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U.S. DEPARTMENT OF COMMERCE
TECHNOLOGY ADMINISTRATION
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U.S. DEPARTMENT OF COMMERCE
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Mary L. Good, Under Secretary for Technology

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Arati Pabhakar, Director

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1 Introduction

1.1 Purpose of this Document

This document describes user requirements for implementing STEP[1] (Standard for the Exchange of Product model data) in a production environment for packaging applications used in the auto industry. The main purpose of the document is to report the results of a requirements survey of AutoSTEP project participants concerning the implementation of STEP in production practice. The intended audience for this document is the members of the AutoSTEP project.

1.2 Document Organization

An overview of the AutoSTEP project is given in Section 2. Section 3 describes the existing communications infrastructure in the AutoSTEP project. Section 4 presents requirements for implementing STEP in production. Section 5 discusses the different viewpoints of OEMs and Suppliers, and Section 6 provides a summary. Interview questions are attached in the appendix and the document also includes a glossary and references.

2 Overview

2.1 AutoSTEP Project

The AutoSTEP pilot project is directed by the Automotive Industry Action Group (AIAG), a trade association consisting of automotive manufacturers, suppliers, and software vendors. The AutoSTEP pilot will demonstrate practical product data communication processes in production use and create a foundation for industry acceptance of product data transfer using a neutral format. When product data exchange becomes simple and reliable, it can happen more freely. The AutoSTEP project will not just demonstrate the technology, but will build a business case for re-engineering the design and development processes in order to maximize data exchange throughout the entire supply chain.

Efficient exchange of product data throughout a supply chain is critical to effective product and process design. AutoSTEP focuses automotive industry attention on the adoption of STEP to improve the exchange of product data. This standard is rapidly gaining acceptance among the leading industrial nations of the world. AIAG and the AutoSTEP project will strive to ensure that STEP development efforts will meet the needs of the automotive industry. AutoSTEP will focus on the interfaces between companies, the processes deemed to be noncompetitive among the participants, and the enabling communication technologies that allow competitive processes to take place. Issues related to STEP that are identified by AutoSTEP will be fed back into the standards development process.

AutoSTEP is a three to four year activity divided into three phases. Each phase is constructed around the same basic outline. The first phase is designed to establish STEP capabilities for product data exchange between the automotive companies and first-tier suppliers. Phase 2 will extend the nature of the information exchanged and add in second-tier suppliers. Phase 3 will

[1]STEP is the commonly used term for ISO 10303

further extend the information and depth of the supply chain involved. By the end of Phase 3, AutoSTEP will demonstrate the use of STEP to support most aspects of automotive mechanical design.

Participants

AutoSTEP is being led by the Automotive Industry Action Group (AIAG), an industry trade association. Phase 1 participants include General Motors, Ford Motor Company, and Chrysler Corporation along with six of their major suppliers: Eaton Corporation, Allied Signal Automotive, TRW Automotive, Delphi Saginaw, Dana Corporation, and Sealed Power Technologies. Supporting organizations include CAD vendors: EDS/Unigraphics, Dassault/CATIA, PTC/ProE, CV and SDRC; STEP tool suppliers: STEP Tools, Inc., International Technology Group, Inc., Industrial Technology Institute, PDES, Inc., the National Institute of Standards and Technology (NIST), Oakland Community College, and others.

Funding

AutoSTEP is funded by AIAG which receives its funding through member companies.

As-Is Assessment and Requirements Gathering

The as-is assessment and interoperability requirements provide an understanding of how the participants in the pilot currently work together in product development and how product data is currently exchanged. The interoperability requirements gathering will identify user requirements for implementing new data exchange technologies. Without the baseline provided by such an evaluation, effective planning for improvement activities would be impossible.

2.2 Interoperability Requirements Gathering Project

The interoperability requirements gathering project is part of the AutoSTEP - Phase 1 effort to evaluate the state of existing CAD STEP translators [Dev95] and identify requirements for implementing STEP in production use. These requirements provide information to assist CAD vendors in focussing their efforts on upgrading their systems.

Scope

The requirements gathering project collected the requirements, metrics, and standards for CAD solid model exchange for packaging applications.

Objective

The object of AutoSTEP is to identify user requirements for solid model exchange, establish metrics, identify CAD modeling standards from AutoSTEP participants for packaging applications, and report findings to AutoSTEP project participants and the entire automotive industry.

Method

The objective was accomplished by written questionnaire and on-site interviews with AutoSTEP participants. The interoperability requirements team sent out a written questionnaire prior to the

on-site interviews. The questionnaire was designed to let the participants know what to expect during the on-site interviews and to give their technical staff a chance to collect data and identify requirements.

On-site interviews were held with each of the AutoSTEP participants. During the interviews, interoperability team members collected information on existing and planned communications mechanisms, CAD data exchange requirements, efficacy of existing CAD modeling exchange standards, and model exchange validation metrics.

3 Infrastructure

Infrastructure defines the basic facilities, equipment and installations needed for the functioning of a system.

