prostep ivip

Recommendation

prostep ivip PSI 14-2 Recommendation V2.1

JT Recommendation

Comprehensive Collection of Industrial JT Use Cases

Abstract

The JT data format (ISO 14306:2017) enables the creation and utilization of high-performance 3D models for all life stages of the product lifecycle. The compressible data format contains a CAD-neutral description of product data and acts as a key factor in the integration of multiple CAD and PDM systems.

This Recommendation gives an overview about JT, the lightweight format for 3D data. After a short introduction a look in the brief history is given. Within the JT Workflow Forum project group, use cases for the application of JT in the context of virtual product engineering were specified. These are presented in this document.

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1 Introduction

CAD has become what today is referred to as a "commodity". It goes without saying that design engineering relies on authoring systems that enable a realistic model of the product being developed to be created on the screen – or on a power wall – that everybody understands. But the model is not only easier to understand. It also allows digital methods to be used for validation, testing and quality assurance where once physical prototypes were imperative. The benefits reaped have now whetted the appetite of completely new domains that had previously never shown any interest in technical details. While technical drawings could only be read by "insiders", design engineers, people with specialist know-how and spatial visualization abilities, the 3D model can serve a wide variety of purposes for a wide variety of people.

At the same time, an enormous demand for exploiting this potential has developed. Theoretically – and technically – there is hardly any task that cannot already be completed with the help of a virtual product model. Theoretically, therefore, there is hardly any department in a modern manufacturing enterprise or other enterprise that would not also benefit from access to the 3D models created in the product development department. In practical terms, however, there are still a number of obstacles to be overcome.

If we want to put a name to the main obstacles involved, they are: CAD systems require too much specialist know-how to allow them to be used everywhere – they are simply too expensive for that; in its original format, the volume of data for the precise geometry and product structure is too big and the data is ill-suited for a number of tasks; its handling is too complicated and the overhead involved in converting it to the required format is too great. And in addition to the actual geometry, this data also contains know-how that should not be exchanged at all.

On the one hand, these obstacles have meant that many of the benefits offered by CAx technologies have not yet been exploited to an extent that actually makes sense from the point of view of the processes, costs and quality of the work results. That is the negative aspect. On the other hand, they have also resulted in the creation of alternatives that allow industry to avoid these obstacles. That is the positive aspect. One of these alternatives is JT (Jupiter Tessellation). The reason why the VDA PLM working group, together with the prostep ivip Association, is working on JT activities is because this alternative enjoys both great popularity and widespread use within member companies. If the next stage of virtual product development is to be achieved and physical prototypes are to be rendered even more obsolete, it must be possible to display and use the data generated in the development departments with the required level of quality, regardless of its origin. And with the guarantee that, in this format, the data is based on internationally recognized standards and will therefore remain valid and processable for years to come.

1.1 Brief history: from proprietary format to ISO standard

JT was originally developed by the US Company Engineering Animation, Inc. (EAI) under the name Direct-Model toolkit. EAI was founded in 1987 in Iowa with the aim of realizing the physically correct animation of technical systems. In court, the animated models were used to help illustrate technically complicated car accidents and other complex legal claims, for example. To do this, a data format had to be found for animation purposes that would allow the rapid representation of extremely large assemblies involving thousands of components. In 1999, the company was taken over by UGS and the data format was developed further as JT. The division of EAI that was involved in the visualization of technically complex legal claims was spun off at the beginning of 2001 and today goes by the name of Demonstratives, Inc. (DI).

In 2003, UGS PLM Solutions established the JT Open initiative to encourage wider use of the technology. The initiative is financed by membership fees. The aim of the initiative is to improve the options available for using the format in downstream processes. The activities aimed at ISO standardization were also initiated by JT Open. The year 2003 also saw the founding of the JT User Group, which was initiated by specialists at Siemens and Bosch. The aim of the group is to provide a platform for sharing experience relating to the industrial application of JT based on day-to-day practice.

The JT data format was published in December 2006 and is available to the general public. This was one of the key preconditions that allowed standardization of the format to be initiated. In April 2007, UGS PLM Solutions submitted an application for the standardization of JT to the International Organization for Standardization (ISO). In May 2007, the company was acquired by Siemens Industry Automation and its name was changed to Siemens PLM Software. In early summer 2009, the standardization organization decided to bring the evaluation of JT and other formats, including U3D and Collada, to a close in that same year. JT 8.1c was published as a Publicly Available Specification (PAS) in September 2009. In December 2012, JT has been officially published as ISO 14306:2012.

Technically, ISO 14306:2012 is based on JT version 9.5. ISO 14306:2012 provides the description of the structure and content for a binary file having the extension of .jt. A binary file with the .jt extension is generally referred to as a JT file. All documents needed for the implementation are available royalty free. This includes patents formerly held by Siemens PLM. The advantages for JT and its standardization are shown in Figure 1.

Figure 1: ISO JT is a mature Standard

In 2017, the standard has been revised by ISO 14306:2017 JT edition 2.

In addition, DIN SPEC 91383:2021-07 JT Industrial Application Package (JTIAP) has been standardized by DIN – the German Institute for Standardization. This revision is based on the latest JT version 10.5 and has been published in June 2021.

With all necessary information for implementation available in the ISO standard, the implementation and usage of JT is not depending on a certain vendor. To ensure the interoperability between several JT implementations, guidelines for implementation and usage of ISO 14306 are developed.

1.2 Collaboration with other communities

prostep ivip is accepted worldwide as the Single Point of Contact (SPOC) for JT and AP 242XML related requirements and ISO-standardization of these data formats.

The activities of prostep ivip and VDA are approved by the GAAG (Global Automotive Advisory Group). The groups also communicate with other JT-related workgroups, such as the JT Open program, and workgroups developing other standardized engineering data formats, such as STEP AP242, Automation ML and PDF/E. Aim of this communication is to avoid redundant work, to achieve common goals and to ensure interoperability between the different formats. The cooperation of the individual instances is visualized in Figure 2.

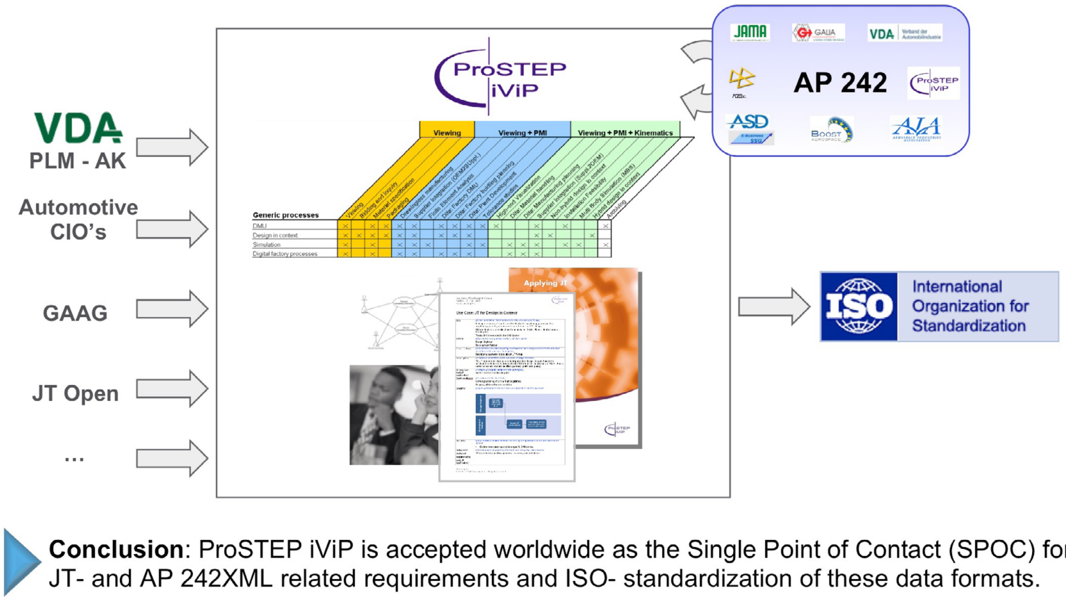


Figure 2: Joint activities of different boards

By using JT and STEP AP242 XML together, geometric data and information directly related to the geometry can be stored in JT files, while structure, kinematic and PDM-relevant metadata are stored in STEP AP242 XML, like displayed in Figure 3.

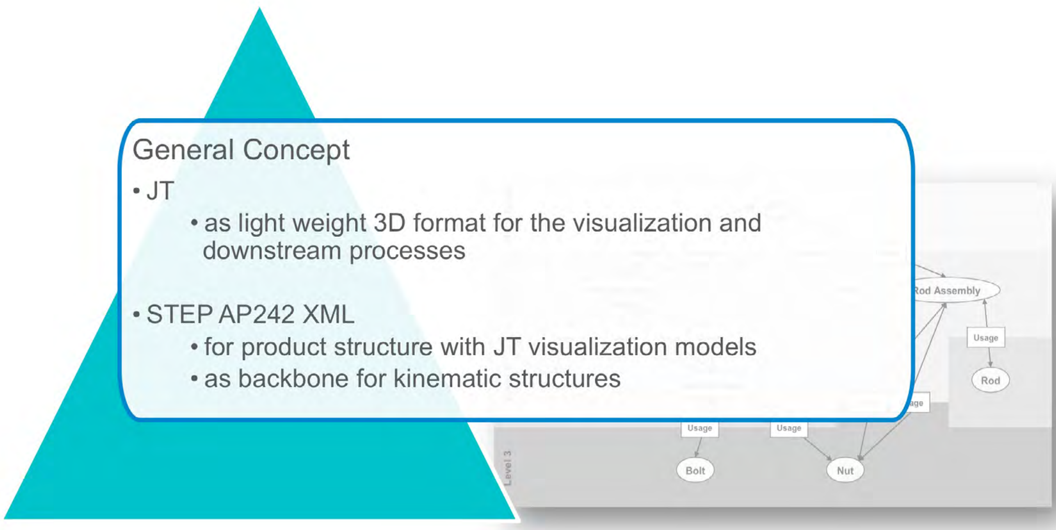


Figure 3: Interaction of JT with AP242 XML

The enhanced merger of AP 203 and AP 214, the standard for "managed model-based 3D engineering", is available as ISO 10303-242:2020. An integral part of the standard is the business object model, an XML representation of PDM-relevant information.

To enhance the coverage of application scenarios, JT is often used together with STEP AP 242 XML as an accompanying format. The collaboration between the two formats is illustrated in Figure 4.

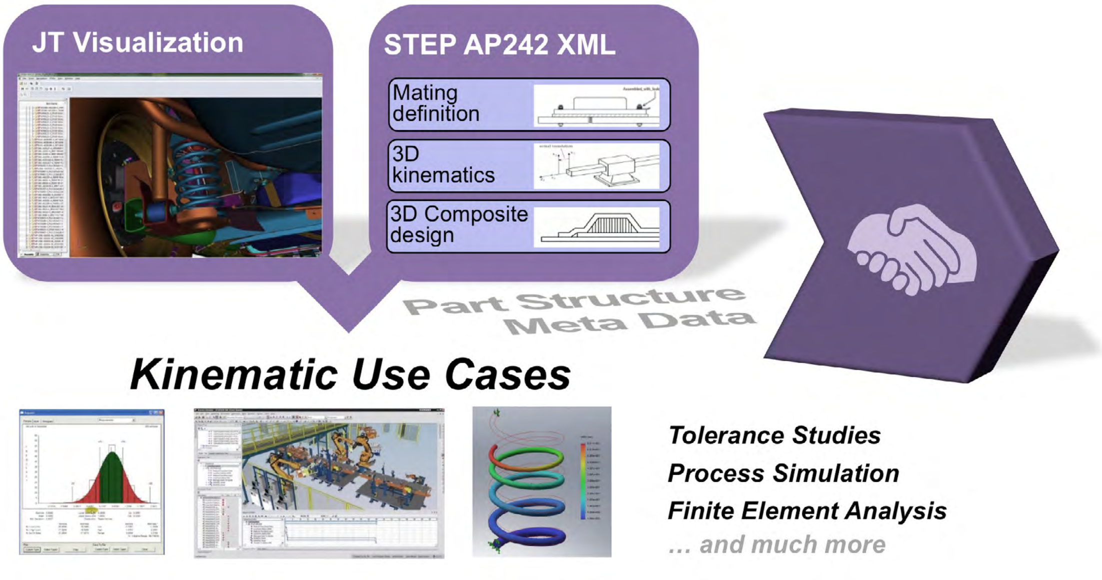


Figure 4: JT & STEP AP242 XML fits together

The concept of combined usage of JT and STEP XML, e.g. for kinematic use cases, has already been proven by users and software vendors. The groups in charge of the further development of STEP AP242 XML and JT are in constant dialogue with each other.

1.3 Many good reasons for neutral format – and more

The path from proprietary format to ISO standard was not, of course, as straightforward as the brief history of JT makes it sound. After all, more than ten years have passed since DirectModel, the forerunner of JT, was first used as a neutral data format at Ford. The intervening years were characterized by a gradual and largely low-key, but nonetheless considerable, increase in use. The reason for this was that, at the same time, the motivation for using neutral viewing systems had also increased enormously.

Distributed development and manufacturing, which involves a more or less large number of partners working together on the same project, has become the norm. The purchasing department has to be able to reference unambiguous, up-to date and valid product data. The requirements according to which a supplier creates his specification should also be based as closely as possible on the data and models from the development department. The time needed to exchange development data during a project is time that is not available for actual team work. Testing and assessing the results of partial developments, running through possible alternatives, virtually simulating and validating the assembly of complex products – everywhere you look, the entire technical side of modern industry relies on the 3D model of the product being developed. These are just some of the reasons that have led to the massive proliferation of neutral viewers.

The other reasons have to do with the overall processes. Access to product data and product models has also long been a basic prerequisite for the economically efficient execution of numerous tasks unrelated to research and development. Preparing for production, the planning and commissioning of production facilities, production control – without the visualization of product and plant models, these would all be uneconomical. The creation of technical documentation for installation and customer service, the publication of operating manuals for large facilities in 14 different languages, preparing the market for a new product using various advertising measures – all would be cost intensive, ineffective and not conducive to creating customer loyalty without the ready availability of data from the development department. In relation, the 3D data are used of many more people and departments for visualization, as there are people generating the data. This proportion is illustrated in Figure 5.

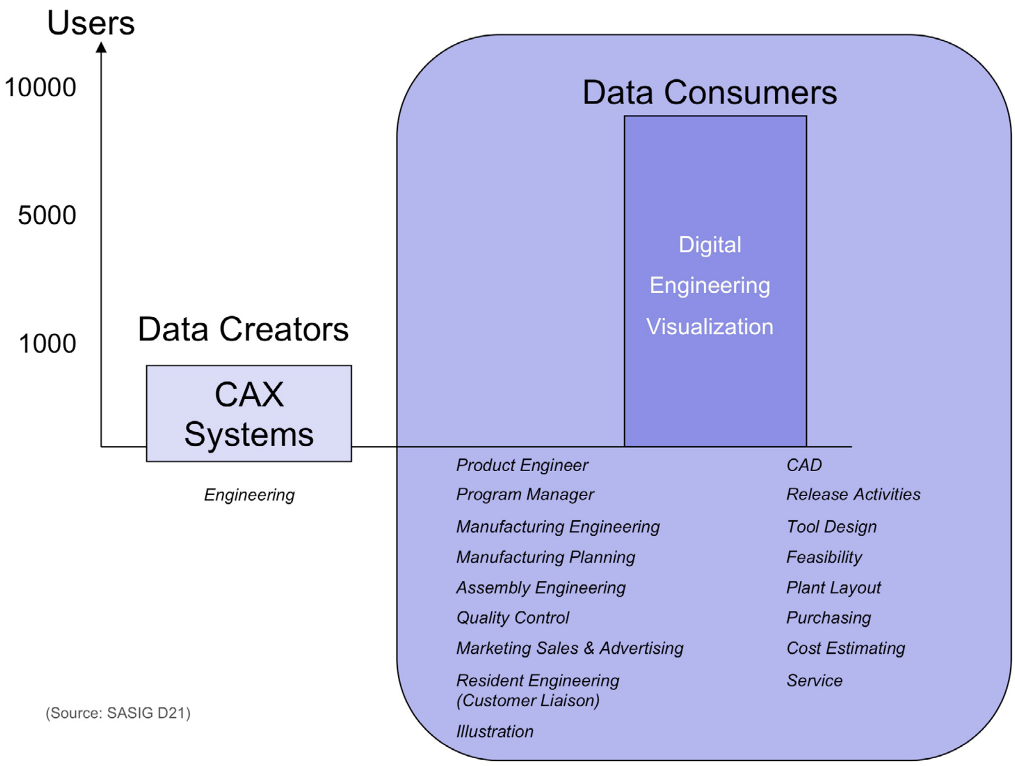


Figure 5: Proportion of creators/consumers of visualization data

The CAD programs and other software tools used to generate the relevant data are special systems whose operation requires appropriate know-how that is not otherwise required outside of the respective specialist department. The specialists themselves are unfamiliar with each other's tools. The mechanical engineer does not understand the electrical engineering or electronics system, the SPS programmer knows nothing about MCAD, and the computational engineer is not a design engineer. It is, however, in the context of the digital factory that the different domains that use completely different tools for their work collide. Not to mention the fact that the various systems have their own formats that do not permit combined representation. And then there is the heterogeneous world within the domains, which themselves only too often make multi-CAD the order of the day.

Even the availability of central data management systems has not remedied the problem. Although the files are stored in their respective valid version together with the product structure in question and, in principle, can be accessed from anywhere outside the department in which they were generated, they can still only be opened, viewed and utilized in other processes using the appropriate authoring system. Unless, of course, there is an option that allows data from completely different sources to be accessed and processed.

Utilization of the original data from the engineering departments also harbors a grave risk: In addition to the actual geometry and graphics, the models also include a multitude of things that represent a company's know-how. These parts of the data, e.g. the history of a 3D design or the specialized engineering know-how concealed in the design parameters – all part of the knowledge basis of the manufacturing company – are also what make the data too big and too heavy to be viewed and used easily in other departments.

There are therefore many good reasons why JT in particular and neutral formats in general have become a veritable mega trend. The vendors of authoring systems have seen which way the wind is blowing and today provide appropriate technologies, to some extent free of charge.

With over 5.000.000 users, JT is established in many industrial branches worldwide. More than 26.000.000 JT files exist in the PDM database of leading automotive OEMs Volkswagen, Daimler, Ford and BMW with num-bers rising every day, these numbers and relationships are illustrated in Figure 6.

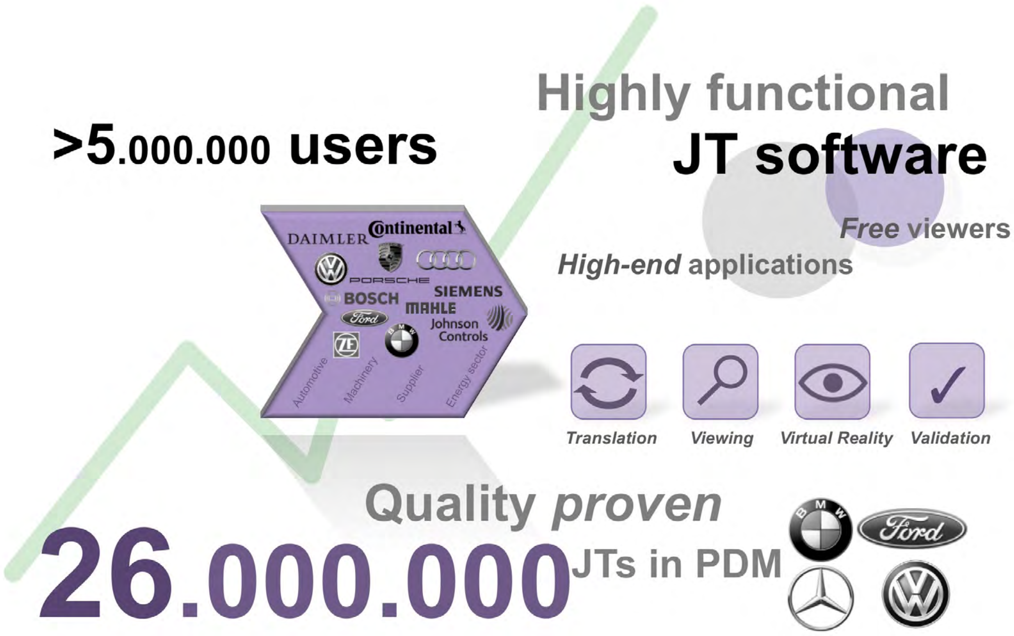


Figure 6: JT is proven by industry (12/2015)

There is a large amount of JT software available on the market. Starting with free viewers to high-end visualization and engineering tools, available software covers many use cases. Translators are available for all major 3D-CAD formats. The quality of the tools is proven in several benchmarks.

From simple visualization to advanced analysis, the JT format covers multiple engineering use cases and several topics. Some of these use cases or topics are shown in Figure 7.

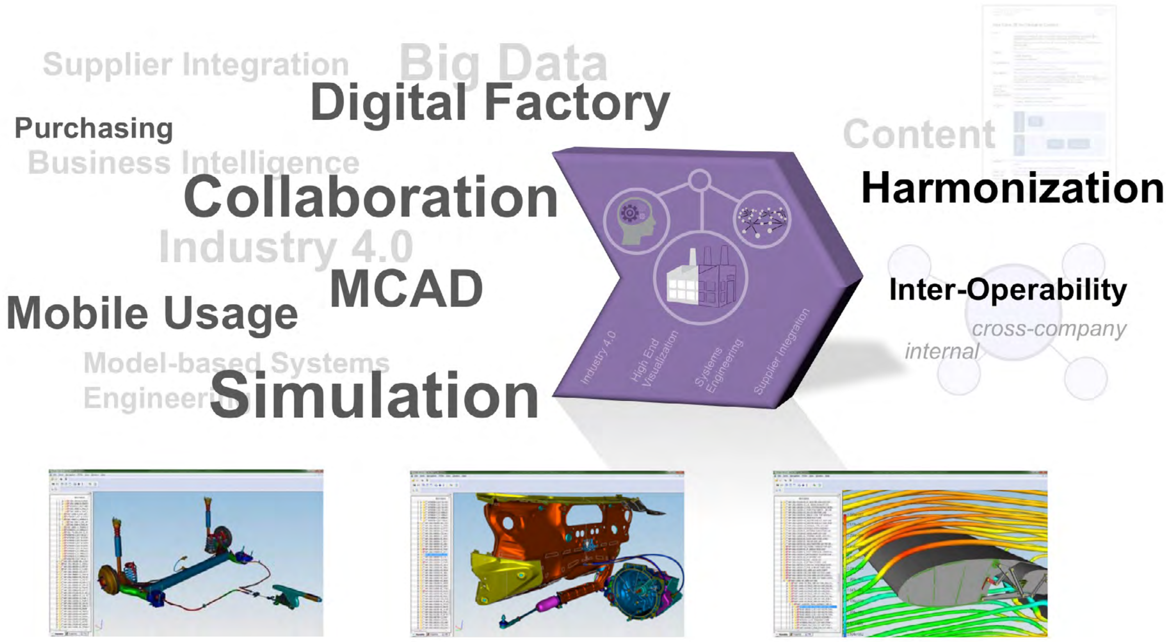


Figure 7: JT covers engineering use cases

The prostep ivip/VDA JT Workflow Forum (JT-WF) has so far elaborated 40 use cases for the application of JT; these are explained in detail in chapter 2. The use cases cover fields such as simulation, digital factory, drawing less processes, engineering collaboration, supplier integration and the use on mobile devices. With the ability to store lightweight visualization, exact geometry, PMI and metadata, JT fulfills all mandatory requirements.

The ability of available software to make use of the capabilities of JT is proven in several JT application benchmarks and software demonstrations to the JT-WF.

1.4 Data model

Not all the elements which are today part of the JT data model were part of ISO/PAS version, which was the basis for publication of the ISO standard in 2011 and the first JT translator benchmark in 2012.

The second edition of ISO 14306 cancels and replaced ISO 14306:2011, which has been technically revised. JT version 9.5, which includes several extensions and enhancements like JT ULP, for example, is now part of ISO 14306. Today, JT version 10.5 is available and is part of most recent DIN SPEC 91383:2021.

The data model for JT includes more than just geometry models. On the one hand, it offers the option of displaying the models in various degrees of precision and, on the other hand, other information that is important for product development and downstream processes can be stored together with the model.

In addition to the ability to display geometry, it was the fact that product manufacturing information (PMI) such as tolerances, tolerance dimensions and information about surface properties could be displayed together with the 3D models and processed further that contributed to its fast proliferation.

Geometry:

- At one of the lowest levels, simple regular geometry such as cuboids, cylinders and pyramids – for the definition of designed spaces for example – are located in what is referred to as the bounding box.
- Tessellated or faceted geometry allows the representation of solids and surfaces. JT offers the option of defining different levels of detail (LOD), i.e. specifying how precisely something is to be represented. A very low LOD means less precision and a smaller volume of data, a very high LOD means a level of precision approaching the exact geometry and a larger volume of data.
- The latest form of compression is JT ULP (the working title was LIBRA), which was released in 2008 and allows the volume of data to be reduced to almost one hundredth the size of the original data.
- BREP (boundary representation) geometry offers the highest level of precision. They are an exact representation of the solids and surfaces that were generated in the CAD system, for example. The exact JT file is also only a fraction of the size of the original file. In addition to the former used JT BREP, the newer XT BREP, which is based on the PARASOLID kernel, is part of the standard since 2017. XT BREP features the representation of regular geometry, among other things, and is fully supported by the converters.

