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Study of using 3D-model based technical specification

– a tool for comparing UG loader’s and truck’s size envelopes


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Study of using 3D-model based technical specification

– a tool for comparing UG loader’s and truck’s size envelopes

The aim of the thesis was to find a tool for comparing underground loader’s and truck’s size envelopes. The tool is a software, already existing, or a new one.

Most common 3D model comparison software were researched and compared with each other to see how the software match the requirements set to the comparison software. Six software were chosen to be compared with each other.

The requirements for the comparison software were defined with interviews of the needs of the client. Client’s employees were interviewed to find out what kind of needs they had. Four key requirements were chosen.

The most suitable software, which was chosen, matched the most with the four key requirements, as well as was a reasonable investment money and time wise. The possibility of a brand new software, customized for the needs of the client, was also considered.

Keywords:

comparison software, software selection, comparing tool

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Sanni Murto

Tutkimus 3D-mallipohjaisen teknisen tiedon käytöstä

- työkalu maanlaisten kuormaajien ja kuorma-autojen kokomääritysten vertailuun

Opinnäytetyön tavoitteena oli löytää työkalu, jota voitaisiin käyttää maanalaisten kuormaajien ja kuorma-autojen kokomäärityksen vertailussa. Työkaluksi haluttiin ohjelmisto. Opinnäytetyössä selvitetään onko olemassa jo sopivaa ohjelmistoa vai pitääkö kehittää uusi ohjelmisto.

Yleisimmät 3D-mallien vertailuun käytettävät ohjelmistot tutkittiin ja niitä vertailtiin keskenään, jotta nähtäisiin mikä ohjelmistoista vastaisi parhaiten vertailutyökalulle asetettuja vaatimuksia.

Työkalun halutut ominaisuudet selvitettiin haastatteluiden avulla. Neljä päävaatimusta asetettiin ohjelmistolle näiden haastatteluiden avulla.

Ohjelmistoista valittiin sopivin ohjelmisto, joka vastasi parhaiten neljää päävaatimusta. Valittu ohjelmisto oli järkevä sijoitus rahallisesti, sekä ajallisesti. Täysin uuden ohjelmiston mahdollisuutta harkittiin myös.

Asiasanat:

vertailuohjelmisto, ohjelmistovalinta, vertailutyökalu

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List of abbreviations (or) symbols

CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
DPD	Dynamic Parcel Distribution
PDM	Product Data Management
PMI	Purchasing Managers' Index
UG loader or UG truck	Underground loader or underground truck

1 Introduction

The aim for the thesis is to perform research for a tool, which can be used to compare 3D models and size envelopes of underground trucks and loaders.

1.1 Client

Client of the thesis is Sandvik, which is a high tech and global engineering company. It was founded in Sweden in 1862 and its headquarters are still there, now located at Stockholm. Sandvik employs about 37,000 people and has revenues over 86 billion SEK (Sandvik, 2021)

Göran Fredrik Göransson founded the company. Already in the 1860's the product range included drill steel for rock drilling. The company was listed in the Stockholm Stock Exchange in 1901. Manufacturing of stainless steel began in 1912 and cemented carbide in 1942. In the 70's the company name was changed to Sandvik Ab. (Sandvik, 2021)

Today Sandvik concentrates on certain core areas: Tools and tooling systems for industrial metal cutting, equipment and tools, service and technical solutions for the mining and construction industries, as well as advanced stainless steels and special alloys as well as products for industrial heating. (Sandvik, 2021)

Sandvik's business is divided in four areas (see Fig. 1).