The infrastructure required for the AutoSTEP project includes computer systems, software systems, and communication methods necessary to transfer product data. The AutoSTEP project participants are structured as supply chain trading partners, see Figure 1. Each trading pair must establish a suitable translation path for neutral STEP exchanges and a means of communication between each other's systems. The AutoSTEP project will adopt preferred communications mechanisms for project participants.

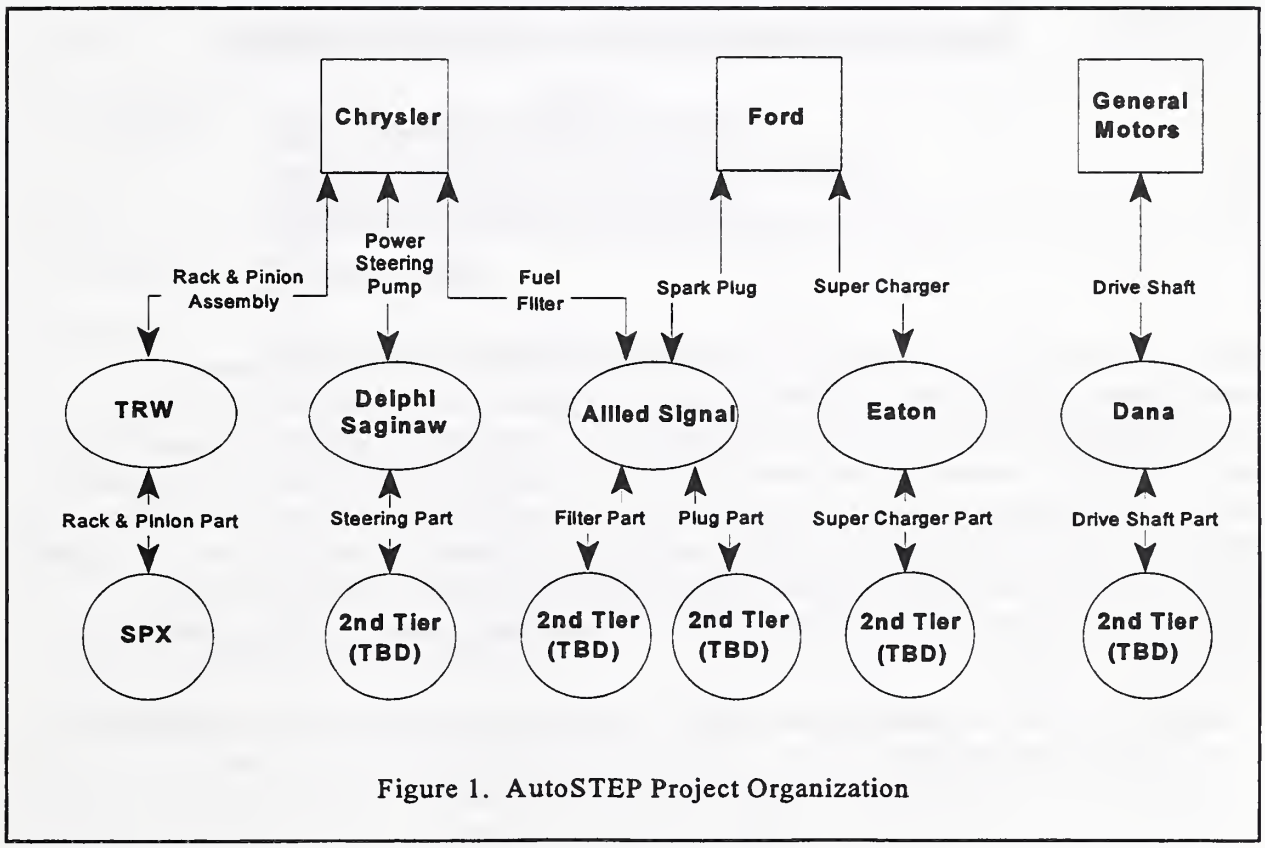

Figure 1. AutoSTEP Project Organization

3.1 Communications

CAD file transfers by AutoSTEP participants currently run the gamut of available mechanisms and formats including a full range of magnetic media and an assortment of electronic means. Magnetic media includes tapes and diskettes with 8mm and 4mm tapes replacing 1/4 inch and 9track tapes. Electronic file transfer modes include dedicated lines, proprietary networks, modems, internal (company-wide) networks, and the Internet.