Other information:

- Product structure (assembly, part, instance)
- Lighting (point light, infinite light, light set)
- Textures
- Product manufacturing information (PMI) (dimensioning, surface properties, etc.)
- Attributes

The different configurations of JT files which have been described above are used in various fields. Due to the different file contents different file sizes result. These relationships are illustrated in Figure 8.

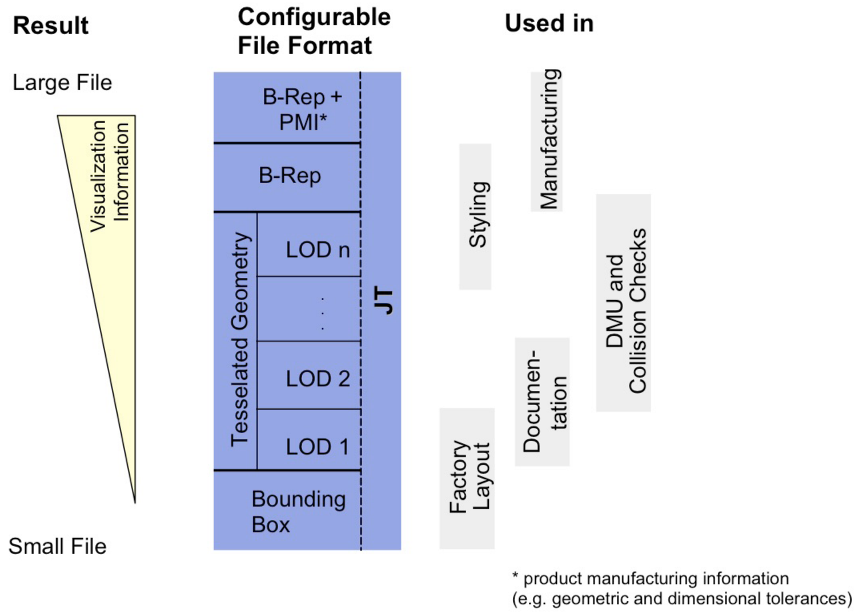


Figure 8: Geometry in JT

2 Use Cases

A study conducted by the VPE has already clearly indicated that the use cases are too widely scattered to reasonably allow them to be examined within the framework of a project group. The identified examples involve design engineering itself, the validation of the design results with the help of digital mock-up and high-end visualization, various types of simulation, cross-enterprise data exchange, the digital factory and production, purchasing, sales and marketing.

Certain things cannot be avoided when a new technology seeks a "natural" route for its application. Even within the same field of application, use develops very differently from company to company. Some companies use only tessellated data, others also use precise geometry; some companies use only geometry, others also metadata; some companies always store the JT data together with the original data; others decide on a case-by-case basis.

Despite its great popularity and, to some extent, wide-spread use, it cannot by any means be said that JT has become widely established. JT is currently most frequently used for visualizing geometry. In this context, there is already a wide range of examples from every branch of industry – primarily relating to the photo-realistic representations of computer generated product models that are suitable for marketing purposes. Since standardization has been achieved, utilization expands rapidly. This was also indicated by deliberations regarding key use cases in the JT Workflow Forum. All the more reason, therefore, to determine which application areas require JT support most urgently.

There are a lot of possibilities to divide the use cases into different categories. One possible classification into categories is shown in Figure 9.

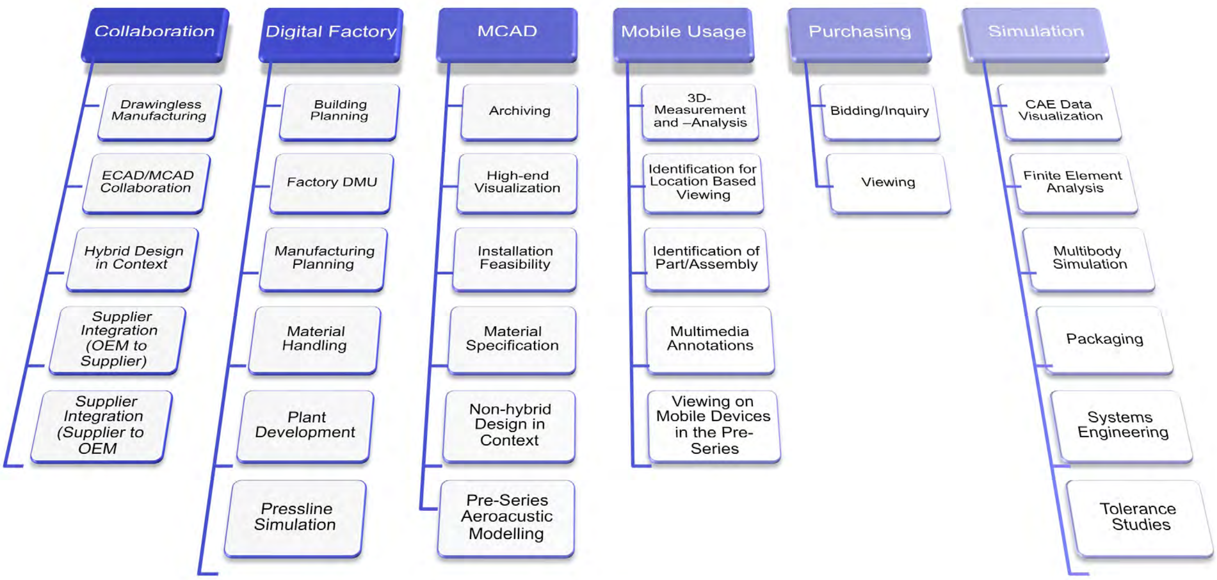


Figure 9: Use cases in categories

The use cases are presented in detail in the following chapters in alphabetical order, first the structure is explained.

2.1 Structure of the use case descriptions

The use cases are presented in the following chapters. Each use case has a uniform structure which is explained below.

The use case description is divided into three sub-chapters: "Use Case", "Description" and "Benefit". In the sub-chapter "Use Case" the aim of the use case is described in form of a short sentence. After that the actors are listed. These are the main human and machine entities and their roles. Next the preconditions are explained. This is a description of anything being assumed to have happened before the activities described in the use case description. The sub-chapter "Description" contains a narrative description of the use case or usage scenario, followed by the postconditions where the final state is described. Afterwards a diagram in form of a simple illustration of the use case as sequence or activity diagram is shown. Finally, the benefits are described in the sub-chapter "Benefits" in form of a documentation of main benefits concerning the application of this use case for the actors. If there are any important decisions or open issues, they are explained at the end of this sub-chapter.

2.2 JT for 3D Measurement and –Analysis and Reverse engineering

Use Case

JT in combination with I++ can be used to store metrology surface data, tolerance information and features. These data could either be reference or analysis data.

The actors of this use case are Metrology software, Measurement planning engineer, Measurement technician, Quality Engineer.

The precondition of this use case is a JT file including geometric data and PMI with geometric tolerance information exists.

Description

The Design Engineer exports JT with PMI, structure and metadata (1). This information contains shape and positi-oning tolerances. The measurement planning engineer loads the JT file into his planning software and creates a measurement plan based on the JT data (2). The measurement plan is exported as an I++ file (3). Based on this information the measurement technician will create a measurement program for measurement (4). The measurement program is also exported as I++ file (5). On a measurement system this program will create a set of points either by tactile or optical means (6). These points will be transformed to a surface and/or feature set describing the geometric features. These features will be stored in a JT file with geometric files and PMIs and/or are stored to an I++ file (7 abs). A quality engineer will load this file and the original JT file from step 1 into a tool to compare geometric differences and display PMIs related to measurement information (8, 9). A report is created to publish results (10).

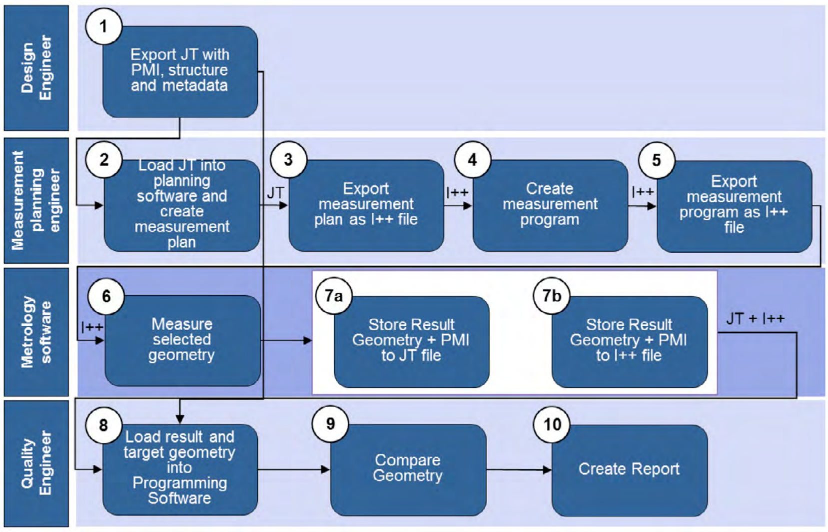


Figure 10: Use case diagram "JT for 3D Measurement and -Analysis and Reverse engineering"

Benefit

JT in combination with I++ can be used for metrology process.

2.3 JT for Archiving

Use Case

The aim of this use case is that JT can be used for archiving. JT data can be extracted (automated or manual) out of IT (CAD/PLM) systems and be used for archiving purpose. (Export from source system/later Import into target system if necessary.) In this case Archiving means middle/long-term archiving (storage not in focus). The actors in this use case are the release engineer the data requestor and possibly an archiving system. The preconditions for this use case are that CAD/PLM/JT data are released and requested for archiving and an available archiving system. Additionally, it is required that no geometric meta- and structure information is covered by PLM metadata container (PLM-Services-STEP/PLM-XML …). The Archiving process for PLM metadata container exists in parallel to JT for Archiving process, and is linked to it.

Description

Native data are available and released within a PLM system. Next the automated or manual archiving process starts and the JT data is generated. The data will be stored in the archiving database (Storage/Tapes). On demand the JT data will be restored by manual/automated processes and be transferred into the user environment. Possible variants of this description are native data, Tiff, 3D-PDF, STEP or "microfiche" or paper based archiving.
The postcondition of this use case is that JT data are available for data requestor.
The process flow with all stakeholders and the individual process steps is shown in Figure 11.

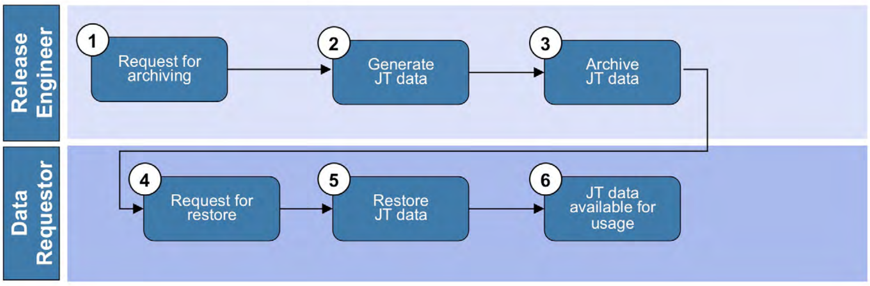


Figure 11: Use case diagram "JT for Archiving"

Benefit

The benefit of this use case is that the CAD/PLM archiving is independent from current and future IT infrastructure (CAD/PDM system). JT is the unique format for archiving and downstream processes. The requirements for restored data quality need to be defined.

2.4 JT for Bidding and Inquiry

Use Case

This use case describes using JT for bidding purposes. It does not address the bidding process itself, but much rather the preparation of it. The actors in this use case are the Procurement manager and the Data exchange engineer. The preconditions for this use case are that the PDM-tool allows neighborhood search for the assembly of components in context.

Description

The procurement manager sends a request to the data exchange engineer, outlining the required product data (1).

Based on the procurement manager's request, the data exchange engineer follows one of three sub-use cases: he assembles (possibly creating an assembly JT) the requested JT components (2a), if specific JT components are requested. Alternatively, he assembles JT components in context of specific product data (2b). Third, a combination of the above is possible. When the assembly of product data for the bidding process is complete, the data exchan-ge engineer or a batch-process selectively removes master data from the assem-bled data set (3). Possibly, specific materials must be prepared external of JT (4). The updated JT dataset is exported and uploaded to a business platform (5), to be acknowledged (6) for bidding.

The postcondition is that a JT may be exported, storing new views and sections.

The process flow with all stakeholders and the individual process steps is shown in Figure 12.

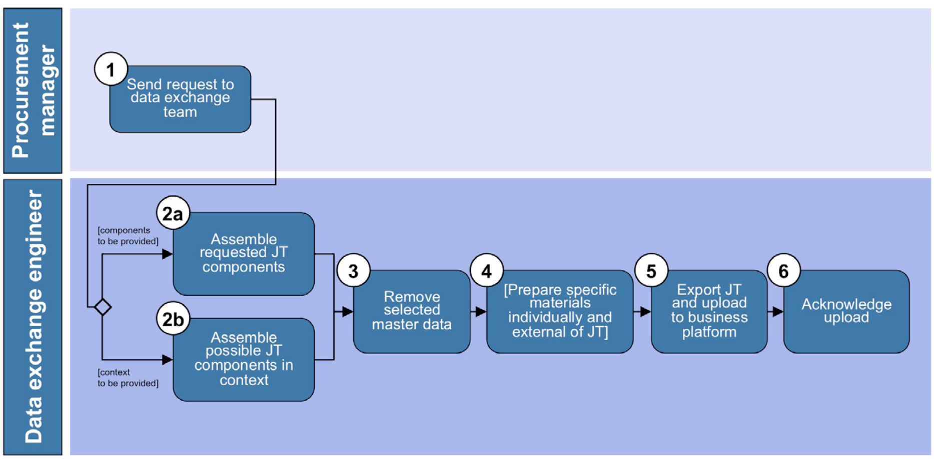


Figure 12: Use case diagram "JT for Bidding and Inquiry"

Benefit

The benefits of this use case are that JT can be used to assemble product data and launch bidding. Thereby no CAD-licenses are required for the assembly and no CAD-licenses are required by bidding partners.

Open issues to be detailed, in part for better understanding of the use case:

- What is the form (textual …) and content (version, configuration information …) of the procurement manager's request?
- How are components assembled, based on the procurement manager's request (what are the underlying steps)? Is this always a PDM-based procedure? How is context assembled (via bounding volumes …)? This plays a role, because depending on the procedure, specific information is required in the JT files (certain properties and / or bounding volumes in a specific form).
- Must kinematics be integrated as well?
- How must special materials be denoted, in order to be able to identify them and accordingly the need to separately prepare further information thereon?
- Explain which master data must definitely remain in the JT dataset.

2.5 JT for Digital Factory Building Planning

Use Case

The aim of this use case is that JT can be used as layout data carrier and to support data exchange scenarios between building planning and plant design. The actors in this use case are the Plant Design engineer, the Building Planner and the Engineering Planner. The preconditions for this use case are that 3D Data for building exist and JT data and metadata are quality checked.

Description

The Building Planner creates or updates the building layout and stores the geometry and metadata in the JT format. In parallel the material handling equipment layout is created. The Plant Design Engineer uses the JT content and metadata to display the plant in his CAD system. The Building Planner uses the analysis results from the Engineering Planner and the design of the Plant Design Engineer to update the building layout.

The postcondition of this use case is that the building layout is updated with a material handling simulation and the hull geometry of the Plant design.

The process flow with all stakeholders and the individual process steps is shown in Figure 13.

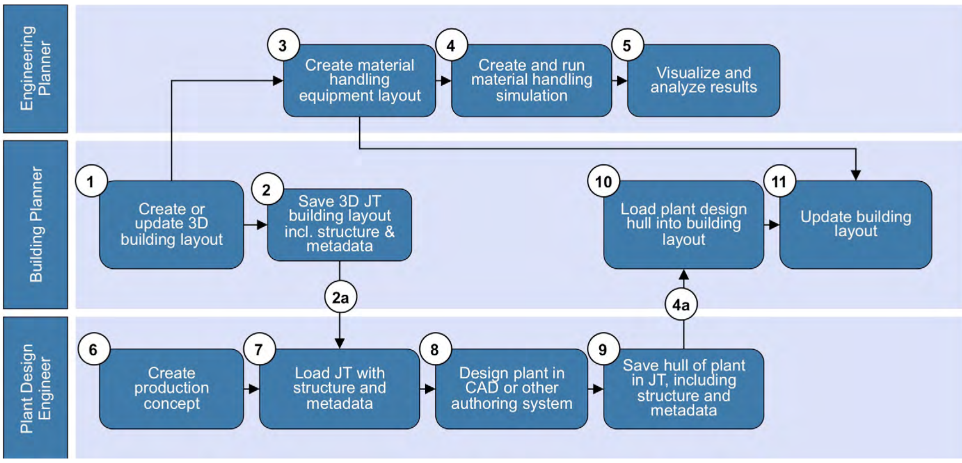


Figure 13: Use case diagram "JT for Digital Factory Building Planning"

Benefit

The benefit of this use case is that JT can reduce the size of the data amount.

2.6 JT for Digital Factory Manufacturing Planning

Use Case

This use case describes using JT for the development of plants or aggregates in the scope of Digital Factory (DF) activities, based on a product design. The actors of this use case are the Design engineer and the Plant development engineer.

Description

The design engineer creates product structure and geometry (1), and exports to JT (2).

The plant or aggregate development engineer imports NF-contents into a standalone JT-viewer or a process planning tool (3), to judge producibility (4). If a product is considered not producible by in-house resources, partners are contracted. Underlying activities are out of this use case's scope. In case the product is considered producible within a craft, a work sequence (route sheet) is defined or automatically generated (5). It represents a manufacturing strategy and includes a description of the product, as well as the materials, resources and steps (drill, mill, etc.) associated to the manufacturing process. Based thereon, a detailed production (manufacturing) concept is created (6a), possibly as a batch process based on various rules and digitalized manufacturing know-how. In order to do so, it may be required to recognize features within the product design. For example, a step within the production concept may be to drill a set of holes with certain drill-heads and constraints, for which companies typically cultivate internal guidelines depending on the type of holes, which are in turn defined as a feature by the design engineer. A detailed production concept gives insight into the way that product geometry is affected. For example, when integrating a Computerized Numerical Control (CNC)-mill into the manufacturing process, ejectors will collide with the product, possibly resulting in a mark. Such information is placed onto the JT's geometry (6b), in addition to Reference Point System (RPS), which represent measurement positions to later verify the manufactured product against the digital product data. JT-files with affecters are imported by the design engineer (7) to be verified (8). The plant or aggregate develop-ment engineer exports different product states to JT (9), used by follow-up stakeholders, e.g. for bulk material handling. Also, with the production concept set, the detailed plant is designed, including, for example, cooling aggregates (10). When finished, its hull geometry is exported to JT (11), again for follow-up stakeholders, e.g. for updating building layouts.

The postcondition for this use case is that the original JT-product data may be enhanced by manufacturing information.

The process flow with all stakeholders and the individual process steps is shown in Figure 14.

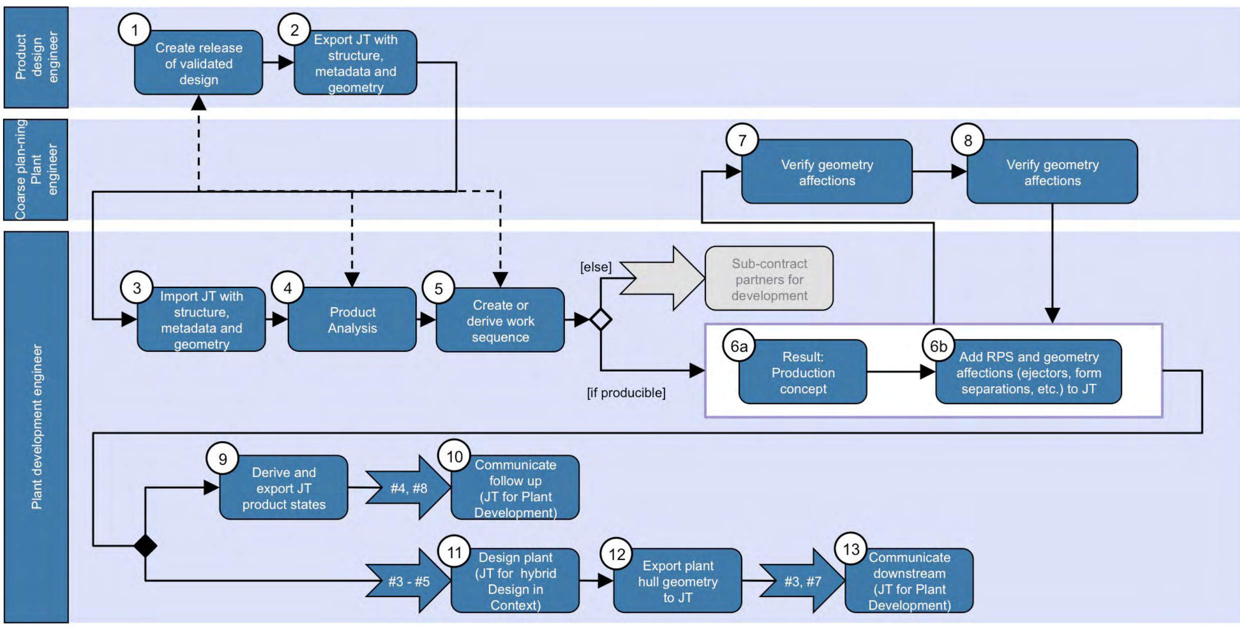


Figure 14: Use case diagram "JT for Digital Factory Manufacturing Planning"

Benefit

The benefits of this use case are that JT can be used for the derivation of a production concept and no CAD-interfaces are required.

Open issues to be detailed, in part for better understanding of the use case:

- What are the detailed steps involved in checking for producibility?
- Generic examples of a work sequence and a production concept should be provided.
- Explain which affecters are possible and accordingly the information required in JT.
- Explain, at best by including images, how product states should be provided.

2.7 JT for Digital Factory Material Handling

Use Case

The aim of this use case is that JT can be used as the data carrier to integrate layout and product data into planning and simulation of bulk material handling (material flow).

It is possible to provide and respectively retrieve a JT file holding as designed product structure, metadata and geometry. The actors in this use case are the product design engineer, the building planner and the material handling planner. The preconditions for this use case are that 3D data for building exist and JT data and metadata are quality checked.

Description

The Building Planner creates the building layout. The Material Handling Planner creates a conveyor layout. In the next step the Material Handling Planner loads product data with structure, metadata and geometry which are created from a Product Design Engineer and runs a material handling simulation. In the last step the simulation results are analyzed. The postcondition of this use case is an analysis with material flow simulation results.

The process flow with all stakeholders and the individual process steps is shown in Figure 15.

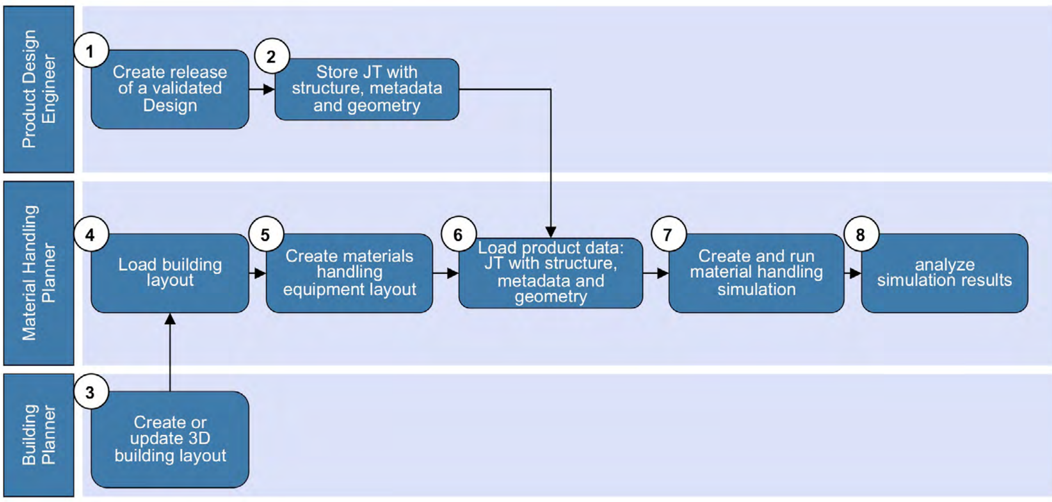


Figure 15: Use case diagram "JT for Digital Factory Material Handling"

Benefit

The benefit of this use case is that JT can reduce the size of the data amount.

2.8 JT for Digital Factory Plant development

Use Case

This use case addresses JT for planning the logistical flow of a product in creation. Its aim is to identify working areas and collisions, e.g. between aggregates (with product). The actors in this use case are the building planner, the bulk material handling planner and the plant development engineer. The precondition for this use case is that the Building planner communicates with plant development engineer, integrating plant hulls. This is not further detailed in this use case.

Description

The building planner creates a building layout (1), and exports it to JT (5).
The plant development engineer designs a plant (1), and exports its hull (outer geometry) to JT (3). Given components of the plant can include kinematical connections, and accordingly information on mass, moment of inertia and center of gravity. In designing the plant, he also derives and exports states to JT, for the product to be created (4).

The bulk material handling planner imports the building layout (6) and the plant hulls (7) to create a simulation layout. Into this simulation layout, the different product states are imported (8). Based on the sum of this information, a detailed simulation of the material flow is setup (9), run and analyzed for collisions.

The process flow with all stakeholders and the individual process steps is shown in Figure 16.

