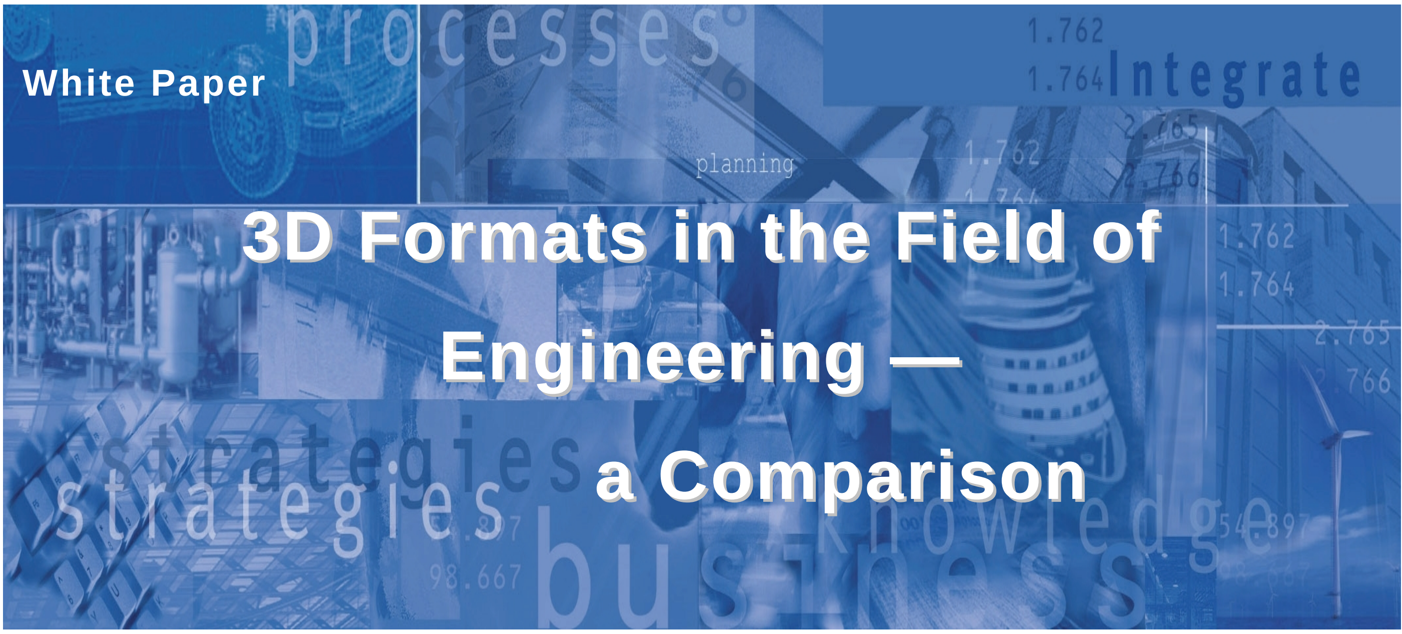
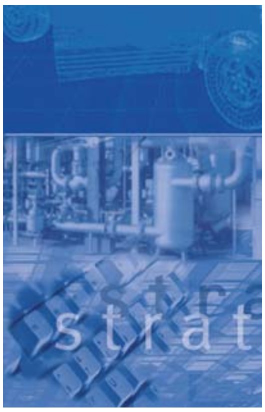


White Paper

3D Formats in the Field of Engineering — a Comparison

When the source system is not available, too costly to propagate widely, or full model fidelity is not required, neutral 3D formats are essential when exchanging and distributing 3D models in the engineering and other domains. The choice of a format has many implications, including which options are available for using the data and what follow-up costs will result. Which neutral 3D format is the right one for a company is determined by a multitude of criteria.

This White Paper provides the reader with an overview and serves as an orientation guide for identifying which 3D format is the more appropriate for a given use case.



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Summary

In the world of movies and television, 3D is the new buzz word. In the field of engineering, the three-dimensional representation of products had been a reality for some time. What were once physically constructed models are now virtual models, and these virtual 3D models are being used in an increasing number of areas outside of engineering. Because CAD systems are not available everywhere and the system landscapes in the engineering domain are extremely heterogeneous, neutral 3D formats are the formats of choice when exchanging and distributing 3D models with other domains and throughout the extended enterprise.

A large number of “neutral 3D formats” are available for the transfer of 3D models. Each of these formats has different attributes, such as a high level of precision regarding the images being displayed, small file sizes, versatility and many others.

When parts are developed in 3D for the engineering domain, the data is initially stored in the original format of the software used to design the part. If this 3D CAD data is to be made available to people who do not have this software, neutral 3D formats come into play. Essential to the selection of the four 3D formats examined here - STEP, 3D XML, JT and 3D PDF, is disclosure of the format specification, wide-spread use of the format and its (potential) application in other future engineering activities.

The four formats were examined to determine the extent to which their attributes are suited to five use cases that are most frequently found in companies. Usability for the use cases was also the deciding factor in selecting the four aforementioned formats for examination rather than other formats such as IGES, CGM, DXF, VRML, COLLADA and X3D, which are not widely used in the selected use cases.

The following use cases were defined: viewing engineering data, data exchange, digital mock-up (DMU), documentation and archiving, and use in the portable PLM document, i.e. use of 3D and additional information in domains related to engineering.

In the last two use cases mentioned, the extremely high level of versatility that 3D PDF offers made it the clear forerunner.

3D PDF also satisfied the key requirements of the “Viewing” use case. Taken as a whole, the attributes that JT offers also makes it very well suited for this use case.