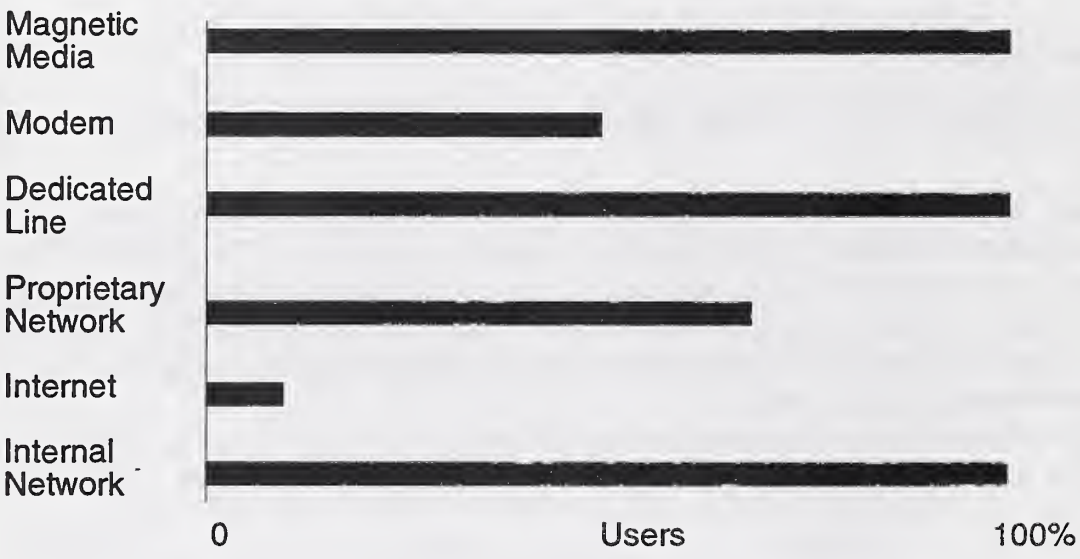

Figure 2. Electronic File Transfer Mechanisms

AutoSTEP participants are moving to electronic file transfer as their preferred means of communication. OEMs will eliminate virtually all magnetic media within the next two years. Several OEMs will specify electronic file transfer only. First tier and second tier suppliers will use both electronic transfer and magnetic media. Small suppliers will continue to use magnetic media as their primary communications mechanism. Several participants cited the high cost of network connections as the biggest problem with using electronic file transfer. Many participants cited security concerns about using the Internet, although most were using the "secure" AutoSTEP FTP site at NIST to exchange files. Communications statistics of some interest include the following:

The ratio of electronic / tape file transfers is currently approximately 20 to 1 for OEMs and 1 to 1 for first tier suppliers.

All AutoSTEP participants have dedicated lines to customers and suppliers.

All AutoSTEP participants have internal, company-wide networks.

Internet access of all AutoSTEP members is strictly controlled because of security concerns.

3.2 Standards / Formats

All AutoSTEP participants transfer files using native CAD format. Participants also use IGES, direct translators, DXF, and proprietary formats, but the overwhelming majority of CAD model transfers are in native CAD format. OEMs are increasingly insisting on native CAD format only and are actively eliminating non-strategic CAD systems from their operations. Second tier suppliers will continue to use IGES and DXF formats to transfer files. First tier suppliers are caught in the middle and must maintain a host of different CAD systems to satisfy customer requirements and match their supplier capabilities. Figure 3 compares the number of AutoSTEP users of each format.

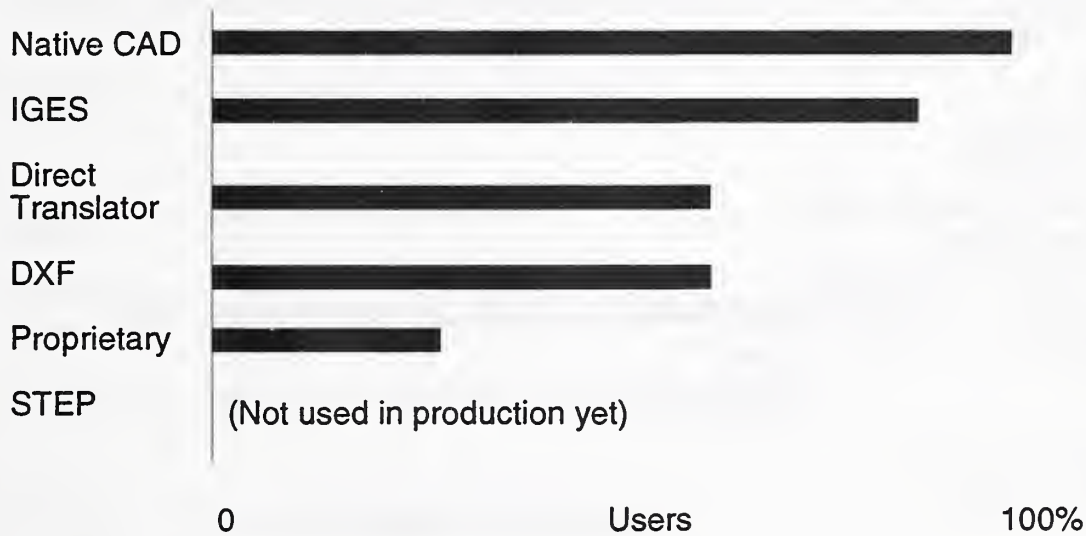

Figure 3. File Exchange Standards / Formats used in Production

4 Interoperability Requirements

AutoSTEP participants were asked to identify their requirements for making STEP "production ready." To facilitate this, participants were asked to discuss their current problems with file translations, applications that use product data, the file validation metrics they use, their view of model complexity, and future requirements they see for STEP.