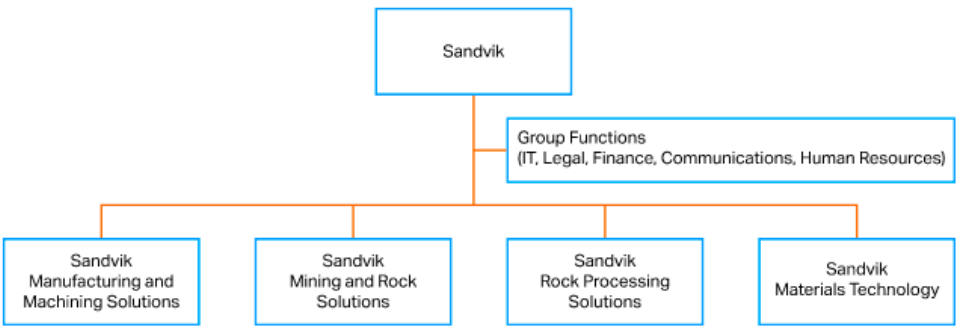

Figure 1 Sandvik's business areas (Sandvik, 2021)

1.1.1 Business areas

Sandvik's Manufacturing and Machining Solutions manufactures tools and tooling systems for industrial metal cutting as well as services, which optimize machining operations such as turning, milling and drilling. It also has expanded to additive manufacturing and digital manufacturing. This specific area employs over 17,000 people. (Sandvik, 2021)

Mining and Rock Solutions is a supplier of equipment and tools, parts, service and technical solutions for the mining and construction industries. Different applications include rock drilling, rock cutting, loading and hauling, tunneling and quarrying. This area employs over 12,000 people. (Sandvik, 2021)

Sandvik Rock Processing Solutions is a supplier of equipment, tools, parts, service and solutions for processing rock and minerals in the mining and construction industries. Applications include crushing, screening, breaking and demolition. This area employs a bit less than 2,000 people. (Sandvik, 2021)

Materials Technology manufactures advanced stainless steels and special alloys for industry. They have a large variety of product forms, such as tube, pipe, bar and strip steel as well as products for industrial heating. This area employs around 5,000 people. (Sandvik, 2021)

1.2 Underground loaders, trucks and size envelopes

Sandvik has eight types of underground loaders, or UG loaders, available on the market. Loaders are designed to work underground and they are used to clean drilled matter, such as rock material, out of the tunnels. Sandvik's UG loaders are equipped with technology with intelligence, connectivity and digital solutions. (Sandvik, 2021) An example of a UG loader is shown in Figure 2.

Figure 2 Sandvik LH621i underground loader (Sandvik, 2015)

Sandvik has nine types of underground trucks, or UG trucks, on the market. These trucks are designed to transport rock material safely from tunnels. UG trucks have possibilities to turn in small spaces and move with fast speeds. (Sandvik, 2021) See Figure 3 to see an example of a UG truck.

Figure 3 Sandvik TH663i underground truck (Sandvik, 2021)

Size envelopes are the space needed for these UG loaders and truck to work. The space the loaders and trucks must have to work safely need an envelope of space between the machine and the tunnel wall. This space includes the space the machine needs for functioning, for example turning, and it also regards possible attachments on the tunnel wall, such as wires. The size envelopes

become highly important when AutoMine is used. AutoMine is Sandvik's automation system, which allows the autonomous and tele-remote operation of the machines. The automation system can be scaled from a single machine to to multi-machine control as well as full fleet automation with automatic mission and traffic control capability. (Sandvik, 2021)

2 Comparison software

Software is a set of instructions, which control what a computer does. Software is another name for a computer program. (Press, 2013) To compare the wanted specifications of the models, a software suitable for comparison is a must-have. The sotware can be a pre-existing software modified to fit the purpose, or a newly developed software just for comparison purposes.

3D models are nowadays increasingly used as inputs in product life management, such as comparing and retrieving products. Using 3D models in product comparison has made product management more straightforward and accessible. (Rivest, et al., 2013)

Comparison software can be used for multiple different uses, such as product information reuse, product ratianalization and standardization, model management, data translation and remastering, model authoring and engineering management. (Rivest, et al., 2013) Software, which works well with pre-existing product data management (PDM), can be useful and help with the product data managing.

