Procedure for Product Data Exchange Using STEP Developed in the AutoSTEP Pilot

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I. Introduction

I.A Assumed Audience

This document describes a process through which product model data exchange using ISO 10303, commonly known as STEP (STandard for the Exchange of Product model data), can occur in a production environment. Such a process is currently in use in the AutoSTEP Pilot Project. This document is of interest to manufacturers and suppliers involved in the development and exchange of manufactured products. The reader is assumed to be knowledgeable in manufacturing processes in general, and issues relating to exchange of product model data within a supply chain in particular. In addition, the reader should be familiar with CAD (Computer Aided Design) system technology. Finally, the reader should have some familiarity with the relevant parts of the STEP standard. A general overview of the concepts and terminology of STEP may be found in [1]. A discussion of STEP AP (Application Protocol) 203, the part of STEP which is the focus of this document, may be found in [2]. Many of the appendices of this document contain forms and tables which may be used for tracking product model exchanges and recording significant exchange metrics. These are of interest primarily to the participants of the AutoSTEP Pilot.

I.B Background

The AutoSTEP Pilot Project, directed by the Automotive Industry Action Group (AIAG), is an effort whose goal is to promote the use of STEP as a neutral mechanism for product data exchange within the automotive industry[1]. To explore and demonstrate the capabilities of STEP, AutoSTEP organized a number of "trading pairs" to exchange product model data represented in STEP AP203 conformance class six, or model data represented with advanced boundary representation (b-rep). In phase one of the pilot, each pair consisted of an automotive company and one of its first-tier suppliers. Trading pairs would exchange product model data which relate to packaging applications. Phase two and later phases will include product model data which relate to other applications, and will extend the information exchange further down the supply chain. Model data would be transferred from one company's CAD system to its partner company's system via STEP. The results of the transactions would be logged and recorded in a database, and reports assessing the results would be produced. The results of these studies will be used to develop a business case for re-engineering the design and development processes used in automotive supply chains in order to

[1] Funding for the AutoSTEP Project is being supplied in part by NIST through the Systems Integration for Manufacturing Applications (SIMA) Office, and in part through contributions by the members of AIAG.

optimize data exchange.

The role of NIST in the AutoSTEP Pilot is primarily in the area of data administration. NIST is maintaining private ftp locations to allow participants to exchange proprietary data and files at protected ftp sites. NIST employees have also designed a database to retain all metrics generated by exchanges and to generate reports summarizing these exchanges. Lastly, NIST has been involved in outlining the complete process that product model data undergoes in exchanges between participating companies. The states through which model data progresses have been identified along with the significant metrics which are generated at each state. It is this process description which is the focus of this document.

I.C Purpose of this Document

This document serves two purposes. First, it provides a complete description of the product model data exchange scenario envisioned for transactions using STEP. It outlines the entire process that model data undergoes in STEP exchanges, and it identifies the significant metrics throughout the process. Second, this document serves as a practical guide for the AutoSTEP exchange participants in phase two, and later phases of the AutoSTEP Pilot. It provides full, step by step instructions for the participants in performing exchanges and logging metrics, and contains a collection of forms and tables in order to facilitate this process.

I.D Document Contents and Organization

This document consists of the following:

- A high-level description of the exchange process envisioned for product model transfer using STEP (section II).
- A list and explanation of the critical metrics with which an exchange may be tracked and its success may be measured (section III).
- A detailed description of the stages model data passes through during an exchange, and the metrics which should be recorded at each stage of the process (sections IV-V).
- Instructions, tables, and forms that participants of the AutoSTEP Pilot will use for capturing and reporting metrics and resolving problems (section VI, appendices).

II. Process Description

This section outlines the basic process through which product model data may be exchanged between companies using STEP. The process described here is being followed by participants of the AutoSTEP Pilot to demonstrate the capabilities of STEP, AP203 conformance class six, in product model exchange.

A pair of companies would often be involved in product model data exchange during the design of manufactured products. A common example of this would involve a manufacturing company, and one of its first tier suppliers. The supplier may be producing a single component of the final product to be constructed. Typically, the supplier would design the component and send the design to the

manufacturer. The manufacturer would review the model, request modifications, and send the part back. Many iterations of this round-trip process may be involved before the supplier is ready to begin producing the part. Such exchanges could be accomplished via STEP using the following basic process (detailed flowcharts of this process will appear in Sections IV and V):

- The supplying company, C1, generates a part design on its local CAD system and verifies its correctness.
- C1 translates the native file into STEP, verifies its correctness, and sends the file to the manufacturing company, C2.
- C2 receives the STEP file, translates it into its CAD system's native format, and reviews it as a solid model. This is the conclusion of the *outbound leg* of the exchange.
- C2 performs changes to the part, generates a STEP file from the changed part, verifies its correctness, and sends it back to C1.
- C1 receives the STEP file representing the modified model, and generates a valid solid model file in the native format of its local CAD system. With this, the *inbound leg* of the exchange is concluded and an entire round trip exchange has been completed.

The product model data in the above process transitions through many stages, or *states*. At each state a unique set of metrics is gathered to record basic information about the model at that state. The values of these metrics are checked to determine if any errors or abnormalities have been introduced into the model. If errors are not found, the model may progress to the next state of the process. There are two basic types of metrics which must be examined, *simple metrics* and *process metrics*. Simple metrics are metrics which may be calculated directly from the model data. They are used to check for actual error conditions in the model, such as an incorrect number of solids or tessellation errors in the model. Process metrics are metrics which are not computed directly from the model, but are determined by comparing the simple metrics of the model at different states. Examples of process metrics are, the change in the file size of model data as a result of its translation into STEP, and the difference in volume between an exported and imported model.

Sections IV-V will define completely the states the model passes through, and the set of metrics which must be measured at each state. The following section lists and describes the metrics themselves.

III. Significant Metrics

This section lists the metrics which are significant and must be recorded at the various stages of an exchange process using STEP. The choice of metrics reflects the opinions of experts in the domain of product data exchange. The list was compiled in part during a requirements survey of the AutoSTEP participants carried out as a part of the project. The results of this survey are reported in [3].

