direct translators for its clients, Intergraph recognized the need for a neutral format--both as a general standard and to reduce the time needed to develop special-purpose translators for its clients.[3]

At the time of SIF's development, Intergraph was primarily supporting drafting activities for mapping, petrophysical exploration, and facilities management. Since then, general cartographers, utilities, and land use managers have used the SIF format. Most major CADD systems now offer SIF translators.[4]

The SIF is divided into four major categories of data definition: characteristic, geometric, textual, and miscellaneous. The characteristics category provides geometry and text with basic parameters such as line width, color, line type, and text with height, width, size, and rotation. This is defined before any lines and text are sent and remains in effect until new commands are sent to alter the parameters.

[3] P. Brown, "ISIF: An Alternate Standard Interchange Format for Graphic and Nongraphic Information," Presentation to the CAD/CAM Standards Conference on ICES and Alternatives (May 1983).
[4] P. Brown.

The geometry category defines the specific types of geometry to be drawn. In the current version of SIF, the geometry represented can be either two- or three dimensional (not solids or surface modeling) with similar commands supporting each type.

SIF currently supports two types of textual data: (1) the single line of text and (2) multiple lines of text treated as a block of data. The miscellaneous category supports definitions of associated (nongraphic) information.

SIF files are designed with user edit capability. To support this function, Intergraph made the format free, without major ties from one line of text to the next. However, this capability has a price. First, the nongraphic information that can be associated with the graphics has limitations. Also, there is no ability to provide backpointers in the data. In the hierarchical database management system (DBMS) that Intergraph currently markets, this is not a problem. However, in the network DBMS soon to be offered, the backpointers would be lost. The SIF is claimed to be extendible, although major revisions will be required to support a network DBMS capability. In addition, the editing ability will be lost, but this is not really an essential feature. Currently, the backpointers may be of little use in some drafting systems, this will soon be a very important feature in design systems and advanced drafting systems as well. Table 1 gives a detailed list of SIF entities.

Initial Graphics Exchange Specification (IGES)

While Intergraph was developing SIF for its users, the U.S. Air Force (USAF) was attempting to develop a computer-aided design/computer-aided manufacturing (CAD/CAM) standard for the manufacturing industry. The IGES was a project under the USAF Integrated Computer-Aided Manufacturing (ICAM) program. Funded by the USAF, Army, Navy, and NASA, the IGES committee was formed to provide an acceptable standard for communicating drawing and geometry data between CAD/CAM systems. As the result of a Department of Defense Manufacturing Technology Advisory Group meeting in September 1979, the IGES committee was charged with developing a format to meet the needs of Government and industry by early 1980.[5]

A USAF ICAM contract was let to the National Bureau of Standards to direct and coordinate the IGES effort. In addition to the 1980 target date, the contract required that two committees be formed to support IGES' implementation. These committees were to be (1) a working group for technical guidance as the IGES project became a standard, and (2) a steering group to guide management decisions. By summer 1980, over 42 companies had participated in the IGES effort by having one or more members on these committees.[6]

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[5] B. M. Smith and J. Wellington, IGES, A Key Interface Specification for CAD/CAM Systems Integration (National Bureau of Standards, November 1983).
[6] B. M. Smith and J. Wellington.

Table 1

Detailed Format Comparison

	CAEADS*	IGES	SIF
General Definitions			
Character form			
ASCII	X	X	X
BINARY		X	X
Measurement units	X	X	X
General leader information			
System ID, software version	X	X	
Translator identification	X	X	
Project identification	X	X	
Designer	X	X	
Organization	X	X	
Size of definition space	X	X	X
Mathematics precision		X	
Minimum resolution		X	
Geometric Definitions			
Point	X	X	X
Line	X	X	X
Line string	X	X	X
Circular arc			
Defined by center		X	X
Defined by edge	X	X	X
Conic arc		X	X
Complex string (composite curve)		X	X
Ellipse		X	X
User defined shape	X	X	X
Copious data (pairs, triples, sextuples)		X	
Planes (bounded/unbounded)	X	X	
Transformation matrix	X	X	
Tabulated cylinder		X	
Surface of revolution		X	
Ruled surface	X	X	
Parametric spline curve		X	
Parametric spline surface		X	
Graphic Characteristics			
Line weights	X	X	X
Line types, patterns	X	X	X
Line color	X	X	X
Area patterns	X		X