4.1 Requirements Scope

The scope of the AutoSTEP pilot is the exchange of product data for mechanical design. The project focus in Phases 1a and 1b is on STEP AP 203[2] with packaging as the initial application selected for STEP implementation. Project members identified data requirements for CAD models in terms of application to packaging. CAD models of production parts will be exchanged by each of the supply chain pairs. The initial parts selected are shown in Figure 1.

4.2 Uses of CAD Data

AutoSTEP participants use mechanical CAD data in many diverse applications. The majority of these applications fall into three main categories: design, engineering, and manufacturing. For any kind of CAD data translation to be employed in practice, translated models must be usable in downstream applications. Applications used by AutoSTEP participants include the following:

Design
- 2D design/drafting
- 3D design/drafting
- Surface modeling
- Solid modeling

Engineering
- Digital mock up
- Fluid dynamics
- Finite element analysis (FEA)
- Mold flow analysis
- Motion analysis / kinematics
- Packaging
- Visualization (e.g., stereo lithography)

Manufacturing
- Numerical control (NC)
- Tool / Die design

Data requirements vary greatly between applications. Packaging was selected for this pilot project because it is perhaps the least demanding solid modeling application in general use. AutoSTEP participants identified auto meshing for finite element analysis as the most demanding application for files that have been transferred using STEP. Meshing requires knowledge of how the model was constructed. Model creation history is not currently part of STEP.

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[2]AP 203 is an application protocol that defines the data representation for 3-D solid modeling in STEP.

4.3 Packaging Application

The initial focus (scope) of the AutoSTEP project is packaging. Packaging is used for interference checking. Solid models of various components in an assembly (e.g., components inside an engine compartment) are combined and referenced to a single coordinate system. Interferences are identified and components are redesigned as required. Packaging models must be true solid models, but need only represent external features. In the case of a component that has motion, the packaging model represents the entire envelope swept out by that component. Since packaging models do not have internal geometry, they are less complex and potentially easier to transfer to other CAD systems. Also, in many cases, complex features (i.e., hard to transfer entities) such as fillets can be eliminated prior to translation with no impact.

4.4 Problems Encountered

Problems with current systems are requirements for future systems. Participants were asked to list problems they have encountered with their current systems and set ups in an effort to identify requirements for STEP implementation. AutoSTEP participants presently have only limited experience using STEP. Therefore, participants identified problems not only with STEP, but existing problems with IGES and direct translators as well.