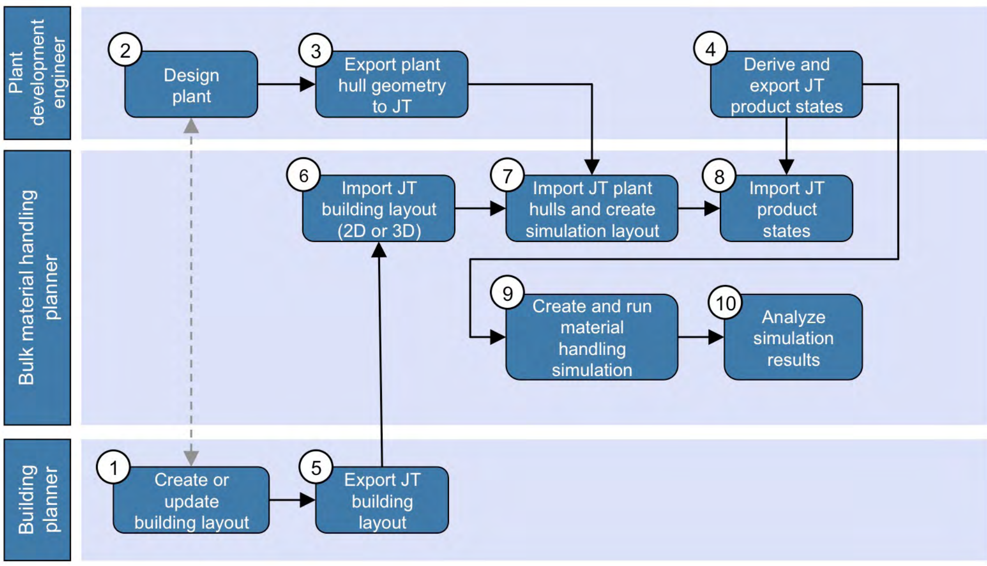


Figure 16: Use case diagram "JT for Digital Factory Plant Development"

Benefit

The benefits of this use case are that JT can be used to gather and combine a multitude of data and no CAD-licenses are required.

Open issues to be detailed, in part for better understanding of the use case:

- How must product states be provided (layers within a JT file)?
- Which product states are required for the simulation? Presumably, entry and exit states to each plant suffice for the material flow simulation.

2.9 JT for Drawingless Manufacturing

Use Case

For use in paperless manufacturing JT has to display dimensioning and PMI (Product manufacturing information). A Complex assembly has got a high number of PMI, through that the reading of the dimensioning is getting complex. The actors in this use case are the design engineer and the mechanical engineer. The preconditions for this use case are a 3D CAD file with PMI information, a JT Translator which is capable of con-verting PMI from native CAD to JT. Moreover, a viewing tool that can display PMI in JT as well as a training for end users who are used to use 2D drawings is needed.

Description

A 3D CAD file with PMI information has to be converted into JT. To improve clarity the PMI information in the JT file are edited. Editing contains hiding, viewing and adding of annotations. Changing of annotations is not allowed. Last a report with measurements and adaptions of the manufactured part will be created. The measurements will be stored as annotations in the JT file. The postcondition for this use case is a JT file with PMI information.

The process flow with all stakeholders and the individual process steps is shown in Figure 17.

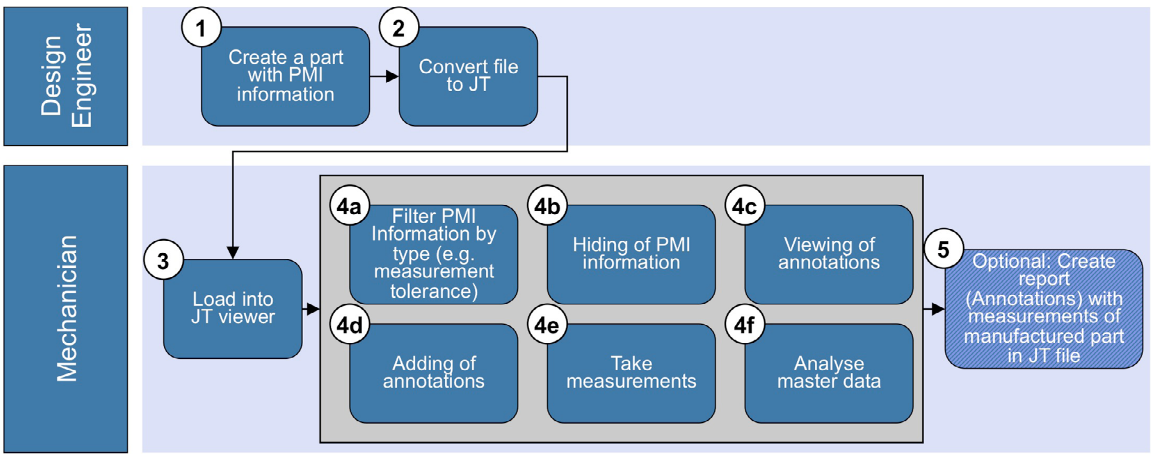


Figure 17: Use case diagram "JT for Drawingless Manufacturing"

Benefit

The benefit of this use case is that drawings are no longer necessary for dimensioning.

2.10 JT for ECAD/MCAD Collaboration

Use Case

The aim of this use case is that JT is used for ECAD/MCAD Collaboration between different companies, e.g. first and second tier suppliers. Proprietary formats (e.g. IDF) are replaced in the data exchange.

The actors in this use case are the MCAD and the ECAD designer.

The preconditions for this use case are that a collaboration process is established and JT is supported by ECAD and MCAD systems.

Description

The MCAD-Designer creates the geometry model of a part or assembly (ECU) that contains electronic components. The ECAD-Designer creates the layout of the electronic components.

Information about clearance in the mechanical design and restricted areas from the electrical design are exchanged via JT. The postcondition of this use case is that the needed geometric data is available to the ECAD and MCAD designer.

The process flow with all stakeholders and the individual process steps is shown in Figure 18.

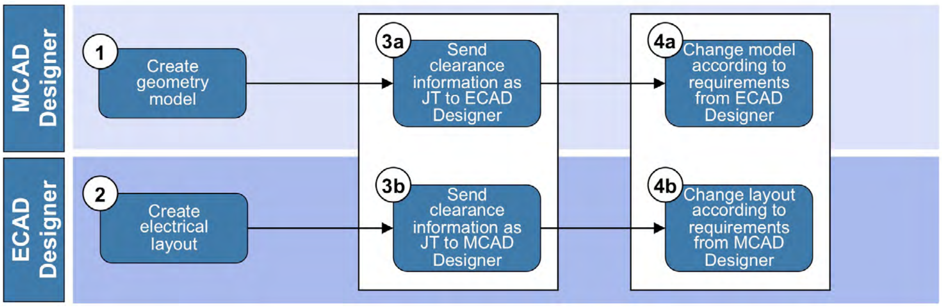


Figure 18: Use case diagram "JT for ECAD/MCAD Collaboration"

Benefit

The benefit of this use case is enabling external ECAD/MCAD collaboration based on ISO standards.

2.11 JT for Factory DMU

Use Case

The aim of this use case is that JT can be used as a data carrier to exchange information between standard and high-end visualization DMU/VR-tools, and plant and building design-tools. The actors in this use case are the engineering planner, the DMU engineer, the building design engineer and the plant design engineer. The preconditions for this use are that factory and building layout have reached a certain project status and are available in JT.

Description

The Building Design Engineer creates und stores a certain project status of building design in CA-native format. The Plant Design Engineer creates und stores a certain project status of plant design in CA-native format. The DMU Engineer stores B-Rep geometry, structure and metadata in JT format and loads JT layout data into a DMU/VR application to present a certain project status on special visualization equipment such as power wall. He will operate model flythrough on advice of the Engineering planner. Engineering planner will lead through presentation and discuss the 3D-model in teamwork with building design engineer and plant design engineer. The team will check the complete 3D-model for intersection and clashes. In case of an incident a work sequence is created.

There are analogies with certain process parts within JT for high-end visualizations and JT for Digital Factory Building Planning.

The postcondition for this use case is that the data of a certain project status for the whole factory layout or the whole building and resource layout are available in JT.

The process flow with all stakeholders and the individual process steps is shown in Figure 19.

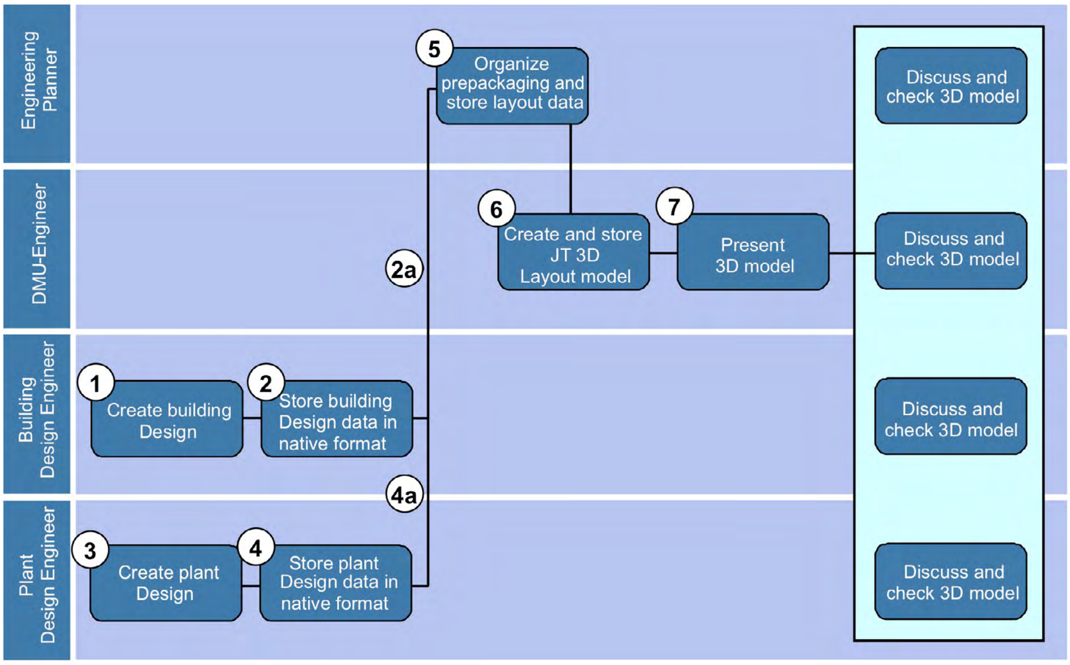


Figure 19: Use case diagram "JT for Factory DMU"

Benefit

The benefit of this use case is that JT can reduce the size of the data amount, which enables planners and engineers to navigate through a huge amount of Layout data.

2.12 JT for Finite Element Analysis (FEA)

Use Case

This use case describes using JT for FEA-scenarios, e.g. validating the robustness of a design based on applied forces and materials. The actors in this use case are the design engineer and the FEM engineer. The preconditions of this use case are that the FEA-tool is able to calculate a mesh using exact geometry provided in JT. Adaptive meshing can be done automatically or region-driven by user-interaction. In the scope of loading simulation results (deformed and colored JT-parts) into the CAD-system (Steps 9 and 10 to 11), there exists a mapping between JT-parts and the respective native geometry. Accordingly, JT-parts are positioned correctly.

Description

The design engineer creates structure and geometry in a CAD-system (1). Within the design, kinematical bearings are set up (2a), meaning mechanical connections between bodies with respective attributes or between a body and ground. Additionally, information on fasteners, e.g. screws (2c), welds, e.g. points or seams (2d), and materials (2b) is set. Welds are modernly provided via CAD-functionality on PMI. The design engineer exports structure, metadata and geometry to JT (3).

The FEA engineer imports the JT-contents into the FEA-simulation tool (4), deriving a mesh from the B-Rep geometry, automatically or semi-automatically (e.g. parameter-driven, region-driven or per-part). Specifying initial conditions and constraints, the simulation is set up (6) and subsequently run (7). The details of the preparation phase are out of this use case's scope. Numerical results, e.g. a force field, are mapped to vertex data within JT, for example holding color-encoded vertex deformations on parts with a respective color legend. By adding a respective layer (8), the deformed parts are integrated into the existing JT (9). Alternatively, a new JT is exported (10), holding only the deformed and colored parts. In either case, the resulting JT-parts can be imported back into the design engineer's CAD-system (11), allowing an analysis therein. Based on the analysis, the existing design can be updated, defining an iterative cycle of optimization to the analysis.

The postcondition for this use case is that the JT parts are deformed, color-encoded and displayed in the native CAD system.

The process flow with all stakeholders and the individual process steps is shown in Figure 20.

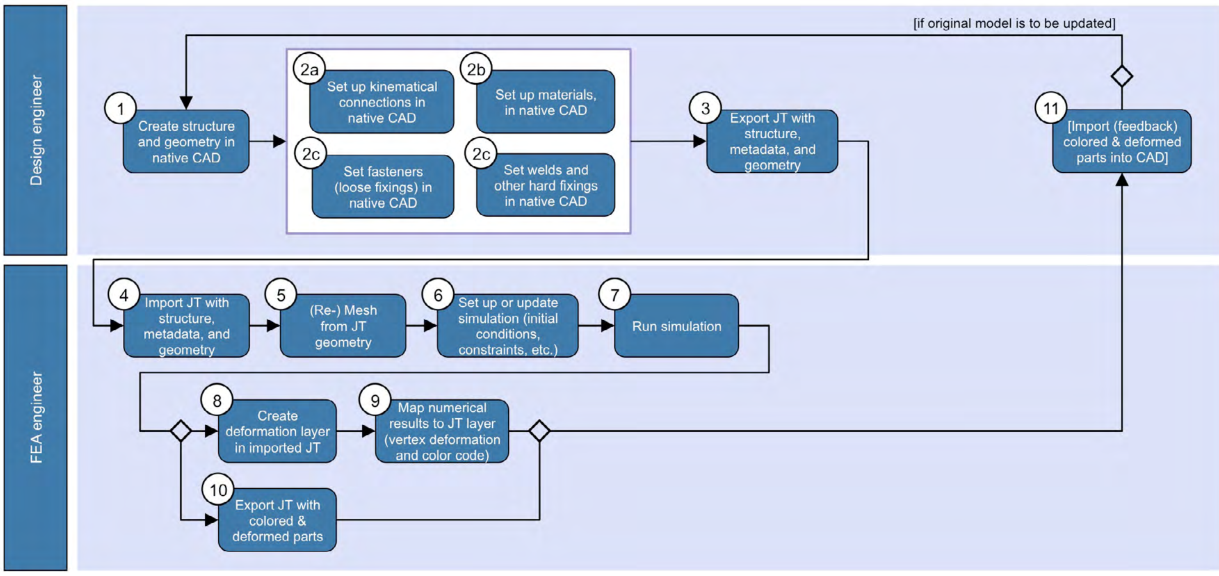


Figure 20: Use case diagram "JT for Finite Element Analysis (FEA)"

Benefit

The benefits of this use case are that JT can be used to in part prepare FEM based simulations and there is no need for a direct interface between the simulation tool and the CAD system.

Open issues to be detailed, in part for better understanding of the use case:

- Detail whether or not bearings can be provided by common kinematical joints, or if additional data is required (feature technology)

2.13 JT for high-end Visualization

Use Case

The aim of this use case is that JT can be used to prepare and view high-end (photo realistically) product data. It is possible to provide a JT file that contains structure, metadata and geometry. The actors in this use case are the design engineer and the DMU engineer. The preconditions for this use case are that PMI's and kinematics are included in the metadata and JT data and metadata should be quality checked.

Description

The Design Engineer stores structure, metadata and B-Rep geometry, including material properties, in the JT files. Alternatively, the materials and metadata can be imported from the PDM System. The DMU Engineer loads JT data into a high-end viewer, in which he is able to associate textures and GPU shaders with parts. Additionally, he may change further visual attributes, such as color or form of representation (e.g. wireframe or solids). The high-end viewer may be coupled with a Virtual Reality system. Changed parts can be stored. (It is possible to import the data with or without the B-Rep information; the PMI's are handled correctly.)

The postcondition of this use case is that possibly changed JT parts are stored that include textures, GPU shaders and changed visual attributes.

The process flow with all stakeholders and the individual process steps is shown in Figure 21.

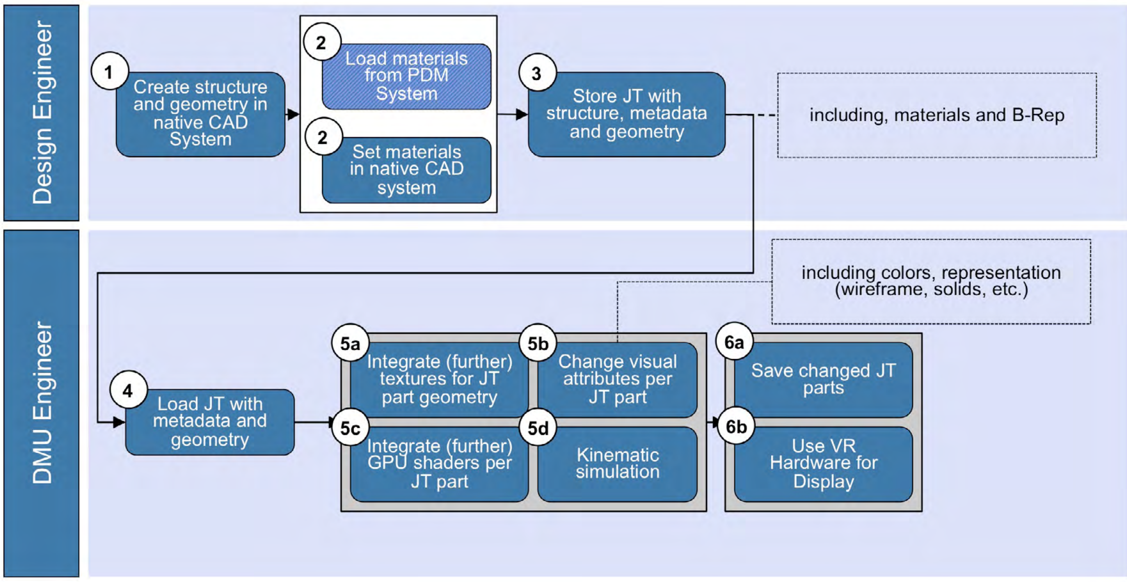


Figure 21: Use case diagram "JT for high-end Visualization"

Benefit
The benefit of this use case is that JT can be used to prepare and view high-end visualize product data.

The focus of this use case is photorealistic visualization, not DMU functionality, such as analyzing Installation Feasibility or Packaging. This use case may, however, be seen in combination with such DMU related use cases. Accordingly:

- It is a requirement to include PMI data.
- It is a requirement to include kinematics for high-end VR scenarios.

2.14 JT for hybrid Design in Context

Use Case
This use case describes the course of using JT for design in context. The difference between non-hybrid and hybrid display is that the context data based on JT can be loaded into the native CAD-environment, displaying native CAD- and JT-data in parallel. JT-data is not converted to a CAD-internal format. Depending on a given set of parameters, e.g. distance to viewer, JT-contents are visualized in respective quality via different LODs or exact geometry. The actor in this use case is the design engineer.

Description
A design engineer creates particularly product structure and geometry (1), which is to be used as context by another design engineer. He exports JT-files, including PMI, such as dimensions and tolerances (2). Selective features are included as well, in order to be extracted by the receiving design engineer.

The receiving design engineer loads JT-geometry into the native CAD-system (3), which is then displayed hybrid to native CAD-geometry, with the possibility to switch between different resolutions of tessellated geometry, or to exact geometry (4e). This allows handling of large assemblies. Native CAD-geometry may continuously be modified, with the addition of now being able to position CAD-data in relation to certain JT-content (4a), such as edges, vertices, faces, or auxiliary geometry, e.g. point, axis or plane. Exact geometrical references, e.g. curves, are also possible. New PMI can be added, associating native CAD and/or JT-based geometry (4c). Going beyond typical PMI (GD&T, surface finish, etc.), selective advanced features, e.g. a drill hole with its parametric definition, are selected and its contents displayed (4b). Optionally, the parametric definitions can be altered. When creating a technical drawing, new PMI and loaded NF-content are included as well (6).

If new PMI are provided based on JT, they are communicated back to the original CAD-model (5a), which is respectively updated. Likewise, if feature parameters were changed in the JT, they are communicated back to the original CAD-model (5b).
The postcondition of this use case is that native CAD-geometry is positioned correctly in relation to JT-context geometry. New PMI and feature definitions are updated in the original CAD-model. Further, a technical drawing is created.

The process flow with all stakeholders and the individual process steps is shown in Figure 22.

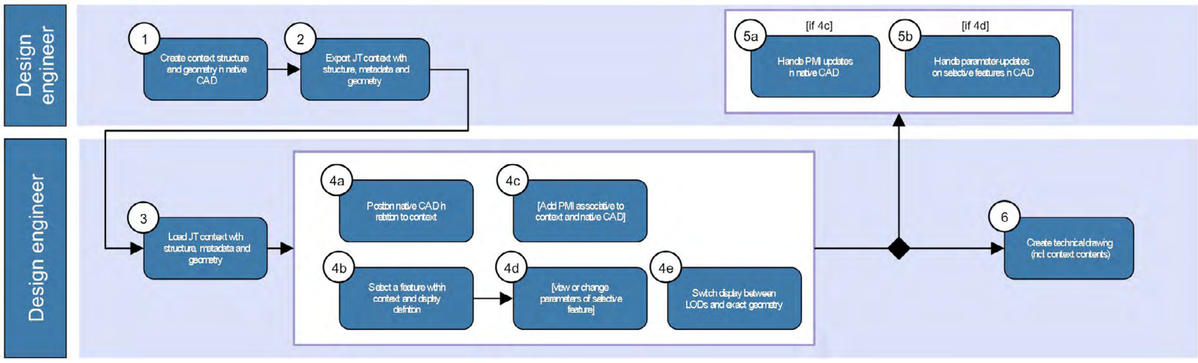


Figure 22: Use case diagram "JT for hybrid Design in Context"

Benefit

The benefits of this use case are that JT can be used to design in the context of existing product data. Additionally, "real" Multi-CAD design is possible. Between multiple CAD systems no JT imports or direct interfaces are required. A protection of intellectual property by including only selective features is possible. A benefit is also the performant visualization (more effective work) due to lightweight JT integration.

Open issues to be detailed, in part for better understanding of the use case:

- Specify a subset or examples of features with parameters that are required
- Specify list of assembly-level PMI types that are considered necessary

2.15 JT for Identification of Location Based Viewing

Use Case

The aim of the use case is the identification of location (for example molding press) dependent parts/assemblies.

The actor is a worker who needs to view location dependent information (for example for evaluating of product quality).

The preconditions for this use case are that the production line location information is attributed to parts and/or assemblies and that a QR-Code is locally attached.

Description

A worker walks to a location at production line to evaluate a certain situation (for example design vs. as-built comparison) (1).

To identify the affected parts/assemblies he scans within the viewing application a QR-Code1 with the mobile device integrated camera. (2)

The viewing application now identifies the location (3) and opens exactly the parts/assemblies of that location (4) for further work steps. (5)
Alternatives to this process are the use of location identification by in-house GPS (or similar) coordinates or the use of RFID2 instead of QR-Code.

The postcondition for this use case is that parts/assemblies in dependence to production line location are opened in viewing application.

The process flow with all stakeholders and the individual process steps is shown in Figure 23.

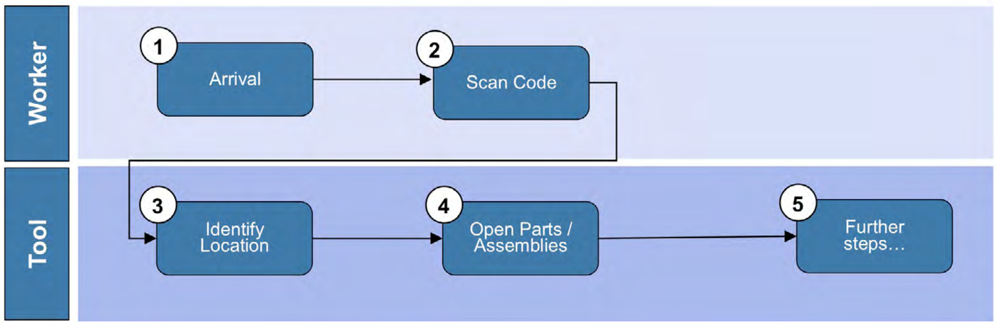


Figure 23: Use case diagram "JT for Identification of location Based Viewing"

Benefit

The benefits of this use case are time savings because of "one click" (for scanning) part/assembly filtering and the quality increase because of automated vs. manual filtering.

2.16 JT for Identification of Part/Assembly

Use Case

The aim of the use case is the identification of parts/assemblies. The actor of this use case is a worker who needs to get design information of certain parts/assemblies. The preconditions of this use case are that identification information is attributed to parts and/or assemblies and that a QR-Code is locally attached.

Description

A worker gets in contact with certain part/assembly to evaluate a certain situation (for example design vs. as-built comparison) (1).

To identify the part/assembly he scans within the viewing application a QR-Code with the mobile device inte-grated camera. (2)

The viewing application now identifies the part/assembly (3) and opens it (4) for further work steps. (5)

Alternatives to this process are the use of location identification by in-house GPS (or similar) coordinates or the use of RFID instead of QR-Code.

The postcondition of this use case is that the part/assembly is opened in viewing application.

The process flow with all stakeholders and the individual process steps is shown in Figure 24.