Table 1 (Cont'd)

	CAEADS*	ICES	SIF
Area color	X		X
Dimensions			
Angular	X	X	?
Linear	X	X	?
Ordinate		X	?
Point	X	X	?
Radius	X	X	?
Diameter	X	X	?
Centerline	X	X	?
Witness line	X	X	?
Flag note	?	X	?
General note	X	X	X
Leader	X	X	?
Arrowhead types			
Open	X	X	X
Closed	X	X	?
Slash	X	X	?
Dot	X	X	?
Rectangle		X	?
Text			
Line	X	X	X
Paragraph	X		X
Character set definition	X		X
Font definition	X		X
Mixed case options	X		X
Text justification	X		X
Vertical text		X	
Logical Relations			
Associativity definition	X	X	X
Associativity instance	X	X	X
Property	X	X	
Subfigure definition	X	X	X
Subfigure instance	X	X	X
View	X	X	
Drawing identification	X	X	X
Macro definitions (e.g., shape)	X	X	X
Macro instance	X	X	X
Overlay	X	X	X
Data structure			
Hierarchical		X	X
Network			X
Relational		X	X

*CAEADS--Capabilities required to interface with CAEADS; ICES--capabilities currently available; SIF--capabilities currently available.

The IGES Version 1.0 Specification resulting from IGES committee work was submitted to the American National Standards Institute (ANSI) for approval as an ANSI standard. The ANSI subcommittee Y14.26 on Computer Aided Preparation of Product Definition Data voted to include Version 1.0 as Sections 2 through 4 of a five-part draft standard to be submitted into the formal review procedure. After technical review for consistency, the final document was approved as an ANSI standard in September 1981.[7]

Adoption by vendors has been swift, with two separate surveys[8] showing a clear trend toward implementation. The first survey showed that 10 vendors supported IGES translators, whereas the second survey showed 20 companies offering these translators with an additional 19 companies currently developing them. The latest data[9] indicate that 15 different translators can pass files correctly in public intersystem testing and a fairly large number are now marketed (Table 2).

IGES Format. As with SIF, IGES' file structure is divided into several major components: start, global, directory entry, parameter, and terminate sections. The start section is not machine readable; its purpose is to provide a prologue to the file. Any number of cards can be used in this section to provide the user with general information about the file.

The global section contains information about the source system's post-processor so that the receiving system's preprocessor can process the file properly. Information such as the date of file generation, minimum resolution used, and unit of measure is listed.

The directory entry section consists of two records for every entity used. These records contain information common to all entity types. Information such as the type and version of that entity, the level on which it is to be located, and line weight are examples of information in these records. In the IGES format, an entity can be one of two major types: geometry or structure. Lines, arcs, and other more sophisticated graphic elements comprise the geometry type. The structure type handles all nongeometry to be supported--associativity definitions, properties, annotation (e.g., notes, dimensions) and its most powerful function, the ability to define a view (see Other Capabilities).

The parameter cards support definition of the specific entity. For example, if a circular arc entity was being defined, information about the location of the center might be required. If a general note or properties of the arc were to be added, parameter cards support this type of definition. For each entity required, an associated parameter card also will be needed to help define the entity.

The terminate section consists of one card. This section is required to define the end of the project file, completing the IGES deck.

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[7] B. M. Smith and J. Wellington.
[8] C. Machover, "Status Report: Vendor Update," Presentation to the CAD/CAM Standards Conference on IGES and Alternatives (May 1983).
[9] B. M. Smith and J. Wellington.

Table 2

Availability of ICES Translators

This list includes firms that have general-purpose drafting systems and specialized A/E packages.