JT is very well suited to the use case “DMU”. In principle, 3D XML is also well suited to this use case, but it is currently limited to a great degree to applications within the Dassault Systèmes product family.

If the focus is placed on using a format for data exchange purposes, the STEP format, which was standardized a number of years ago and offers numerous applications, is the best choice.

The table below provides an overview of the results of our examination with regard to the suitability of the neutral 3D formats for use in the individual use cases:

Use Case	STEP	3D XML	JT	3D PDF
Viewing	●	●●	●●●	●●●
Data Exchange	●●●	●	●●	●
DMU	●	●●	●●●	●
Documentation and Archiving	●●	●	●●	●●●
Portable PLM Document	●	●	●	●●●

Legend

●●●	Highly suitable
●●	Well suitable
●	Suitable with reservations

There is no single right answer to the question of which of the 3D formats is the “better”. Each format exhibits different strength in different areas. Which format attributes are to be considered an advantage will depend on the circumstances and the use cases in which the format is to be used. PROSTEP is confronted with this issue on a day to day basis and in this White Paper provides readers with an overview and an orientation guide for identifying which 3D format is appropriate for a given use case.

Introduction

When CAD data is exchanged with development partners or used directly in development processes, it is of vital importance that an appropriate data format is selected. This format will determine which options are available for using the data in downstream processes, how future-proof the solution is and what follow-up costs will result.

One key attribute of any neutral 3D format includes versatility, which allows development data to be used in departments outside of the engineering department, a high level of data security and the ability to extend the format to include future developments.

In order to come to a conclusion about which 3D format is better suited for use in companies, especially in engineering-oriented processes, the following four neutral 3D formats were examined:

- STEP (STandard for the Exchange of Product model data),
- 3D XML (eXtensible Markup Language),
- JT (Jupiter Tessellation),
- 3D PDF (Portable Document Format).

Essential to the selection of these four formats is disclosure of the format specification, wide-spread use of the format and its relevance for the use cases. Therefore other formats such as IGES, CGM, DXF, VRML, COLLADA and X3D, which are not widely used in the selected use cases, were not taken into account.

To assess the suitability of a neutral 3D format, criteria were selected that are relevant to its use in practice. This includes easy access to the world of 3D data through the use of free viewers. Equally important is the availability of appropriate software and converters so that the options and advantages that a format offers can be fully exploited. Suitable software development kits (SDKs) should be available to ensure that a format can be adapted to a company's existing system landscape and individual business processes and, if necessary, be extended.

The size of the file created as a result of converting data into a 3D format can also be important as far as handling the data is concerned since a crucial factor determining the efficient use of system resources is also file size.

The disclosure and availability of a format specification within the framework of standardization can be seen as a good indication of the level of investment protection a 3D format offers and the extent to which the future of the format is guaranteed. All these criteria ultimately influence the costs that arise when a format is used.

In order to provide the basic criteria for comparison, the following questions need to be answered:

- Which free viewers are available?
- What converters and products exist that can produce and handle data in the respective neutral 3D format?
- Which SDKs and support mechanisms are available for the (further) development of software?
- What are the differences in file size?
- Has the format been ratified by a recognized standards organization?

The formats are then evaluated on the basis of these aspects within the context of the following typical use cases:

- Visualization of engineering data

- Data exchange involving exact geometry
- Use in digital mock-up (DMU)
- Documentation and archiving
- Use of 3D information in engineering-related domains (portable PLM document)

The results of this evaluation are shown in matrix form, which allows the suitability of a 3D format for a particular use case to be assessed. How the attributes of a format are to be weighted with regard to a concrete use case within a company can only be determined within the framework of a competent, independent, and individual customer consultation.

It is almost impossible to provide a comprehensive comparison of all aspects of the 3D formats. This examination is therefore limited to the aspects which experience has shown to play an important role in selecting a 3D format in practice.

Since the basic parameters dictated by business practice will continue to evolve, it is intended that this White Paper be updated regularly.

Development and technical attributes

STEP

STEP is a standard for describing product data and is formally defined in the International Organization for Standardization (ISO[1]) standard 10303. The description includes not only the physical aspects but also the functional aspects of the product.

The development of STEP started in 1984 as a successor of the formats IGES, SET and VDA-FS. In 1994/95, ISO published the initial release of STEP as an international standard (IS). Today, the most important parts of STEP relevant to discrete engineering are the application protocols (AP) 214 and 203, which are included in ISO IS 10303. These APs can be used by a large number of CAD, CAM and CAE systems to import and export product data. The ProSTEP iViP Association[2] and PDES, Inc.[3] were the driving forces behind the development of STEP.

In STEP, the geometry of a product can be displayed as a wireframe model, a surface model or as a solid. Data compression and simplification are not supported. Since STEP is an ASCII format, file size can be reduced significantly by means of external compression, e.g. in ZIP format. Although the STEP data model provides for tessellation, this function is not supported by the applications available on the market.

STEP continues to be the subject of further development. At the moment, AP 203 and AP 214 are being merged to create AP 242 with the intention of providing a joint standard for the aerospace and automotive industries. The business object model will be defined in UML (Unified Modeling Language) and XML, thus making it consistent with the current state of the art. JT is currently being integrated as a format for the simplified representation of the geometry.

3D XML

3D XML was published in 2005 by Dassault Systèmes[4]. The 3D XML format is based on XML, a standard for creating human-readable documents in the form of a tree structure.

In 3D XML, parts and assemblies are displayed using an XML-based faceted geometry representation. The 3D XML mesh, which is comprised of surfaces and edges, is described using nodes, which in turn are connected by means of triangles (for surfaces) and lines (for edges). The mesh can also include several Levels Of detail (LOD). LOD management allows the definition of a number of tessellation levels (from fine to coarse) for a mesh.