Name	**Code**	**Description**

Creation Time	CT	This is the time that was required by the designer to build the original part model. This primarily refers to the time necessary to draw the model in the CAD system. The design and planning stages of the part creation are not intended.
Name	**Code**	**Description**
Visual Check	VC	This is a qualitative metric to provide assurance that the CAD model represents the intended part shape.
Number of Solids	NS	Probably the most basic metric of a part model. In the context of this document, exchanges of single solid models only will be discussed. This is also the current focus of the AutoSTEP Pilot.
Number of Shells	NSh	This is a count of the shells that make up the solid. This metric is computable for both native and STEP files. For a native model, the host CAD system can usually be queried for this metric. For a STEP file, it may be computed by applying the entity counter application to the file, developed at the Industrial Technology Institute (ITI) (see Appendix C).
Number of `shape_repre-sentation` Subtype Instances	NSRS	Number of `shape_representation` Subtype Instances in a STEP file. This is a STEP entity type, or object, and maps closely to solid model. It serves the same purpose for a STEP file as NS does for a native model. It may be computed by applying the ITI entity counter application to the file (Appendix C).
Number of Faces	NF	This is a count of the faces that make up the solid. For a STEP file, it may be computed by applying the ITI entity counter application to the file (Appendix C).
Number of STEP Rule Validation Errors	NRV	This is the number of STEP rule violations in a STEP file of the model. It is computed by applying the ITI rule validator for AP203 on the file (see Appendix C).
Volume	Vol	This is the volume of the part in a particular state as computed by the CAD system.
Surface Area	SA	This is the surface area of the part as computed by the CAD system.
Centers of Gravity	CG	This refers to the centers of gravity for the three axes of the part (three values). It is computed by the CAD system.
System Validation	SV	Most CAD systems have a set of tests which they apply to a solid model to determine if it is valid. This pass/ fail metric is the result of this set of tests.

Number of Tessellation Errors	NTE	The earlier phases of AutoSTEP are focusing on product exchange in the domain of packaging. In this context, a count of the number of tessellation errors is a good measure of a CAD model's suitability for this application. This is typically computed by the CAD system itself.
File Size	Sz	This is the size of the STEP or native file for a part, measured in kilobytes.

Name	**Code**	**Description**
Time Stamp	TS	This is recorded for a model/file at most states at the point when it is ready to transition to the next state.
Translation Time	Tr	This is recorded whenever a native file is translated into STEP, or a STEP file is imported into a native CAD system. If an importing system is unsuccessful in importing a STEP file, it is often necessary to adjust the system's tolerances and to re-import the file. In such a case, the entire time required for all of the import attempts should be considered in determining the translation time.
Fix Up Time	Fix	This is the time required to fix an imported CAD model, translated from STEP, into a valid solid model. (A typical import from STEP will require some amount of fix up until the imported model is completely valid.) It is a critical factor in determining the expediency of STEP translators.

IV. Outbound Leg States and Transition Conditions

This section provides a detailed description of the outbound leg of product model exchange using STEP. It presents a step by step explanation of the states through which the model passes, and the critical metrics which should be recorded and examined at each state.

The states of the outbound leg of a transaction are depicted in the flowchart in figure 1 (end of this section). A rounded rectangle is used to represent a state. It contains the name of the state and the corresponding metrics which must be inspected at that state. In a parallel column to the right of the flowchart appear the names of the tables and forms which will be used by the AutoSTEP Pilot participants to record the metrics of each state. (The tables and forms themselves appear in the appendices of this document, and are provided for the benefit of the AutoSTEP participants.) After each state appear one or more diamonds. The diamonds contain conditions which must be met to ascertain if the preceding state was successfully reached, and if the process is ready to continue. If the conditions are met, the flowchart proceeds to the next state. If not, directions are provided for evaluating and/or correcting the problem and returning to a previous state. It should be noted that after a problem is evaluated and recorded, it may not always be possible to continue the process. If, for example, a STEP file is unable to be imported (cannot proceed from states 3 to 4), it will be

impossible to avoid the problem until C2 receives a newer translator version. Until that point, the exchange will have to be halted.

Many of the decision diamonds contain precisely defined criteria for progressing to the next state. These criteria are based on estimates of experts in the domain of packaging, the focus of AutoSTEP. These were gathered in part during a requirements survey of the AutoSTEP participants carried out as a part of the project. The results of this survey are reported in [3]. Some of the criteria require that metrics be "reasonable", or that they are within a tolerable range. Such criteria are not defined more precisely because they may be more situation or domain dependent. Whether or not such criteria are, in fact, reasonable should be determined by the implementation experts of that domain.

A brief discussion of the outbound states follows. The forms and tables which are provided for the benefit of the AutoSTEP participants, along with instructions for filling out the forms, appear later in this document.

State 1 Valid Single Solid Model This state is reached when a solid model of the part has been created in the native CAD system at C1. If the metrics satisfy the four conditions following state 1, the model is ready to transition to state 2. (Recall that this document deals with single solid model exchange only.) These conditions are, `NS1 = 1`, the number of solids in state 1 be 1; `NSh1 = 1`, the number of shells be 1; `NTE1 = 0`, the number of tessellation errors be 0; and `SV = pass`, or that the model passes all system validation tests on the native CAD system.

State 2 Conforming STEP File This state is reached upon translation of the native model of state 1 into STEP. If the conditions in the diamond following this state are satisfied, the file can be sent to C2. The condition `Tr = reasonable` ensures that it has not taken inordinately long to generate a conforming STEP file. The condition `NRV allowable` says that the STEP file may contain only those rule violations (if any) that have been permitted by this pilot project. (This is sometimes necessary since some CAD system vendors view certain AP203 rules as too restrictive.) If the conditions following this state are not satisfied, the problem should be analyzed and recorded. Preferably, such translator problems should be reported to the CAD vendor. For AutoSTEP exchanges, problems are reported to NIST and if possible, a resolution is obtained.

State 3 Conforming STEP File at Site 2 This state is reached upon receipt of the valid STEP file at C2. The critical condition associated with this state is that the size of the STEP file received be the same as the size recorded at the previous state.

State 4 Imported CAD Model at Site 2 This state is reached upon translation of the STEP file into the native format of the CAD system at C2. (The imported model is not yet necessarily valid. It is converted into a valid model in the next state.) As explained in section III, the translation time, `Tr`, is calculated by summing all the attempts made to translate the STEP file to the importing system. If an attempt had to be repeated as a result of tolerance inconsistencies, all of the time spent importing the file and adjusting the tolerances should be considered.

The critical condition associated with this state is that the number of faces `(NF)` of the model should

not differ from the number of faces in state 2 by more than 25%. This condition ensures that file size growth attributable to the translation is kept reasonable. Beyond this, the file size `(Sz)` of this part file should not differ too significantly from that of the part file at C1.

State 5 Valid Solid Model at Site 2 This state is the final state of the outbound leg. It is reached by fixing up all of the geometric features of the model which may have become distorted or corrupted during the import. To ascertain whether the outbound leg was successful, the set of conditions which appears downstream of this state is applied to the model. The first diamond contains the condition `Tr4+Fix5 ≤ 0.1CT1`, which means that the combined translation time and fix up time required to convert the incoming STEP file to the native CAD system should not exceed 10% of the creation time for the original model. This represents the concern that it not take exceedingly long to import a model from a different CAD system using STEP (to transition from states 3 to 5). If the import time is greater than 10% of the creation time, it is generally not considered worthwhile to translate and fix up a model (at the risk of introducing unnoticed errors), but to recreate the model from scratch on the importing system. The second diamond contains such critical conditions as that the volume and surface area of the solid model in this state do not differ significantly from the surface area and volume computed in state 2.