	Demonstrates IGES Capability	Supplies Tape for Testing	Performs Public Intersystem Testing	Supplies Translators to Customers	Reference Note
Applicon	Y	Y	Y	2	2
A. M. Bruning	N				2
Autotrol	Y	Y	Y		5
Bausch & Lomb	Y	Y	Y		2
Cadam Inc.	N				4
Cadling	N				2
Calcomp	N				3
Calma	Y	Y	Y	12	6
Camax	N				4
ComputerVision	Y	Y	Y	50-100	4
Control Data	Y	Y	Y	40	4
Data Technology	N				4
Decision Graphics	N				4
Engineering Systems	Y				4
Gerber	Y	Y	Y	5	4
Graftek	Y	Y	Y		4
Holguin	N				4
IBM	Y	Y	Y	Y	5
Information Displays	N				4
Interactive Systems	N				4
Intergraph	Y	Y	Y	25	4
K & E	N				2
Marc Software	N				4
Matra Datavision	Y		Y	1	2
McAuto Unigraphics	Y	Y	Y		6
MCSI	Y	Y	Y	120	4
Prime	Y	Y	Y	Y	6
Project Software	N				4
Summagraphics	N				4
Systemhouse	N				4
Tektronix	N				4
T & W Systems	N				4

Source: B. M. Smith and J. Wellington.

Reference notes: (1) ICES questionnaire 5/82, (2) telephone contact, (3) third-party source, (4) Machover survey 5/83, (5) press release, (6) IGES Committee.

Other Capabilities. IGES supports two concepts not found in SIF which are very important in developing an advanced drafting system and imperative in computer-aided design. These concepts are (1) providing backpointers from the associated information and (2) defining views. The need for backpointers in networking database systems was mentioned earlier; this is needed primarily to support increased intelligence in systems.

With the views concept, IGES allows two types of information to be translated from one system to another: the drawing that may or may not represent the actual building model and the building model. IGES permits the picture on the drawing to come indirectly from an actual building model if needed. This gives designers the flexibility to design the model in three dimensions and, in effect, take pictures or cuts through the building using the view command. Figure 3 shows how the model, which is defined in three dimensions, and its two-dimensional representation are separated. This concept allows both design drawings and the actual building model to be translated without a data loss. Further, changes could be made to the model that would allow the drawing to be updated automatically. This is a primary difference between current drafting systems and a modeling system such as CAEADS. Future building design systems will generate the model as well as the drawings for Corps review. Therefore a translator format is needed that can support both current drafting systems and future modeling systems. To date, IGES is the only format that provides that capability.

Other Neutral Formats

One neutral translator format that has been used improperly with limited success is the CALCOMP. This format was designed specifically to provide a machine-independent format for Calcomp Corporation's family of graphics plotters. As a result, it cannot support the transfer of nongraphic information between machines. It has had limited success in passing simple files, such as design details, between machines. However, even this is not easy since there is no way to determine at what level the lines are to be placed. Because of these major limitations, no further consideration was given to this format as a standard neutral translator.

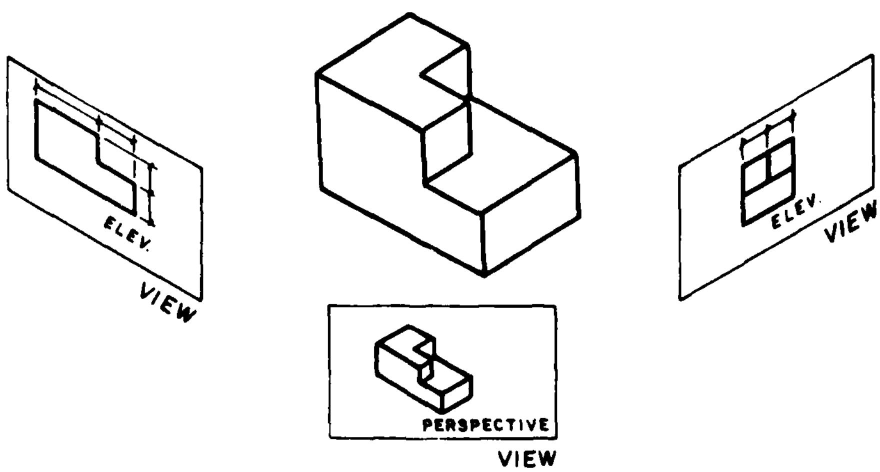

Figure 3. IGES View concept--two-dimensional display of three-dimensional model.