With the announcement of V6, Dassault Systèmes has announced “3D XML with Authoring” in addition to the previously disclosed “3D XML for Viewing”. It is intended to be used for the data exchange of exact geometry between V6 applications.

JT

JT is a format for describing 3D data that also supports object data and metadata.

The format was developed in the 1990s by the US company Engineering Animation Inc., which was taken over by the UGS Corporation in 1999. In 2007, Siemens acquired the company, which is now called “Siemens PLM Software”[5] and is a business unit of the Siemens Industry Automation division.

JT is a binary format whose data model supports various representations of CAD geometry. The representations can be stored in a JT file individually or together.

- BREP (boundary representation): offers the highest level of representational precision. BREP data is compressed using different algorithms and stored without loss. In the current specification 9.5, two BREP representations are permitted: the traditional JT-BREP representation and XT-BREP, which is based on the Parasolid boundary representation.

- Tessellated geometry: a faceted representation of solids and surfaces. Different levels of detail (LOD) can be defined within a JT file. A low LOD means a lower level of precision but a smaller volume of data, while a very high LOD means an almost exact geometry but a large volume of data.
- ULP (Ultra-Lightweight Precise): The latest compression method is ULP. The ULP format enables a lightweight, semi-precise representation of the 3D geometry. The level of precision that ULP offers is significantly higher than for tessellated geometry while the file size is significantly smaller. The primary focus lies on providing high quality surface geometry that exhibits only minor deviations from the original BREP geometry.

JT version 8.1 has been published by the ISO as a publicly available specification (PAS). The ISO standardization process (q.v. Standardization aspect) is currently under way for the recently published JT version 9.5, which has been expanded to include the specification for ULP and semantic product manufacturing information (PMI, product metadata) among other things.

3D PDF

3D PDF is the name of the PDF format which also provides native support for 3D data (starting with Version 7 of Adobe® Acrobat® [6]). In 2008, 3D PDF was published as the international standard ISO 24517-1 (PDF/E).

The following CAD geometry representations can be stored in a 3D PDF:

- U3D (Universal 3D) was developed by Ecma International[7] and is a compressed file format for 3D data that is natively supported by the PDF format. 3D objects in U3D format can be inserted into PDF documents and visualized interactively using Adobe Reader Version 7 or higher. The PDF standard supports the first and third editions of U3D; both these versions can include only tessellated geometry and animation data.
- PRC (Project Reviewer Compressed) was purchased in 2009 by Adobe Systems Incorporated. This format can be used to store representations as tessellated or precise (BREP) geometry. When converting to PRC, different levels of compression can be used. Support is also provided for PMI data including geometric dimensioning and tolerancing, as well as functional tolerancing and analysis.
  PRC ISO 14739 is currently (as of March 2011) in the Committee Draft (CD) ballot process.

3D PDF also offers all the options that conventional PDF offers, such as multimedia data content, access protection and encryption, forms and many more. This makes 3D PDF a format with possible applications that extend well beyond the realm of engineering.

Use cases

The variety of processes in any company means that there are a multitude of possible requirements relating to neutral 3D formats and the use of these formats in engineering practice. Based on many years of experience, an attempt has been made to aggregate this multitude of possible requirements in five common use cases, which in turn provide the basis for assessing the 3D formats.

The following are typical use cases in which the original data is transferred to a neutral 3D format:

Viewing engineering data

If the use of a CAD system is not desired, the visualization of engineering data using 3D viewers comes into play in a number of different situations: the presentation of product data, the representation of 3D models for information purposes (e.g. for a design review or marketing) and the realistic representation in virtual reality systems.

The use case can vary according to the concrete application context involved. While the simple viewing of the geometry is sufficient in many cases, in other cases metadata or product and manufacturing information (PMI) also needs to be displayed.

The high-performance visualization of large assemblies or design spaces and neighboring geometries is often an important criterion. In cases such as these, it is especially important that simplified representations are used.

The most important requirements are:

- The source system-independent representation of the model data (geometry and metadata) with the required level of detail.
- The ability to filter the product structure, e.g. using views or layers.
- The execution of simple measurements.
- Representation of product and manufacturing information (PMI).
- The ability to represent textures and sources of light for applications in the area of virtual reality.
- The availability of easy to use, cross-system viewers.

Data exchange

In development processes it may be necessary to exchange exact geometry between different CAD systems. This is, for example, the case if a supplier uses a different CAD system than the one used by the manufacturer. Another common situation is that one of the development partners makes a change to the geometry after it has been exchanged. In this case, merely viewing the data is not enough. What is needed is a typical and frequently used modeling method involving design in context of existing geometry.

When exchanging exact geometry, additional information describing the product is often needed. In this context, a distinction is made between PMI and metadata. While metadata refers to descriptions that consist only of text, e.g. information about the author or the release status of a model, PMI is often added in the form of 3D annotations. This makes greater demands on the underlying data format and on the application doing the processing. This means that grouping and filter options are needed to ensure clarity.

Another frequent requirement is that the processing of PMI be possible subsequent to data exchange. The protection of intellectual property (IP) is also playing an increasingly important role in data exchange, and it should therefore be possible to take this aspect into consideration.

The most important requirements are:

- The transfer of exact geometry and the entire product structure.
- The transfer of metadata as well as PMI annotations (depending on the concrete use case involved)
- Ensuring correlation between the original model and the target model.