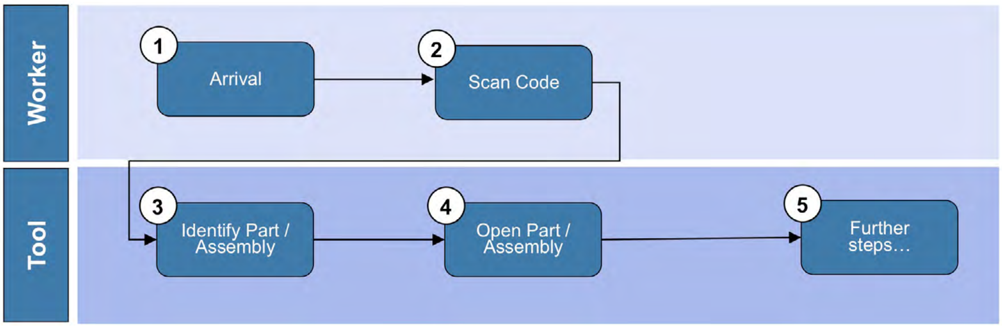


Figure 24: Use case diagram "JT for Identification of Part/Assembly"

Benefit

The benefits of this use case are time savings because of "one click" (for scanning) part/assembly filtering and quality increase because of automated vs. manual filtering.

2.17 JT for Installation Feasibility

Use Case

This use case describes the utilization of JT for a typical installation feasibility analysis. Primary goal of the analysis is to check whether or not assemblies and parts collide during installation. The actors in this use case are the design engineer and the DMU engineer. The precondition for this use case is that the moving of assemblies and parts with correctness regarding kinematical joints is considered an integral part of this use case, not a prerequisite in terms of CAD-adapter functionality.

Description

The design engineer creates structure and geometry in a CAD-system (1). Based thereon, he defines fixes and joints (2) with respective attributes, e.g. axis of rotation, and calculates kinematical part properties (3) (mass, center of gravity and moment of inertia). Optionally, a kinematical simulation may be run within the CAD-system, e.g. using a Multibody Simulation module (4). If such a simulation is run, a keyframe animation is stored. The design engineer exports structure, metadata and geometry to JT (5). The JT includes the kinematical connections and the keyframe animation sequence if a simulation was run.

The DMU engineer imports the JT-contents into the DMU installation feasibility analysis tool (6). If desired, he can further tessellate geometry based on the exact B-Rep information (7). This allows a flexibility regarding preciseness of the geometry and following functionalities that are dependent of it, such as collision detection. In order to tessellate, typical parameters are to be specified, such as chordal and angular restrictions. The DMU-tool displays the 3D-geometry and allows the user to move assemblies and parts (8b). In doing so, the application uses the kinematical connections to correctly constrain the movement. Alternatively, if and only if an MBS was run in Step 4, an animation sequence can be triggered and run (8a). In any case, a collision detection algorithm runs on tessellated geometry in the background (8d), highlighting colliding parts. The DMU engineer can perform exact measurements (8e) based on B-Reps. He can further enhance loaded contents by multiple views (8f), updating the underlying JT-files. For better flexibility between performance and accurate visualization, the DMU-tool enables a switch between different LODs and exact representations (8c). The analysis is concluded with a report, having critical parts highlighted, and the underlying JT contents integrated into a PDF or a similar document (9).

It is conceivable to create a static snapshot of moving components, and export this snapshot to JT. Such a snapshot can include the same geometry at different positions, representing its position and orientation over time.

The postcondition of this use case is that new views may be created within the underlying JT-files and a report is created. The process flow with all stakeholders and the individual process steps is shown in Figure 25.

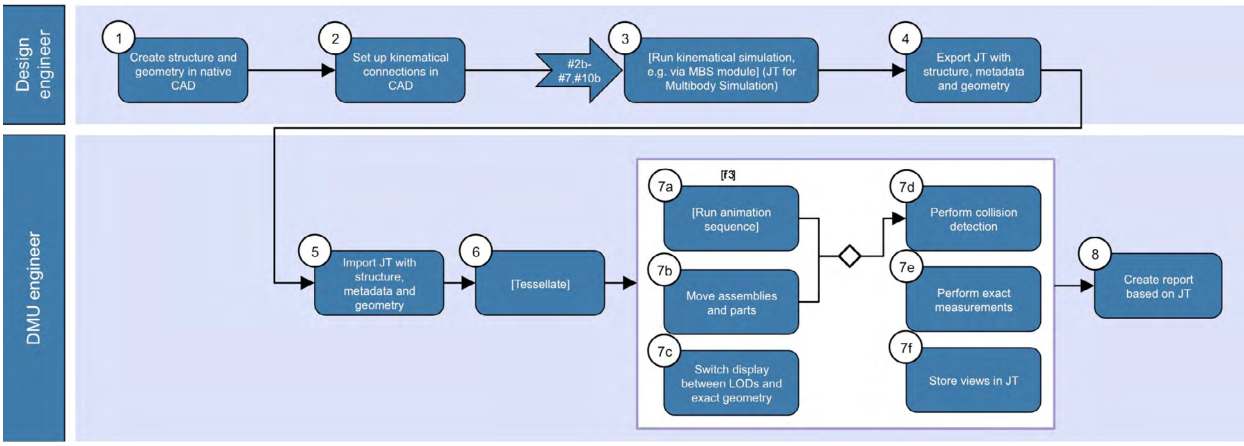


Figure 25: Use case diagram "JT for Installation Feasibility"

Benefit

The benefits of this use case are that JT can be used to run installation feasibility analysis and no CAD-licenses are required.

2.18 JT for Material Specification

Use Case

Among the geometry the description of the used materials can be saved in the JT file to provide this information for further workflows. (Bidding and Inquiry, Drawingless Manufacturing, FEA, High-End-Visualization, Multi Body Simulation, Supplier Integration, Archiving, Design Review and Design Release, Exchange of Standard Catalog Parts, NC-Programming, Product Documentation, Tooling, mass calculation, drawing generation, drawing and product check and release).

The material description will be integrated into the CA design process. The actors of this use case are the design engineer and the material engineers. The precondition of this use case is that the VDA recommendation "Material Dataset" allows an explicit specification of materials and is approved by the VDA-Werkstoffausschuss and AK PLM.

CAx systems allow the assignment of material specifications to geometrical features.

Description

Geometry and material are defined parallel or iterative during the design process. It is a practical approach that the design engineer assigns the materials in the CAD system.

Materials, coatings and material treatments can be supplied to the engineer for selection in the CAD system as approved material metadata.

Multiple material specifications can be assigned to geometrical features (e.g. composite or coated materials). Alternate materials can be assigned. The declaration of local material conditions is possible (e.g. radii, inductive heat treatment). These material specifications are saved linked to the geometry on creation of the JT file and are available to downstream processes.

The alternatives to this use case are the usage of JT as exchange format for material data in PDM systems. The postcondition of this use case is that JT data is expanded to include material data fields.

The process flow with all stakeholders and the individual process steps is shown in Figure 26.

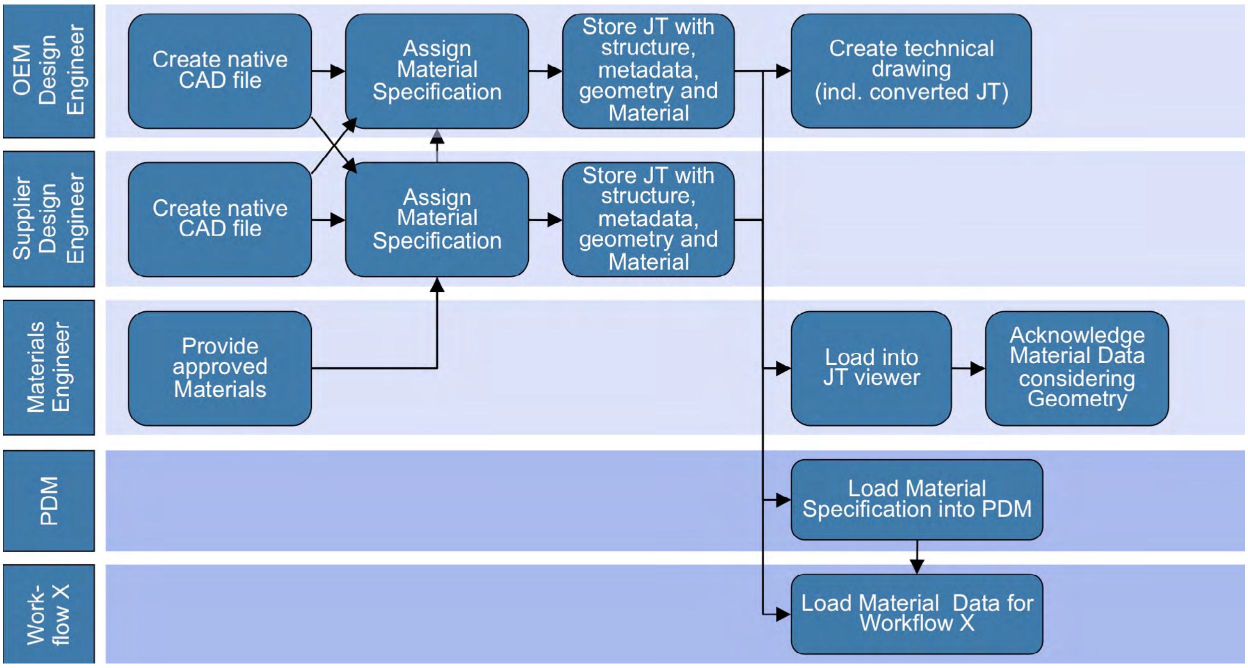


Figure 26: Use case diagram "JT for Material Specification"

Benefit

The benefits of this use case are that JT can be a defined exchange format for material data. The material information is available for downstream processes and it could be a prevention of manual processes.

2.19 JT for Multibody Simulation (MBS)

Use Case

This use case describes using JT for MBS scenarios, e.g. validating the design of a chassis within the automotive development process. The actors of this use case are the design engineer and the MBS engineer. The precondition for this use case is that flexible parts are defined as such in the CAD-system, if the simulation is to include this information. The term "kinematical connections" does not include forces and drivers.

Description

The design engineer creates structure and geometry in a CAD-system (1). Based thereon, he defines fixes and joints (2a) with respective attributes, e.g. axis of rotation, and calculates kinematical part properties (2b) (mass, center of gravity and moment of inertia), within the CAD-system itself. Previously, he specifies part materials (not explicitly modeled as an activity in the swim-lane). He exports structure, metadata, geometry and the kinematical connections to JT (2c). Alternatively, the design engineer prepares the kinematical definition independent of the CAD-system. Therefore, structure, metadata and geometry are exported to JT (3) and imported to a neutral application (4a). Part properties are calculated (4b) and kinematical connections set up (4c), before reexporting to JT (4d). A combination of both procedures is also possible, specifying kinematics in CAD to a given extent, and completing the specification in a neutral application.

The MBS engineer imports the JT-contents into the simulation tool (5), optionally allowing him to derive further attributes required for a simulation, e.g. surface area or density (not required in the JT). He sets up (6) and runs (7) the simulation including flexible parts. Setup of the simulation includes definition of constraints on time and other simulation relevant parameters. Alternatively, the simulation is set up (8) and run (9) without flexible parts. Subsequently, results are analyzed (10a), e.g. by diagram-based investigations of force or positional progression over time and can be exported to JT (10b), including a keyframe animation.

Depending on the scenario, this use case can be considered an integral part of the use case "JT for Installation Feasibility", referring to Step 3 therein.

The postcondition of this use case that JT file(s) is/are enhanced by keyframe animation sequence.

The process flow with all stakeholders and the individual process steps is shown in Figure 27.

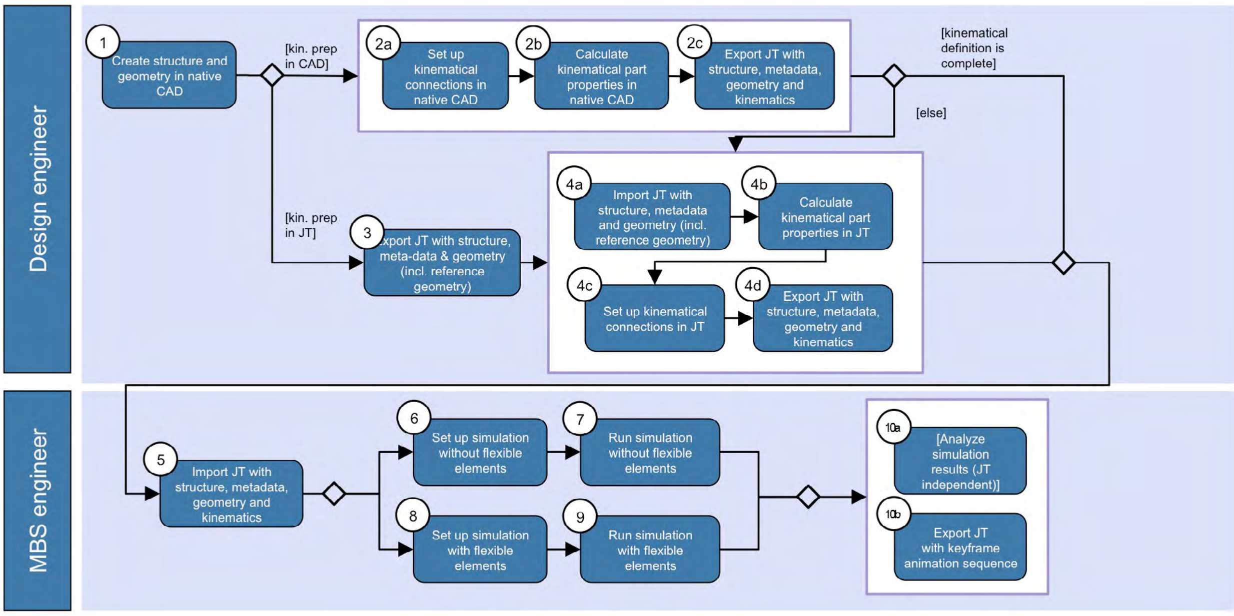


Figure 27: Use case diagram "JT for Multibody Simulation (MBS)"

Benefit

The benefits of this use case are that JT can be used for the definition of kinematics, no CAD-licenses are required and it is possible to use “Multi-CAD” in simulation preparation. Additionally, JT can be used for the import into an MBS-tool and no CAD-CAE interfaces are required.

Open issues to be detailed, in part for better understanding of the use case:

- Identify and classify flexible elements, and the information required for each
- Should multiple routings of elements associated with flexible parts (fixings, connectors, etc.) be included?

2.20 JT for Multimedia Annotations

Use Case

The aim of the use case is to have the possibility to attach Multimedia (picture/sound/film) data to parts and/or assemblies.

The actor in this use case is a user who needs to capture or view multimedia data linked to certain parts/assemblies.

Description

First the user has to choose a certain part or assembly. (1)
After that there are two swim lanes:

- “Capturing”
  The user captures with the integrated devices (camera/microphone) multimedia data (2a). After that the application links that data to the preassigned part/assembly. (3a)
- “Viewing”
  The user chooses the Multimedia data linked to the part/assembly (2b). After that the application shows that data. (3b).

If data was captured, the postcondition is that data is persistently linked to the preassigned part/assembly. The process flow with all stakeholders and the individual process steps is shown in Figure 28.

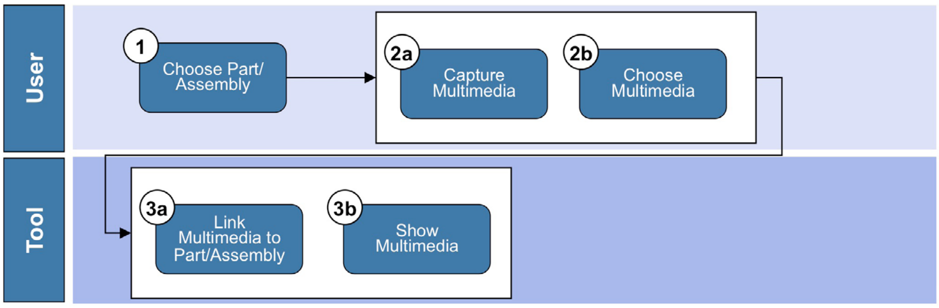


Figure 28: Use case diagram "JT for Multimedia Annotations"

Benefit

The benefit of this use case is the possibility to process helpful data.

2.21 JT for non-hybrid Design in Context

Use Case

This use case describes another course of using JT for design in context. In this case, the JT-context data can be imported into the native CAD-environment. JT contents are converted to an internal CAD-representation (compare JT for hybrid Design in Context). The actor in this use case is the design engineer.

Description

A design engineer creates particularly product structure and geometry (1), which is to be used as context by another design engineer. He exports JT-files, including PMI, such as dimensions and tolerances (2). Selective features are included as well, in order to be extracted by the receiving design engineer.

The receiving design engineer imports JT geometry into the CAD-system, which is then converted to a CAD-internal format (3). In doing so, JT-based LODs are to be converted to CAD-internal LOD mechanisms, allowing a switch between different resolutions of tessellated geometry or to exact geometry (4e). Based on the internal format, PMI-data should be preserved. Native CAD-geometry may continuously be modified, with the addition of now being able to position CAD-data in relation to certain converted content (4a), such as edges, vertices, faces, or auxiliary geometry, e.g. point, axis or plane. Exact geometrical references, e.g. curves, are also possible. New PMI can be added, associating native CAD and/or converted geometry (4c). Going beyond typical PMI (GD&T, surface finish, etc.), selective advanced features, e.g. a drill hole with its parametric definition, are selected and its contents displayed (4b). Optionally, the parametric definitions can be altered. When creating a technical drawing, new PMI and converted JT-content are included as well (6).

If new PMI are provided, they are communicated back to the original CAD-model (5a), which is respectively updated. Likewise, if feature parameters were changed, they are communicated back to the original CAD-model (5b).

The postcondition of this use case is that native CAD-geometry is positioned correctly in relation to context geometry. New PMI and feature definitions are updated in the original CAD-model. Further, a technical drawing is created.

The process flow with all stakeholders and the individual process steps is shown in Figure 29.

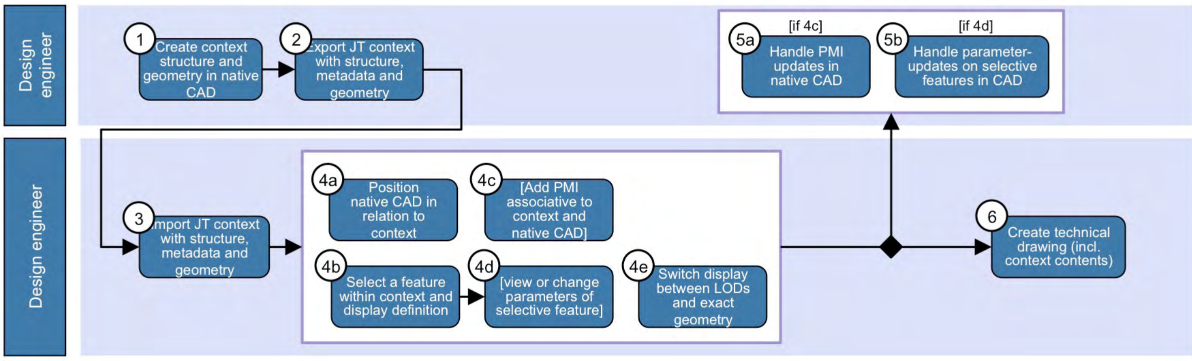


Figure 29: Use case diagram "JT for non-hybrid Design in Context"

Benefit

The benefits of this use case are that JT can be used to design in the context of existing product data. "Semireal" Multi-CAD design is possible. There are no direct interfaces between multiple CAD-systems required, but JT imports. The protection of intellectual property by including only selective features is possible as well as performant visualization (more effective work) due to lightweight JT integration.

Open issues to be detailed, in part for better understanding of the use case:

- Specify a subset or examples of features with parameters that are required
- Specify list of assembly-level PMI types that are considered necessary

2.22 JT for Packaging

Use Case

This use case describes the usage of JT as the source for packaging analysis within the field of DMU, where packaging primarily relates to the activity of positioning product assemblies and parts against the background of critical criteria, such as heat accumulation near sensitive material. The actors in this use case are the design engineer and the DMU engineer.

The precondition for this use case is the possibility to create static hull-geometry of moving components prior to the analysis is considered a prerequisite to the CAD-system or an adapter therein, excluding, amongst others, the need for kinematical joints in JT. While the derivation of geometrical varieties, e.g. due to vibrations, is also conceivable via neutral JT-based applications, this use case neglects that option. This clearly distinguishes it from the use case "JT for DMU Installation Feasibility".

Description

The design engineer creates structure and geometry within a CAD-system (1). Based thereon, he sets materials (2a) and tolerances (2b). As described in the preconditions, the design engineer can optionally create static hull snapshots of moving geometry (3), before he exports structure, metadata and geometry to JT (4).

The DMU engineer imports the JT-contents into the DMU packaging tool (5). If desired, he can further tessellate geometry based on the exact B-Rep information (6). This allows a flexibility regarding preciseness of the geometry and following functionalities that are dependent of it, such as collision detection. In order to tessellate, typical parameters are to be specified, such as chordal and angular restrictions. The packaging tool displays the 3D-geometry and allows repositioning of assemblies and parts (7a), while a geometry-based collision detection algorithm runs on tessellated geometry in the background (7g), highlighting colliding parts. Alternatively, this use case refers to a more complex use case, namely JT for Tolerance Studies, to integrate specified tolerances into the calculation and analysis of collisions (7h). The multiple combinations of tolerances and their possible effects on geometry are not further considered in this use case. Within scope, however, is the sole display of tolerances for manual analysis by the DMU engineer (7c). Further, he can view specified materials (7b) and perform exact measurements (7d) on given parts, based on B-Reps. For better flexibility between performance and accurate visualization, the packaging tool enables a switch between different LODs and exact representations (7e). The DMU engineer can enhance loaded contents by multiple views (7f), updating the underlying JT-files. Critical areas can play a key role in positioning assemblies and parts. Such areas can be the result of heat sources or components with materials that are in turn highly sensitive to extreme temperatures. These must be identifiable (7i). The analysis is concluded with a report, having critical parts highlighted, and the underlying JT contents integrated into a PDF or similar document (8).

Static hulls of moving parts could be created from the JT, instead of the CAD-files. This would; however, call for kinematical joints and a simulation based on JT (compare use cases JT for DMU Installation Feasibility and JT for Multibody Simulation).
The postcondition of this use case is that new views are stored in JT and a report is created.
The process flow with all stakeholders and the individual process steps is shown in Figure 30.

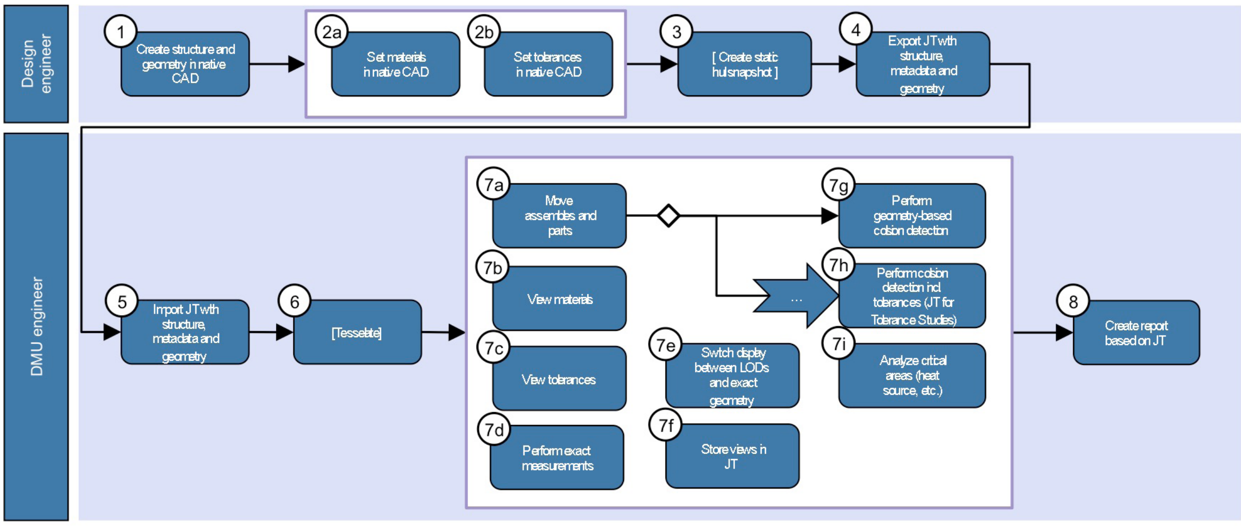


Figure 30: Use case diagram "JT for Packaging"

Benefit

The benefits of this use case are that JT can be used for packaging analysis thereby no CAD-licenses are required and the "Multi-CAD" content can be integrated.

Open issues to be detailed, in part for better understanding of the use case:

- How does the analysis of critical parts work? Are bounding volumes to components required, representing the heat impact? Or are heat sources and other critical components identified as such via certain attributes?

2.23 JT for Pre-Series Aeroacoustics Modeling

Use Case

This use case describes using JT for creating aeroacoustics models for pre-series development, which are typically manufactured by NC milling machines. The actor in this use case is the aeroacoustics/equipment engineer. The precondition for this use case is that JT parts are available (internally, and provided from supplier) and archived in PDM system.

Description

NC Model Design (see also Use Case Design in Context)
From within the PDM system, the Aeroacoustics/Equipment Engineer (manufacturing) views and loads product data to be used within the following milling process (1). Where required, he adds context data, e.g. engine and axes (2),

typically from a predecessor product-series. Additionally, approximated surfaces are added, e.g. the outer body based on a clay model point cloud (3). Such data may be in form of binary STL data, or in future also JT (depending on point-cloud tool and interface support).

Based on loaded product data, the Aeroacoustics/Equipment Engineer designs a welding frame, using hole features and contact points within the context (axes, engine, etc.) (4). Later in downstream processes, the designed welding frame represents the foundation to attach milled NC models.

In steps (5) and (6), NC models are created, primarily by editing already existing models. Different scenarios exist:

- Design based on native data (e.g. for editing floor design)
- Design based on approximated context (e.g. outer body)

After archiving NC CAD-models (7), bills of materials, technical drawings and further documentation is created (8). In doing so, technical drawings may include mixed data, meaning for example JT assembly parts and native CAD sheeting.

