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THE NASA-IGES GEOMETRY DATA EXCHANGE STANDARD*

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SUMMARY

This paper describes the the data exchange efforts and plans supported by the NASA Steering Committee for Surface Modeling and Grid Generation. Current methods for geometry data exchange between Computer Aided Design (CAD) systems and NASA Computational Fluid Dynamics (CFD) analysis systems are tedious and induce errors. A Geometry Data Exchange Standard is proposed, utilizing a subset of an existing national standard titled Initial Graphics Exchange Standard (IGES) (ref. 1). Future plans for Data Exchange Standardization include all aspects of CFD data. Software systems to utilize this NASA-IGES Geometry Data Exchange Specification are under development.

INTRODUCTION

The geometry data received by NASA scientists for analysis and modification is currently supplied in numerous formats which often require hundreds of hours of manipulation to achieve a format capable of being utilized by analysis software. This modified data set usually has lost a level of accuracy from the original data and often may not maintain the design intent of the original data as developed on the original designer's system.

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In the spring of 1991 the NASA Steering Committee for Surface Modeling and Grid Generation (ref. 2) formed a Geometry Data Exchange Subcommittee of technical personnel from the NASA Ames, Langley, and Lewis Research Centers to develop a standard method for transferring complex vehicle geometries between various software systems. Following an analysis of existing and proposed standards, the Geometry Subcommittee selected the existing IGES format as the basis for a NASA standard. In the United States, the IGES format is the most widely used product data exchange method for complex geometries. The latest version of the IGES specification (version 5.1) provides an adequate set of geometric entities to cover the current data transfer needs for CFD research. A subset of the IGES document was selected and a draft NASA Technical Specification was released in September of 1991 titled "NASA Geometry Data Exchange Specification utilizing IGES" (ref. 3) commonly referred to as the NASA-IGES Geometry Data Exchange Specification or simply NASA-IGES. A second draft of the document should be available in early spring of 1992.

The NASA-IGES Geometry Data Exchange Specification is meant to provide a means for rapid and accurate geometry data transfer for engineering analysis utilizing Computational Fluid Dynamics and related methods. Specifically, it is to provide a method for the transfer of data between CAD systems and Grid Generation Software. This will greatly improve the ability of scientists and engineers to rapidly proceed with analysis of a wide variety of vehicle geometries.

This document explains the IGES/PDES Organization (IPO), describes the contents of the NASA-IGES Geometry Data Exchange Specification, discusses the NASA Steering Committee for Surface Modeling and Grid Generation future plans for Data Exchange Standardization, and describes some of the software under development to utilize the NASA-IGES Geometry Data Exchange Specification.

IGES / PDES ORGANIZATION

The IGES/PDES Organization (IPO) is a body of volunteers from industry, government, and academia who are dedicated to the development and implementation of world-wide standards for the digital representation and communication of product data. The IPO efforts focus in two main areas: IGES and PDES.

In the late 1970s and early 1980s The Initial Graphics Exchange Specification (IGES) was designed and developed as a neutral data format to allow the digital exchange of data among incompatible CAD systems. IGES Version 5.0 has been accepted by the American National Standards Institute (ANSI). Version 5.1 was released in September of 1991.

The Product Data Exchange using STEP (PDES) effort is the United States activity which supports the development of the International Standard referred to as the Standard for the Exchange of Product Model Data (STEP). The first version of STEP is yet to be released.

The IPO is headquartered at the National Institute of Standards and Technology (NIST) in Washington D. C. The IPO has regular quarterly meetings. IPO membership is in excess of 600 persons.

For further information on the IPO, see reference 4.

SPECIFICATION DESCRIPTION

The NASA-IGES Geometry Data Exchange Specification differs from standard IGES in one important aspect. Standard IGES files are typically very large and are an attempt to represent every aspect of product data. NASA-IGES is intended to provide a very small subset of this capability. NASA-IGES is designed solely to provide a data exchange format for transferring complex vehicle geometries between software systems. Very little other product data is included in the NASA-IGES Specification. This minimal approach should provide small organizations and individual research scientists with a data transfer method they can afford to utilize in their particular software. The NASA-IGES Specification also will provide software developers with a data transfer method that NASA has committed to utilizing for the foreseeable future. This continuity should allow greater communication between future software packages.

The NASA-IGES Geometry Data Exchange Specification includes several geometry entities and a few other entities. The geometry entities include simple shapes such as circles and conics and a complex representation method utilizing Rational B-Splines. Additional geometry related entities are included to provide information such as coordinate system transformation. The non-geometric entities included were the minimum deemed necessary to convey grouping and visualization information about the object as well as a brief description capability.

The following is a list, ordered by IGES Entity type number, of the specific entities included in the NASA-IGES Specification. For a description of each entity see either the NASA-IGES Geometry Data Exchange Specification or the IGES Version 5.1 document.

