Analysis for a possible implementation of the Create Reduced Part method in the VAN Body in White department

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Preface

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List of Abbreviations

3DM	3D-Master
BIW	Body in White
EDM	Engineering Data Management

1 Introduction

In recent year the amount and size of data are increased at Daimler AG. This is due to the software switch from CATIA to Siemens NX, both are CAD software programs. Furthermore, parts are often reused and altered which increased the variant parts a lot. This combined with the trend to store more and more information into the CAD model makes the growth of CAD files certain. To handle this growth sufficiently the passenger car department developed a new method, named Create Reduced Part (CRP). The research and development VAN IT Engineering department is interested if they will gain something out of the Create Reduced Part method when they decide to switch. The VAN Body in White department is working with another method currently, named 3D-Master. This is why those two methods will be compared in the thesis. Body in White (BIW) is a term for the base construction of a vehicle. Figure 2 shows an example of a BIW. The base construction allows all other parts to be attached to it such as the engine. Furthermore, it is responsible to absorb the force of impact when a collision occurs. Parts for the BIW process are differently manufactured. After the manufacturing of all parts for the BIW are assembled and welded together in the body shop. The end product of this process is called Body in White. This process takes place in front of the painting shop (F., 2016). The powertrain is assembled parallel. It is called the marriage when both the powertrain and the body come together. Then the interior is assembled. Afterwards, the car is ready for testing and sales. Figure 1 shows the general overview of plant process.

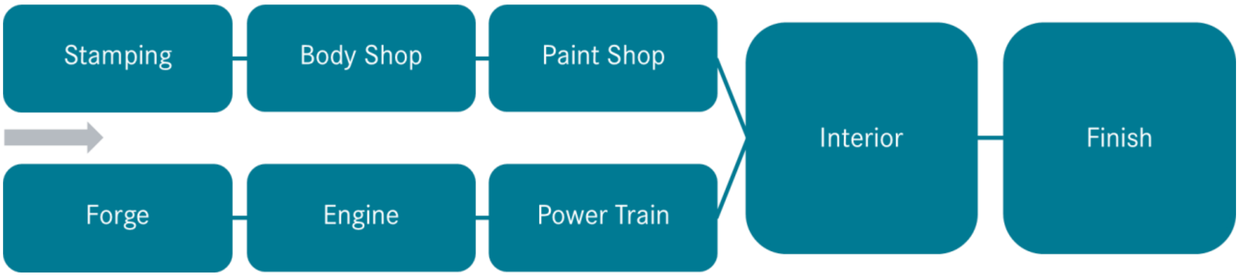


Figure 1: Car production process overview

Figure 2: Side view of a Body in White structure of a Mercedes-Benz Vito

Thesis process

The thesis process will begin with the explanation of stakeholders. Then the analysis will explain the used software and methods for the thesis. Afterwards the thesis is conducted. This section consists out of multiple chapters. At the beginning of this chapter this process is elaborated. The outcomes of the executions are described in the Result and Comparison chapters. The thesis will end with a conclusion and recommendation. Figure 3 shows the process of the thesis. On the left the process is stated with a short description on the right. In the right corner the related chapters can be found.