Digital Validation (see also Use Case Packaging)

Manufacturability is analyzed, amongst others by creating sections, checking collisions when moving various parts, etc. (9a and 9b).

CNC milling and Downstream Processes

In step (10), created NC CAD models (including JT context where available) are loaded into CAD-system, to be holistically stored as JT (11). The JT dataset is then loaded into a CNC-oriented CAM Tool, e.g. TEBIS, or other systems on the market (12) by a respective JT interface. Therein, CNC-programs are created and executed (13). For further analyses, finished goods end up in Downstream Processes like assembly and optical measurements.

The postcondition of this use case are that milled goods are available for downstream processes and those NC CAD-models are available, in part including JT.

The process flow with all stakeholders and the individual process steps is shown in Figure 31.

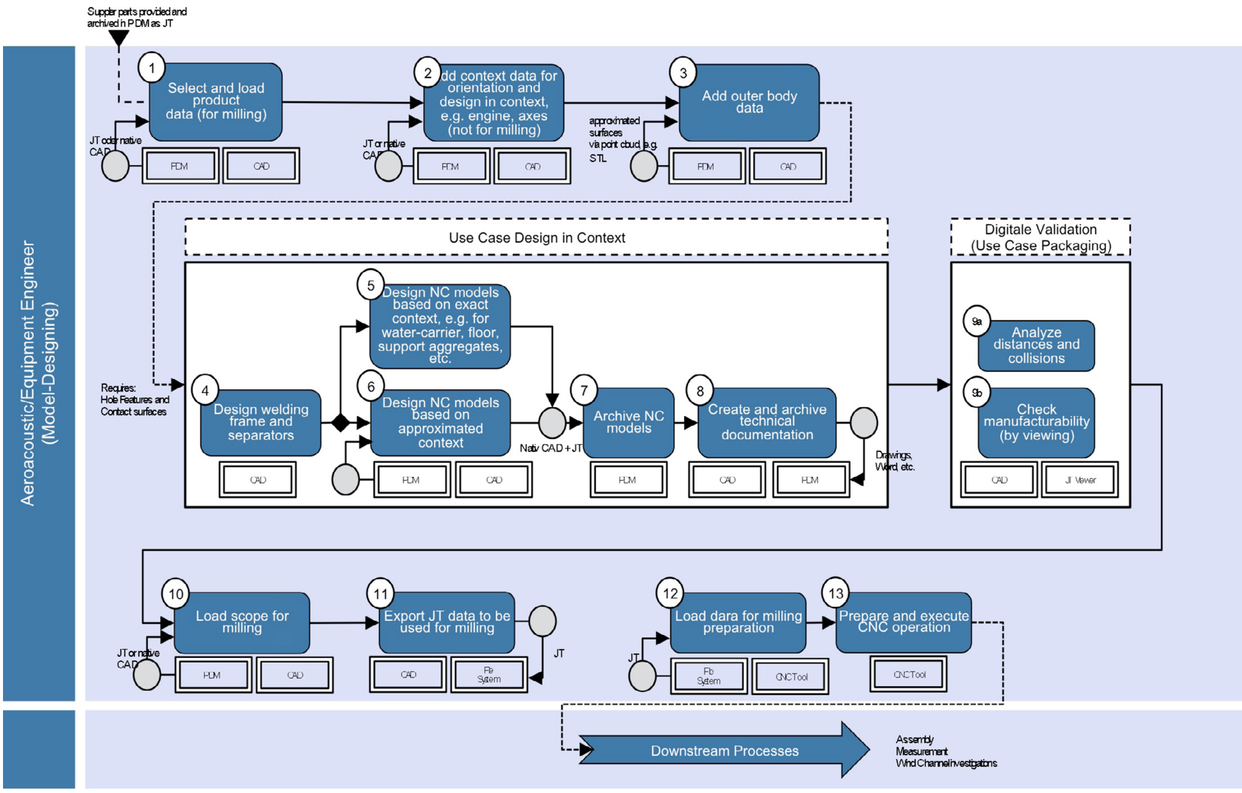


Figure 31: Use case diagram "JT for Pre-series Aeroacoustics Modeling"

Benefit

The benefits for this use case are that JT can be used for designing equipment in context and JT can be used for storing surfaces derived from point clouds (single input format for design in context, less interfaces needed) and JT can be used for the actual milling process (no CAD-licenses required).

Requirements addressing design/styling tools and respective translators:

- Storing surfaces based on a point cloud in JT format (tessellated geometry)

Requirements addressing CAD-system and respective translator:

- Detection and working with hole features based on JT data, consisting in particular of
    - Point, type, thread, direction (vector), depth, basis fit
- Detection and working with contact surfaces (contact point and position), meaning the point must be selectable, and the referenced surface highlighted.

Requirements addressing CNC-system and respective translator:

- Read and process JT by direct JT interface

Requirements addressing JT format (e.g. coming from supplier):

- Exact XT B-Rep geometry
- Tessellated geometry
- Hole feature information
    - Point, type, thread, direction (vector), depth, basis fit
- Contact surfaces
    - Contact point and association to referenced surface

2.24 JT for Pressline Simulation

Use Case

The JT is the carrier of geometry information. In the assembly structure (AP242 XML) possible degrees of freedom are stored. Encouraged by a movement (e.g. gravity with vector or press movement) a kinematic will be stimulated within the simulation application. The actors in this use case are data producer which are: process planner, press pass planner/jigs designer (TMZ) and tool designer, as well as data consumer which is the pressing plant series planner. The precondition for this use case is a coordinated collaboration model/structures of method-press-tool.

Description

The design disciplines (method, DLP, tool-design) carry out the layout of the production facilities within the PLM process chain.

As the press contains degrees of freedom as well as controlled movements, the user can visualize beside the pure geometry the motion sequence in addition.

The alternative to this use case is that the data consumer must use complex authoring systems (e.g. CAD systems) respectively licenses.

The postcondition of this use case is that in the database the assembly with degrees of freedom exists. The assembly can be restimulated by varying the input kinematics.

The process flow with all stakeholders and the individual process steps is shown in Figure 32.

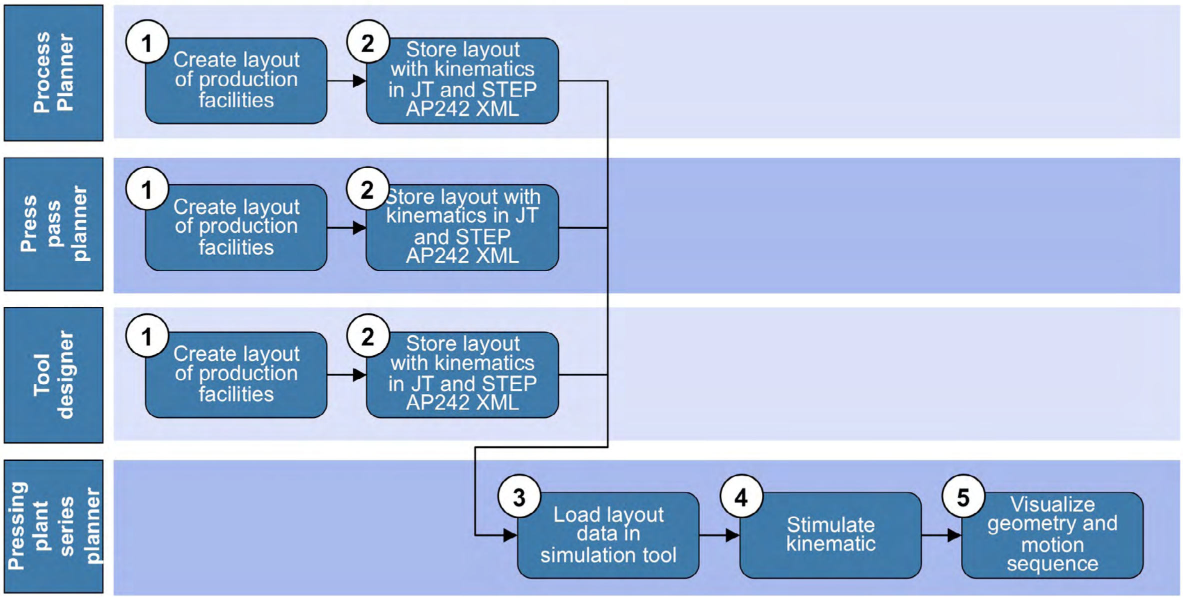


Figure 32: Use case diagram "JT for Pressline Simulation"

Benefit

The benefits of this use case are that the data consumer can carry out analyzes without an authoring system. Furthermore, the degrees of freedom are retained in the assembly.

2.25 JT for Supplier Integration (Customer to Supplier)

Use Case

The aim of "JT for Supplier Integration" is to send the validated JT geometry with all needed metadata to the Supplier. The actors in this use case are the Customer design engineer, the data preparation tool, the data exchange tool and the supplier design engineer. The precondition for this use case is that a simplified native 3D CAD file with material properties is converted to JT either as single parts or as an assembly.

3D CAD Data is validated and quality checked in advance. A check seal is created by the data check tool. A structure file is created by the PDM system in any case e.g. for structure analysis.

Description

The OEM Design Engineer stores the JT data with structure, metadata and geometry. Next the Master data are edited and the delivery notes are generated. The data will be transferred to the data exchange tool. After that and a package file is generated and will be send to the Supplier. Last the transmission will be recorded and data will be acknowledged. The alternative to this use case is the use case JT for Supplier Integration (Supplier to Customer). In some cases, preferred suppliers are enabled to access the PDM system and to provide themselves with data. The role "Customer Design Engineer" is then fulfilled by the supplier design engineer.

In some cases, the package files are made available for download to suppliers.

The postcondition of this use case is that data can be imported on supplier side.

The process flow with all stakeholders and the individual process steps is shown in Figure 33.

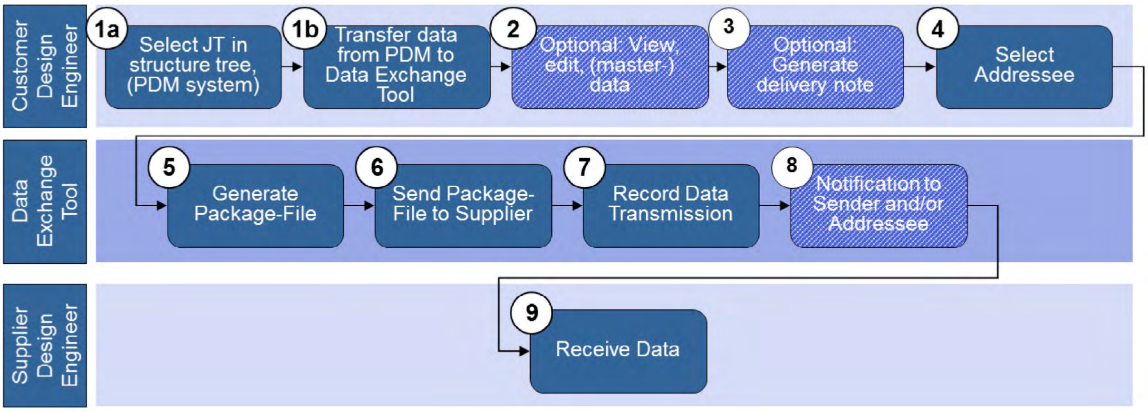


Figure 33: Use case diagram "JT for Supplier Integration (OEM to Supplier)"

Benefit

The benefit of this use case is that CAD data exchange is independent from CAD systems.

2.26 JT for Supplier Integration (Supplier to Customer) Sub UC1: Early phases

Use Case

The aim of this use case is to send a monolithic JT (enveloping surface and connection points, no inner structure) with all needed metadata to the Customer. The actors in this use case are the OEM design engineer (sender) – who integrate the supplier part in the model of module/car (positioning of part in context has to be done manually), the data exchange tool – secure and traceable exchange of engineering data and the supplier design engineer (receiver) – construct (CAD-model of) supplier part.

The preconditions for this use case are:

- Data source: 3D CAD systems were defined as data source. The different 3D CAD systems were defined in the workgroup or in inhouse test.
- Conversion: JT files were exported using a JT translator (defined by workgroup or inhouse tester)
- Data quality: JT data has to be quality checked against a defined check profile. The quality check will ensure the completeness of master data, geometry (e.g. open faces), colours etc. Every time JT contents were created – even if they were created on the fly – they have to be quality checked (maybe in batch pro-cess).
- Metadata: Units of measurement (weight, length), surface area, material thickness, volume, material information, centre of gravity and moment of inertia.

An optional precondition is a JT version agreed between customer a supplier should be used.

Description

If a part or assembly shall be sent to a customer, the Design Engineer checks and possibly edits the meta-data of that part or assembly in the CAD-system. Then, he exports a monolithic JT containing standard meta-data (master data) and geometry (enveloping surface with connection points, no inner structure). Alternatively, he exports structure (STEP AP242 XML) plus JTs containing standard meta-data and attributes. Or he exports structure plus kinematic (STEP AP242 XML) plus JTs containing standard meta-data and attributes. The Design Engineer edits the project specific master data in JT. Optionally he enhances the JT file with 3D annotations. Optionally he checks the data quality in an appropriate tool with respect to the criteria given by the customer the data should be send to. Finally, the Design Engineer transfers the data to the Data Exchange Tool (e.g. SWAN). While doing this, he enters the properties for the data transmission (e.g. receiver). The Data Exchange Tool optionally generates a delivery note containing the results of the quality check. It generates a package file (e.g. .tar-packet) containing all data that should be send to the customer. This package file is then sent by the tool to the data receiver (Design Engineer on customer site). The Data Exchange Tool records the whole data exchange operation. This enables the traceability of actions afterwards. The receiver on customer site and the sender on supplier site will receive an email notification when the data package arrived. The notification contains information about sender and receiver and the content of the package file as well as a link to the data. The receiver follows the link and stores the data. By doing this he acknowledges the datatransfer.

The alternative to this use case is the use case JT for supplier integration (Customer to Supplier). The postcondition of this use case is that JT and metadata can be used in development process on OEM site.

The process flow with all stakeholders and the individual process steps is shown in Figure 34.

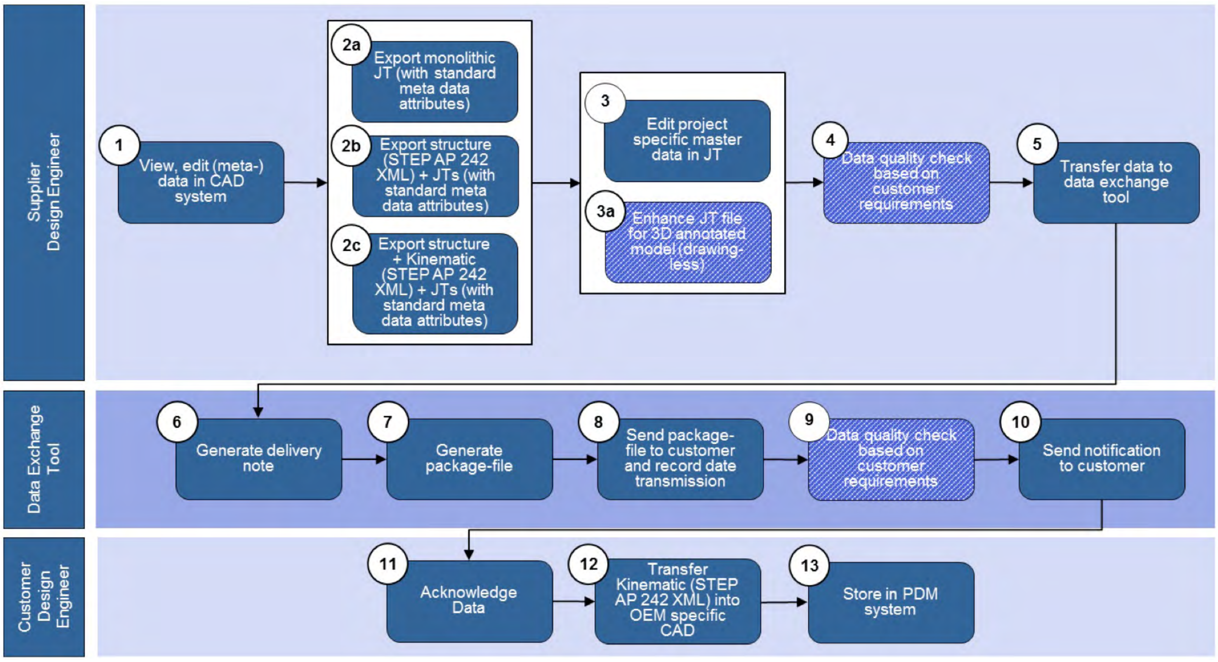


Figure 34: Use case diagram "JT for Supplier Integration (Supplier to Customer)" Sub UC1: Early phases

Benefit

The benefits of this use case are that CAD data exchange is independent from CAD systems, a smaller data volume of JT-files is exchanged and interiors of the supplier part are hidden.

Instead of a DFÜ-tool a web based platform could be used, to easy data exchange with suppliers.

2.27 JT for Supplier Integration (Supplier to OEM) Sub UC2: Project phases

Use Case

The aim of this use case is to send a "per Part" JT (enveloping surface and connection points, no inner structure, but with further fixing and context relevant data) with all needed metadata to the OEM.

The actors in this use case are the OEM design engineer (sender) – who integrate the supplier part in the model of module/car (positioning of part in context has to be done manually), the data exchange tool – secure and traceable exchange of engineering data and the supplier design engineer (receiver) – construct (CAD-model of) supplier part.

The preconditions for this use case are the data source, the conversion and the data quality and as optional preconditions metadata and the JT-file version. The terms are described below. The 3D-CAD-systems were defined as data source. The different 3D-CAD-systems were defined in the workgroup or in inhouse tests. To conversion is to say that the JT files were exported using a JT translator (defined by workgroup or inhouse tester). The data quality has to be checked against a defined check profil. The quality check will ensure the completeness of master data, geometry (e.g. open faces), colors etc. Every time JT contents were created – even if they were created on the fly – they have to be quality checked (maybe in batch process). Metadata include the units of measurement (weight, length), surface area, material thickness, volume, material information, center of gravity and moment of inertia. Because of long term archiving reasons, the same JT file version should be used as in ISO 14306.

Description

If a part or assembly shall be sent to an OEM, the Design Engineer checks and possibly edits the meta-data of that part or assembly in the CAD-system. Then, he exports "Per Part" JTs containing relevant master data and geometry. Project specific master data is added to the JTs. JT files should contain enveloping surface with connection points - no inner part structure - but content information and possibly surrounding parts (for mounting, fixing). (Precondition: He checks the data quality of the "Per Part" JTs in a tool (e.g. Q-Checker) with respect to the criteria given by an OEM the data should be send to). He (optionally) validates all JT files against the native 3D-CAD-files in case of geometry and metadata (incl. PMI). Finally, the Design Engineer transfers the data to the Data Exchange Tool (e.g. SWAN). While doing this, he enters the properties for the data transmission (e.g. receiver). The Data Exchange Tool optionally generates a delivery note containing the results of the quality check. It generates a package file (e.g. .tar-packet) containing all data that should be send to the OEM. This package file is then sent by the tool to the data receiver (Design Engineer on OEM site). The Data Exchange Tool records the whole data exchange operation. This enables the traceability of actions afterwards. The receiver on OEM site and the sender on supplier site will receive an email notification when the data package arrived. The notification contains information about sender and receiver and the content of the package file as well as a link to the data. The receiver follows the link and stores the data. By doing this he acknowledges the data-transfer.

The alternative to this use case is the use case JT for supplier integration (OEM to Supplier). The postcondition of this use case is that JT and metadata can be used in development process on OEM site.

The process flow with all stakeholders and the individual process steps is shown in Figure 35.

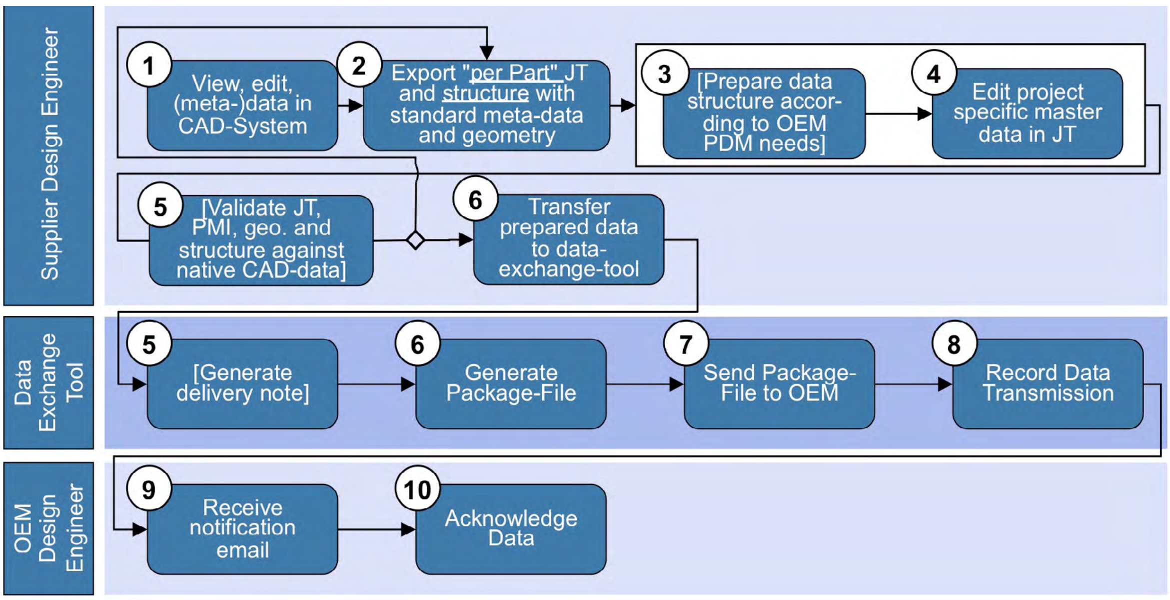


Figure 35: Use case diagram "JT for Supplier Integration (Supplier to OEM)" Sub UC2: Project phases

Benefit

The benefits of this use case are that CAD data exchange is independent from CAD systems, a smaller data volume of JT-files is exchanged and interiors of the supplier part are hidden.

Instead of a DFÜ-tool a web based platform could be used, to easy data exchange with suppliers.

2.28 JT for Systems Engineering

Use Case

As first step, focus is on sup and the use of JT to support this. The actors in this use case are the requirements engineer, the design engineer – responsible for the design of the product and the PLM database. The preconditions of this use case are that Customer/supplier collaboration exists and a Specification is available. A ReqIF file with JT as visualization should be exchanged. A PLM database exists, containing the design and analysis data created by the design engineer. A STEP AP242 XML file could reference the ReqIF and the JT file.

Description

Requirements Engineer analyses the specification. The requirements are verified, commented or rejected. He uses a database to gather the information he needs. The information is added and linked to the data sent by the customer. Eventually, the design engineer(s) have to be consulted.

The postcondition of this use case is a model with all relevant information is embedded in the specification. The specification is sent back to the customer.

The process flow with all stakeholders and the individual process steps is shown in Figure 36.

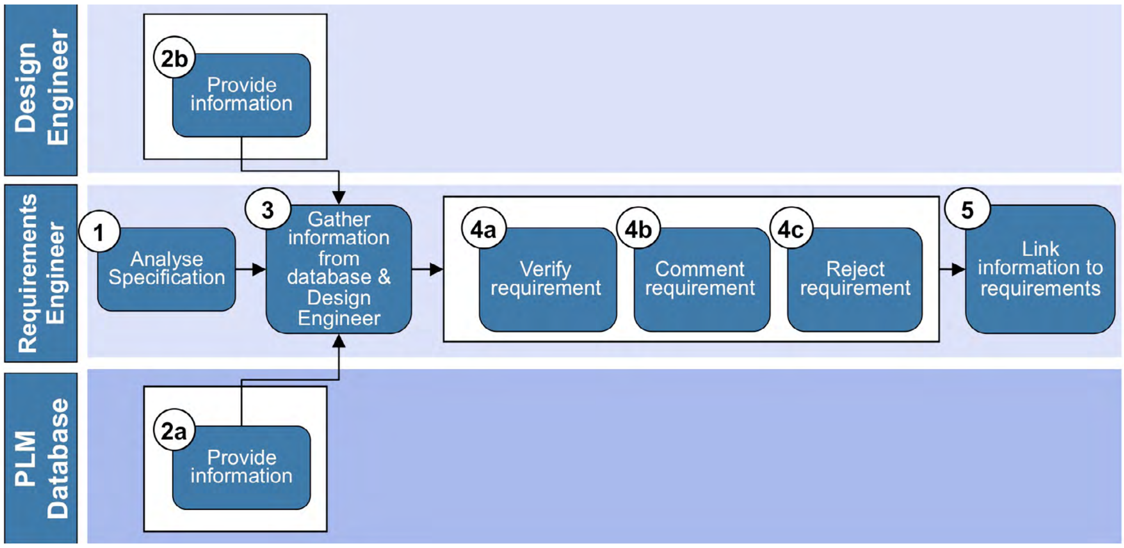


Figure 36: Use case diagram "JT for systems engineering"

Benefit

The benefit of this use case is that a direct link between the requirements and the design information exists. This results in a more efficient collaboration process.

2.29 JT for Tolerance Studies (VSA)

Use Case

The aim of the use case is to verify and optimize the influence of tolerances regarding the functional product and design requirements. The actors of this use case are the design engineer, the tolerance specialist, the process engineer and a CAD to JT translator. The preconditions for this use case are that GD&T data are included within native CAD.