Fig. 1 Outbound Leg States and Transition Conditions (next 2 pages)

Figure 1 (page 1): Outbound Leg States and Transition Conditions

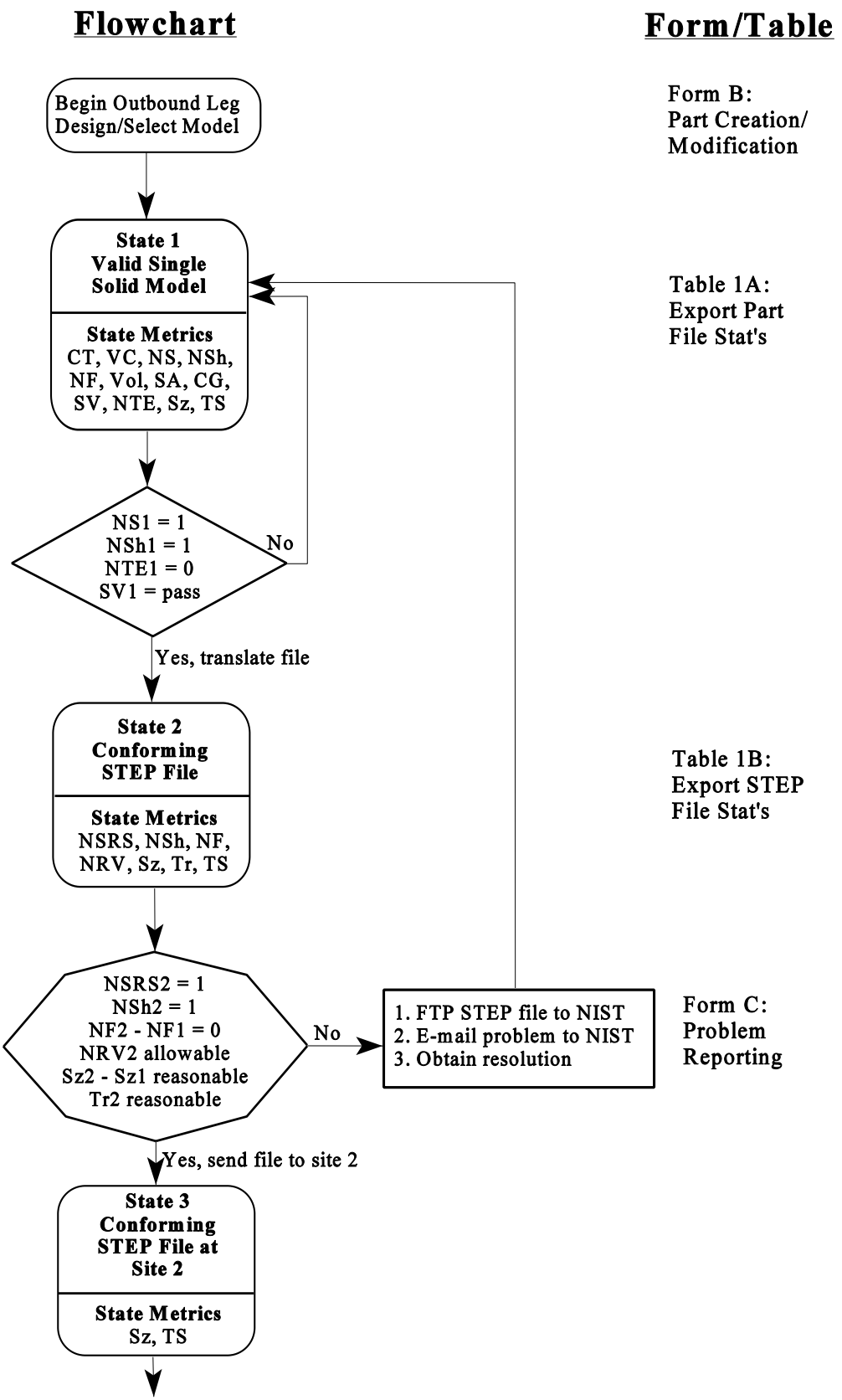
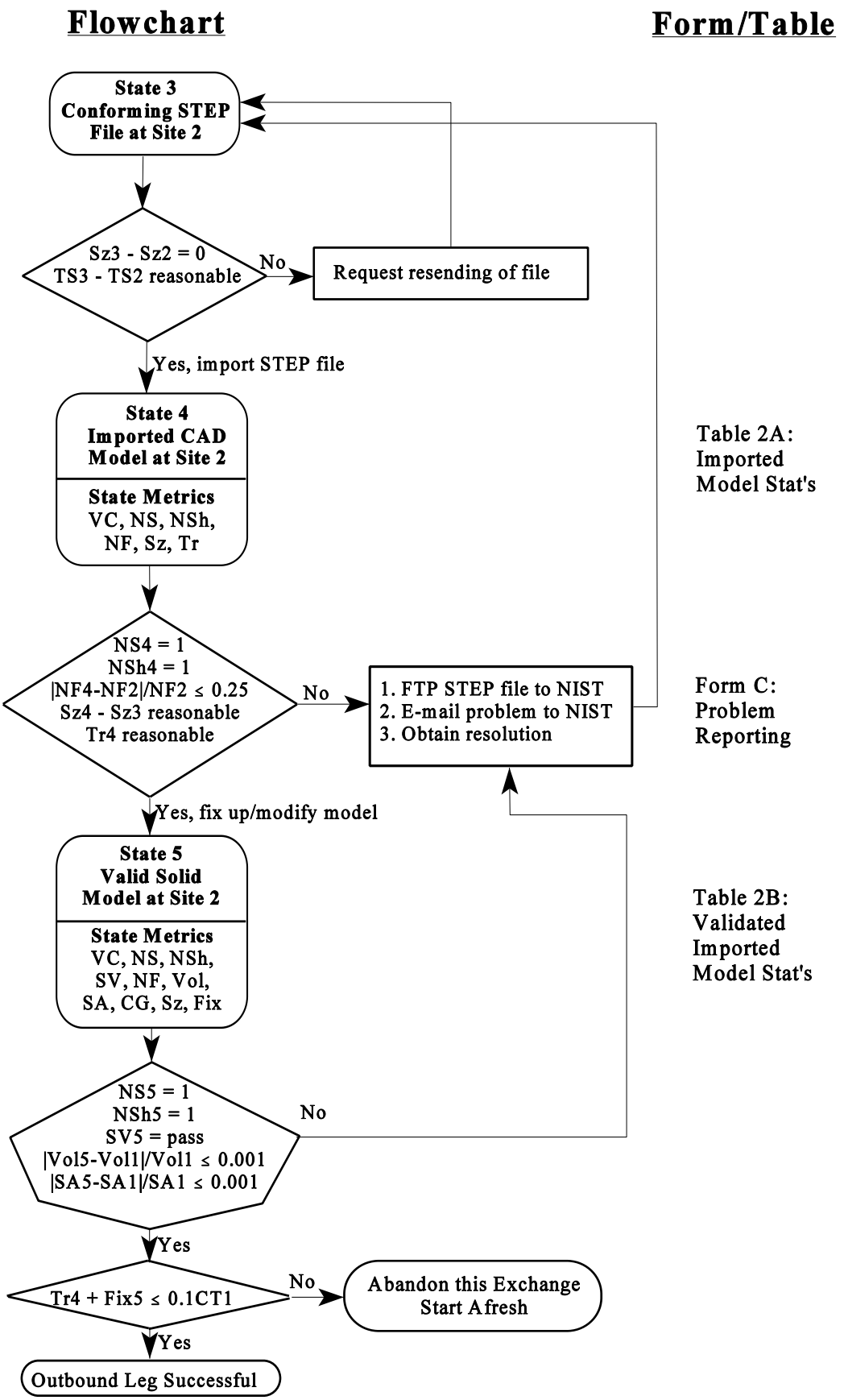