Digital mock-up (DMU)

In digital mock-up (DMU; computer-aided test model), the mechanical properties of a product are examined and checked. This can involve checking the overall geometry with regard to dimensions and shape, interference checks, collision checks for assembly and disassembly, as well as design space checks.

For these purposes, the geometry, product structure and metadata are displayed and analyzed in a DMU application. A distinction is made between static and dynamic DMU analysis. In the case of static DMU, an examination of the static parts is performed. In the case of dynamic DMU, the dynamic parts or assemblies are examined.

The result of the DMU analysis is subsequently summarized and documented in a report.

As a general rule, a simplified, tessellated representation of the envelope geometry is usually sufficient for use in DMU. In the case of measurements, however, it should be noted that the level of tessellation accuracy must always be higher than the required measuring accuracy.

The most important requirements are:

- The availability of applications that support the respective required DMU functionality (e.g. assembly checks and collision control).
- Use of models from different source systems (multi-CAD).
- High-quality examination of large assemblies.
- Transferability of kinematics from the original model to the target model for dynamic DMU analysis.

Documentation and archiving

For the purpose of documenting and archiving engineering data, it is normally necessary to factor in exact data representation, including all metadata and PMI. The latter is especially important with regard to product approval and product documentation if drawings and technical documents are being replaced by digital 3D models. There are also often compliance requirements that need to be satisfied.

The most important requirement relating to the documentation and archiving of engineering data is that all relevant information be stored in a format that can be read irrespective of a specific IT infrastructure and after a long period of time – in the aerospace industry, for example, an archiving period of up to 99 years is possible in extreme cases.

The most important requirements are:

- Proper consideration is given to all product data.
- Problem-free combination of data from different source systems.
- Ensuring that the data can be accessed even after long periods of time (standardized format)

Portable PLM document – the use of 3D information in engineering-related domains

In modern product development processes, the utilization of 3D information does not end in the engineering department. Integrated product development requires that departments such as purchasing, quality assurance, technical documentation, planning and manufacturing also have to be able to access 3D information in combination with a wide variety of different documents such as

- bids and requests for quotes,
- quality control checklists,
- technical and manufacturing documentation,
- information for digital factory planning,
- and many more.

It is important that this content can be combined in a multimedia container that includes all the information and can therefore also be used offline.

The respective application areas are as different as the departments involved in integrated production development and their processes, such as:

- procurement processes,
- maintenance, repair and overhaul (MRO),
- cross-enterprise development and release processes in which suppliers and development partners are integrated.

The “Portable PLM Document” use case includes all the engineering-related departments mentioned above. In this environment, in particular, there is a steadily increasing demand for solutions that allow 3D data and other information to be used easily, securely and cost-effectively.

The most important requirements are:

- Information in the form of 3D data, metadata such as 2D representation, text data and binary data can be combined in a single file and can be managed there.
- The data can be combined easily with information from various source systems like PLM, ERP, CAD and from productivity suites.
- Comprehensive control options for file access (IPP, Intellectual Property Protection) exist.
- Easy to use, cross-system viewers are available.

Criteria for comparing the 3D formats

The criteria for comparing the 3D formats on the basis of use cases primarily involve technical constraints and the options that a format offers. The criteria include the availability of free viewers for a given format and the features the viewers offer, available software and converters, software development kits for the individual format, the level of compression that can be achieved and file size, and standardization aspects.

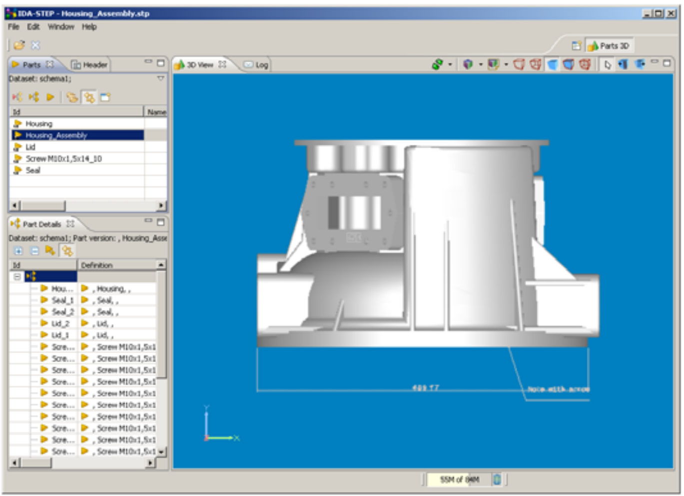
Free viewers

Only viewers for 3D formats that are available free of charge are included here. The criteria for evaluation are the range of functions that a viewer offers, how widely used it is among users and the platforms it supports.

Free Viewers for STEP

One example of a free viewer for STEP is *IDA-STEP Viewer Basic*[8] from LKSoftWare GmbH. The viewer is available for the operating systems Microsoft® Windows® and Linux.

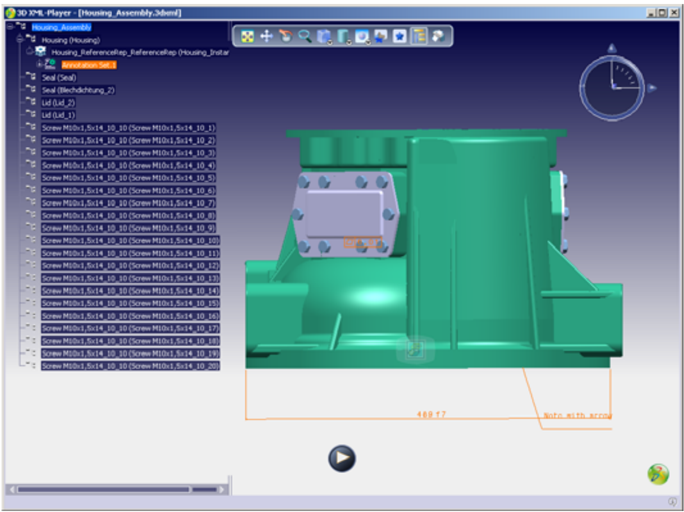
In addition, all widely-available 3D viewers (which are subject to a charge) support the display of STEP geometry.