With 3D model comparison, one usually can check following issues: detect translation errors, check for geometry or design defects or changes, find quality defects or changes, study revisions, intended or unintended, and check part or assembly structure. (Nguyen, 2021)

This chapter introduces the basics of comparison software as well as some options for the software. Pre-existing software introduced in this chapter are the most common ones, which came up in the research of this thesis.

2.1 How does comparison software work?

Software performs instructions and these instructions can be modelled to fit the preferred actions. Figure 4 shows some actions, which can be used when modelling a comparison software.

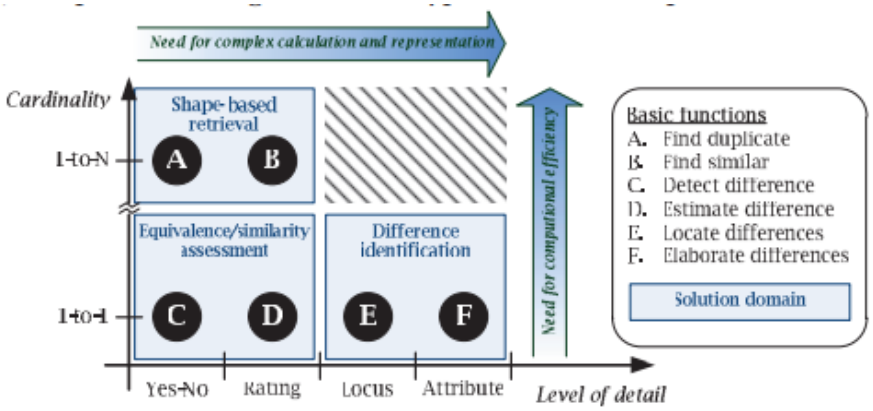

Figure 4 Comparison software inputs (Rivest, et al., 2013)

Cardinality is a reference model, which may either be compared to a single target model (1:1), or to many models (n:1), which are usually from larger sets. *Level of detail* is the amount of detail expected of the comparison. (Rivest, et al., 2013)

Table 1 will explain certain basic functions as a relation between cardinality and level of detail.

Function	Question	Expected result
Find duplicate	Which models are equivalent?	Finite set of objects
Find similar	Which models are similar?	Ordered, scale-based distributions
Detect difference	Are the models different?	Binary results (Yes/No etc.)
Estimate difference	How different are the models?	Qualitative, global, scale- based measures
Locate differences	Where are the differences?	Graphical reports, loci, regions
Elaborate differences	What are the differences?	Classifications, local measures, descriptions

Table 1 Basic functions of 3D CAD model comparison (Rivest, et al., 2013)

These basic functions are organised by solution domains.

2.2 Capvidia

Capvidia is a provider of different software. They offer a software called Comparevidia, which is developed for comparing different 3D CAD models. Capvidia is compatible with multiple software, for example Catia, Solidworks and NX. Comparevidia offers five different options for 3D model comparing. (Capvidia, 2021)

First option for comparing models is validating CAD translations. This allows one to load any 3D CAD model and compare the derivative against an authority model. One can compare for example sizes or meshes with it. (Capvidia, 2021)

Second option is DPD compliance. DPD stands for Dynamic Parcel Distribution. (Interparcel, 2021) This is used for example by Boeing, which manufactures aeroplanes. Compliance system allows one to get a validation report in seconds. (Capvidia, 2021)

Third option is semantic PMI comparison. PMI stands for Purchasing Managers' Index. It is "an index of the prevailing direction of economic trends in the manufacturing and service sectors". (Investopedia, 2020) PMI comparison allows to make comparisons between different models' cost structures. (Capvidia, 2021)

Fourth option for comparing models is engineering change management, which lets compare revisions of a model. Changes can be marked as intended or unintended to make sure the revisions don't have anything not belonging to them. (Capvidia, 2021)

Fifth option is automatic customizable reporting. This gives automatic reports of the models in comparison, such as pass/fail reports, CAD geometry, PMI and assembly structure. (Capvidia, 2021)