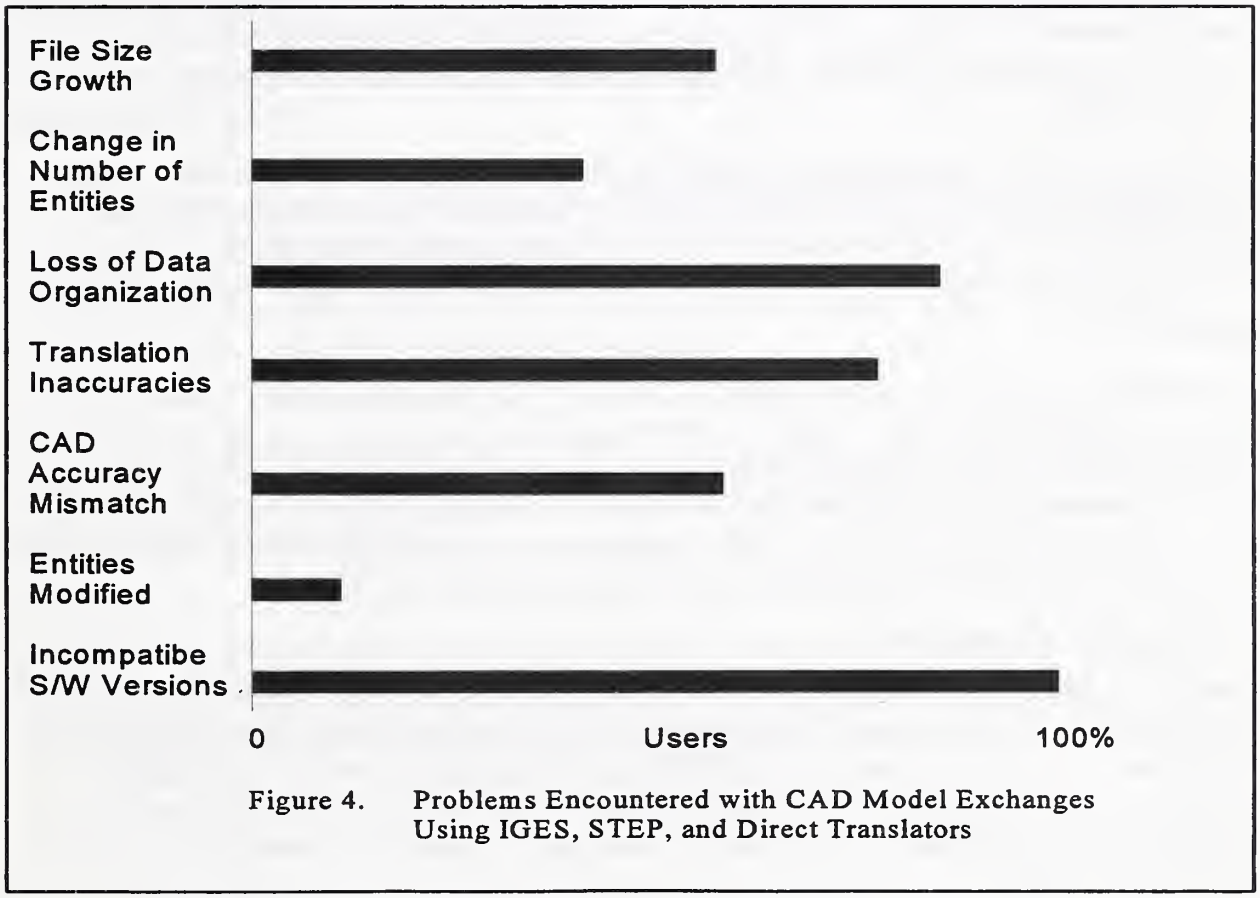

Figure 4. Problems Encountered with CAD Model Exchanges Using IGES, STEP, and Direct Translators

The most ubiquitous problem reported by users was incompatible versions of CAD systems and translators. Some software revisions are four or five levels deep (Version, Revision, Modification, Fix, Patch). When systems are out of sync, no usable transfers can occur. Almost all participants stated this was their biggest problem. Although not a requirement for STEP, this problem must be addressed if STEP adoption is to succeed.

CAD system accuracy mismatch was identified as a problem, but only with certain CAD systems. Excessive file size growth was reported with some STEP translations, as was loss of entity data. AIAG and NIST have established a data base for the AutoSTEP project participants to record results of file exchanges and identify problems with translators. More information on this is available [Ros96].

4.5 Requirements for STEP Implementation

The absolute, fundamental requirement for adopting STEP (or any other data exchange format) is that the implementation of STEP has to work better than what is presently being used. "It has to work better than IGES," was a statement made by all AutoSTEP participants ("better" meaning more successful file transfers). STEP has to be shown to reduce costs, save time, or overcome some major technical hurdle in order for it to be placed into production use. Almost all of the AutoSTEP participants expressed a desire to use STEP or something like STEP. If STEP can meet requirements, acceptance will be immediate. There were no cultural or "not invented here" barriers identified by AutoSTEP participants. The requirements for STEP implementation are purely technical.

STEP implementation requirements must be addressed on two separate technical levels: 1) The STEP standard itself and 2) CAD vendors implementation of STEP translators. AutoSTEP participants did not identify any near-term requirements that are not met by the STEP standard. The CAD systems themselves and the STEP translators are the primary focus of this project.

Geometry

AutoSTEP participants use and exchange 2D drawings, 3D wireframe models, surface models, CSG solids, and B-Rep solids. Most AutoSTEP participants are moving to 3D design as a standard practice. Geometry requirements for packaging applications are satisfied by STEP AP 203 conformance class 2 (wireframe and surfaces) and conformance class 6 (advanced B-Rep). Data on the processing capabilities of STEP translators for specific features and entities was not available because users have not had enough experience exchanging STEP data.

Configuration Management

Configuration management was identified by all participants as one of the most important issues associated with CAD data transfer. Configuration management data is essential to maintain control over product data, especially design changes. Participants did not provide detailed requirements for configuration management data because the AutoSTEP project has not fully introduced this to participants. Configuration management attributes that were cited by participants included:

Version control

Approvals

Electronic sign-offs

Dates

Change history

Designer names

Electronic sign-off was identified by several participants as having great potential for time and cost savings by eliminating the transfer of documents through the mail.

Accuracy

CAD systems and STEP translators must be capable of better than typical machining accuracies, i.e., 0.0025 mm. Packaging accuracy requirements ranged from 50 mm to less than 2.0 mm. Although these requirements present no problems for workstation hardware and CAD software, several participants reported that they were unable to achieve the required accuracy for certain applications after translating the file into a different CAD system. STEP translators must be capable of maintaining dimensional accuracy.

The following scenario is a somewhat extreme example, but does illustrate real world requirements for STEP:

> A part to be machined is sent out to a prototype shop. The prototype shop uses a particular CAM system which will only accept files from the shop's CAD system. No direct translator is available. The file is transferred as follows:
>
> CAD system A - solid - surface - IGES - CAD system B - surface - solid - NC application - post processor - machine tool controller - **bad part.**

In this case the part has minor deviations from the original model, but it is impossible to tell who is at fault since the file has been translated. Users will not accept STEP unless they can **use** the data in downstream applications.

Tolerances

Tolerances are required for manufacturing operations. Participants did not identify any specific manufacturing tolerance requirements. The AutoSTEP project is not currently testing manufacturing applications (tolerances are out of scope for AP203, but are within the scope of the APs under consideration for future phases of AutoSTEP).

Processing Times

Processing time for file translations and file transfers was not a major concern for most AutoSTEP participants. These activities can be accomplished off-line and most participants queue up batch jobs for overnight processing.