Figure 1 (page 2): Outbound Leg States and Transition Conditions



V. Inbound Leg States and Transition Conditions

This section deals with the inbound leg of the exchange cycle. In a typical exchange scenario, the manufacturer, C2, would review the received model, suggest design modifications, and send the model back to the supplier, C1, using STEP. C1 would import it into its CAD system, verify the correctness of the model, and view the modified model. If the transition conditions contained in the diamonds following each inbound state are satisfied, the inbound trip will be deemed a success. Figure 2, at the end of this section, depicts the inbound leg of the exchange cycle. The exchange procedure and associated metrics for the inbound leg are similar to those of the outbound leg. Differences are highlighted below.

State 6 Modified Valid Solid Model at Site 2 This state is reached upon completion of the modification of the model in state 5. As in the outbound leg, the CAD system's system validation test `(SV)` is required before proceeding on the inbound leg. It is important that native part models are validated before interoperability testing begins.

State 7 Conforming Modified STEP File at Site 2 This state is reached upon successful translation of the model in state 6 into STEP. If the conditions following this state are not satisfied, AutoSTEP participants should report the problem to NIST and if possible, the problem will be resolved.

State 8 Conforming STEP File at Site 1 This state is similar to state 4 and is reached upon successful transfer of the STEP file to C1.

State 9 Imported CAD Model at Site 1 This state is reached upon translation of the STEP file into the native format of the CAD system at C1. Care should be taken to calculate the translation time `(Tr)` properly, as discussed in section IV. As in state 4, the critical condition associated with this state is that the number of faces `(NF)` of the model should not differ from the number of faces in state 7 by a factor greater than 25%.

State 10 Valid Single Solid Model at Site 1 This state is reached upon the successful translation of the STEP file into the native format of the CAD system at C1. As in state 5, a critical condition at this point is that the translation and fix up time required to import the STEP file into the native system is not greater than 10% of the original creation time for the model. A number of conditions downstream of state 10 determine if the exchange was successful. As in state 5, the equivalence of volume `(Vol)` and surface area `(SA)` are important criteria.

Fig. 2 Inbound Leg States and Transition Conditions (next 2 pages)