2.3 Inventor

Inventor is a 3D modeling software made by Autodesk, which may be best known by their 2D drawing program, AutoCAD. Inventor can be used for modeling parts or making assemblies. It is connected to AutoCAD, as all the drawings of Inventor parts and assemblies are made into AutoCAD files. (Autodesk, 2021)

Fusion is a cloud based software platform for 3D modeling, CAD and CAM functions. It is an interface to combine all this functions as one working cell. Fusion is offered by Autodesk, so it is available for Autodesk's programs, such as Inventor. (Autodesk, 2021)

Fusion can be used for observing different models. Shapes and sizes can be compared and optimized. Revisions can be modelled against each other. Fusion also has an option to simulate scenarios. (Autodesk, 2021)

The software does not support other files than Inventor's own files. (Autodesk, 2021)

2.4 NX and Teamcenter

Siemens NX is a 3D modelling software provided by Siemens. NX offers modelling parts and assemblies, simulation and manufacturing solutions. NX also supports the digital twin. (Siemens, 2021) Digital twin is a virtual simulation made out of a machine or production line. It can describe the function of the real machine or production line in real time. (Etteplan, 2021)

Teamcenter is Siemens' Product Lifecycle Management (PLM) software, and can be used with NX. It provides digital mockup and visualization abilities, and can collaborate 2D and 3D data (for example 3D assemblies and 2D drawings). Teamcenter allows one to visualize and investigate data easily. (Siemens, 2021)

Siemens offers a digital mockup software, which allows effective and easy design reviewing. A mockup of an assembly, production line, or even a plant can be made in the mockup software for reviewing. The digital mockup has multi-CAD 3D visualization, an opportunity to report things in the digital mockup, product assembly analysis, even for larger scale, and universal collaboration capabilities. (Siemens, 2021)

View and markup of 2D and 3D data is also available on Siemens. It is possible to markup data throught the data's or product's life cycle. This is mostly a tool for optimizing product lifecycle and reducing IT burden, as it's easy to share 2D and 3D data amongst users. This software also let's users to measure, annotate, compare and mark up data, both 2D and 3D. Teamcenter let's the user to perform these options through light JT format. This makes the work done with view and markup faster. (Siemens, 2021)

JT file is an open CAD file developed by Siemens. It's an open, high-performance, compact, persistent storage format for product data. They are mostly used for product visualization, collaboration and data sharing. It has been accepted as ISO international standard for 3D visualization. (Siemens, 2021)

Siemens has a desktop application for JT, which allows easy access to visualization data. It is distributed as a free software. (Siemens, 2021) This software can be useful for comparing data.

2.5 Ledas

Ledas is a custom software development company, which provides different software options for their customers. They have ready-made software packages as well as they design new software. Ledas is capable of providing 2D and 3D geometric modelling software, which can be in the cloud or as a desktop application. (Ledas, 2021)

Ledas Geometry Comparison (LGC) software is designed for 3D models and point the differences in them. The software shows differences by groups of modified faces, not just by Boolean substraction operators, such as volume. It allows to move parametres, constraints and attributes to be moved from one model to another. LGC also allows translated and rotated models to be compared to each other. (Ledas, 2021)

LGC is integrated with an easy-to-use application programming interface to a pre-existing software. It supports an extensible set of open and proprietary 3D part and CAD formats. It's a cloud based system. LGC works with many different file types, such as parasolids. (Ledas, 2021)

With the Geometry Comparison software, it is possible to perform five different comparison tasks. The first option is to compare revisions from product Data Management (PDM). The software can pinpoint the differences in each revision easily. It can handle large amount of files of the PDM. (Ledas, 2021)

The second option is automated testing of CAD geometry. LGC can work as a geometric comparison engine, and solve the problem of automated testing in any code, which produces geometric data. This data includes for example geometric kernels, data converters, tessellation engines, and modeling libraries. It can be a helpful tool in quality assurance process. (Ledas, 2021)

The third task is to pinpoint differences in 3D models. The software uses tolerance control to separate important differences from small defects. When just a part of a part's face is different, it will highlight it to show that the is a difference. LGC collects all the differences and makes a list out of them to be more accessible and noticeable. (Ledas, 2021)