Vendors' Problems

Several vendors have written translators since the adoption of IGES as an ANSI standard in September 1981. These systems have been only partially successful, partly due to a lack of definition in the IGES format and to the general understanding among translator developers.

By evaluating an implementation of this standard, it is possible to understand the vendor's problems. The Corps is testing Intergraph drafting systems at Huntsville Division (military) and St. Louis District (civil works) for their potential in the Corps' design process. These systems are representative of the larger systems being used by many A/E firms country-wide and were used in this evaluation.

Intergraph's approach has not been to consider a translation device for any other vendor's equipment. Rather, the only consideration has been to provide a translation from IGES to the Interactive Graphics Design System (IGDS) and back to IGES. With this loop closed, Intergraph considers that the translation requirements to IGES Version 1.0 have been met and that any difficulty in reading files produced on another system must be blamed on the other system. This point is important. All of IGES Version 1.0 is supported through the Intergraph translator; however, this does not mean an IGDS file produced using generic software under normal operating procedures will transfer completely into an IGES file. To prove the translation on their system, users apply a reversal; that is, a file is translated from IGDS to IGES and from IGES back to IGDS. For a true evaluation, the translator should be used with a different system as well.

An informal task group of approximately 40 users with IGES concerns met in 1983. Roughly one-third of the group had installed IGES but only one had translated successfully from IGDS to IGES and back to IGDS. Translations between Intergraph and ComputerVision systems are now completed routinely.

The IGES translation is done by two separate processes, IGI and IGO, and is supported by the Intergraph Standard Interchange Format (ISIF). IGES-input, or IGI, is the IGES translator that changes data from the IGES format to an ISIF ASCII file. IGES-output, or IGO, is the IGES translator that changes data from an ISIF ASCII file to the IGES format. The IGES standard refers to these translators as pre- and postprocessors; thus, IGI is a postprocessor and IGO is a preprocessor.

Figure 4 shows how Intergraph supports these two IGES translators. IGI translates three-dimensional graphics data in IGES format to an ISIF ASCII file. IGO translates a three-dimensional ISIF ASCII file into an IGES formatted file. Both translators use the ISIF to create and decode the actual IGDS design file. In effect, IGI reads an IGES file and creates an ISIF ASCII file, whereas IGO reads an ISIF ASCII file and translates it into an IGES file.