Free Viewers for 3D XML

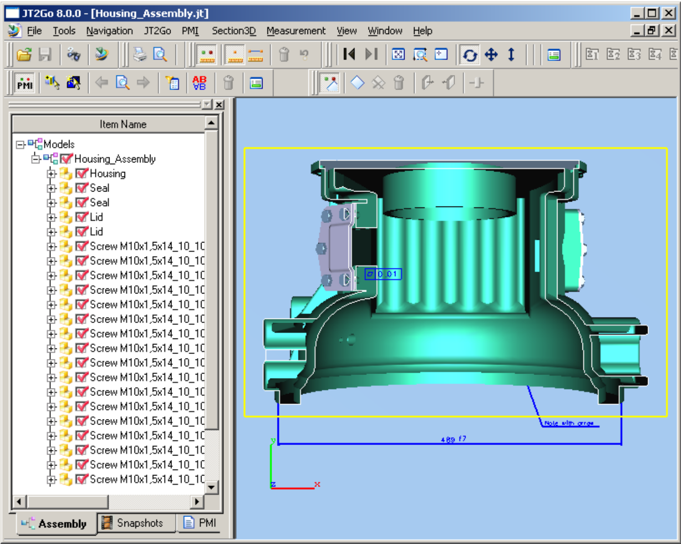
The most widely-used viewer for 3D XML is *3D XML Player*[9] from Dassault Systèmes. It is available free of charge and allows the representation to be viewed and filtered according to, for example, the product structure. This viewer is only available for the Windows operating system.

The use of ActiveX technology allows 3D XML data to be integrated in Microsoft Office® documents. The data can also be integrated in online content via an Internet browser.



Free Viewers for JT

The most widely-used viewer for JT is *JT2Go* [10] from Siemens PLM Software. It is available free of charge and allows the representation to be viewed and filtered according to, for example, the product structure. Basic measurements can also be performed.



JT2Go visualizes the tessellated variants of JT. The viewer is only available for the Microsoft Windows operating system.

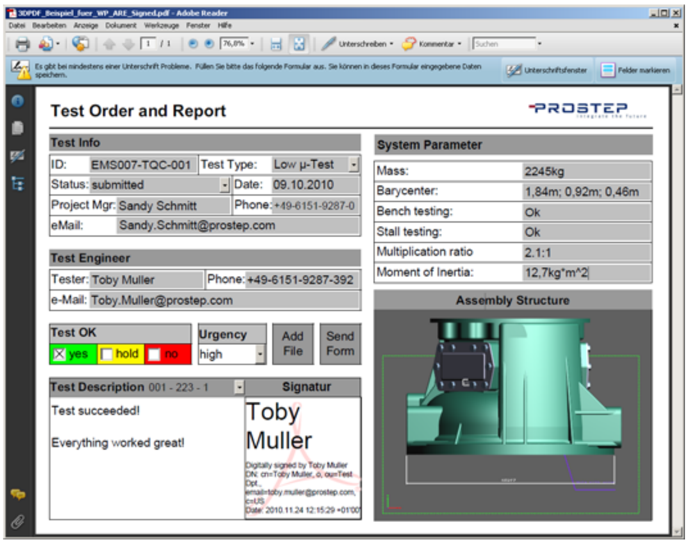
Software that is based on ActiveX and Java can also visualize JT data. This allows the integration of JT data, for example, in Microsoft Office documents.

The JT format can normally be processed by the 3D viewers widely available on the market (which are subject to a charge).

Free Viewer for 3D PDF

The viewer for 3D PDF is the free *Adobe® Reader®* [11]. It is available for Microsoft Windows, Apple® Mac OS® X, Linux and Oracle® Solaris. Adobe Reader is available almost everywhere in the world and because of it versatility, it is widely used outside of the engineering domain.

Adobe Reader offers a wide variety of different options for displaying and navigating 3D content. Functions such as measuring and cutting can be added to a PDF file when a 3D PDF is created. These functions are then automatically available in Adobe Reader.



Double-click picture to open PDF.

Converters and software

The software and converters available for 3D formats normally have to be purchased. The most important aspect here is the availability and quality of the software products and converters from system vendors and third-party vendors.

STEP

System vendors provide a STEP converter for almost every 3D CAx system. In addition, there are a large number of third-party vendors that provide converters. The software is mature since STEP has been in use for a long time and offers a high level of quality – also due in part to the quality assurance measures, such as benchmarks, developed by the ProSTEP iViP Association.

All widely-available 3D viewers can process and display STEP files.

3D XML

Dassault Systèmes provides converters for 3D XML; there are currently only a few third-party vendors that offer 3D XML converters.

3D XML is the format used in Dassault Systèmes´s 3DVIA-brand products. 3D XML has been integrated in almost all Dassault’s products and is often used as the format for exchanging data between these products.

JT

PLM vendors offer JT converters for a large number of 3D CAD systems. There is also a large number of third-party vendors of JT converters.

JT is the data format used in many applications from Siemens PLM Software and in the Teamcenter Lifecycle Visualization products in particular.