Description

The product incl. all GD & T data is designed in native CAD system. CAD data is translated into JT files. The Tolerance Specialist creates a process definition as PDO file. This includes the assembly flow, measurement points (as provided by the Process Engineer), and the JT references. The tolerance simulation creates statistical deviations and the contributors of the analyzed requirements. View the simulation results and analyze with the Process Engineers.

The alternatives to this use case are tolerances of flexible part structures. The postcondition of this use case is updated CAD data with respect to the simulation results.

The process flow with all stakeholders and the individual process steps is shown in Figure 37.

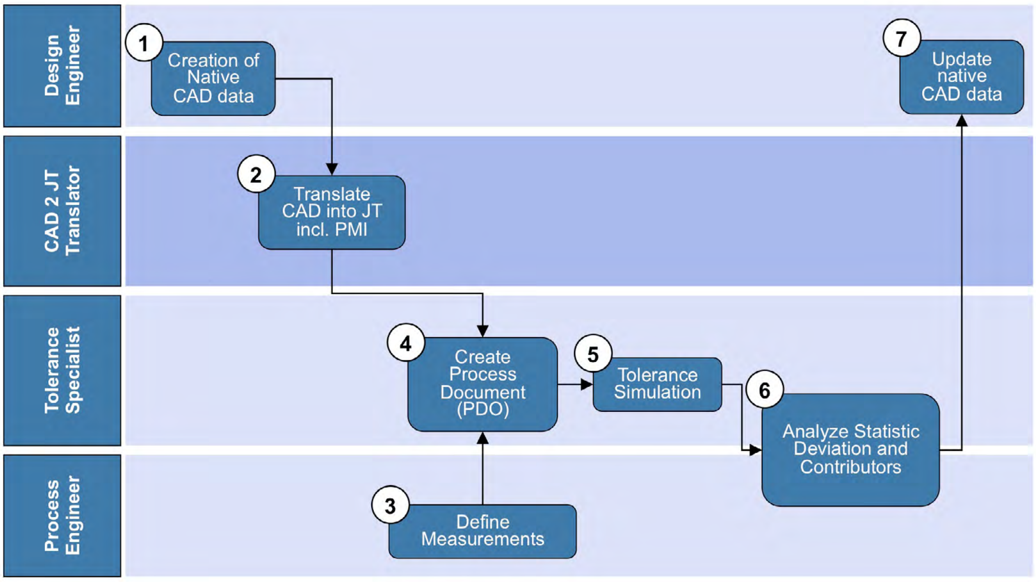


Figure 37: Use case diagram "JT for tolerance studies"

Benefit

The benefits of this use case are that multiple import files are possible, light weight input data and more easy data distribution.

Additionally, PDO Documents are required. The complete Tolerance process document is separately stored within a PDO document. This defines the assembly flow and the quality features.

2.30 JT for Viewing

Use Case

This use case describes using JT for essential viewing purposes, basically by arbitrary stakeholders. Viewing of PMI was left out because it is considered essential for more specific viewing-related use cases. Similarly, viewing of motion was left out. Motion is covered by the "JT for DMU Installation Feasibility Analysis" use case. Viewing of kinematical connections is not in scope either. The actors in this use case are the design engineer and arbitrary stakeholder.

The precondition for this use case is trivial functionality regarding possibility to view colors, textures; product structure is considered a prerequisite and not added as "activities" within the use case diagram and description.

Description

The design engineer creates product structure and geometry (1), and exports to JT (2).
Any stakeholder can import JT-contents into a viewing application (2). He can select between exact geometry and different levels of detail (4f) for performant visualization. Not only can the stakeholder define sections (section plane and view) in the application (4d), he can later store such definitions (5). Based on exact geometry, he can perform measurements (4a). Master-data can be reviewed in form of properties (4b). Viewing can be filtered either by selecting

or deselecting nodes in the product structure (4c), or by selecting layers stored in the JT dataset (4e). Filtering via layers refers to storing layers in JT via layer properties. Each layer holds certain assemblies and parts. Layers can be selectively toggled, hiding or showing associated product nodes. New views can be created (4h), and the stakeholder can add new views to the loaded dataset (4g). The stakeholder may export changes in views and sections to JT.
The postcondition of this use case is that JT may be exported, storing new views and sections.

The process flow with all stakeholders and the individual process steps is shown in Figure 38.

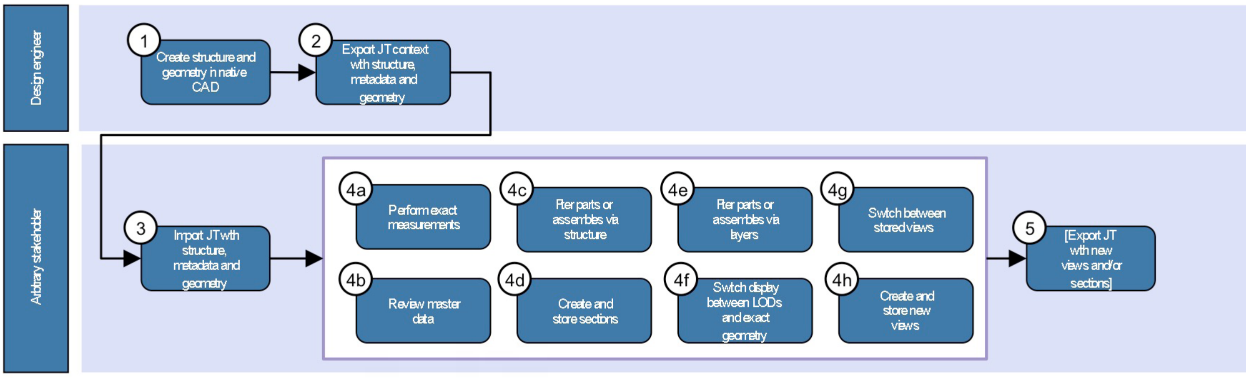


Figure 38: Use case diagram "JT for Viewing"

Benefit

The benefits of this use case are that JT can be used to communicate product data and no CAD-licenses are required.

Open issues to be detailed, in part for better understanding of the use case:

- Which master-data must be included?
- Which layers and accordingly layer filters must be included?

2.31 JT for viewing on mobile devices in the pre-series

Use Case

The aim of the use case is to improve the pre-series development by viewing of product data and "jigs and tools" data on a mobile device. The actors of this use case are the pre-series worker and the production engineer. The preconditions for this use case are that the relevant data is prepared as JT/PLMXML and stored in a file system, the file access has to be granted and the data size can be up to 500 MB it is also needed that WIFI is available.

Description

The relevant dataset is selected in the file system (PLMXML). Then the data is loaded on the mobile device. After that interaction on device is possible such as pan, zoom, rotate and intersection.

Alternatives to this process are data streaming instead of data loading or data loading via UMTS.
The process flow with all stakeholders and the individual process steps is shown in Figure 39.

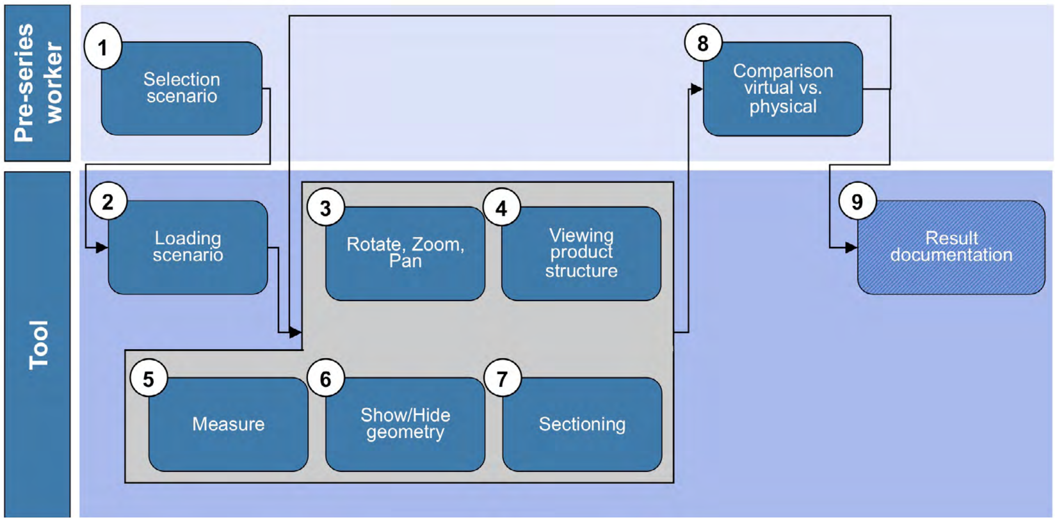


Figure 39: Use case diagram "JT for viewing on mobile devices in the pre-series"

Benefit

The benefits of this use case are that all relevant data is available everywhere, time saving is possible (distance to local station or office for checking virtual vs. physical) and it is possible to avoid hardcopy.

2.32 JT for CAE Data Visualization

Use Case

This use case describes using JT for visualization of Thermal & Aero Systems Engineering (TASE) CAE results in a 'Functional Buck' to enable integrated geometrical and functional assessment. The goal of this JT use case is to enable the transfer and visualization of CFD (Computational Fluid Dynamics) result data (which has been created in a dedicated post processor) via the JT format in JT based visualization tools. Example TASE CAE results are animated streamline, animated section cut, animated iso surface with a color code illustrating e.g. velocity.

The actors in this use case are the CAE engineer, the package engineer, the CAD engineer and the Component engineer/management.

The preconditions for this use case are an existing CAE pre-processor, solver and post-processor which support usage of JT format for data exchange. The CAE analysis results are exported from CAE post processor in JT format. JT based visualization tools support the visualization of TASE CAE analysis results including animated or transient data.

Description

The CAD engineer / component engineer creates structure and geometry in the native CAD and PLM system (1). The data is translated to JT (automatic process within the PLM system) and JT data is stored with related CAD data in the PLM system (2).

The CAE engineer identifies and selects relevant data for the CAE model build in the PLM system (3) and exports / imports the required data in JT format into a CAE preprocessor including the assembly structure, metadata and geometry (4). The CAE engineer builds the CAE model for TASE analysis via the CAE preprocessor (5). Non-geometric data (like material properties – e.g. density, thermal conductivity) is added for the simulation setup as required (6). Usage of JT geometry combined with non-geometric data is supported. The CAE engineer runs the simulation (7) and post processing (8) (in batch mode and / or interactively) to extract simulation results.

The CAE engineer then exports key simulation results in JT format and stores the data in the PLM system (9). That way key CAE results are communicated and made available for reviews with Package Engineers, CAD / Component engineers and Management. Geometric data and CAE simulation results are visualized in a 'functional buck' for integrated geometrical and functional assessment (10&11). If required as a result of the CAE analysis, the existing CAD design is updated in the native CAD/PLM system, defining an iterative cycle of optimization based on CAE analysis (1).

The postcondition of this use case is that the Key TASE CAE simulation results are available in JT format including animated and transient data, e.g. it is possible to animate streamlines, section cuts and iso surfaces in the JT viewer, legends for color codes are supported.

The process flow with all stakeholders and the individual process steps is shown in Figure 40.

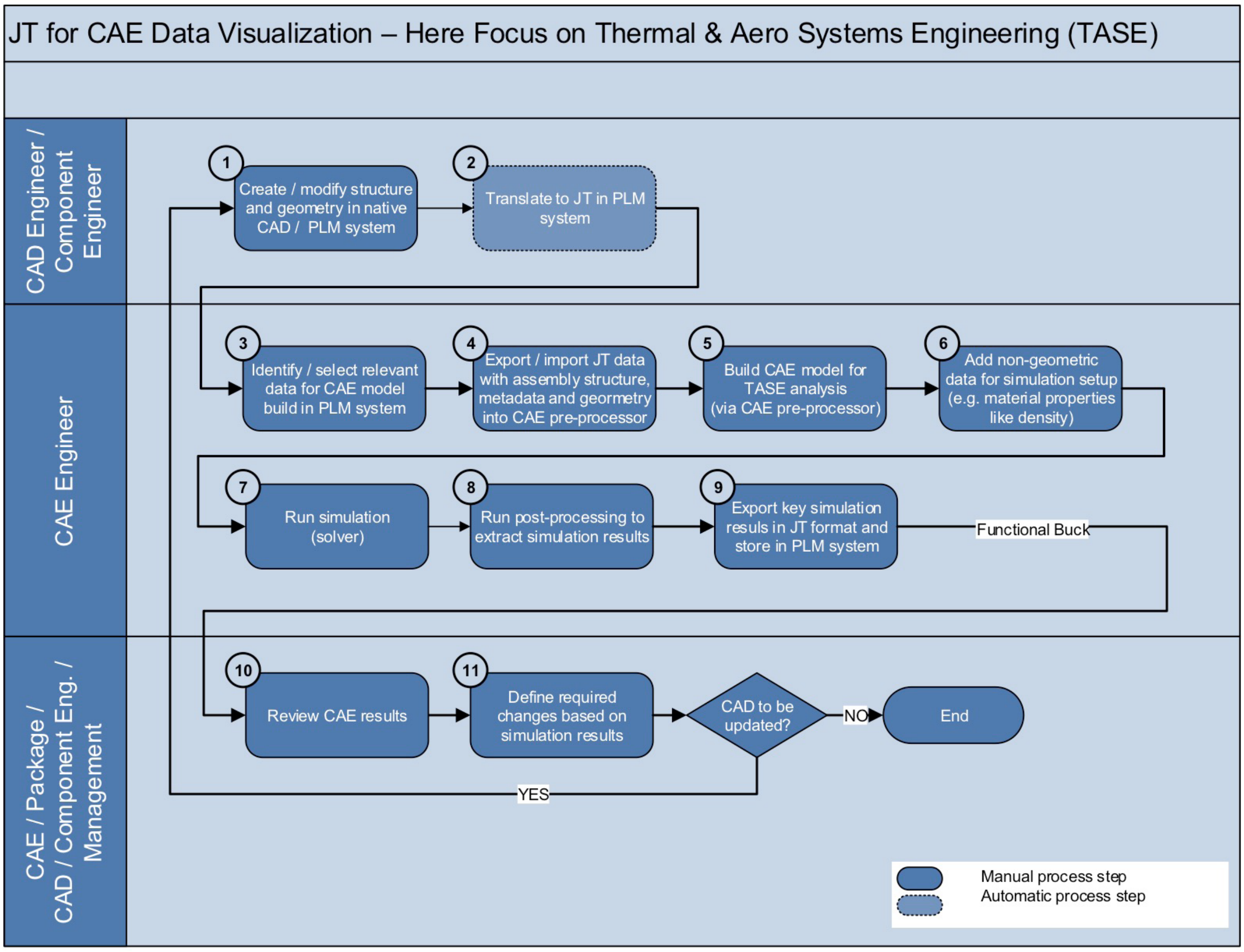


Figure 40: Use case diagram "JT for CAE Data Visualization"

Benefit

The benefit of this use case is that the JT format is supported throughout the full TASE CAE attribute compliance analysis process covering TASE model creation, simulation, post-process, geometrical and functional assessment, sharing and storing of results.

2.33 Maintenance of manufacturing machines and products

Use Case

This Use Case enables Enable an enhanced collaboration between maintenance planner and maintenance technician through enriching 3D models in JT format with additional information.

The actors in this use case are the maintenance planner and the maintenance technician.

The preconditions for this use case are the parts of the manufacturing machines and products are accessible in the JT format. A catalogue of all the model parts exists. The maintenance technician is able to view 3D models on a mobile device.

Description

The maintenance planner creates maintenance instructions based on a digital catalogue using JT models. In preparation for the maintenance technician, he prepares the model color highlights, additional text information or views. Eventually the maintenance technician can view the instructions as well as the 3D model on a mobile device and can optionally order spare parts from the initially mentioned catalogue.

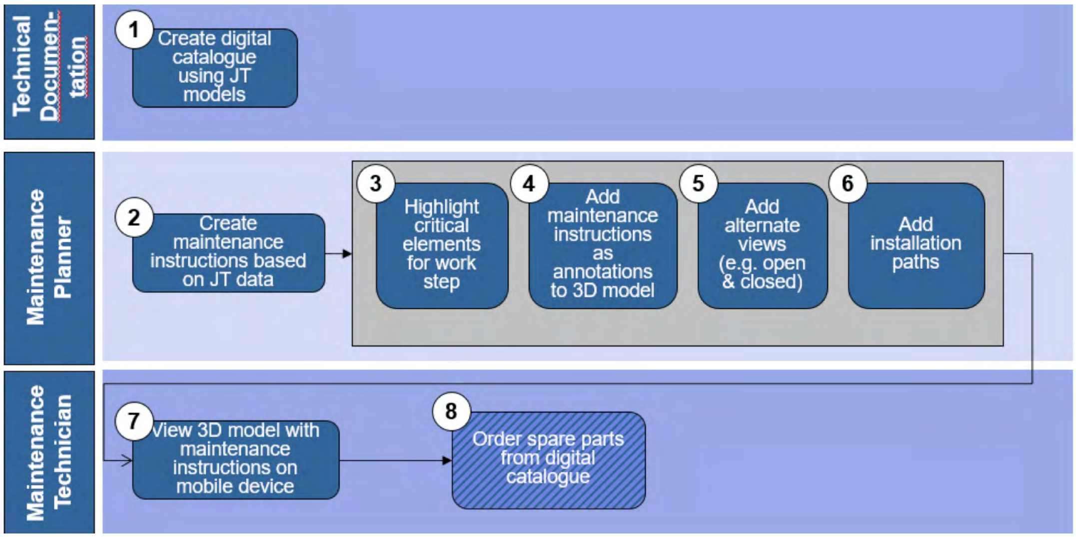


Figure 41: Use case diagram "Maintenance of manufacturing machines and products"

Benefit

The benefit of this use case is a direct link between maintenance instructions and 3D model and faster understanding of the machine inspection through 3D visibility and link to 3D parts.

2.34 Simultaneous development of product and production facilities

Use Case

This use case enables an enhanced collaboration between product design engineer and production design engineer through JT format with additional information like structure, PMI and metadata.

The actors in this use case are the product design engineer and the production design engineer.

Description

The product design engineer provides the production design engineer with a JT file with structure, PMI and metadata. The production design engineer will then execute a product analysis and communicate the changes needed for production back to the design engineer who will adapt the changes. In the further process, geometry affections like ejectors or form separators can also be added to the JT file.

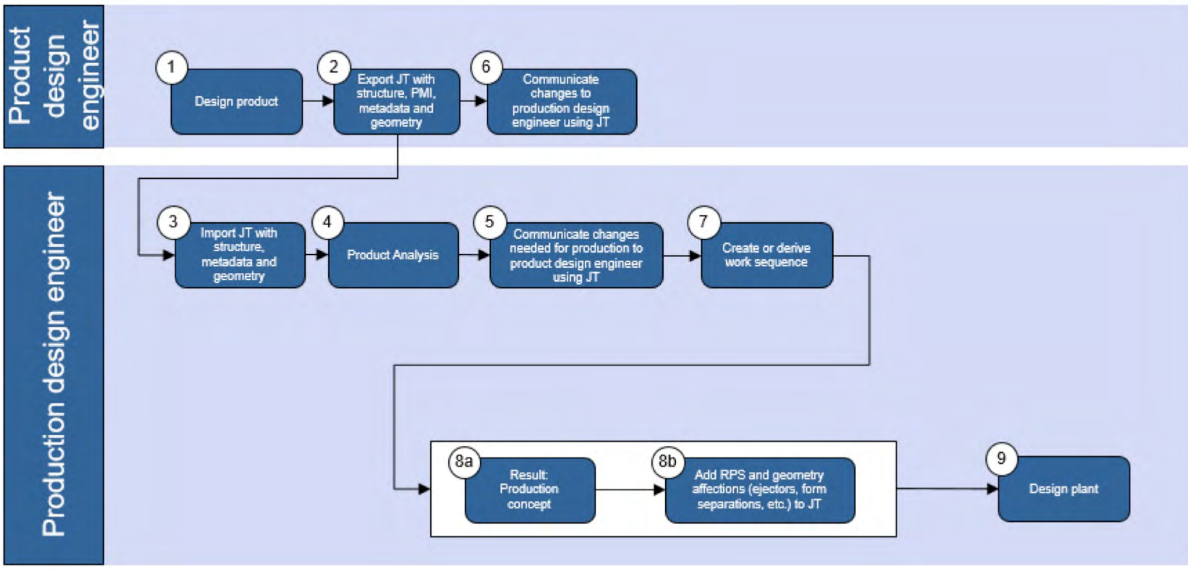


Figure 42: Use case diagram "2.34 Simultaneous development of product and production facilities"

Benefit

The benefit of this use case is that the production plant can be simultaneously developed with the product itself. Through the easy exchange of the JT format a close collaboration between the product design engineer and the production design engineer can be enabled.

2.35 JT and AP242 XML providing PMI to the product development process

Use Case

This Use Case is meant to support a JT WF driven development of a holistic approach to the usage of PMI in context of the JT and AP242XML throughout the product development and production process.

The actors of this use case are the Design Engineer(s), DMU responsible, Measurement Planning Engineer and Quality Engineer.

The preconditions of this use case are

- Common understanding of the PMI usage and PMI types has been reached (JT WF and IF); Scope has been defined and harmonized.
- Data quality: STEP AP 242 and JT Files have to be quality checked against a defined check profile. The quality check will ensure the completeness of PMI elements and information, their compatibility with PMI definition and their relationship to the required geometry.
- All Viewing Tools interpret/read – and display PMI in the same way.

Description

Usage, availability and reliability/stability of PMI is essential for methods as 3D Master, 3D Measurement Data Management (3DMDM), Manufacturing Information Model (MIM) and others. PMI is the enabler for JT as a multi-disciplinary 3D-backbone for the digital enterprise. According the method specifications a Design engineer creates PMI in the CAD system. - Customer design engineer – designs original CAD models with PMI, sends or receives neutral exchange files (STEP 242 XML, JT)

Supplier design engineer – designs original CAD models with PMI, stores CAD data in PDM.

CAD2JT: Conversion tool – translates geometry with PMI elements (and product structure) to and from JT file format; no information loss.

Quality checker tool – verifies the PMI relating content and associativity

Part owner sends or receives neutral exchange files (STEP AP 242, JT)

Customer receives data (AP242 XML +JT); DMU responsible checks data.

Another stakeholder – visualize and handles PMI mentioned above

Viewing tool – visualizes PMI information coming with /stored in STEP AP242 and JT.

MDM and other downstream processes/ tools: read and interpret the PMI; provided PMI is machine-readable.

Measurement Planning Engineer creates new Measurement features and Tolerances and stores them in the JT file.

Customer In-house design and downstream in scope: result of CAD2JT including PMI used in in-house processes.

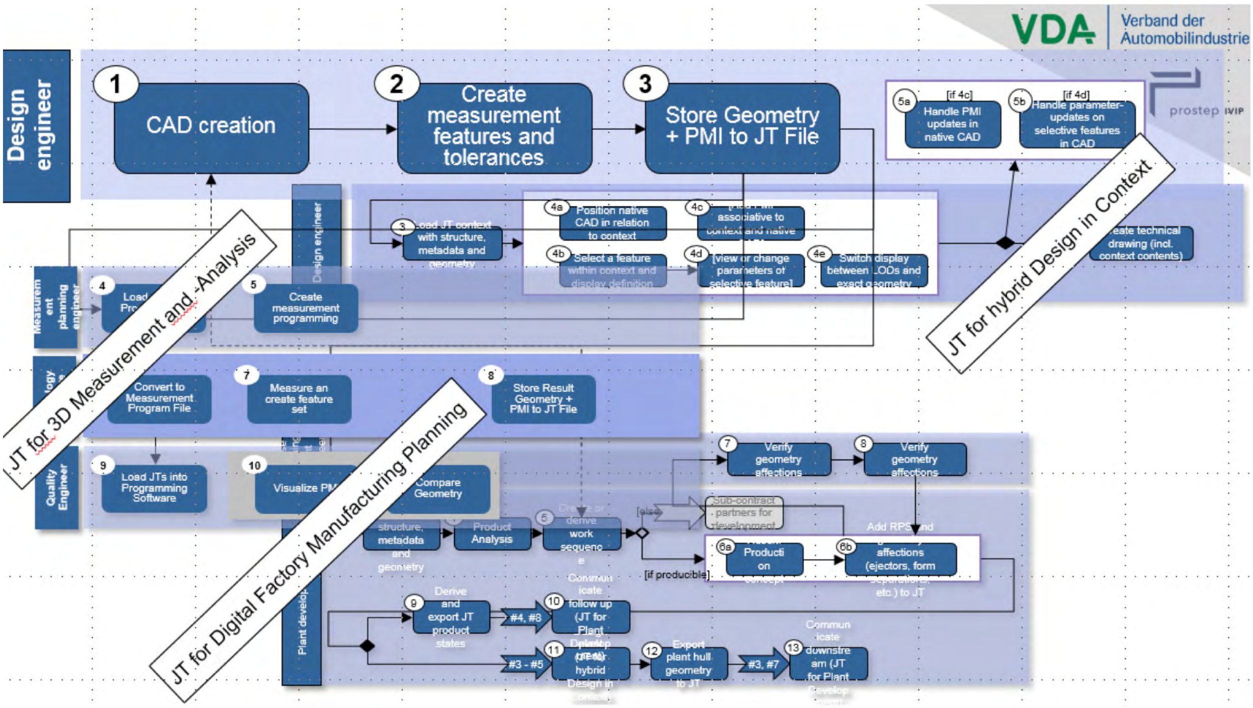


Figure 43: Use case diagram "2.35 JT and AP242 XML providing PMI to the product development process"

Benefit

The benefits of this use case are:

- PMI info stays semantic throughout. Apart from viewing in GUI machine readability is given.
- Faster development possible due to automated processes.
- 3D Master processes and others can now strongly rely on the PMI.
- Another building block for the holistic approach of a JT as the multidisciplinary 3D Backbone for the digital Enterprise.