Figure 2 (page 1): Inbound Leg States and Transition Conditions

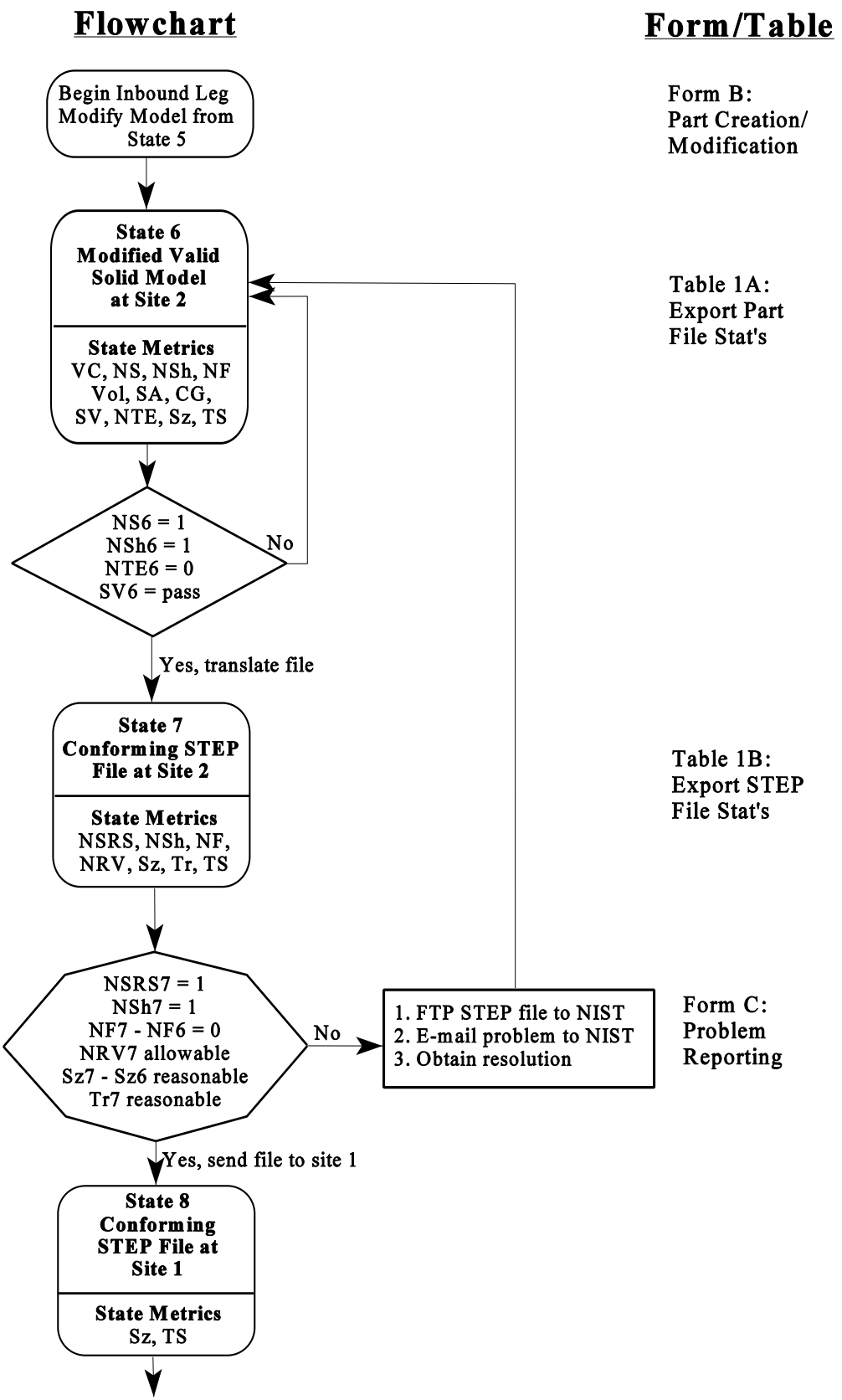
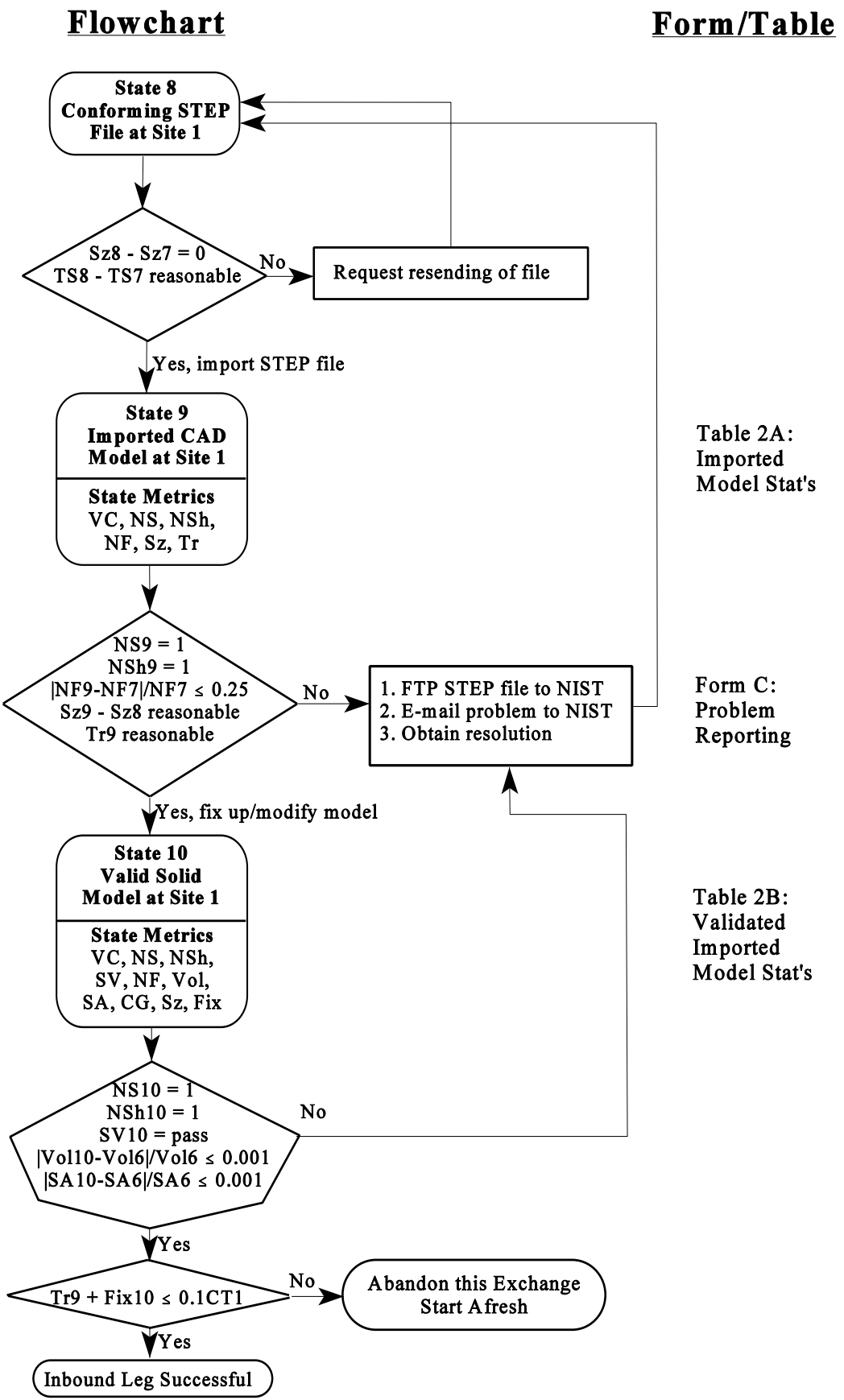


Figure 2 (page 2): Inbound Leg States and Transition Conditions



VI. Instructions for Participants

This section provides complete instructions for participants of the AutoSTEP Pilot involved in product model exchange for phase two, and later phases of the project. This includes the steps which must be taken to initiate a transaction, and instructions for recording metrics during the course of a transaction.

VI.A Before initializing a transaction

The first step required in the initializing of a transaction is the selection of a set of suitable parts. Each part should consist of a single solid only, and in AutoSTEP phases one and two should be relevant to packaging applications. Three to six parts will be selected, and they will range from simple to complex. Possibly, the parts will be different sections of an assembly which is used in packaging applications. As exchanges are initiated with each part, Form B should be completed to register the part in the AutoSTEP Database, as will be explained in section VI.B.

Before beginning actual exchanges, there are a number of system tests which must be performed on each company's CAD system. These tests ensure that each of the trading partners will be able to process and perform various system tests on the part models being exchanged. Each company should do the following:

1. Define a system validation test on its CAD system. This test determines whether a model is a valid solid model. This pass/fail test is one of the metrics collected during transitions between certain states.
2. Verify that its CAD system has the capability of performing tessellations on solid models. The number of tessellation errors is another metric collected during transitions between certain states.
3. Ensure that it has an assigned ftp location and user account at NIST in order to upload and download exchange files. Protected ftp sites will be provided by NIST for each trading pair to allow the exchange of proprietary data.
4. Ensure that it has access to the following two STEP software tools, developed at the Industrial Technology Institute, Ann Arbor MI: the AP203 rule validator and the STEP entity counter. Both will be used to collect metrics and are maintained at the NIST general AutoSTEP directory, which may be reached from each participant's private AutoSTEP account. Instructions on using the tools may be found in Appendix C.

Lastly, both companies should complete Form A in Appendix A.1 and send it to NIST. In Form A each company specifies the CAD system and translator version it is currently using in AutoSTEP phase two. This form should additionally be logged whenever a company receives an upgrade of its CAD system or translator version. It is imperative that this information remain current throughout the AutoSTEP Project.