Faster is better, however. Translators that are too slow will be unacceptable to users. Processing times are dependant on file size, but the average desired processing time cited by AutoSTEP participants averages at about 5 min./Mb (e.g., a 4 Mb file should take about 20 min. to process).

Repair Ratio

The repair ratio is a metric used by several participants to decide if it is more cost effective to fix a file or recreate a model from scratch. The repair ratio is the estimated time to repair a file divided by the time it took to create the original model. This ratio varied between participants with 10-20% being the cut-off. When viewed as a requirement, this means translators must be capable of producing part models which have an average repair ratio within a certain limit, e.g., 10%. A small repair ratio is preferable because of the intrinsic value of recreating the model on the native system (e.i., there is enough benefit derived from recreating a model on the native system to offset some amount of extra time required to recreate the model).

Future Requirements

Model Creation Technique

Solid model creation technique, e.g., how the model is constructed, was identified by several AutoSTEP participants as a crucial factor for CAD data exchange.

Parametric / Feature-based Design

Many CAD systems include parametric modeling (where relationships between model features and parameters are captured). STEP does not currently address parametric modeling. STEP must address this in the future because all AutoSTEP participants indicated they will move to parametric / feature-based design in the next several years as an increasing number of CAD systems include this capability.

4.6 Metrics

AutoSTEP participants use a variety of tests and metrics to determine if file translations/transfers are successful. However, participants identified no specific requirements regarding tests and metrics. Almost all participants use some validation tests when receiving files. Several participants employed validation tests prior to translation and transfer. Visual inspection was by far the most common technique for translation validation.

Validation tests and metrics cited by users included:

Loop test - read file back in and compare to original model

Solid validity - Unigraphics has a facility to determine if the model is a valid solid

Shading - if the model can be shaded, it is probably a valid solid

Visual inspection - model matches picture received from sender

Surface area - compare surface area with surface area from originating system

Volume - compare volume with volume from originating system

Mass properties - compare mass properties with mass properties from originating system

Gaps between surfaces - search for gaps between surfaces

Moments of inertia - compare mass moments with mass moments from originating system

Entity count - compare entity count to entity count from originating system

Error reports - check for error reports generated by translators

Target applications - try to use the model in an application (e.g., stereo lithography, finite element analysis, numerical control). This metric is also used prior to translation.

Repair Ratio - Time to repair model / Time to create model. Participants use this metric as a means of determining if they will try to repair a file or recreate the model from scratch.

For surface and mass properties, a 1% difference between the models on the sending and receiving systems was considered acceptable by most participants.

4.7 Model Complexity

The definition of model complexity is a very controversial subject. If a CAD vendor claims a STEP translator can process complex models, what does that mean? AutoSTEP participants defined model complexity in several different ways: entity types, features, file size, and ability to process in downstream applications such as FEA meshing.

Class	Typical Features	Size	FEA Meshing
Simple	Basic shapes (cylinder, sphere, block, etc.)	<2 Mb	Can be meshed easily
Moderate	B-spline surfaces Conical shapes	2 - 10 Mb	Difficult to mesh
Complex	Sculptured surfaces Blended surfaces Trimmed surfaces Fillets Intersections of curves	>10 Mb	Cannot mesh without

A more thorough discussion of model complexity is available [Wil95].

4.8 User Observations

Anecdotal requirements are not the same as objective, quantitatively defined requirements, but are, nevertheless, a good indication of how well STEP will have to work to satisfy users. The following are quotes from AutoSTEP participants concerning their personal requirements for STEP implementation:

** "It has to be better than IGES." (in terms of transfer success)
"50% of all our IGES files received need to be fixed."
"Last year, we spent 10% of our department budget fixing or recreating CAD files received from suppliers... We won't do that again."
"We gave up on IGES."
** "Our biggest problem with STEP right now is trying to get the software versions to match down to the latest patch." (VERSION-REVISION-MODIFICATION-FIX-PATCH)
"We won't use STEP unless CAD vendors can show total, seamless, 100% error-free transfers. It must be totally invisible to the user."
"We have to maintain seven CAD systems to meet our customers' mandates for native CAD files, work with our manufacturing folks, and work with our suppliers."
"If STEP worked, acceptance would be immediate."
"Model creation technique will become the major issue."
"Everyone is headed toward parametric CAD modeling."
**Expressed by all interviewed participants.

5 OEMs vs. Suppliers

During the interview process, it became apparent that a major dichotomy exists between OEMs and suppliers. OEMs are moving to a single CAD system paradigm where they require suppliers not only to provide them with native CAD models, but also to build those models in the native CAD systems. Suppliers, on the other hand, must contend with multiple CAD systems to satisfy customer demands and match their suppliers' capabilities. OEMs are attempting to reduce their costs by eliminating multiple formats, while suppliers are incurring increasing costs. Some differences in OEM and supplier viewpoints are listed below:

OEMs	Suppliers
One CAD system	Many CAD systems
Native CAD only	Multiple formats
Formal CAD policies	Informal CAD policies
Limited IGES use	Extensive IGES use

Mandates native CAD	Would like to use a neutral format
STEP would have to be 100%	Could live with fixing some files

The ultimate irony of this situation is suppliers need STEP the most and OEMs are in a position to influence STEP the most.