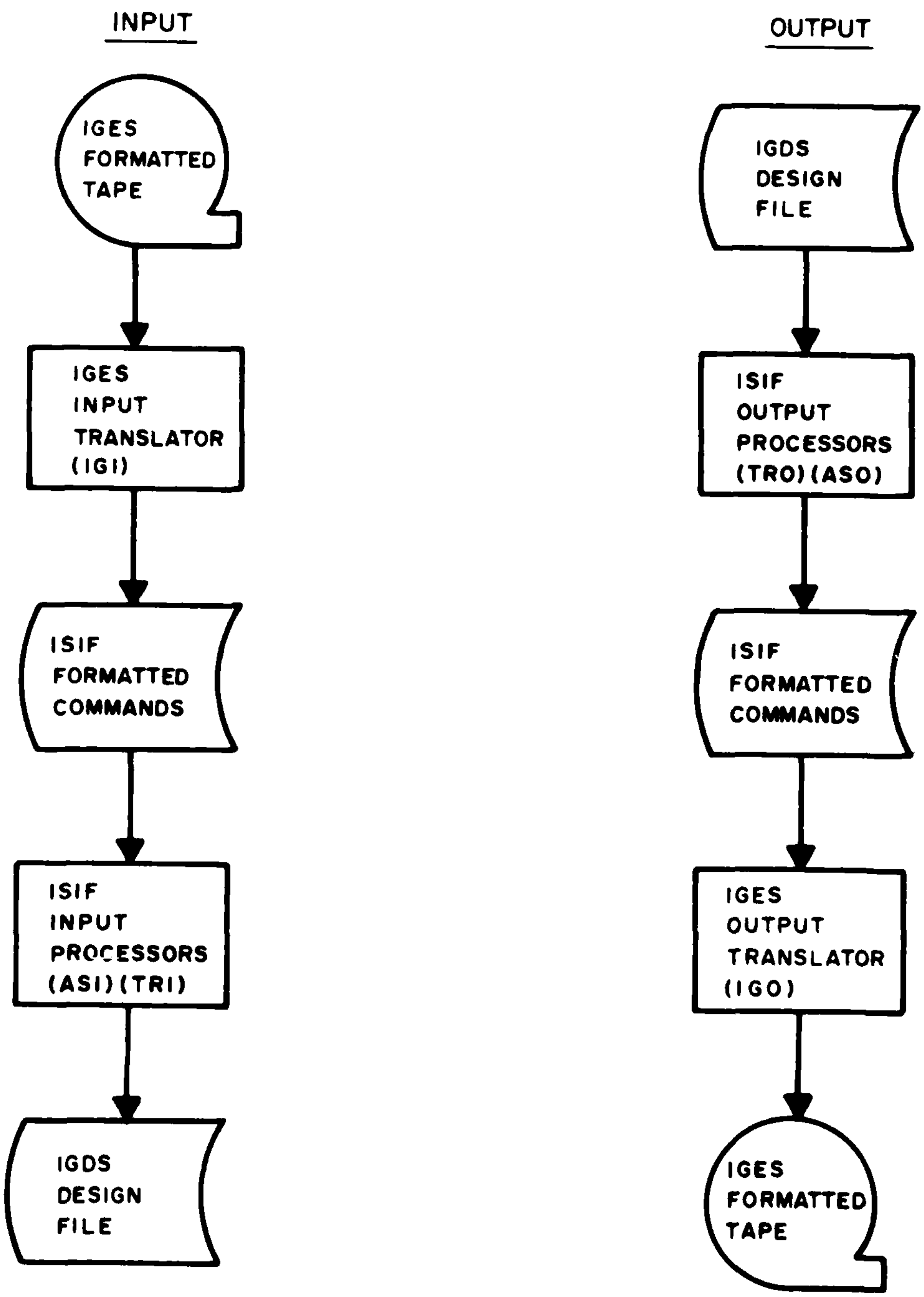

Figure 4. Intergraph IGES translation process.

Elements Supported by IGES

In its initial form, the Intergraph implementation of IGES supports about 40 entity types. In IGES terminology, all graphic and nongraphic data types are called "entities" and are classified as one of the following:

1. Geometry

2. Annotation

3. Structure

These correspond roughly to the following Intergraph IGDS concepts:

1. IGDS graphic elements

2. IGDS text and dimensioning elements

3. IGDS graphic group, cell patterning, font definition, property, and attribute information.

IGES does not lend itself to a one-to-one mapping with IGDS. Since IGES is an incomplete specification and does not support some files held within the Intergraph system, Intergraph chose to map IGES entities into IGDS, and back out to IGES rather than attempting to map all IGDS entities into IGES. The geometric entities supported are:

1. Circular arc

2. Composite curve

3. Conic arc

4. Copious data

5. Plane

6. Line

7. Parametric spline curve

8. Parametric spline surface

9. Point

10. Ruled surface

11. Surface of revolution

12. Tabulated cylinder

13. Transformation matrix.

Nongeometric entities supported are:

1. Angular dimension
2. Centerline
3. Diameter dimension
4. Flag Note
5. General label
6. General note
7. Leader (arrow)
8. Linear dimension
9. Ordinate dimension
10. Point dimension
11. Radius dimension
12. Section
13. Witness line.