IGES Entity Type Number	Entity Name
Entity 0:	Null Entity
Entity 100:	Circular Arc
Entity 102:	Composite Curve
Entity 104:	Conic Arc
Entity 106:	Copious Data
Entity 108:	Plane
Entity 110:	Line
Entity 116:	Point
Entity 124:	Transformation Matrix
Entity 126:	Rational B-Spline Curve
Entity 128:	Rational B-Spline Surface
Entity 141:	Boundary
Entity 142:	Curve on a Parametric Surface
Entity 143:	Bounded Surface
Entity 212:	General Note
Entity 314:	Color Definition
Entity 402:	Associativity Instance
Entity 406, Form 1:	Definition Levels
Entity 406, Form 15:	Name

It is expected that most grid generation and analysis software that utilizes NASA-IGES data will represent the geometry internally as Non-Uniform Rational B-Splines (NURBS). Because of this, it is desired that CAD systems be able to provide geometry in a NURBS based form (entities 126 and 128) rather than as a Circular Arc, Line, Copious Data, Plane, Point, or Conic Arc. Also, Entity 104 (Conic Arc) was included so simple CAD systems utilizing only this geometric modeling capability could be utilized and to allow development of simple shapes when desired for a specific purpose. Due to accuracy problems in the method IGES uses to represent conics, it is highly desirable to always convert conics to B-Splines before generating a NASA-IGES file.

Existing CFD grid generation programs often input a mesh of points to represent the geometry. Because of this, the geometry data is often represented solely as a mesh of points. This mesh is often redistributed several times before achieving the desired grid for CFD. This meshing and re-meshing of the vehicle surface geometry induces and propagates errors. For this reason, the NASA-IGES Specification emphasizes the use of the original design curves and surfaces with continuous derivatives as the correct way to represent geometry rather than utilizing a mesh of discrete points. The intent is to transfer the highest order surface representation available.

To summarize, it is desirable to represent all geometric objects utilizing the following entities:

Entity 126:	Rational B-Spline Curve
Entity 128:	Rational B-Spline Surface
Entity 141:	Boundary
Entity 142:	Curve on a Parametric Surface
Entity 143:	Bounded Surface

The following geometry related entities are also needed:

Entity 102:	Composite Curve
Entity 124:	Transformation Matrix

The following geometric entities are allowed but discouraged for most purposes:

Entity 100:	Circular Arc
Entity 110:	Line
Entity 106:	Copious Data
Entity 108:	Plane
Entity 116:	Point

The following geometric entity is allowed but discouraged at all times:

Entity 104:	Conic Arc

The following non-geometric entities are available:

Entity 0:	Null Entity
Entity 212:	General Note
Entity 314:	Color Definition
Entity 402:	Associativity Instance
Entity 406, Form 1:	Definition Levels
Entity 406, Form 15:	Name

FUTURE PLANS

The NASA Steering Committee for Surface Modeling and Grid Generation has started a coordinated effort to standardize the exchange of geometry, grid, and solution data used in the analysis of computational aerophysics problems. The initial purpose is to provide rapid and accurate geometry data exchange between CAD systems and grid generation software. The long term goal is to provide a rapid, accurate, and stable data exchange method for use in comprehensive engineering design and analysis in support of such fields as Computational Fluid Dynamics (CFD), Computational Electro-Magnetics (CEM), and Finite Element Method (FEM) Structural Analysis.

The following timetable has been agreed to by the NASA Steering Committee for Surface Modeling and Grid Generation. Several items relate to national standards organization efforts, and therefore the time frame for completion is dependent upon performance by those organizations.

NASA-wide consensus on the NASA-IGES Geometry Data Exchange Specification:	- 4th quarter 1992
Approval of an IGES Application Protocol following the NASA_IGES Geometry Data Exchange Specification format:	- 4th quarter 1993
Approval of a STEP Application Protocol providing the geometry data exchange capability desired for CFD:	- estimate 1993 - 1994
NASA-wide consensus on a NASA specification describing grid and solution data for structured and unstructured methods:	- 2nd quarter 1993
Approval of an IGES Application Protocol for grid and solution data for structured and unstructured methods:	- 2nd quarter 1994
Approval of a STEP Application Protocol for grid and solution data for structured and unstructured methods:	- estimate 1994 - 1995

SOFTWARE UTILIZING NASA-IGES

The three NASA Research Centers are currently developing grid generation software capable of utilizing geometry data in the form specified in the NASA-IGES Geometry Data Exchange Specification. In direct support of this effort, personnel at the Numerical Aerodynamic Simulation Facility at NASA Ames are developing a reader-viewer-translator for IGES data files (ref. 5). NASA personnel at all three Research Centers are planning to modify software to utilize NURBS based NASA-IGES geometry data. A few of the programs include S3D - an interactive surface grid generation tool (ref. 6), VGRID - an unstructured grid generator and flow solver developed by ViGYAN under contract to

NASA Langley (ref. 7), GRIDGEN - a structured grid generation system being enhanced by MDA Engineering under contract to Computer Sciences Corporation for NASA Langley (ref. 8), and a turbomachinery analysis code under development NASA Lewis.

SPECIFICATION AUTHORS

The authors of the NASA-IGES Geometry Data Exchange Specification include more than 15 engineers and scientists from NASA Ames, Langley, and Lewis Research Centers. The coordinators of the project are listed as authors on this paper.

REFERENCES

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2. NASA Steering Committee for Surface Modeling and Grid Generation, organized through the NASA Office of Aeronautics and Space Technology (OAST), contact Pam Richardson, NASA Headquarters

3. Geometry Subcommittee, NASA Steering Committee for Surface Modeling and Grid Generation, Matthew W. Blake Project Lead, NASA Geometry Data Exchange Specification Utilizing IGES (draft), September 30, 1991. To obtain a copy, contact Matthew Blake, MS258-5, NASA Ames Research Center, Moffett Field, CA 94035 or e-mail blake@nas.nasa.gov

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