The fourth option is mapping faces between two 3D models. After a model is modified, it can seem similar to the original model, but some, or all, mapping between faces is missing. This means that the modified model cannot replace the original without removing and re-applying all the constraints first. The software does this on its own, so no removing or re-applying of the constraints is needed. (Ledas, 2021)

The fifth task is parallel computations in the cloud. It is faster and more robust than the usual CAD program comparison functions, because it doesn't rely on Boolean operators, which can consume time, especially if there's many to perform. LGC can perform a 1000 face model in seconds and then delivers a report of it to the user. (Ledas, 2021)

2.6 Solidworks

Solidworks is a software provided by Dassault. It is made for 3D modelling (parts and assemblies) as well as 2D drawings. Solidworks can also be used for manufacturability and cost checks. It has simulation possibilities for stress analysis and has an option to integrated motion analysis tools. (Dassault Systemes, 2021)

Solidworks desktop application can be used with cloud-connected solutions. Solidworks has a cloud platform, which allows sharing desktop models and assemblies to others, as well as access these models through any web browser. (Dassault Systemes, 2021)

Solidworks has a function of comparing in the modelling application. Using this compare command it is possible to compare two models at a same time. These models cannot be put on top of each other, but are in different windows that show the chosen differences in each part. (Dassault Systemes, 2021)

2.7 Catia

Catia is also a product of Dassault. It is used to model 3D models and assemblies and can draw out 2D drawings as well. Catia has possibility to do mechanical engineering with the software. It also has Cross-Discipline Systems Development Process, which integrates the cross-discipline modeling, simulation, verification and business process support. (Dassault Systemes, 2021)

Catia has DMU Space Analysis workbench, which has a feature called Compare Products. Two different version of a model can be compared. The software can compare visually or geometrically two different versions. It highlightes the differences on the screen, which has two windows displaying the two different models. When performing geometrical comparison, it also shows a detailed calculation and enabling the geometry to be saved out as a 3Dmap file. (Thomas & Early, 2021)

3 Specifications for the software

The comparison software will be used by employees of Sandvik. It is utmost important that the software is designed for the employees needs.

Employees of different departments were interviewed to resolve what kind of features the software should have. Five different employees were interviewed.

In this chapter, the interviews are disclosed. Specifications for the software are drawn out based on the interviews, and are summarized at the end of this chapter.

3.1 Interviews

The interviews were conducted via Microsoft Teams. The following questions were asked from each interviewee:

- What is your backround and position at Sandvik?
- Are there any troubles finding a suitable model or assembly for a project?
- Are there any problems comparing parameters between different models or assemblies?
- Do you wish that comparing two different models or assemblies in one software would be possible?
- What kind of properties would you wish the software to have?
- Do you have anything else to say or add?

3.1.1 Finding a suitable model, assembly or parameters for a project

As the goal is to help design a comparing software for different models and assemblies, it was important to know, if there was any troubles finding a suitable model or assembly when starting a new project.

All of the interviewees had been working for some time at Sandvik, some over 10 years. They have an extensive knowledge of the company, people working

in the company, as well as knowledge of the products and the software the company is using. (Sandvik, 2021)

Sandvik uses Siemens NX for modelling and Teamcenter for product data management. Other data than 3D models are in 2D format as drawings or pdf-documents. Projects need different sorts of information, and some of the information is only available in pdf-documents. For example design recommendations for underground tunnel dimensions is only available in pdf. These design recommendations are used, when deciding the size of the machinery. (Sandvik, 2021)

Parameters for different projects can be found on designing recommendations or guides as well as calculated for each project depending on the client and where the machinery is used. (Sandvik, 2021)

There has been no problems in finding suitable parameters or models for a project. (Sandvik, 2021) This might be due to the fact that people working at Sandvik are knowledgeable of the products and are able to acquire information of the right parameters and models if needed.