VI.B At the start of a transaction

At the start of both the outbound and inbound legs of a transaction, Form B of Appendix A.2 should be completed. Form B has two functions: to describe a part model the first time it is introduced, and

to describe the modifications that were done to a part at the start of a new leg of the exchange. As soon as a part is selected before its first outbound journey, Form B should be completed to describe the part and record its creator, creation date, and creation time (CT). Before beginning later transaction legs, both inbound and outbound, Form B should again be completed to describe the modifications which were made to the part file, if any. In particular, to begin an inbound leg it is necessary to transition from states 5 to 6, which generally requires that the part be modified.

At the start of either transaction leg, the form contained in Appendix D should be completed. This form is used to record the minimum set of configuration management data for AP203 class 1. It should not be submitted to NIST. Rather, it should be retained for future reference. This form will give the participants an idea of the information and logging requirements for AP203 class 1. It will also provide AutoSTEP with an indication of the value of this information in model exchanges.

VI.C During a transaction

The metrics associated with each state of the exchange scenario, including the conditions which must be met to proceed from one state to the next, were described in sections IV and V. This section discusses the forms and tables which will be filled out to record each state's metrics. The forms and tables themselves may be found in the appendices of this document. Many of the metrics pertaining to STEP files must be recorded using the ITI STEP tools. Details on their availability and use may be found in Appendix C.

At every state of the AutoSTEP exchange scenario, there is an associated set of metrics. Many of these metrics must be logged in the tables which appear in appendices B.1 and B.2. Alternatively, the metrics may be submitted by way of ASCII file. The latter method is strongly preferred as it allows transaction results to be entered directly into the database.

Appendix B.1 contains the exporting system tables. They contain all metrics which relate to the translation and export of a part file from an exporting system. This relates to states 1-3 of the outbound leg, and states 6-8 of the inbound leg. (Note that the state 1 metric CT, the creation time for the part, is not contained in the export table, but was already recorded in Form B during the part selection.) While executing states 1-3 and 6-8, metrics should be recorded in these tables (if they are not recorded in a file). At the successful conclusion of state 3 or 8, when the file is sent to the receiving company, the completed export tables should be sent to the receiving company and to NIST.

To record the export statistics in an ASCII file, do the following steps:

(1) Complete the sections of the export table in Appendix B.1 which are marked with an asterisk. Most of these fields contain non-numeric data which is not meaningful to the database. The database generally associates an index value with all textual information. Since these indices are internal to the database, these values must be added by hand.
(2) In the data file section of table 1b, enter the name of the file which will contain the export data.
(3) Write an ASCII file which contains the remaining fields of the table. The list of fields which must be entered is contained at the end of Appendix B.1. Enter the metrics shown there, (in the

order shown) separated by commas only. The date should be formatted mm/dd/yy, with leading zeros omitted. If data is not available for a field, be sure to leave the correct number of commas anyway, (i.e., enter a comma only instead of a field plus a comma). More than one export may be reported in a single file. Each export should be entered on a separate line.

(4) Upload the file to your AutoSTEP account.

Appendix B.2 contains the importing system tables, Tables 2A and 2B. They contain all metrics which relate to the translation and import of a STEP file into an importing CAD system. This relates to states 4-5 of the outbound leg, and states 9-10 of the inbound leg. While executing these states, metrics should be recorded in these tables. At the completion of states 5 and 10, the completed tables should be sent to the exporting company and to NIST. To submit metrics by file, the preferred method, follow the same set of instructions outlined for the export tables above. Fill out the sections of the table marked with an asterisk. Include in the file all the fields listed at the bottom of Appendix B.2, separated by commas.

The importing system table should be completed even if the import was not a complete success. So long as an import was successful enough to create a valid model and generate some metrics, the table should be filled out and submitted to NIST. If the import did cause errors in the importing CAD system, besides very simple ones which are commonly disregarded, the problem reporting form of Appendix A.3 should additionally be completed, as explained in the next section. Note that it is quite possible that it will be required to submit both the import table and the problem reporting form for the same transaction.

Note that not all metrics which appear in section III and the flowcharts are recorded in a table. This is because many of the metrics of section III must be considered during transition from one state to the next, but need not be recorded permanently in the database. For example, to progress from state 1 to 2, `NS`, the number of solids, must equal 1. If this condition is met, it is not necessary to record this in the database. Had this condition not been met, the transaction would not have proceeded at all. If the transaction did proceed, it can be assumed that `NS` did, in fact, equal 1. Often, such pass/fail metrics are not recorded if they pass, but must be included in the error report sent to NIST if they fail (see next section).

VI.D Problem Reporting

Problem reports should be sent to NIST using Form C, found in Appendix A.3. In the outbound leg, this form should be used if a participant is unable to successfully reach states 2, 4, or 5 (i.e., the conditions in the diamond following one of these states were not satisfied). In the inbound leg, this form should be used if a participant is unable to reach states 7, 9, or 10. (Form C need not be used in every error situation. Some error states, such as the ones resulting from difficulties reaching states 1 and 3, are handled by the participants without logging a report at NIST.) Included in this form should be all incorrect metrics associated with the state.

If the problem involves a STEP file (i.e., it involves converting to or from STEP, as in states 2, 4, 7, and 9), the STEP file should be ftp'ed to the trading pair's private ftp site at NIST. The complete

pathname of the STEP file should be included in the form. If the problem occurs with a part file (in creating a valid solid model, as in states 5 and 10), the part file should not be sent to NIST, but a complete description of the error must be sent.

Form C should be completed whether or not a problem resolution is sought from NIST. A company may be able to resolve an issue itself or through another source of information. In such a case, Form C should still be completed, and should include the resolver of the problem and the method by which it was resolved. It should be noted that often, problems are resolved some time after a transaction was first attempted. If Form C was completed and afterwards the problem was resolved, it is important to complete an updated form promptly after the resolution.

Appendices

The appendices of this document contain forms and tables to be used in the recording of metrics in the AutoSTEP Pilot Project. These forms may also be found in electronic format in the general AutoSTEP account ("autostep_share"), a parallel directory to the individual AutoSTEP directories. (Details on how to access this directory may be found at the beginning of Appendix C.) The forms are stored in MS Word™ 6.0, WordPerfect™ 5.1 and WordPerfect™ 6.1. Other formats are available upon request.

Appendix A.1: Form A - CAD System Information

Form A should be used to record the CAD system and STEP translator version used by a company in the AutoSTEP Pilot Project. It should be completed when a company first initializes a transaction, and whenever a company receives a newer version[1] either of its CAD system or of its system's STEP translator. It should also be completed if a company receives a substantial upgrade of its supporting hardware or operating system.