3D PDF

Version 9 of Adobe Acrobat Pro Extended can be used as a multi-format converter. This means that PDF files with 3D data can be created from all the CAD formats available on the market even if you do not have the native CAD system. In the new version, Adobe Acrobat X Pro, these converters are available as plug-ins. There are also several third-party vendors for converters.

PROSTEP PDF Generator 3D (formerly Adobe LiveCycle ES), for example, is a server-sided conversion solution for automating 3D conversion in business processes which can convert various CAD formats into PRC and U3D and embed them in PDF files.

In addition, several CAD vendors offer automated solutions that essentially support conversion to U3D.

Software Development Kits (SDKs)

You will need an SDK for a format if you want to develop or adapt applications yourself. Important criteria for evaluating an SDK are availability, the range of functions offered, the openness and accessibility of the SDK, and the programming languages supported.

STEP

There are a number of vendors of SDKs for STEP. One example is *ST-Developer*™[12] from STEP Tools Inc., which is subject to a charge. It is a comprehensive SDK for reading and writing STEP and other formats. STEP Tools supports C++, C and Java on almost all platforms.

All of the SDKs for STEP that are available on the market are very robust and offer a full range of functions.

3D XML

The XML schema and the corresponding documentation are needed to develop 3D XML applications. To obtain both, you first have to register[13] (free of charge) with Dassault Systèmes.

Standard XML tools are entirely sufficient for reading and writing 3D XML.

JT

Paid membership in JT Open[14] Community provides access to the *JT Open Toolkit* for JT. This toolkit can be used to develop extremely complex applications in C++.

JT Open Toolkit is currently the only SDK available for JT. However, it can be assumed that the number of available toolkits will increase as a result of the standardization process that is currently under way.

3D PDF

PDFlib is a development tool for creating and processing PDF files and is subject to a charge. It supports almost all operating systems and relevant programming languages. PDFlib can be licensed from Adobe for use in proprietary applications.

HOOPS 3D Exchange[15] from Tech Soft 3D is a toolkit (which is subject to a charge) for reading and writing 3D PDF files.

There are also a large number of PDF-related tools from third-party vendors that can be used to implement the wide range of functionality offered by PDF documents.

Compression and the resulting file size of the 3D formats

A reduction in file size is seen as an advantage when dealing with neutral 3D formats. In order to compare the file size of the 3D formats, five assemblies from each of three CAD systems were used to generate the 3D formats.

For JT, a distinction was made between tessellated content, exact XT BREP and compressed ULP.
Along the same lines, a distinction was made between tessellated content, exact PRC BREP and compressed PRC for the 3D PDF format.
The format 3D XML was generated only from CATIA V5.

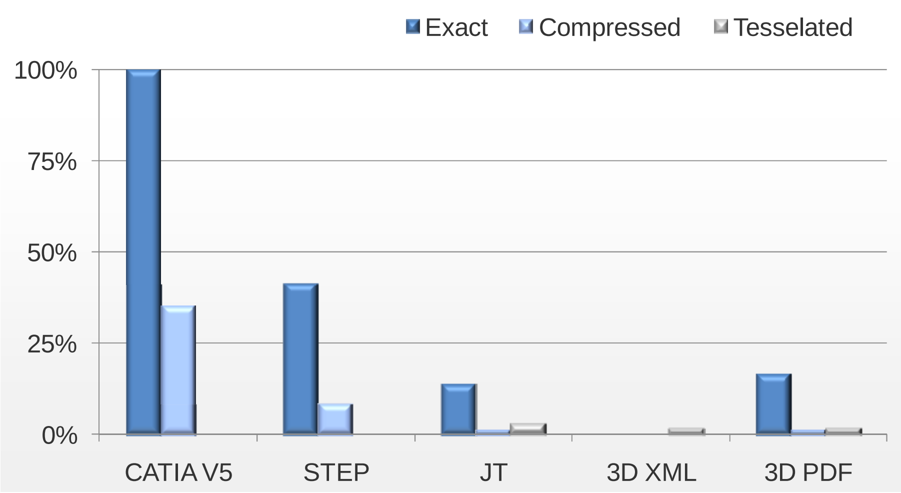
Performance (time needed to perform conversion and load time) could also be of interest when dealing with 3D formats. Detailed examinations are planned for a later point in time.

The following diagrams for comparing file sizes are based on sample models and provide an overview of the individual compression rates achieved. Conversion was performed without any further optimization in the translators.

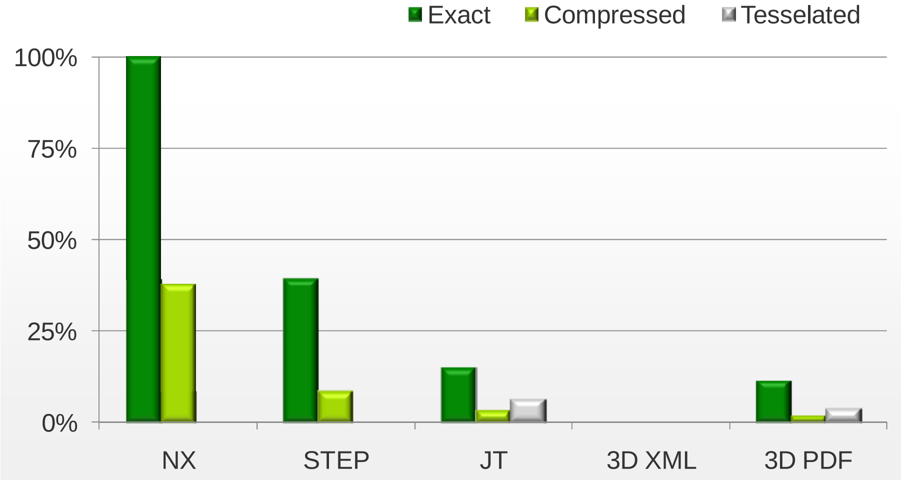
An accuracy/chord error of 0.5 mm was used for the tessellation. An accuracy of 0.01 mm was used for generating JT data with ULP and for the PDF with compressed BREP.