Finding suitable models in not a problem for the employees per se, but mentions of easier demonstration of models, for example for clientele or less knowledgeable people working on the projects, were made during the interviews. (Sandvik, 2021)

3.1.2 Comparing

Since the software is meant to be a comparing software, questions of comparing were raised.

Most of the interviewees weren’t opposed of the idea of using a specific software to compare different products. Many wishes of possibilities to compare Sandvik’s own products to models of competetitors were made. (Sandvik, 2021) Comparison with competitor’s products are dependent on the availability of the products on public distribution.

The possibility to compare different products with the client's tunnel size on different projects was also wished. This is particularly an interesting opportunity to show the clientele what kind of products Sandvik would have to offer them. An opportunity to clarify things for the clients via the comparison software lies especially in the turn radius of the machines, particularly when using AutoMine automation. The inspection of the turn radii and comparing which machines would fit would also be beneficial for the designing team. (Sandvik, 2021)

Wishes for comparing different revisions of the models were not made. (Sandvik, 2021)

3.1.3 Hopes for the software

Even if some of the interviewees had not tought about a comparison software and using it during projects, the idea of the software was well received.

The interviewees were asked what kind of hopes they had for the software. Most said that they'd wish the software was easy and light to use. (Sandvik, 2021) Many modelling software are heavy to use and take loads of time to process, start and open models. When performing changes these programs may freeze or be slow. This is also connected to the performance of the computer used, but sometimes when handling bigger models, the program itself cannot perform in an expected way.

Ease of use will also cater to current and future users of the software. If the software is hard to use, it will not be used and utilized. The future users could also benefit from the software's comparing abilities when they aren't yet familiar with all of the products and services Sandvik has to offer.

Many wished multiple times to have the opportunity to compare the tunnel sizes versus different machine models. Also use of this software in displaying products to customers was a thought brought up multiple times. (Sandvik, 2021)

3.2 Software properties

Concerning the interviews, properties for the software were condisered.

Easy to use: This helps people to encage with the software and also keep using it, as well as utilize it.

Light to use: Freezing, crashing or slow software makes the use more arduous. The lighter the software, the more people are willing to interact with the software.

Comparison properties: Comparison between different models should be included in the software. Revision comparison is not particularly needed, but may be included as well.

Placing products in the tunnels: Comparing product sizes in the models of the tunnels should be included in the software as well. This helps with choosing the right models and showing different product options for the clients.

4 Software selection

In this chapter all of the comparing software introduced in chapter two are looked over and compared to the specifications set in chapter three.

4.1 Capvidia

Capvidia is marketed as easy to use. (Capvidia, 2021) It is a not similar to NX, which is used at Sandvik, but it seems simple enough to use. Capvidia has quite simple commands and it has a clear layout. Models would have to be downloaded into the software, which makes it more arduous to use. It supports NX and parasolid files, so no conversion has to be done. No conversion lessens the workload when starting the comparison.

Since Capvidia is an desktop application, it needs enough power from the computer to run efficiently. It is said to be fast to use, so it should be light enough to not freeze or crash while using. (Capvidia, 2021)

Capvidia offers model comparison between two different models. This allows the comparison between different products, not just their revisions. The software shows clearly the differences in the models. The models cannot be layed on top each other, though. (Capvidia, 2021) Figure 5 shows how the differences are shown in Capvidia.

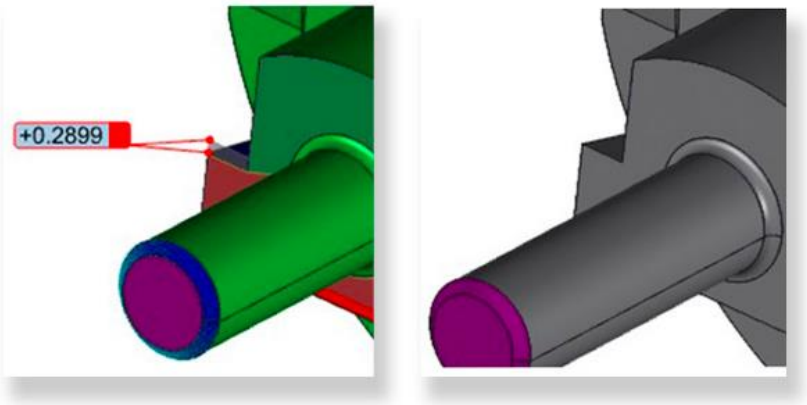

Figure 5 Differences shown in Capvidia (Capvidia, 2021)