Filled by: _____

Company: _____

Phone: _____

Date Submitted to NIST: _____

CAD System: _____

Version[1]: _____

Translator Version: _____

Date Installed: _____

Hardware:
- ❑ DEC (MIPS)
- ❑ DEC (Alpha)
- ❑ Hewlett-Packard
- ❑ IBM - RS/6000
- ❑ Silicon Graphics
- ❑ Sun
- ❑ Other: _____

Operating System: _____

[1] "Version" implies the current version number of the CAD system (or translator), up until but not

including the patches.

Appendix A.2: Form B - Part Creation/Modification

Form B should be used to record the information about a part model at the start of either the outbound or inbound leg of a transaction. For the first outbound leg, when the part is first introduced, the creation time and part description are the primary concerns. For later legs of transaction, a description of the modification should be provided, and the creation time is not applicable.

Filled by: _____

Company: _____

Phone: _____

Date Submitted to NIST: _____

Part Name[1]: _____

Complexity[2]: ❑ Simple ❑ Moderate ❑ Complex

Developer/Modifier: _____

CAD System: _____

Creation/Modification Date: _____

Creation Time[3]: _____

Trading Partner: _____

Brief Description of Part/Modification[4]:

_____

_____

_____

[1] This corresponds to the basic name of the part, not including any of the prefixes and suffixes required by the NIST naming convention.

[2] The proper value for this metric will be determined during the part selection process in conjunction with Simon Frechette of NIST.

[3] This is the metric `CT`, associated with outbound state 1. This is only required at the first outbound leg of a transaction, when a part model is first introduced.

[4] This should be a brief description of the part, including the type of part (e.g., sparkplug) and a one sentence description of its topography.

Appendix A.3: Form C - Problem Reporting

Form C should be used to report problems and error conditions encountered during the course of a transaction. Specifically, if a part file cannot be converted into a valid STEP file, (i.e., state 2 or 7 was not reached successfully), if a STEP file cannot be imported into a CAD system, (state 4 or 9 could not be reached), or an imported part file cannot be validated (state 5 or 10 could not be reached), Form C should be completed. In the first two situations, if a STEP file exists, it should be ftp'ed to the NIST private ftp site designated for this trading pair, and the complete STEP path and file name should be provided in this form.

This form should be filled regardless of whether a resolution must be obtained from NIST, or whether it was already obtained from another source. In the latter case, the source of the resolution and a description of the resolution should be included.

Filled by: _____

Company: _____

Phone: _____

Date Submitted to NIST: _____

Part Name: _____

Exporting Company: _____

Importing Company: _____

Transaction Leg: ❑ Outbound ❑ Inbound

State[1]: _____

Metrics[2]:

_____

_____

_____

_____

_____

Problem Description[3]:

_____

_____

_____

_____

_____

_____

_____

Full pathname of STEP file (if applicable):

_____

Logged with Vendor: ❑ Yes ❑ No

If Yes, Vendor Problem Report Number: _____

Resolved by[4]: _____

Date: _____

[1] Enter the state in which error conditions are occurring. (I.e., you cannot satisfy the conditions contained in the diamond(s) *after* the state.)

[2] Enter the list of metrics associated with this state which are in error.

[3] Quote each error message produced by the CAD system, and explain its meaning, if possible. If a resolution was already obtained, the problem description should also describe the cause of the problem.

[4] If a resolution was already obtained elsewhere, complete the remainder of this form.

The following tables contain the metrics and information which should be recorded when translating and exporting a part model. They should be used during states 1-3 of the outbound leg and states 6-8 of the inbound leg. When the tables are complete, they should be sent to the importing company and to NIST. Fields containing an asterisk ('*') must be filled even if an ASCII file is submitted. Complete instructions for filling out these tables may be found in section VI.C.

Table 1A: Part File Stat's (States 1 & 6)

date	exporting company *	exporting system *	part file *	modification *	version *	mass properties					number of faces (NF)	part file size (Sz)
						volume (Vol)	surface area (SA)	center of gravity (CG)				
								x	y	z		
date of export	co which did actual translation[1]	CAD system and translator version	complete name of file acc. to AutoSTEP convention	mod # and vers # of this file (based on the naming convention)								size in KB

[1] This may not be one of the original trading pair companies. Sometimes if a company does not have the most current translator version, it uses the CAD system of a second company to do the actual translation.

Table 1B: STEP File Stat's (States 2 & 7)

translation time (Tr)	step file size (Sz)	number of rules violated (NRV)	model units*	data file (optional)
trans time in min	size in KB		units of measure used by system	name of ASCII file which contains most of this data

If an ASCII data file is used to submit data, each export should be listed on a separate line. The following metrics should be entered for each export, separated by commas. If no data is available for a metric, a comma should still be present for the missing metric.

date(MM/DD/YY),volume,surface area,x center,y center,z center,num faces,part file size,translation time,step file size,# rules violated

The following tables contain the metrics and information which should be recorded when importing a STEP file. They should be used during states 4-5 of the outbound leg and states 9-10 of the inbound leg. When the tables are complete, they should be sent to the exporting company and to NIST. Fields containing an asterisk ('*') must be filled even if an ASCII file is submitted. Complete instructions for filling out this form may be found in section VI.C.

Table 2A - Imported Model Stat's (States 4 & 9)

date	importing company *	importing system *	part file *	mod *	vers *	transla-tion time (Tr)	number of faces (NF)	part file size (Sz)	error messages *
date of import		CAD system and translator version	complete name of file acc. to AutoSTEP con-vention	mod # and vers # of this file (based on the naming convention)		trans time in minutes	# faces at time of import	file size (KB) as soon as part is imported	yes/no. If yes, problem reporting form (Form C) should be completed

Table 2B - Validated Imported Model Stat's (States 5 & 10)

Fix up time (Fix)	types of cor-rections *	mass properties					number of faces (NF)	part file size (Sz)	other differ-ences, com-ments *	model units *	data file (opt)
		volume (Vol)	surface area (SA)	center of gravity (CG)							
				x	y	z					
fix up time in minutes	what types of cor-rections were nec. to create a validated model (brief)						# faces after fix up	size (KB) after part is vali-dated	e.g, param's lost; visible diff's/prob's with image (may be results of VC)	units of measure used by system	ASCII file con-taining stats

If an ASCII data file is used to submit data, each import should be listed on a separate line. The following metrics should be entered for each import, separated by commas. If no data is available for a metric, a comma should still be present for the missing metric.

date,translation time,num faces(1),part file size(1),fix up time,volume,surf area,x center,y center,z center,num faces(2),part file size(2)

Appendix C - ITI STEP Tools

This appendix describes the STEP tools, developed at the Industrial Technology Institute (ITI), which must be used to gather metrics within the AutoSTEP Pilot Project. Both of these tools are located in a subdirectory of the AutoSTEP general directory ("autostep_share") but may be run directly from the individual AutoSTEP accounts. Both tools are command line and may be run remotely at NIST.