For comparison purposes, each of the original files, as well as the generated STEP models, were also compressed using an external data compression program.

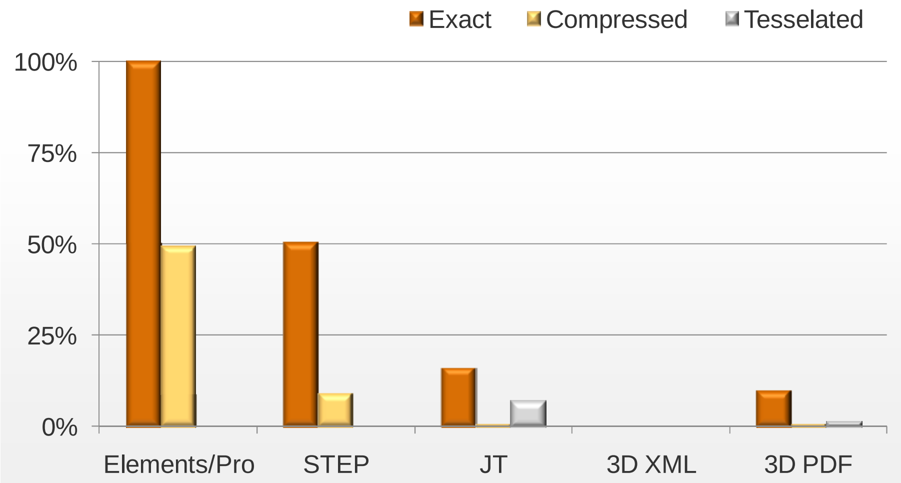
Models created with Dassault Systèmes CATIA V5



Models created with Siemens PLM Software NX



Models created with PTC Creo Elements/Pro (formerly Pro/ENGINEER)



Generating data in a neutral 3D format results in a significant reduction in volume. The volume of data is determined more by data content then by the format itself. The volume of exact BREP data after conversion to JT is approximately the same as after conversion to 3D PDF. The same applies to tessellated content, where the result for both formats is about the same as for 3D XML. In the case of simplified BREP data, the volume of data for both JT and 3D PDF are approximately the same. In the case of STEP data, use of an external compression algorithm achieves a marked reduction in size.

Standardization aspect

Standardized formats offer users and system vendors a broad, open and standardized approach; in addition – especially in the case of long-term investments and in the area of archiving – a future-proof format is indispensable. This also reduces the market risks for all involved.

This refers in particular to international standards, which are created by applying the World Trade Organization's (WTO) principles of transparency, openness, impartiality and consensus; with worldwide participation in their development possible.

Since users demand open standards, the owners of proprietary formats (like Adobe Systems Incorporated, Dassault Systèmes, Siemens PLM Software and others) are keen to have their formats standardized on an international level. Standardization by the ISO, for example, can take the following paths:

- ISO PAS (Publicly Available Specification): the format specification is published in unaltered form after a single vote and is valid for a maximum of six years. The owner transfers the copyright to the ISO.
- ISO IS (International Standard): the format specification goes through the normal standardization process, which is based on consensus building, with several international votes.

The status of the standardization process at ISO for the individual 3D formats is as follows:

- STEP: standardized as ISO IS 10303 in 2004. At the moment, the merging of the two application protocols AP 203 and AP 214 in ISO 10303 to create a new application protocol, AP 242, is currently under way and is expected to achieve Committee Draft (CD) status at the ISO in 2012.
- 3D XML: Dassault Systèmes submitted Version 4 of 3D XML to the ISO as a PAS in 2009. This, however, has been postponed due to unanswered questions regarding the copyright. In the mean time, Dassault has disclosed what were previously the proprietary parts of the format in Version 5.0 and transferred them to XML structures. Dassault has not yet submitted this version to the ISO.
  It is not yet known whether the format "3D XML with Authoring" announced by Dassault Systèmes will be disclosed.
- JT: published as ISO PAS 14306. The development of an international standard (IS) was added to the ISO's work program as a new work item (NWI) in November 2010, publication as an IS is planned for mid-2012.
- 3D PDF: the PDF format has been standardized as PDF/E (ISO IS 24517-1:2008) within the framework of ISO IS 32000. U3D is part of this standard. PRC ISO 14739 (TC 71/SC) is currently (as of March 2011) in the CD ballot process and will be part of the PDF family of standards.

Which 3D format for which use case?

If you take a look at all the criteria examined and apply them to the selected use cases, you end up with the following evaluations regarding the use of the 3D formats.

For the use case "Viewing"

In addition to the format specification, the following criteria are particularly relevant for evaluating this use case:

- Free viewers
- Converters and software
- File size

Because of the capabilities they offer for processing faceted representations and the available viewers, JT and 3D PDF are ideal for this use case.

3D XML also satisfies the key requirements but it is not as flexible as JT and 3D PDF with regard to the applications available.

Because of its data structure and the lack of implementation of faceted representations, STEP is less suitable.

JT and 3D PDF are best suited for this use case.