Structure entities supported are:

1. Associativity definition
2. Associativity instance
3. Drawing
4. Line font definition
5. Macro definition
6. Macro instance
7. Property
8. Subfigure definition
9. Subfigure instance
10. Text font definition
11. View.

Further explanations and definitions of these entities are available elsewhere.[10]

Associated data not supported include the entire Data Management Retrieval System (DMRS) file. This Intergraph file can link nongraphic attribute data with graphic elements and is designed with a hierarchical structure.

The ability to define graphic elements as cells (groups of entities that can be manipulated as single units) as well as nested cells (cells grouped together to form complex cells) is lost after translation into IGES. Complex elements are also lost when transferred into IGES. For example, a polygon drawn using the "Place Block" or "Place Shape" command will not transfer. Place Block allows the user to define a rectangle by locating diagonal corners. To modify the element, any corner can be relocated. Since the block was originally defined by a diagonal, the diagonal is being modified. Place Shape allows the user to define any irregular polygon by locating successive points as long as the first and last points are coincident. To modify the polygon, any vertex can be relocated and the two sides pertinent to the vertex will be adjusted as required. These elements must be redefined as line strings to allow transfer.

For a thorough definition of the entities supported by IGES Version 1.0, a review of ANSI Y14.26M-1981, Sections 3 and 4, is highly recommended. IGES Version 2.0 was published in February 1983 and clarifies some of Version 1.0; however, the ANSI committee has not yet adopted this document, and Version 3.0 to address solids modeling is under development.

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[10] American National Standards Institute (ANSI) Standard Y14.26M-1981, "Engineering Drawing and Related Documentation Practices--Digital Representation for Communication of Product Definition Data" (1981).

5 STATUS REPORT OF EXISTING IGES TRANSLATOR

As part of a contract with the USAF Product Definition Data Interface (PDDI) project, Booz, Allen and Hamilton were tasked with the evaluation and verification of the ANSI Y14.26M version of the original IGES proposed standards.[11] That study gives an independent view of the current translators' success. It assessed the translators' level of development and evaluated IGES' ability to deal with product definition data. The work was done within the limits of current CAD technology, including two-dimensional drafting, three-dimensional wireframes modeling, and three-dimensional surface modeling. Since solids modeling is not supported in the ANSI standard, it was not considered (it will be available in IGES Version 3.0).

In a 3-month study of 12 sites representing 12 different vendors, separate tests were done to evaluate both preprocessors and postprocessors. The test examples were from aerospace system manufacturers but are acceptable for assessing basic capabilities. They are not, however, suitable for testing the database sizes expected for architectural/engineering/construction (A/E/C) projects. It is generally agreed that IGES expands the native databases 5 to 6 times. In some Corps projects, integrated IGES files could grow as large as 60 MB (native), or 360 MB in IGES format.

The study found that, in general, IGES can suitably transfer mechanical parts models between CADD systems and that support for IGES within the CADD vendor/user community is widespread. However, the study showed that several problems with IGES are slowing its progress.

Moreover, as in virtually any attempt to interface dissimilar systems with a specified format, the IGES approach is not "neutral." This is because "IGES is based on first generation commercial CAD system representation of geometry and annotation" and, "as such, (newer) systems that differ from this representation have difficulty in processing some IGES entities." The industry's continued development will probably see more and more vendors using different representatives--a trend that will escalate this problem.

Indeed, in the case of CAEADS, it would be rather straightforward to write an IGES out translator that would be usable by most drafting systems. However, the reverse is not true. Topology and other related data missing from a "dumb" system are very hard to create. In general, you can only lose information in a translation, not gain it. Very few drafting systems store this kind of information.