6 Summary and Recommendation

Infrastructure
The AutoSTEP project should adopt 8mm tapes and the NIST FTP site as the standard means of file transfers. This would allow easy communications between all AutoSTEP participants, including ITI and NIST.

Requirements
The STEP standard currently satisfies all requirements for implementing STEP in production for the packaging application, but problems exist with CAD systems and STEP translators.

APPENDIX

AIAG AutoSTEP Phase 1a. Interoperability Project
CAD Requirements Gathering Pre-Interview Questions

Background

Phase 1 of the AutoSTEP program is an as-is assessment and will provide an understanding of how the participants in the pilot currently work together, how product data is currently exchanged, and what are the product data requirements of each participant. The Phase 1 program consists of four sub-projects: Translator Capability Evaluation, Interoperability Requirements Gathering and Test Methodology Development, Business Process Analysis, and AUTOTECH Pilot Demonstration.

The Interoperability Requirements Sub-project will gather information on CAD requirements, critical metrics, and standards. Requirements gathering will be accomplished by on-site interviews with appropriate AutoSTEP partner staff. The interoperability requirements team will send out a list of questions prior to the on-site interviews. ***These questions will let you know what to expect and give your staff a chance to collect data and prepare for the interview***. The pre-interview questions intended to ensure that interviews are as efficient and successful as possible. Interviews should last no more than two hours.

On-site interviews will be held with each of the AutoSTEP members. During the interviews, Interoperability Project staff will collect information on CAD model exchange requirements, use of existing standards, and CAD model metrics. At the end of the project the information will be compiled and a final report will be presented to AIAG and the AutoSTEP project members.

Any questions about this study should be directed to: ***Mr. Ravi Krishnaswami,*** *Automotive Industry Action Group, 26200 Lahser Road, Suite 200, Southfield, MI 48034, Phone: 810-358-3570, FAX: 810-358-3253*

Purpose

The purpose of this effort is to obtain information on CAD geometry exchange requirements, standards, and metrics with particular emphasis on solids use for "Packaging." These requirements will be used for the development of a structured test methodology to be used in Phase 1b of the AutoSTEP pilot. The requirements will also be used to gauge how well commercially available STEP translators are meeting the key metrics identified.

Instructions

This pre-interview questions will be used to facilitate the on-site requirements gathering interviews. It is intended to provide a means to collect appropriate data and to identify key staff necessary to provide requirements to the Interoperability Project team. You should use this material to:

1. Collect thoughts and answers prior to the interview.
2. Obtain data in electronic or hardcopy form to the provide to the interoperability team.

3. Identify the appropriate person or persons from your staff to participate.

Part 1. Infrastructure

1.1 What CAD data exchange method(s) do you use with your partners?

Tape

9 track	❒
1/4 inch	❒
8 mm	❒
4 mm	❒
floppy	❒
other	❒ _____

Electronic

modem	❒
ISDN	❒
e-mail	❒
FTP	❒
Internet	❒
Dedicated-T1	❒
other	❒ _____

Format

native	❒ (ACIS, UG, Pro Neutral, Aries, etc.)
IGES	❒
STEP	❒
other	❒ _____

1.2 What methods do you plan to use in the near future (next two years)?

1.3 What is your preferred communications mechanism for CAD data exchange? Do you have dedicated lines between your company and your partners?

1.4 What are your current data transfer rates and what are your desired data transfer rates (modem, network, etc.)?

1.5 Have you ever had problems with:
Slowness of file transfers, translations
Partners firewalls

Partners servers / network down

1.6 Do you have a file size limits? What are your average file sizes?
- Applications
- Transferring through network
- Storing
- Translation
- Other

1.7 What are your desired CAD file processing times (at what point would you not use an application because it was too slow)?
- File transfers
- Translations
- Other

1.8 What is the flow of CAD data during the translation process when sending / receiving models to/from your trading partner? Provide a short scenario.
Who is responsible for file translation, transfer to partner, etc?

1.9 Is there a central support organization or contact for specifying, installing, and maintaining computer systems, software, and networks for your organization? (Name and contact info.)

1.10 Which form of archival method does your organization regard as the "master" or "official" product definition?

- Electronic file ❒
  - Native CAD
  - IGES
  - STEP
  - DXF
  - Plot file
- Paper ❒
- Aperture card ❒
- Other ❒ _____

Part 2. Technical

2.1 What is the absolute minimum set of information elements required for an electronic data package, to convey required product information, independent of media or format?