2.36 AP242 XML kinematics for internal viewing

Use Case

The aim of this use case is to write CAD data kinematic elements into STEP AP 242 (xml) which can be visualized by other internal stakeholders.

The actors of this use case are the Design engineer (designs original CAD model kinematics, translates and sends neutral exchange files (STEP AP 242, JT, …)), the DMU engineer (visualizes kinematics mentioned above), a conversion tool (translates kinematic elements and product structure from origin file format to STEP AP242 and vice versa. Translates related CAD geometry to JT format (and vice versa)), a quality checker tool (verifies the content of the neutral kinematics files and their relationship / associativity), a Viewing tool (visualizes and animates kinematic elements and product structure based on STEP AP242 and JT (and vice versa).)

The preconditions of this use case are a data source (3D-CAD-Systems were defined as data source. The different 3D-CAD-systems were defined in the workgroup or in inhouse test.), a conversion (STEP AP 242 and JT Files were exported using a translator (defined by workgroup or inhouse tester)), Data quality (STEP AP 242 and JT Files have to be quality checked against a defined check profile. The quality check will ensure the completeness of kinematic elements, their compatibility with kinematics definition (joints, links, …) and their relationship to the required geometry.)

Description

Design engineer creates kinematics in his original CAD system. CAD data will be checked by the designer or in batch mode as for preparation of the data exchange with another stakeholder. If the check is passed the cad data including kinematics will be translated to neutral file description (STEP AP242 + JT) manually or in batch mode. Afterwards the data is stored into the PDM system from where it can be loaded for viewing purposes by other stakeholders like DMU engineers. DMU engineer can place markups and save the data back to PDM.

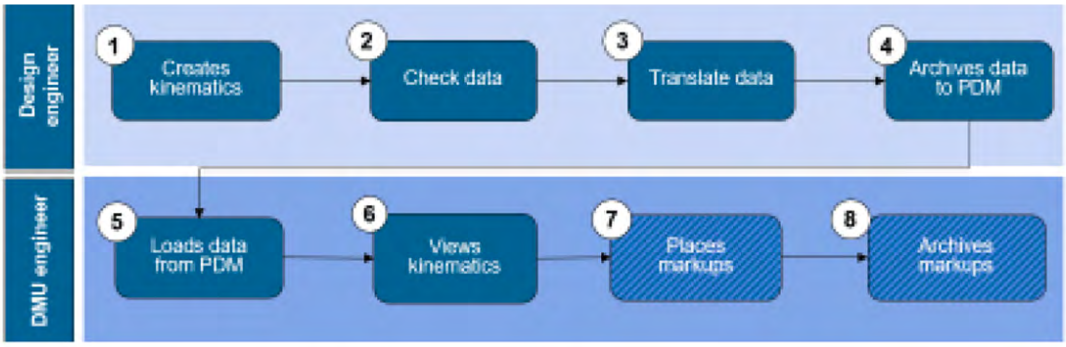


Figure 44: Use case diagram "2.36 AP242 XML kinematics for internal viewing"

Benefit

The benefits of this use case are Kinematic viewing could be independent from CAD systems and CAD licenses, Kinematics definition could be standardized. This could lead into less CAD license costs, less costs of the overall projects costs and could speed up viewing processes.

2.37 Validation for JT product data quality (PDQ) enhancement

Use Case

The aim of this use case is that through the predefinition of validation properties within the JT file the quality of the translation into the JT format can be easily assured.

The actors of the use case are the design engineer and a CAD conversion software.

Description

First, the design engineer creates the model that has to be translated. The validation of conversion is not only applying to pure geometric translation but also to the cases of PMI or Kinematics conversion. In preparation for the conversion of the native CAD file to JT the design engineer is setting up the thresholds for the validation properties in the conversion tool. After converting the file, the software is checking the validation properties based on the predefined thresholds. The created pass/fail report gives the design engineer the assurance of the quality of the conversion. In case of fail, the model and conversion setting have to be checked. In case of pass, the model can be distributed to downstream processes.

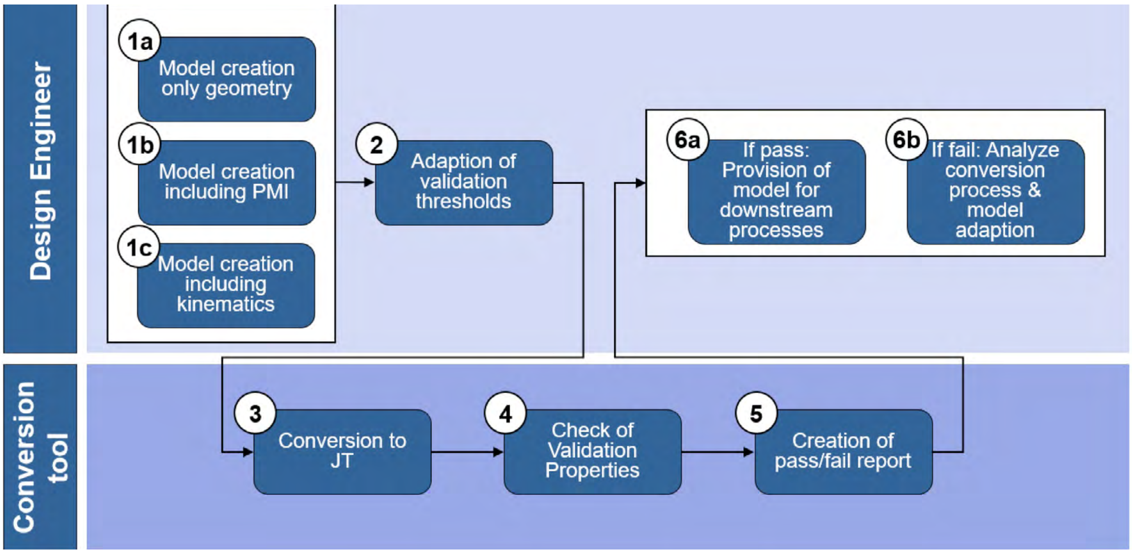


Figure 45: Use case diagram "2.37 Validation for JT product data quality (PDQ) enhancement"

Benefit

With the industry becoming more and more reliant on 3D data for collaboration and manufacturing, it is essential that the data being shared is accurate. Comparing CAD model geometry, PMI and attributes can be frustrating and exhausting. Validation for JT based on views and reports makes it simple, quick, and shareable.

2.38 JT in MBSE

Use Case

JT in Model-based systems engineering (MBSE) addresses 3D visualization in MBSE with particular focus on JT as a standard format for 3D visualization.

The actors of this use case are a system engineer, a requirement engineer and a domain expert.

The preconditions of this use case are the system, subsystem and components of mechatronic or cyber-physicals systems are accessible in the JT format.

Description

Model-based systems engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. The following current and future use cases for 3D visualization in MBSE based on JT might be supported:

- Documentation & Specification: JT can be used as a valid instrument for documentation and specification.
- Communication: Due to the fact that the documented information is easy to use, all of the above mentioned use cases apply to communication as well. Interdisciplinary communication is also a very important aspect.

Coping with function- and system-oriented thinking can be difficult, especially for mechanical engineers. Their understanding of what their colleagues in other domains require and what they can offer them can be made easier when it is visualized as 3D components in a familiar format.

- Interface Definition: In the future, interfaces could be defined directly on the basis of the JT file using AR or VR or visualized on the component
- Dynamic Behavior Modeling: JT is not actively used for dynamic behavior modeling, but it can be used to visualize behavior
- Impact Analysis: Visualization might support impact analysis but it is not likely to be performed using mainly JT files.
- Derivation of Test Cases: Test cases are mainly derived from requirements, which could be visualized next to the component and then be derived manually. Documentation of the derived test cases could then again be presented on JT models

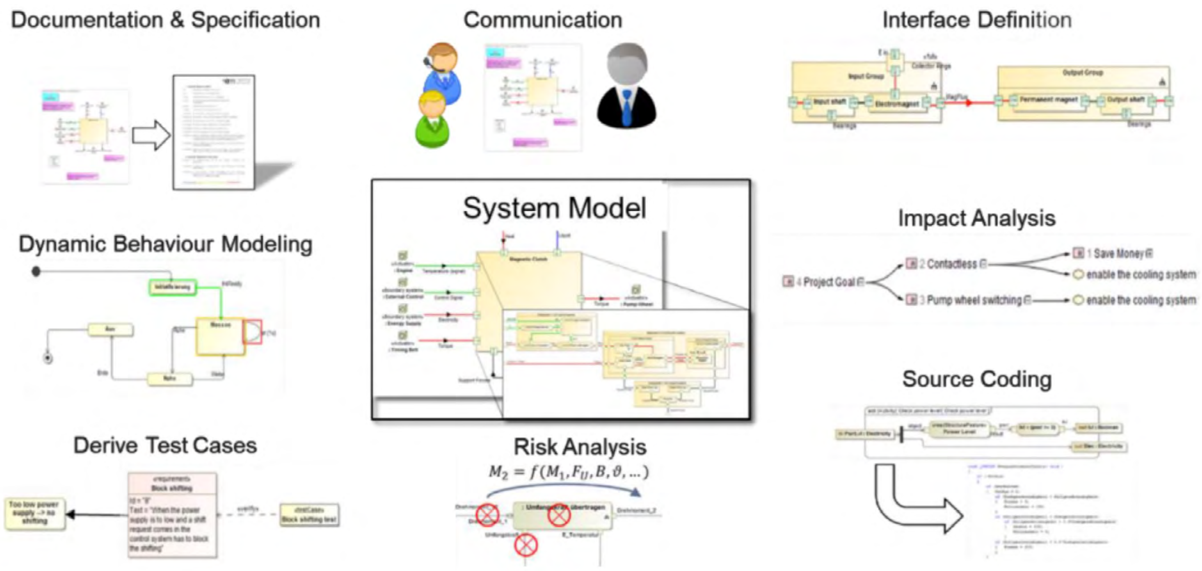


Figure 46: Use case diagram "2.38 JT in MBSE"

Benefit

The benefit of this use case is that JT is a convenient way of presenting information to anyone involved in MBSE. It should therefore be integrated to a greater extent in current MBSE approaches, as it can improve communication between different stakeholders and thus increase support for a transition to MBSE processes.

Note: SysML (System Modeling Language) is a standard notation for MBSE. SysML v2 may include a capability to represent basic two- and three-dimensional geometry of a structural element, including a base coordinate frame.

2.39 JT for AR/VR

Use Case

The aim of this use case is the usage of JT format to distribute lightweight models in the respective VR/AR environment for visualization.

The actors of this use case are the design engineer and VR/AR tools.

The preconditions of this use case are that VR/ AR tools are in place and that tools for CAD data simplification and file size reduction are in place.

Description

The design engineer creates the models and exports them to JT. In case details of the model can be reduced a simplification and file size reduction process can be executed optionally. The reduced file is imported for visualization in the VR/AR environment. Model adaptions that are identified in the VR/ AR inspection, training etc. process can be reported back to the design engineer and directly implemented in the model.

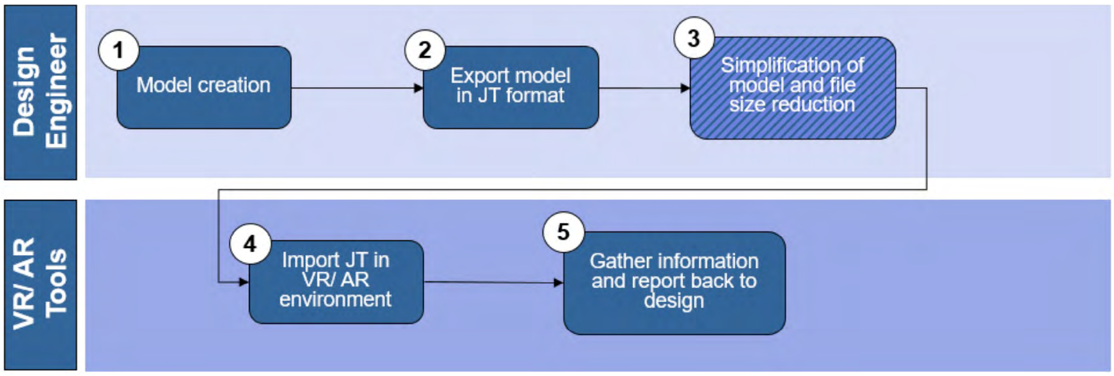


Figure 47: Use case diagram "2.39 JT for AR/VR"

Benefit

The benefits of this use case are that the visualization of complex services and repair scenarios reduces downtime and assembly time and improves quality. Lightweight JT as exchange format ensures reduced distribution time.

2.40 Additive Manufacturing

Use Case

Significant time and cost advantages can be derived from the use of additive manufacturing processes. These advantages result from the fact that within additive manufacturing processes neither costly tools nor time-consuming preparations are needed for the manufacturing of prototypes and components. The characteristic of the process chain enables additional time and cost advantages for each of its use cases. The expression of the process chain is particularly suitable for the manufacturing of small lots to batch size 1.

Description

The additive manufacturing process chain starts with the creation and use of 3D CAD data. Further essential steps within the process chain include pre-processing, manufacturing, post-processing, and component use. Particularly the progress towards the digitalization of the manufacturing process chain requires a comprehensive concept and implementation of the process chain 3D CAD for Additive Manufacturing. The process steps modelling, nesting, and slicing based on the JT data format enable the utilization of the advantages.

Benefit

To achieve optimal and high-quality results through additive manufacturing, the data preparation, process- and technology-specific orientation and positioning of components within the virtual space, the so-called nest-ing based on, are essential.

Today, the process chain is expressed strongly manually. The goal is to automate the process chain. This results in an enormous competitive advantage for a company. Hence, the process chain for additive manufac-turing based on JT lead to a profitable customized manufacturing.

2.41 JT for hybrid Design in Context for inhouse usage

Use Case

This use case describes the course of using JT for design in context in house. As a basic principle for this use case, several CAD systems are engineering masters within their engineering domain and interoperate on the basis of a common PDM system. The interoperational basis for all CAD systems are JT files (including XT-BRep information), that are automatically derived from the engineering masters within the PDM system. As a result, for each data item only one native master and one derived JT are permitted. Changes are incorporated only by changes to the native master. The item is used by all participating CAD systems. The master CAD system always uses the native format, while the other CAD systems use the derived JT file. Those are loaded in parallel to their own native data and must not be changed or stored back.

Several CAD systems are interacting on the basis of a common PDM system.

For parts being authored within one CAD system, the native file is the primary format and a derived JT (including XT-BRep information) is the secondary format.

The structural master format for each assembly is to be decided at the engineering start depending on the product needs.

All CAD systems must be able to visualize and interoperate on the basis of the boundary representations from within the JT files, without the need to store this data back into their native format.

Description

A first design engineer creates the particular product structure and geometry (2), which is to be used as context by another design engineer who uses a different CAD system. The native CAD data is stored within a PDM system as the primary format (1). JT-files derived from the native CAD data, including PMI such as dimensions and tolerances, are also stored within the PDM system, as a secondary format (3). Selective features are included as well in order to be extracted and referenced by the receiving design engineer.

A second design engineer, using a different CAD system than the first design engineer, also creates the particular product structure and geometry, in order to use it in context with the data created by the first design engineer (2’). He then loads the JT-geometry created by the first design engineer from the PDM system into his native CAD-system (4’). The JT is then displayed hybrid to native CAD-geometry, in order to use the included BRep like the native CAD (5’). An example how the data could be used is the positioning of native CAD data in relation to certain JT-content, such as edges, vertices, faces, or auxiliary geometry, e.g. point, axis or plane. Exact geometrical references, e.g. curves, are also possible. In an assembly context, new PMI can be added, associating native CAD and/or JT-based geometry. While native CAD-geometry may continuously be modified, the JT-based geometry may not.

After the modifications, the second design engineer stores his assembly structure back to the PDM system, including dependencies to his own native geometry as well as to the other design engineers JTs. Those JTs themselves may not be stored back, nor may any native format duplicates of them be created within the PDM (1’).

Derived from the native CAD data again JT-files are also stored within the PDM system as a secondary format (3).

Now the second design engineer’s data can be the basis or context for other design engineers’ work, independent of the CAD system they are using.

CAD systems must be able to use JT just like their native data for positioning (constraints) and referencing (associative links, measures, PMI, drawing).

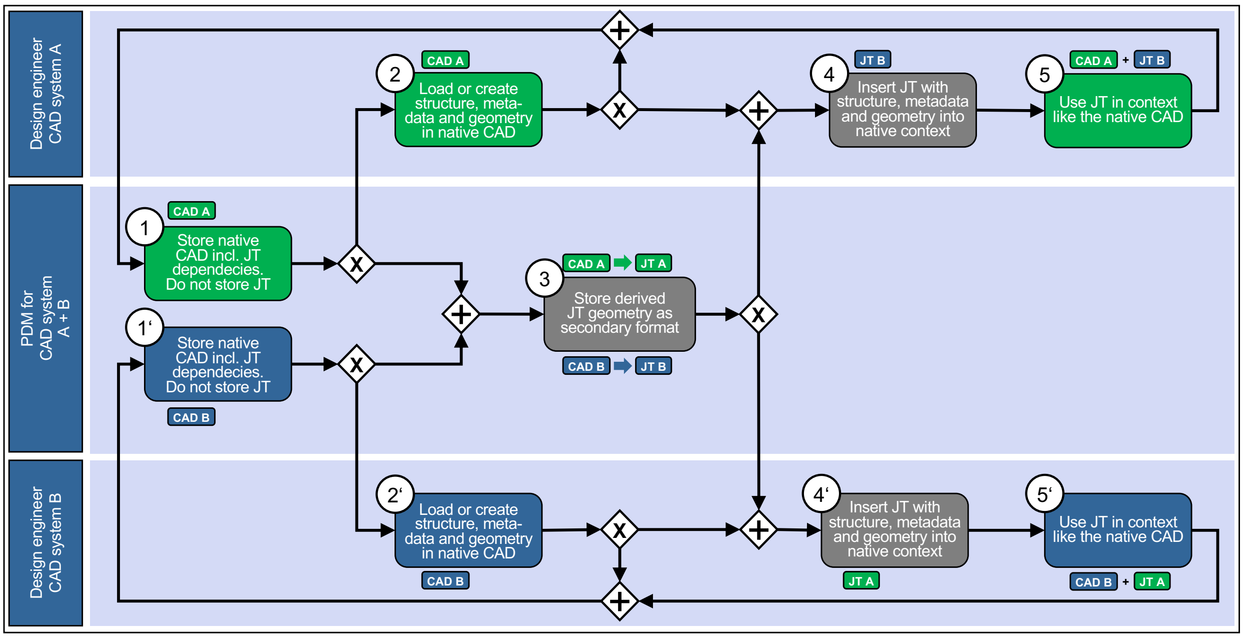


Figure 48: Use case diagramm: "2.41 JT for hybrid Design in Context for inhouse usage"

Benefit

JT can be used to design in the context of existing product data, as no direct interfaces are required between multiple CAD-systems and JT does not need to be stored in the native format:

- Iterative development within simultaneous engineering approaches no longer end at CAD system boundaries.
- Appropriate PDM methods assumed, changes in one domain are available for all domains.
- After changes in one domain, an update of the hybrid structure is possible within the other domain.

3 Final remarks

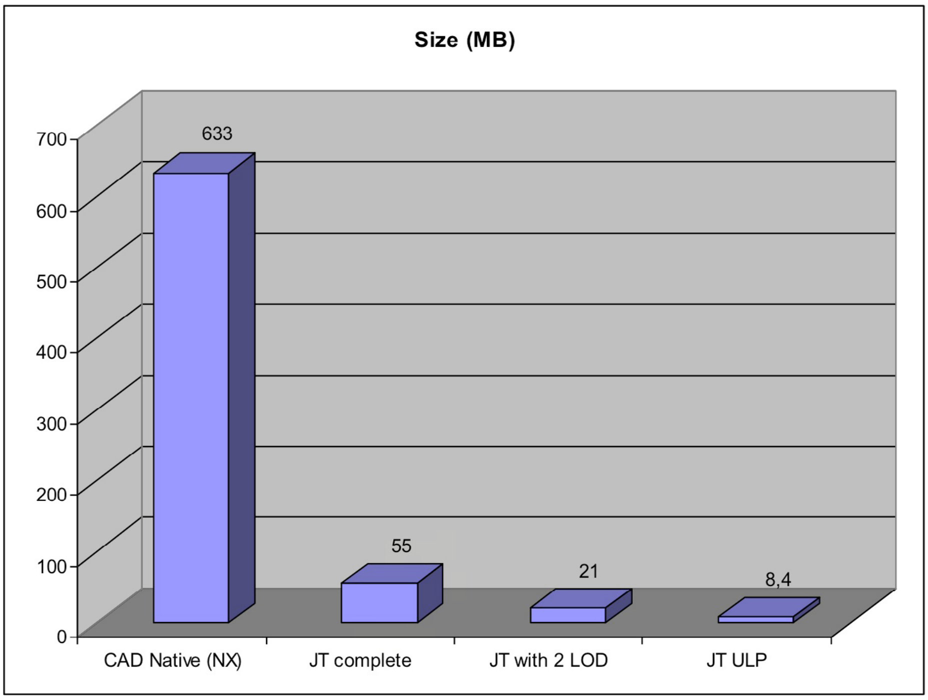
JT will not prove to the cure-all for the complexity of products and product development but rather as a tool for defined use cases. Nevertheless, the first few years of testing have already revealed concrete potential whose exploitation is seen as a sure thing by those responsible in the companies involved.

CAD licenses:
Users are unanimous in their assumption that approximately 30 percent of the costs currently incurred for CAD licenses can be saved permanently as the result of introducing the neutral standard format. This is especially true for companies who are forced, for various reasons, to implement a number of different CAD systems. Some of these implementations may then no longer be needed, provided the exchange of data with partners and customers for certain purposes can be changed over entirely to JT.

Reconditioning:
Data exchange between native formats often results in the need for reconditioning to correct any transfer errors. Once an agreement regarding the use of JT has been reached, the number of transfers required between native formats will be subject to a significant decrease. This means that the amount of work currently required for reconditioning the data from internal and external partners will also decrease markedly.

Data exchange:
The smaller size of the JT files and the simple, often automatic, conversion make it much easier and at the same time faster to exchange data between different CAD systems, for instance for design in context. Figure 48 shows the different file sizes of native CAD data in comparison to the various configurations of JT files.

Processes:
All those involved expect the processes that can be supported in the future as a result of the availability of JT to improve dramatically and, above all, be easier to use. The ability to rely on not words but visual support across departmental borders, in non-technical process and via the Internet will release a considerable amount of energy that was previously inevitably required to search for data, explain documents and disseminate information. In the same way that NetMeeting supports telephone and video conferences and 3D-PDF allows the creation and processing of a wide variety of documents, so can JT become a core element in collaboration scenarios that involve engineering data.



(Source: Siemens PLM)

Figure 49: Sample file size (machine tool, 3584 BOM lines)

Annex A: The role of the prostep ivip Association and the VDA

The prostep ivip Association, together with the VDA, has directed its attention to this topic due to the fact that it is of interest to the whole industry and can only be addressed in a manner that spans corporate borders and the boundaries between the different branches of industry. Long before the move toward standardization was officially made, there were a number of activities that were concerned with the functionality, quality and reliability of formats like JT.

In 2005, for example, the Department of Computer Integrated Design (DiK) at the Technical University of Darmstadt carried out a project study to evaluate the JT data format on behalf of the Association. Four important fields of application in the industry – visualization, collaboration, archiving, analysis/ validation – were evaluated as to their requirements regarding a neutral format and the extent to which JT can meet these requirements.

An Executive Summary had the following to say about the project study: "As a result of the study, it is recommended that JT be used in the areas collaboration and visualization. Not only can the visualization data needed for these application areas be stored in JT format but also information on product structures, product manufacturing information (PMI) and the metadata to be defined (such as, for example, material names and numbers). Simple, dynamic analyses based on visualization information can also be performed well using JT (e.g. collision control and digital mock-up). Only for complex kinematic analyses in "active" DMU is the information required to define equations of motion including forces and torques missing in JT. JT is not recommended for long-term archiving. According to the defined criteria, JT is not an open format. The long-term reusability and interoperability of the information can therefore not be guaranteed. The disclosure of the data model, described using a defined notation, is regarded at the minimum necessary requirement for archiving product data in JT." Publication as an ISO standard addresses the lack of openness, which has been criticized in the study.

Studies conducted in various companies came to similar conclusions. In early 2008, tests involving the usefulness of JT at, for example, Daimler indicated that only a small proportion of the objects – less than ten percent – still had to be disclosed in order to be able to say that all the objects could be read correctly by anyone and without the API from Siemens PLM Software. At the prostep ivip Symposium in May 2008, Daimler was able to confirm to the vendor that it had been possible to close the last gaps. This means that all that is now required for the format to also be used for long-term archiving is official certification as an ISO standard. Figure 49 shows the processes at Daimler before introducing JT.