Since the models cannot be put on top of each other, modelling products inside of a tunnel is not possible. Capvidia also doesn't have an ability to simulate processes, so simulating the movement of the products is also impossible. (Capvidia, 2021)

4.2 Inventor

Inventor is a part of AutoDesk's products and can be used together with AutoCAD. Sandvik uses AutoCAD with their projects. (Sandvik, 2021) This means that Inventor can be easily acquired to the company. Inventor is also very similar to use than AutoCAD, so it is relatively easy to use, if the users has any experience in using AutoCAD. Inventor doesn't support parasolid or NX files, which makes the setup to use the software complicated.

Inventor is relatively light to use, but it is a desktop software, which needs space and performance out of the computer using it. Inventor doesn't get any support after 2021, so it may be quickly outdated. (Inventor, 2020)

Comparison wise it has the Fusion software, which allows geometry and revision comparison. This means that different models may be compared with each other. Fusion also offers simulation possibilities.

It is not possible to do tunnel comparison, if it's not done through Inventor. That can turn out to be too tedious and time consuming.

4.3 NX and Teamcenter

NX and Teamcenter are used at Sandvik. This would make the use easy, since it is used already and employees know how the software works. The infrastructure is also existing and computers can run the software. It would also probably be the cheapest option, because the licenses of NX already are used and available. More licences might be needed for different abilities, but all in all it would be one of the less expensive choices in this study.

Teamcenter has possibilities to make mockups of different structures and machines digitally. This allows machines to be modelled inside the tunnel structures, as well as studying the turn radii of the machines, since there is a possibility to visualize different movements. This can be done in bigger scale as well.

Comparing different models is also possible through Teamcenter. It has the option to layer them and check geometry, revisions or size.

4.4 Ledas

Ledas can be customized to fit different needs, so if all of the wanted specifications are not already available in its comparison software, they can be customized into the software. It already supports many different file types, like parasolids.

The software can be used as cloud based or desktop app. It is quite easy and light to use, if one believes their advertisement. (Ledas, 2021)

Ledas allows comparison between different models in geometry and size. It doesn’t have the opportunity to simulate or visualize deeper, for example the movement of the machines, but it does mange to have tunnel sizes and machines compared together.

An example of Ledas’ comparison view can be seen in Figure 6.

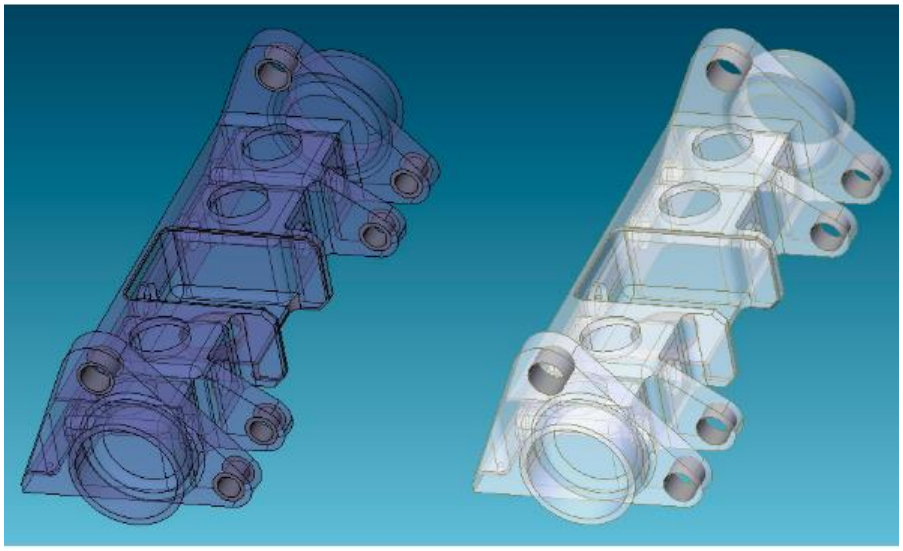

Figure 6 Example of Ledas' comparison (Ledas, 2021)