To access the tools, *telnet* to your AutoSTEP account. (Ftp'ing is not sufficient to allow you to operate the tools.) Each AutoSTEP account contains a ".login" file, so that as soon as you log in, the proper environment and path variables will be set to allow you to run the tools locally. The tools themselves are located in directory /export/proj/elib/privftp/autostep_share/tools/.

The tools should preferably be run remotely via telnet. It is also possible to download the tools and run them at your own site. They require Sun workstations running Solaris 1.x (i.e., SunOS 4.1.x). However, it is necessary to sign a license agreement with NIST to do so. For further information, contact David Rosenfeld.

It should also be noted that various visualizer tools for STEP files are commercially available. The use of any such tool is not required by AutoSTEP, but may optionally be used for the verification of STEP files.

C.1 Entity Counter

The STEP entity counter reads an AP203 STEP (Part 21) file and creates a report containing a count of the total number of instances contained in the file. It also produces a count of the number of shells, faces, and shape_representation subtypes. The tool is named ent_counter and writes to stdout. It may be invoked with the following command:

```
% ent_counter <filename>
```

C.2 Rule Validator

The STEP rule validator, rv_203, performs comprehensive checks on an AP203 STEP (Part 21) file and reports any violations of the constraints as defined in the AP. This includes global rules, local rules (such as WHEREs and UNIQUEs), inverse rules, and bound and type checking.

This tool is run automatically every evening at NIST, and processes all the STEP files located in the AutoSTEP directories. The tool output is stored in files of the same name as the STEP files with suffix ".rv" instead of ".step" or ".stp". The output will be analyzed by Shantanu Dhar of ITI, or David Rosenfeld of NIST. To run the tool yourself, refer to the accompanying README file, which describes in detail the tool usage and functionality. Please note that it will not be necessary to set the environment variable, RV_203_LOG, as discussed in the "Current Functionality" section of the README. This is done automatically by the ".login" file provided in your AutoSTEP directory. (RV_203_LOG points to a log file, "rv_203.log", contained in autostep_share/tools. The log file is used to record the number of times rv_203 is run.)

Appendix D - Configuration Management Data Form

This appendix contains the form for entering the minimum set of configuration management data for AP203 class 1. At the start of each leg of a transaction, this form should be completed to the best of each participant's ability. It should not be submitted to NIST. Rather, it should retained for future reference.

```
PART
  Part Nomenclature                 :
  Part Number                       :
  Part Type (circle one)            :
         assembly, detail, customer_furnished_equipment, inseparable_assembly,
         cast, coined, drawn, extruded, forged, formed, machined, molded,
         rolled, sheared
  Standard Part Indicator           :     yes | no

PERSON_ORGANIZATION TO PART (this links a person_organization to the part in
  the role of owner.  A person_organization combines a person and an organi-
  zation, e.g. a person and his/her employing organization)

PERSON_ORGANIZATION
  Person and Organization Role      :     design_owner
  Person Id                         :
  Person Name                       :
  Organization Id                   :
  Organization Name                 :

PART TO PART VERSION (this provides version information for the part)

PART VERSION
  Make or Buy Code (circle one)     :     make | buy
  Release Status (circle one)       :     released | unreleased
  Revision Letter                   :
  Security Code for this version    :
         (enter a word or phrase like classified, unclassified, top-secret
         etc. to describe the level of classification)
  Security Classification for this version
    Name of Security Classification      :
    Purpose of Security Classification   :
    Date of Security Classification      :

PART VERSION TO APPROVAL (associates an approval with the above part version)

APPROVAL
  Date of approval                  :
  Purpose of approval               :
  Status                            :
    (enter a word or phrase like approved, disapproved, etc to describe the
    status of the approval)

APPROVAL TO PERSON_ORGANIZATION (associates an authorizing person_organization
    with the approval for this version)

PERSON_ORGANIZATION
  Person Id                         :
  Person Name                       :
  Organization Id                   :
  Organization Name                 :
```

```
PERSON_ORGANIZATION TO PART VERSION (associates a creating person_organization
  with this version of the part)

PERSON_ORGANIZATION
  Person and Organization Role      :     creator
  Person Id                         :
  Person Name                       :
  Organization Id                   :
  Organization Name                 :

PART VERSION TO DESIGN DISCIPLINE PRODUCT DEFINITION (associates the ddpd
  below with a part version)

DESIGN DISCIPLINE PRODUCT DEFINITION (A design discipline product definition
  is     an organizational view of the part version)
  Creation Date                     :
  Description                       :
  Discipline Id                     :     design

PERSON_ORGANIZATION TO DESIGN DISCIPLINE PRODUCT DEFINITION (associates a
  creating person_organization with the ddpd)

PERSON_ORGANIZATION
  Person and Organization Role      :     creator
  Person Id                         :
  Person Name                       :
  Organization Id                   :
  Organization Name                 :

DESIGN DISCIPLINE PRODUCT DEFINITION TO APPROVAL (associates an approval with
  a ddpd)

APPROVAL
  Date                              :
  Purpose                           :
  Status                            :
```

Appendix E - Names and Addresses

This appendix lists the names and addresses of members of the AutoSTEP Project team. Any questions relating to the exchange process outlined in this document should be directed to Ravi or David. Any questions relating to the use of the ITI STEP tools should be directed to Shantanu or David. Any questions relating to the completion of the AP203 configuration management form should be directed to Shantanu. All completed forms and tables, including any questions relating to the completion of any of the forms and the AutoSTEP file name conventions, should be directed to David. Paper copies of forms and tables may be sent by fax or mail. Electronic versions should be uploaded to the participant's AutoSTEP account. The participant should then notify David (via phone or e-mail) of their existance. Questions regarding the NIST private ftp locations, and any problems experienced accessing these locations, should be directed to David.

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Appendix F - References

[1] ISO/IS 10303-1, Industrial Automation Systems and Integration -- Product Data Representation and Exchange -- Part 1: Overview and Fundamental Principles, International Organization for Standardization, August 31, 1994.

[2] ISO/IS 10303-203, Industrial Automation Systems and Integration -- Product Data Representation and Exchange -- Part 203: Configuration Controlled 3D Designs of Mechanical Parts and Assemblies, International Organization for Standardization, November 8, 1994.

[3] Frechette, Simon P., *Interoperability Requirements for CAD Data Transfer in the AutoSTEP Project*, submitted to be a NISTIR, National Institute of Standards and Technology, Gaithersburg, MD.