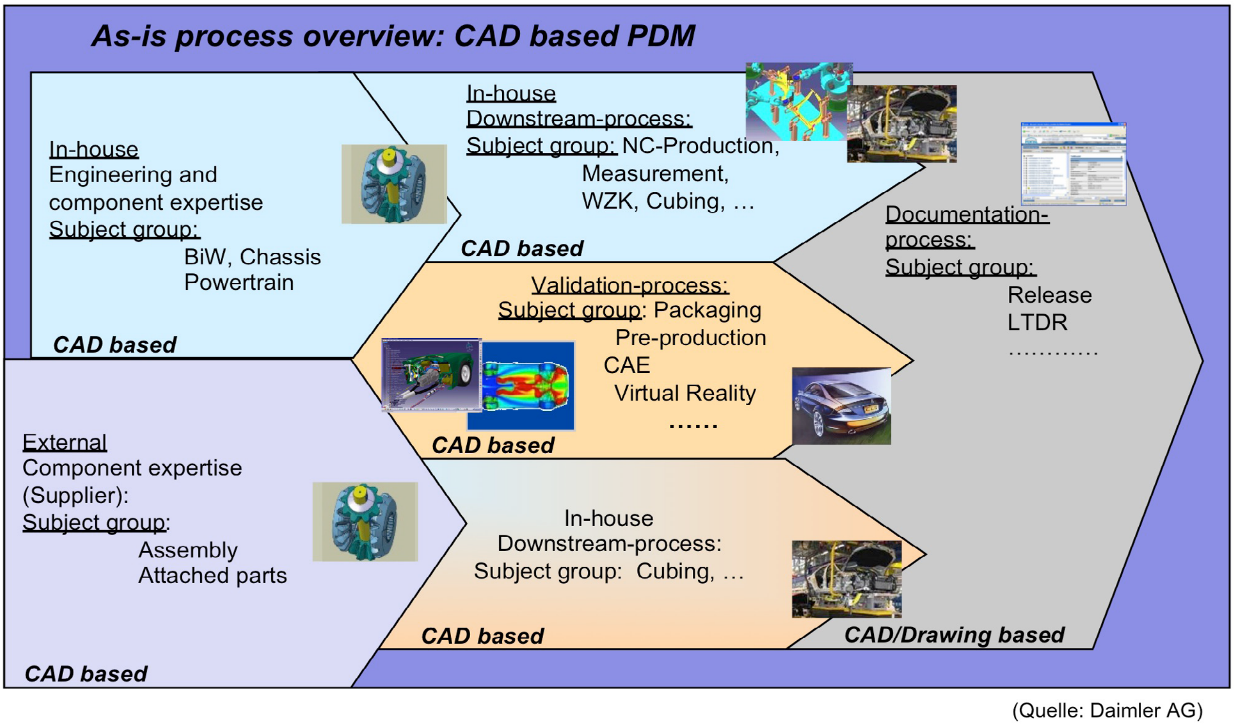


Figure 50: Process chains at Daimler before introducing JT

Subsequent to the cited study, during the years 2005 and 2006, the Association's Collaborative Product Visualization (CPV) project group worked together with the VDA on simplifying and accelerating cross enterprise product data exchange by harmonizing visualization on the basis of compressed data. The result was a recommendation published in 2007 by the Association (PSI 2) and an identical recommendation published by the VDA (VDA 4966), which on the one hand described possible use cases quasi as a reference; and on the other hand, examined the processes to determine their requirements with regard to those involved and the respec-tive software used. The subject matter involved was not JT itself but rather visualization in general, but the results can of course be applied to the topic at hand and provide a basis upon which quality assurance with regard to the application of JT can now be tackled. Figure 50 shows the process at Daimler after introducing JT.

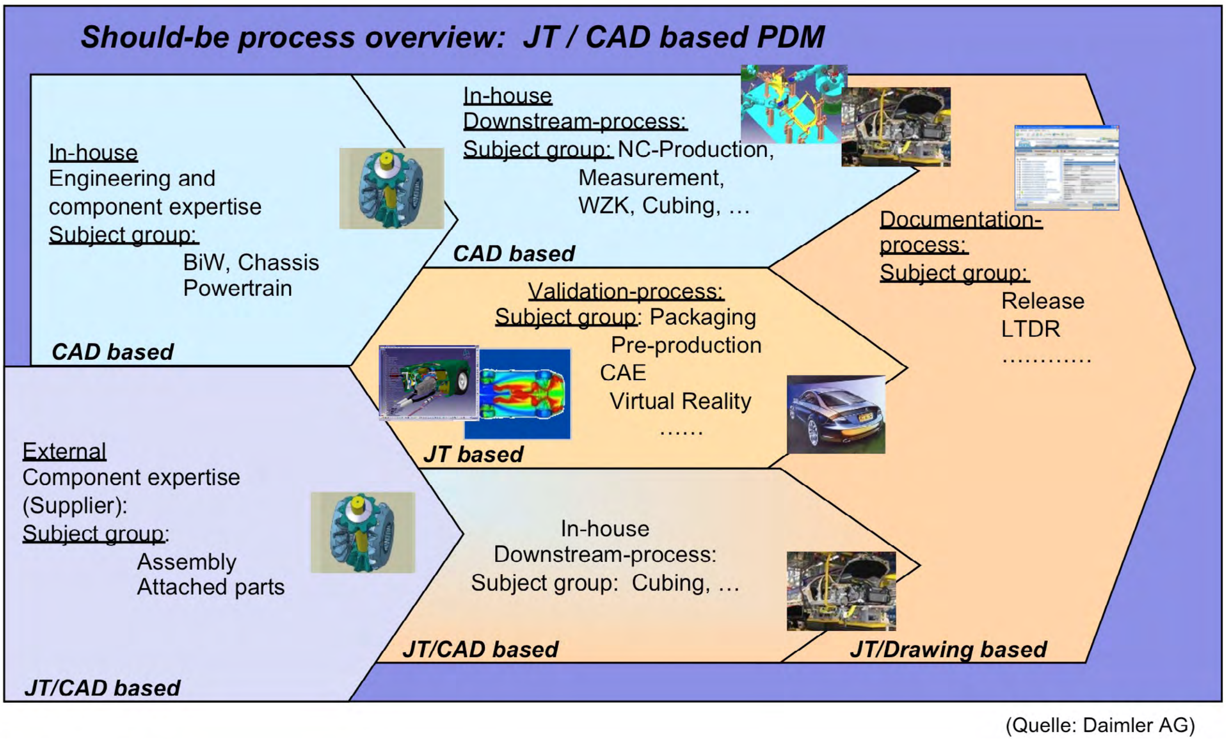


Figure 51: Process chains at Daimler after introducing JT

At the end of 2008, the Association's PDM User Group compiled a catalog of questions which the Institute of Virtual Product Engineering (VPE) at the University of Kaiserslautern used at four OEMs and one supplier to examine the status quo of the application and integration of JT in different fields of application on the one hand and define initial requirements on the other hand. The study made it possible to compare the processes as they are today with the processes as the users hope to see them as a result of using JT.

The previously mentioned JT Workflow Forum project group was set up in early 2009. Basing its work on the existing recommendations published by the Association and the VDA, its primary focus is the following two task complexes:

- Examination of the most important use cases as far as users are concerned and determining the requirements that have to be met by the processes
- Definition of benchmarks and test cases to assess the quality of JT data

There are several documents that provide information on dealing with JT, these are presented below.

The JT ISO specification 14306 is flanked by two major documents, the JT Implementation Guideline and the Content Harmonization Guideline (cp. Figure 51).

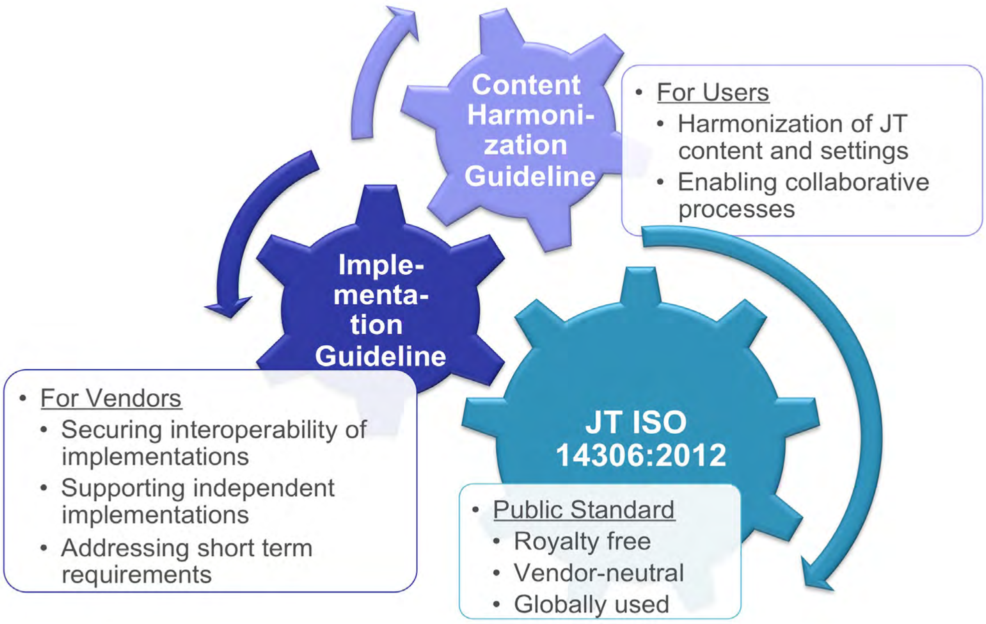


Figure 52: Links between the documents

JT ISO 14306:2012 and JT ISO 14306:2017 The JT specification was published as ISO 14306 at the end of 2012. The specification has been revised in 2017 and is available for license-free industrial use.

Starting in 2019, an effort has been made to publish a third version of the ISO standard. The original intention was to incorporate the suggestions for additional and more detailed information and uses made in the JT WF and JT IF in addition to cover the latest JT version 10.5 in this third version and publish it. It is, however, at present not possible to say if and when an ISO JT V3 will be published.

Implementation Guideline The implementation guideline is aimed to close the gap between the ISO 14306:2017 specification and "real world" implementation tasks. It is also aimed towards vendors with the objective to provide recommendations how to best implement certain aspects of the JT standards, by itself or in combination with accompanying formats such as STEP AP242 XML. The recommendations given in this document have been discussed intensively, and agreed on, by the JT Implementor Forum members and will be implemented by them as a means of enhancing interoperability of application using the JT format. The JT Implementation Guideline is available on the prostep ivip webpage.

Content Harmonization Guideline For selective use cases, some of the necessary process-supporting content (satisfying respective requirements), e.g. the product structure and according master data, can be provided by further formats in combination with JT. There is a need to analyze which contents are to be stored in JT and which contents are to be stored in accompanying formats (e.g. STEP AP 242 XML). If JT and the accompanying format both provide containers for required content, there must be a unique understanding on which of the formats is responsible for the data. This is a prerequisite to application interoperability, in turn a prerequisite to the mentioned optimization of process support. Further, there is a need to harmonize the form in which the above mentioned content is to be provided.

This is done in the Content Harmonization Group, a subgroup of the JT Workflow Forum. It consists of users and vendors as well as academic members. The group has elaborated the Content Harmonization Guideline. In this document, recommendations on the before mentioned topics are given. It contains an agreement on usage of JT, e.g. for naming of user defined attributes, accuracy of LODs or product structure options. The JT Content Harmonization Guideline is available on the prostep ivip webpage.

Annex B: Quality assurance for JT

The VDA PLM working group and the prostep ivip Association have launched not just one but three projects that are being coordinated with each other.

The JT Workflow Forum is a joint project group established by the prostep ivip Association and the VDA (German Association of the Automotive Industry). The objective of the forum is to drive the requirements relating to the application of JT and the accompanying format STEP AP242 XML, to validate them at the participating companies, to document the processes in use cases and to harmonize the necessary characteristic of the used JT as well STEP AP242 XML data content. This also includes the requirements relating to future ISO JT standards. Focus is to document the common viewpoint of industry. Similar to the activities in recent years, this approach will be based on the developed use cases for the application of JT. The JT WF has elaborated 30 use cases so far that have been validated by the members of the project group by means of in-house testing. These use cases are presented in detail in chapter 2.

JT Implementor Forum is also a joint project group established by the prostep ivip Association and the VDA. The objective of the Implementor Forum is to assure the interoperability between different JT applications. Like all other Implementor Forums, the JT-IF has to be seen as a neutral platform for vendors and tool-providers for testing in an atmosphere of mutual trust and exchanging information on experiences already gained. The participating vendors can test their software currently being developed in a closed group. New functionalities can be tested within the prostep ivip / VDA JT Implementor Forum 2015 until they are being declared „ready for market".

The various application scenarios give rise to numerous requirements that need to be met by the JT data. When is precise geometry indispensable and when is tessellated data enough? Which data in addition to the geometry needs to be stored and in which cases? These questions relate to the quality of the JT data supplied by the systems involved. In other words, on the one hand they relate to the authoring systems and on the other hand to the translators which generate JT from a native format or can convert JT into a native format. In order to provide a reliable answer to these questions, systematic benchmarking of the tools involved was needed. The benchmarks are managed by the JT Workflow Forum and JT Implementor Forum. They are a neutral comparison of trendsetting JT applications with regard to the selected test criteria. Therefore, the results of the benchmarks can not only be used to evaluate the application of JT in PLM environments, but also for improvement of the interoperability of the applications. The first benchmark was held in 2009, now five benchmarks were held and a 6th is planned for 2015. The first step involved the previously described definition of key use cases and the related requirements that the JT data needs to satisfy in the JT Workflow Forum, which comprises a number of companies from the automotive industry – both vendors and suppliers – but also providers of translators and system integrations. The following sub-chapters give detailed information to the benchmarks.

In August 2010, the prostep ivip Association submitted the JT specification (Version 9.5) to the ISO for standardization. In December 2012, JT has been officially published as ISO 14306:2012. In 2017, this standard has been revised (ISO 14306:2017). The interaction of the three projects described above is illustrated in Figure 52.

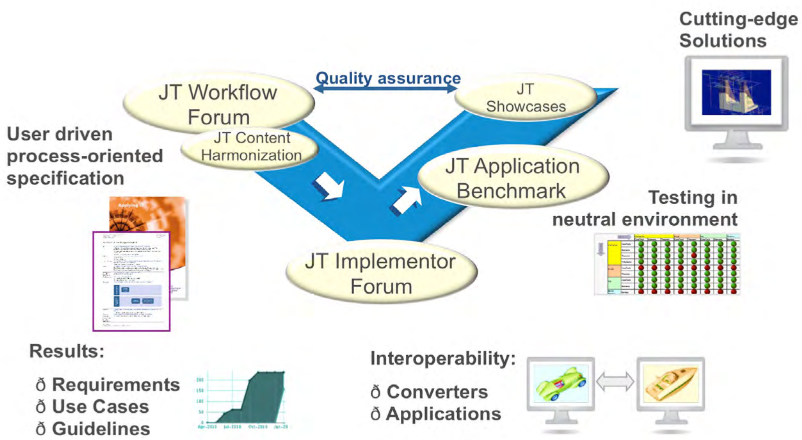
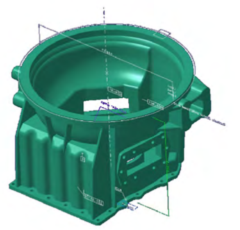
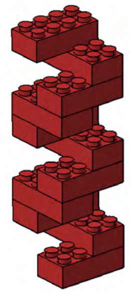
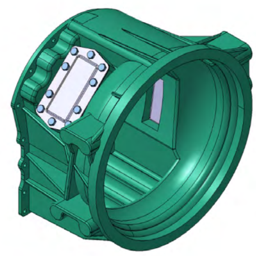
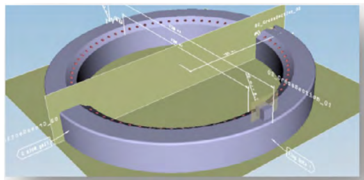
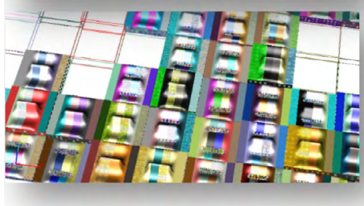
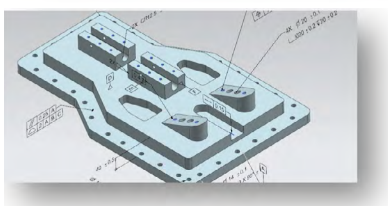
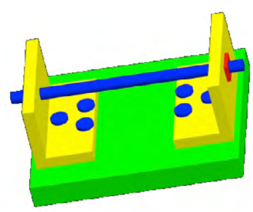
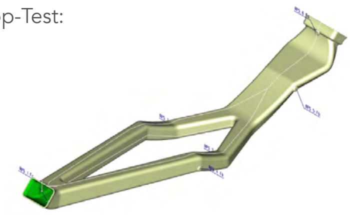
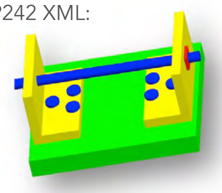
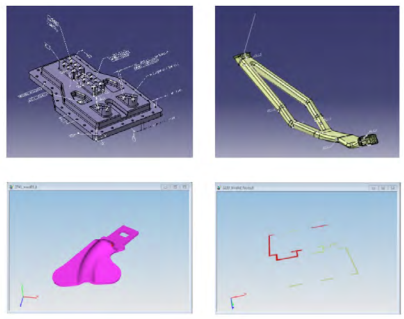
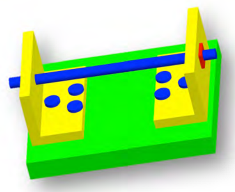
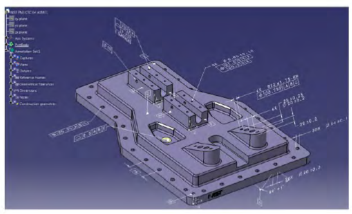
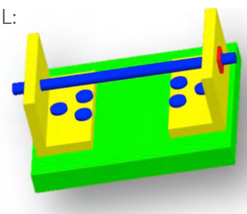


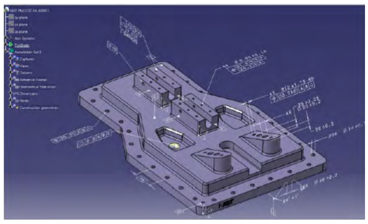
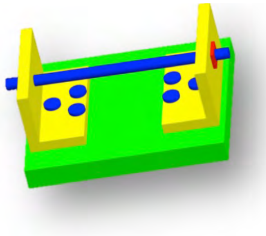
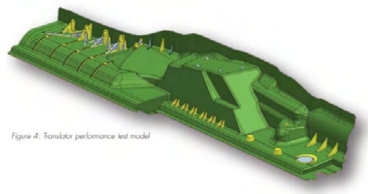
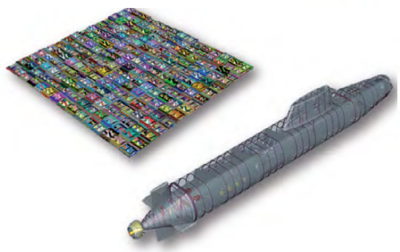
Figure 53: Interaction of the VDA / prostep ivip JT initiatives

Benchmark history

In the years 2009-2019 eight benchmarks were carried out with different test criteria and test models. The following Table 1 provides an overview of the involved software, the used criteria and the different test models.

Year of the Benchmark	Software involved in Benchmark	Test Criteria	Test models
2009	• CAD: CATIA V5 R19, Wildfire 4.0, NX 5, MicroStation V8 XM • Translators: CoreTechnologie, T-Systems, Theo-rem, Siemens PLM, Bentley	• Geometry • Reference geometry • PMI • Part Information • Product Structure with options "mon-olithic" and "per part"	• Solid model "housing" from STEP Benchmark:  • Syntactical assembly with bricks: 
2010	• CAD: CATIA V5 R19, Wildfire 4.0, NX 8 • Translators: CoreTechnologie, T-Systems, Theo-rem, Siemens PLM	• Geometry (XT-BREP) • PMI (Visualization) • Material data • Product Structure • Component Place-ment • Visualization • Attributes	
2012	• CAD: CATIA V5 R19, Pro/E Wild-fire 5, NX 8.01 • Translators: CoreTechnologie, Elysium, ITI Transcendata, PTC, Siemens PLM, Space-Claim, T-Systems, Theorem • Viewers: Glovius (Geometric), JT2Go (Siemens PLM), Teamcenter Visualization (Siemens PLM) • JT Quality Check Tools: CADIQ (ITI Transcendata), 3D Evolution (CoreTechnologie), Q-Checker, Q-Spector & Q-Compare (Transcat), Teamcenter Visualization	• Viewer Benchmark: Data (Load, merge, insert JT data), Navigation/View (navigate through a model), Functionalities (Measurement), Miscellaneous (Performance and hard-ware support) • Translator Benchmark: LOD Definition, Consist-ence of colors in CAD and JT, File size smaller than source CAD file, Graphical presentation of PMI annotations is consistent in CAD and JT, Links between geometry and an-notations must be kept, Links between annotations must be kept, Representation of PMI must be machine-readable, Organization with model views, Different types of PMI must be converted	• Viewer Benchmark:   • Translator Benchmark:  • Assembly conversion with STEP AP242 XML and JT: 

2013	• CAD: CATIA V5 R19, Creo 2, NX 8.5, Solidworks 2012 • Translators: CoreTechnologie, Elysium, ITI Transcendata, PTC, Siemens PLM, Space-Claim, T-Sys-tems, Theorem	• JT-Loop-Test: XT-BREP, PMI, Attributes • STEP AP242 XML with JT: XML Schema, Product Structure, Meta Data	• JT-Loop-Test:  • JT with STEP AP242 XML: 
2014	• **Translators:** CoreTechnologie, Elysium, ITI Transcendata, Siemens PLM, SpaceClaim, Transcat PLM, T-Systems	• **JT-Check-Tool-Test:** Validation: Compare JT XT-BREP to CAD BREP, Completeness of PMI translation, Completeness of Attribute translation Verification: Quality checks (geometry, PMI, attributes) • **STEP AP242 XML with JT:** Product Structure, Assembly Attributes (Meta Data)	• JT-Check-Tool-Test:  • STEP AP242 XML: 
2015	• **Translators:** BETA CAE Systems, CoreTechnologie, PROSTEP, Elysium, PTC, Siemens PLM, Theorem, Transcat PLM, T-Systems	• **JT-Check-Tool-Test:** Correct translation of geometry, Exist of XT-BREP, LOD creation, Consist-ence of colors, Completeness of PMI translation, Completeness of Attribute translation, Translator information is stored correctly • **STEP AP242 XML with JT:** XML file is conformed with STEP AP242 XML schema, Assembly Attributes, Product Structure	• JT-Loop-Test:  • STEP AP242 XML: 

2016	• **Translators/Viewers:** CoreTechnologie, T-Systems, Transcat, Siemens PLM, beta-CAE, PROSTEP, Theorem	• **CAD-JT-CAD:** Correct translation of geometry, LOD creation, consistence of colors, consistence of PMI translation, machine-readable PMI, consistence of model views, correct CAD properties, correct translator information • **JT with AP242 XML:** XML file is conformed to the STEP AP 242 BOM Model XML schema, translation of assembly attributes, product structure	• CAD-JT-CAD:  • JT with AP242 XML 
2017	• **Translators:** CoreTechnologie, Elysium, Siemens PLM, Theorem, T-Systems	• **Translation Quality:** Correct translation of geometry, LOD creation, stored as XT-Brep, consistent assembly structure, correct CAD properties, correct translator information, properties on assembly structure • **Application Performance:** time of translation, time to start application, elapse time measured, delay of re-visualization	• Translation Quality:  • Application Performance:  

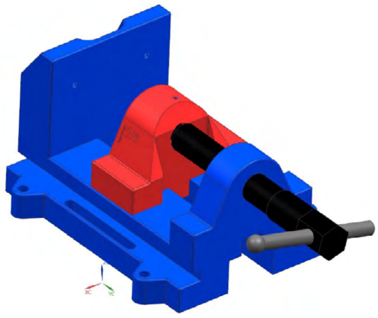
2019	• **Translators:** Elysium, Siemens PLM, Theorem, T-Systems	• **Translation Quality:** Correct translation of geometry, equivalence of as-sembly structure, correct position of instances, consistent assembly components, cor-rect CAD properties, correct translator information, properties on assembly structure	• Translation Quality:  

Table 1: Benchmark history

Benchmark Documentation

The Benchmark results are documented in a short and a long report. The short report is made publicly available; the long report with more detailed information is provided to the project members. Figure 53 shows the short and the long report of the 8th JT Application Benchmark.

Figure 54: Benchmark documentation

The reports can be found on the following URL: https://www.prostep.org/en/medialibrary/publications

Annex C: Software tools for JT

Viewers:
Numerous companies have introduced special viewers onto the market that allow JT data to be displayed and manipulated regardless of the CAD systems involved. Others have ensured that currently available visualization tools are now able to process JT data. Siemens PLM Software alone offers a wide range of JT viewers – from the free JT2GO to the powerful Teamcenter Visualization Mockup from Siemens, which however has to be purchased. Other JT viewers include DeltaGen from Dassault Systemes, Instant3Dhub from Threedy, Lite3D from Technia, Spinfire from Actify, ViewStation from Kisters, etc.

Translators:
More important than visualization is the generation of JT data in various authoring systems and the translation of JT into their native format. On the one hand, there are authoring systems that allow data to be output in JT format and which also automate the reading in of JT data to a great extent. On the other hand, numerous vendors have specialized in developing converters for the various authoring systems. Some convert native data into JT, others JT into CAD, and others can do both. The following systems which are shown in Table 2 are just a few of the available converters:

Vendor:	CoreTech-nologie	Elysium	ITI Transcen-data	PTC	Siemens PLM Soft-ware	Space-Claim	Theorem	T-Systems
Con-verter:	3D-Evolu-tion	ASFALIS	CADfix	JT Inter-face	JT Con-verter	JT Open data ex-ch-ange	CADverter	COM/FOX

Table 2: JT converter

Checkers:
A number of systems that check the correlation between JT and an original format are available from various vendors, such as CADdoctor for JT from Elysium, JT Inspector from Siemens PLM Software LiteComply from Technia or 3Devolution from CoreTechnologie.

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