Another problem shown by the study is that IGES is often too flexible, causing confusion when developing translators. That is, several entity combinations may be available to describe a given part or feature. The manufacturer's choice is based on:

1. Entities available on the CADD system

2. Ease of implementation

[11] Booz, Allen, and Hamilton, Inc., "Report to the NBS IGES Test, Evaluation and Support Committee" (October 1983).

3. Compactness of representation

4. Required accuracy/functionality

5. Other interface requirements.

CADD systems also may have "entities not explicitly defined in IGES that can be approximated by existing IGES entities or created with the user-defined IGES entity structures." In addition, emphasis can be on (1) the preprocessor, by defining the information output in IGES format as explicitly as possible so that little postprocessor interpretation is needed, or (2) the postprocessor, by requiring it to interpret the entities it processes. Thus, although some flexibility is required for mapping entities between dissimilar systems, IGES is too flexible and can lose information during translation. It was found that the IGES demands substantial postprocessor interpretation and that inconsistent interpretation can result.

This study recommends that entity mapping choices be controlled to preserve model accuracy and functionality. It further states that changes to the standard and additional recommended practices are required. "Recommended practices" are informal documents that suggest methods of using translation capabilities. In effect, they are a quick answer to vague requirements in the standard. Although they may solve the problem indirectly, they should be considered for incorporation into the next version of the standard.

The study identified one other major problem of high importance in A/E/C implementations. In particular, wide variations were found in the processing time required to read and write IGES files. Processing times were not quantified, as they were a function of many parameters not controlled in the study (e.g., CPU size and memory capacity and whether the system is dedicated or shared by several users). However, these researchers' estimates of processing time per entity ranged from 0.01 to 1.0 sec for postprocessing. Preprocessing usually is done as much as four times faster than postprocessing because of the known environment and the minimal error checking required. The test method did not consider estimated IGES file sizes that might be found in a manufacturing environment.

The study has reinforced some of the A/E/C subcommittee's concerns. First, much further definition of the building/site model is required to provide efficient translation of files. Also, a way must be found to create compact IGES files. The NBS A/E/C subcommittee is currently working in those two areas with cooperation of the plant/process piping subcommittee.

Three new IGES capabilities have been discussed in committee to resolve the volume of information in the A/E/C environment. First, the ability to segment a file by any reasonable means (e.g., by disciplines or building level) would allow project subsets from several individual design consultants to be transmitted to a lead designer for coordination. This way, updates could be made without retransmitting the entire database.

Although technically feasible, the mechanics involved with such a system are quite complicated. A more modest proposal (technically) is to incorporate a library concept allowing only project unique data to be transmitted. This would require sending and receiving systems to have the same library.

These techniques promise to reduce the size of files to be transmitted. However, as long as a common "neutral" format is maintained, the IGES files will remain much longer than the native files that were used. Future technology may resolve part of this problem by reducing processing and storage costs and by increasing processor speeds.

6 CONCLUSIONS AND RECOMMENDATIONS

Alternative graphics translators have been studied for potential in transferring architectural data between different CADD systems. This study focused on two types of translators--direct and neutral.

Direct translators are not a practical solution to Corps needs because the number of these programs required increases exponentially with the number of systems involved. Neutral translators are more promising. If the Corps were concerned only with the near future, then either SIF or IGES formats would be satisfactory. However, a second generation of systems that use modeling techniques will soon make much more information available if it can be captured. Only IGES has the technical capability to capture the building and site "model" and further, it has the largest following in the industry as a whole. Therefore, it is expected to have the best chance of meeting the A/E/C community's future needs.

The quality of translators in the IGES format is expected to improve greatly as their use increases and vendors learn from experience. In addition, experience in the aerospace and electronics industries should resolve many of the modeling problems before the architectural modelers become available. Some professional organizations are working on standards to help define the building model so it can also be translated in a consistent way.

It is recommended that the Corps continue this work by:

1. Actively participating on the IGES A/E/C subcommittee

2. Requiring a tested IGES translator in the procurement of all Corps design and drafting systems.

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