4.5 Solidworks

Solidworks is relatively simple to use. It supports parasolid files and Solidwork's own files, but not others. Solidworks works relatively well when performing different functions.

The software does not have the option to compare two different models at the same time, just revisions of the same model. It also open the models in two different windows, so if it would be possible to select two models, they cannot be put on top of each other.

Comparing the machines against tunnels is also impossible.

4.6 Catia

Catia functions basically the same way than Solidworks, when it comes to comparing models. It doesn't support other than parasolid and Catia's own files, which makes setup in some ways more difficult – but only if there is no parasolid models of the compared models. Catia is a fairly large software and needs a lot of performance. It it also fairly expensive. (Dassault Systemes, 2021)

Catia has the option to compare revisions. It opens the revisions in two different windows, so there is no chance of putting the models on top of each other and comparing their differences that way.

The software doesn’t allow visualiziation of the models. Thus, it is not possible to compare the machines to the insides of the tunnels.

5 Summary

In this chapter, options for the software are discussed, and the most suitable software is chosen. To help choose the most suitable software, weighted scoring method is used.

Weighted scoring method is a priorization, which uses numerical scoring to rank strategic initiatives against selected benefit and cost gategories. It is helpful for product teams looking for objective prioritization techniques. (Product Plan, 2021)

In table 2, the presented software are ranked using weighted scoring method.

Table 2 Software ranked with weighted scoring method

Software	Ease of use (max. 20)	Light to use (max. 10)	Comparing (max. 40)	Tunnel comparing (max. 30)	Total, max. 100
NX	20	10	40	25	95
Ledas	20	10	40	20	90
Capvidia	20	10	30	0	60
Inventor	10	10	15	0	35
Catia	10	5	10	0	25
Solidworks	10	10	10	0	30

The most suitable software is NX combined with Teamcenter. It offers all of the desired properties. It will also be easy to implement to the company, since Sandvik already uses NX and Teamcenter. Teamcenter can also help visualize the projects better and can be used as a tool to demonstrate the products and their functions to customer better. Implementing more licenses and/or parts to NX would also be the least expensive option.

The second most suitable software is Ledas. It has almost everything, which was desired from the program, and it has the option to be optimized to fit all the needs. This comes with a price tag though. That makes Ledas more expensive than Teamcenter. It also is a new software and needs more induction and training than using Teamcenter.

The third most suitable software is Capvidia. The software lacks some qualities that Teamcenter and Ledas have. It is not customizable to the company's needs. It supports many different files, but file support properties are perhaps the software's best qualities, which leaves much more to be desired.

The third least suitable software is Inventor. Inventor will lack support in the future, and it also doesn't offer all the wanted properties. Inventor's comparison options are mostly for revision comparing work, and it doesn't support many file types. It is also a new software that needs training and implementing to be a good asset in projects.

The second least suitable and the least suitable both fall into the same category, which is the lack of properties in comparison. Solidworks and Catia are both only designed to do revision comparison. This excludes a lot of desired properties out. These software are also new to the company, which makes tedious to start working with. What makes Catia the least suitable, is its price. Catia's licences are fairly expensive and to use them only for comparison, might not be wise.

A new software, designed just for Sandvik's purpose in comparison, is also an option. It would be a time consuming and fairly expensive option though. Designing and coding a new software from scratch takes time and money. there would be investments involved before even getting the software. On top of that, using a brand new software also need training of the staff and implementing to fit the company's ways and other software. If a new software would be chosen, the software should be very useful and widely used within the company, as well as bring extra income to the company.

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