For the use case "Data Exchange"

In addition to the format specification itself, the following criteria are especially relevant for evaluating this use case:

- Converters and software
- Software Development Kits (SDKs)

Because of the numerous applications, STEP comes out slightly ahead. Since STEP is fully matured and was standardized many years ago, there is a wealth of experience relating to data exchange that has been documented in, for example, recommended practices published by the ProSTEP iViP Association. The use of STEP is standard practice for data exchange and is used worldwide in the field of automotive engineering, in the aerospace industry and in the machine engineering sector. Recent STEP developments such as "cloud of points (COPS) validation" can be used to check whether or not the converted models match the original native models.

JT is also well suited to the exchange of exact geometric information but compared to STEP, the converters and software available do not have as high a level of maturity.

Because of the lack of exact data representation, 3D XML is not suitable for this use case.

The same also applies to 3D PDF; although it can be used to transport exact data, it was initially not designed as a data exchange format for 3D geometry.

STEP is best suited for this use case.

For the use case "DMU"

In addition to the format specification, the following criteria are particularly relevant for evaluating this use case:

- Converters and software
- SDKs

- File size

JT is best suited for the DMU use case. Depending on the application context, either lightweight faceted representation can be used or representation of the exact data. Powerful applications are available for using JT in DMU analysis. JT is subject to minor restrictions with regard to extended requirements such as kinematics, where native formats have to be used.

3D XML is basically well suited to this use case, however, this only applies to applications within the Dassault Systèmes product family.

STEP is less suitable due to the lack of a lightweight representation option.

3D PDF does not offer any interfaces to DMU applications, which means that this format is suitable for this use case subject to certain limitations.

JT is best suited for this use case.

For the use case “Documentation and Archiving”

In addition to the format specification, the following criteria are particularly relevant for evaluating this use case:

- Free viewers
- Converters and software
- SDKs
- Standardization

Because of its document-oriented structure, 3D PDF is an excellent solution for this use case. All the necessary information, including explanatory notes, tables, etc., can be stored in PDF documents. The format specification is available as an ISO IS.

STEP is also available as an ISO IS and, as far as documentation and archiving are concerned, provides a very good container for the 3D portion.

Once JT has achieved ISO IS status, it will be equally well suited to this use case.

At the moment, 3D XML can only be recommended for this use case with reservations due to its data model and the fact that only a few tools support this format.

3D PDF is best suited for this use case.

For the use case “Portable PLM Document”

In addition to the format specification, the following criteria are particularly relevant for evaluating this use case:

- Free viewers
- Converters and software
- SDKs
- File size

Because 3D PDF allows 3D information to be represented together with other information, it offers the best prerequisites for this use case. 3D data and PLM data are contained in a single document and can be displayed in their entirety, and even enhanced, with the widely-used Adobe Reader. Access protection mechanisms have also been integrated.

JT allows good representation of the 3D part of this use case. However, for the other parts, integration or combination with other formats is necessary. Furthermore, there are no tools for the presentation and handling of the integrated data. Data security mechanisms are available only by using external applications.

STEP and 3D XML focus on other uses and can therefore only be recommended with reservations for this use case. Again, data security mechanisms are available only by using external applications.

3D PDF is best suited for this use case.

Graphical evaluation of the suitability of the formats for the use cases

Use Case	STEP	3D XML	JT	3D PDF
Viewing	●	●●	●●●	●●●
Data Exchange	●●●	●	●●	●
DMU	●	●●	●●●	●
Documentation and Archiving	●●	●	●●	●●●
Portable PLM Document	●	●	●	●●●

Legend

●●●	Highly suitable
●●	Well suitable
●	Suitable with reservations

Concluding remark

Each of the neutral 3D formats has its own particular strengths and thus offers advantages in one or more of the defined use cases. Therefore, it will be the intended areas of application, above all, that provide the best indication of which format to select. How the attributes of a format are weighted will, however, always depend on the overall requirements of the company involved.

One development that can be observed for all 3D formats and which benefits the user are the efforts being made by the owners of proprietary formats to standardize these formats on an international level. STEP and PDF are already available as standards, and other formats are on their way to being standardized. This provides users with the advantage of being able to select the vendor-neutral technology best suited to their own particular purpose.

Abbreviations

2D	Two-dimensional
3D	Three-dimensional
AP	Application Protocol
ASCII	American Standard Code for Information Interchange
BREP	Boundary Representation
CAD	Computer-Aided Design
CAE	Computer-Aided Engineering
CAM	Computer-Aided Manufacturing
CAx	Computer-Aided Processes
CD	Committee Draft
DMU	Digital Mock-Up
IGES	Initial Graphics Exchange Specification
IP	Intellectual Property
IPP	Intellectual Property Protection
IS	International Standard
ISO	International Organization for Standardization
JT	Jupiter Tessellation
LOD	Level Of Detail
MRO	Maintenance, Repair and Overhaul
NWI	New Work Item
PAS	Publically Available Specification
PDF	Portable Document Format
PLM	Product Lifecycle Management
PMI	Product Manufacturing Information
PRC	Project Reviewer Compressed
SDK	Software Development Kit
SET	Standard d'Echange et de Transfert
STEP	Standard for the Exchange of Product model data
U3D	Universal 3D
ULP	Ultra-Lightweight Precise
UML	Unified Modeling Language
VDA-FS	Verband der Automobilindustrie - Flächenschnittstelle
WTO	World Trade Organization
XML	Extensible Markup Language
ZIP	File format for loss-free data compression

Web links / Sources

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[1] www.iso.org

[2] www.prostep.org

[3] www.pdesinc.org

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[10] http://www.plm.automation.siemens.com/de_de/products/teamcenter/solutions_by_product/lifecycle_visualization/jt2go/index.shtml

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