Part geometry ❒
Part solid model ❒
Part drawing ❒
Assembly drawing ❒
Plot file ❒
Change history ❒
Parts list ❒
Material specs ❒
Tolerances ❒
Analysis data ❒
Other ❒ _____

2.2 What are your product configuration management requirements?

Version control ❒
Approvals ❒
Access control ❒
Naming conventions ❒
Dates ❒
Designer names ❒
Change orders ❒
Other ❒ _____

2.3 What problems do you encounter with CAD model exchanges?

File size growth ❒
Change in number of entities ❒
Loss of data organization ❒
Translation inaccuracies ❒
CAD system accuracy ❒
Entity attributes modified ❒
Incompatible s/w versions ❒
Other ❒ _____

2.4 What types of models do you create / receive?

CSG solids	☐
B-Rep solids	☐
Faceted solids	☐
Surface	☐
2D Wireframe	☐
3D wireframe	☐
Point arrays	☐
Other	☐ _____

2.5 What form of data is used as the "master" to assess the success and completeness of the exchange?

Plot file	☐
Paper drawing	☐
STL file	☐
Other	☐ _____

2.6 Describe the parameters you would use to classify CAD model complexity.

Simple -

Moderate -

Complex -

Very Complex -

2.7 Entities Table

ENTITY	USAGE				TRANSLATION PROBLEMS		
	HIGH	MOD	LOW	NEVER	ALWAYS	SOMETIME	NEVER
POINT							
LINE							
CIRCLE							
ELLIPSE							
HYPERBOLA							
PARABOLA							
POLYLINE							
B-SPLINE CURVE							
TRIMMED CURVE							
BOUNDED SURFACE CURVE							
COMPOSITE CURVE							
OFFSET CURVE							
ELEMENTARY SURFACE							
CYLINDRICAL SURFACE							
SPHERICAL SURFACE							
TOROIDAL SURFACE							
SURFACE OF LINEAR EXTRUSION							
SURFACE OF REVOLUTION							
B-SPLINE SURFACE							
RECTANGULAR TRIMMED SURFACE							
CURVE BOUNDED SURFACE							
OFFSET SURFACE							
C.G. SPHERE							
C.G. BLOCK							
C.G. RIGHT ANGULAR WEDGE							
C.G. TOROID							
C.G. RIGHT CIRCULAR CONE							
C.G. RIGHT CIRCULAR CYLINDER							
C.G. SOLID							
EXACT B-REP							
FACETTED B-REP							

Part 3. Metrics

3.1 What are the CAD system accuracies desired for the specified application?

3.2 What kinds of data loss (if any) are acceptable for the specified application?

3.3 What other metrics are used to evaluate CAD model translations?

3.4 What "first pass" CAD model transfer criteria do you use:
when sending data?
when receiving data?

Can recognize file	❒
Can read-in file successfully	❒
Visual image appears to be correct	❒
File size increases	❒
Change in number of solids	❒
Errors messages in log file	❒
Other	❒ _____

3.6 What measurements or assessments do you make within the CAD system to validate the translation of the resulting CAD model? What tolerances do you use for these measures?

Visual inspection	❒
Dimensions	❒
Point to surface	❒
Curve on surface	❒
Gaps between surfaces	❒
Physical volume	❒
Surface area	❒
Estimated mass	❒
Center of mass (x,y,z)	❒
Other	❒ _____

3.7 What measurements or assessments do you make within the CAD system to validate the CAD model prior to translation to STEP?

Topology	❒

Part 4. Standards

4.1 What standards, regulations, or specifications influence the development, management, or control of CAD data at your organization?

ISO 9000	❒
IGES	❒
ANSI Y14.5M	❒
Proprietary	❒
Other	❒ _____

4.2 What standards or specifications control the exchange of CAD data within your organization?

STEP	❒(AP?)
IGES	❒
DXF	❒
Proprietary	❒
Native CAD	❒(format?)
Other	❒ _____

4.3 What standards or specifications control the exchange of CAD data between your organization and other organizations?

STEP	❒(AP?)
IGES	❒
DXF	❒
Proprietary	❒
Native CAD	❒(format?)
Other	❒ _____

4.4 Are there any internal CAD model development standards/conventions/procedures/guidelines in your company? If so, which specific conventions enhance your capability to exchange data with other CAD systems?

References

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[Ros96] David Rosenfeld, et. al. "Procedure for Product Data Exchange Using STEP Developed in the AutoSTEP Pilot," NISTIR 5833, April, 1996.

[Wil95] Peter R. Wilson. "STEP Interoperability Methodology for Solids Data - Version 1," NISTIR 5794, February, 1996.

Glossary of Terms

AIAG	Automotive Industry Action Group
AP	Application Protocol
AutoSTEP	AIAG STEP implementation project
B-Rep	Boundary representation of a solid model
CSG	Constructive Solid Geometry
CAD	Computer Aided Design
DXF	Design eXchange Format (an industry CAD data exchange format from Autodesk, Inc.)
FEA	Finite Element Analysis
FTP	File Transfer Protocol
IGES	Initial Graphics Exchange Standard
ITI	Industrial Technology Institute, Ann Arbor, MI
NC	Numerically Controlled
NIST	National Institute of Standards and Technology
OEM	Original Equipment Manufacturers - Ford, Chrysler, GM
PDES	Product Data Exchange using STEP
STEP	STandard for the Exchange of Product model data
STL	Stereo Lithography
Supplier	Company that supplies part or parts to OEMs