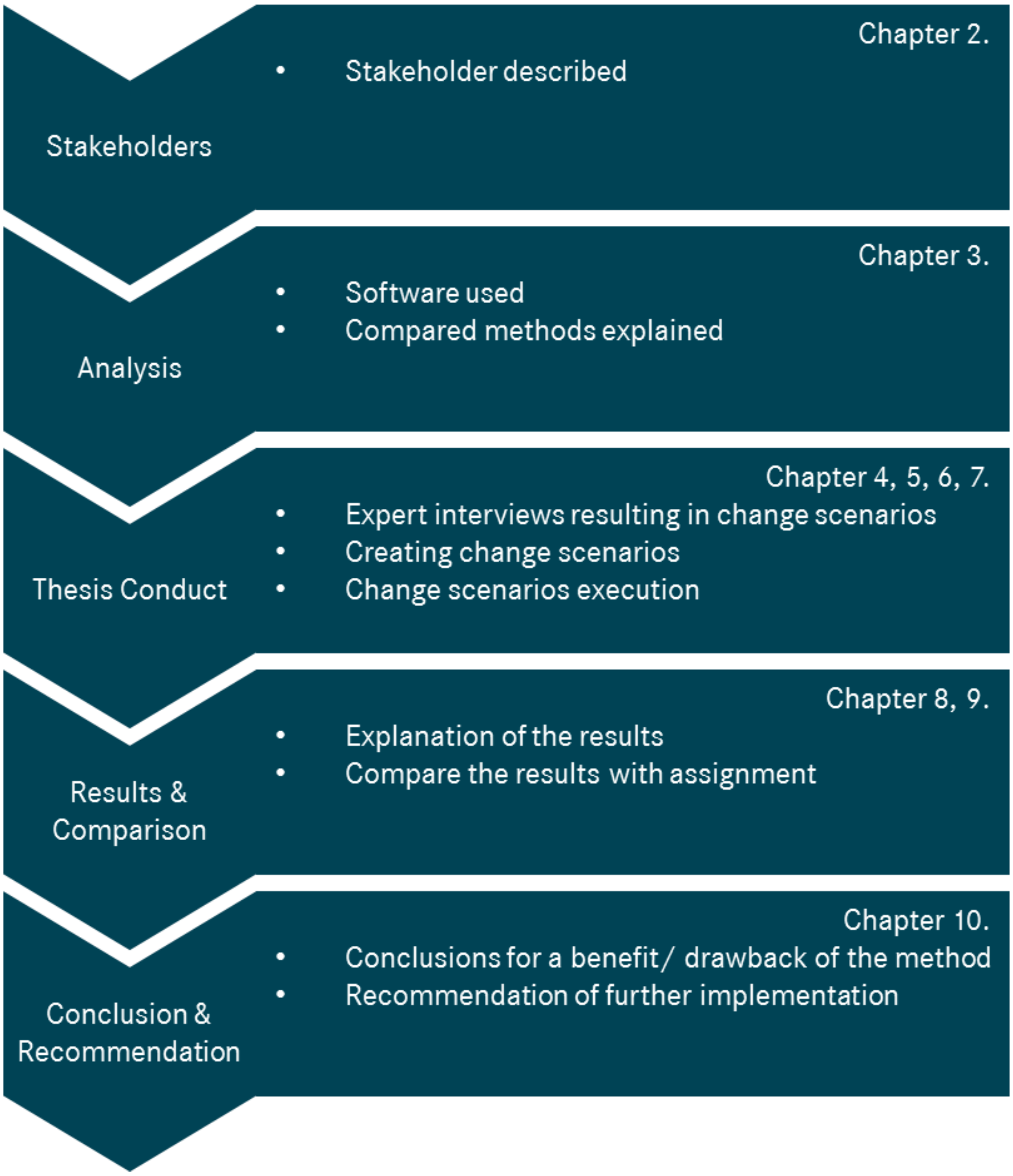


Figure 3: Thesis process overview

2 Stakeholders

This thesis is conducted for Daimler AG. Stakeholders are different parties which are or could be influenced when the new method is implemented. First of all the company Daimler AG will be described in section 2.1. It is a company with multiple departments. Not all departments are relevant to describe. Therefore, VAN IT Engineering in section 2.1.1., VAN BIW in section 2.1.2. and the Car BIW department in section 2.1.3 of the company will be more elaborated in detail. Furthermore, out sourced processes are managed by suppliers. Those are also described while their processes are influenced when Daimler AG implements a change.

2.1 Daimler AG

Daimler AG is originally a German car manufacturer and is present in nations worldwide. Daimler operates in two different sectors namely transportation, finance. The company exists out of a variety of brands. The most known are their personal transportation vehicles which consist out of Mercedes-Benz, AMG and Smart. They produce other vehicles such as: vans, busses and trucks. All have their own departments, with individual processes and requirements. This is just a small part of their portfolio. Furthermore, Daimler AG exists out of other transportation companies such as Freightliner, Fuso and Western Star. The financial sector consists out of Mercedes-Benz Bank, Mercedes-Benz Financial Services and Daimler Truck Financial. Their brand portfolio is shown in figure 6.

Figure 4: Daimler brand portfolio (Daimler AG, 2016)

Its headquarters is placed in Stuttgart, Untertürkheim. The company is always looking ahead for new challenges and innovation. Current challenges are varying between the vehicle types. Though, a few main problems are concerning all vehicles, such as development time, variant management and data security. Through innovation it is their goal is to not lose flexibility and maintain standards. Solving problems with innovation is rooted since they invented the first automobile. Since the beginning of the automobile the company is growing. The size of the company is shown in figure 5.

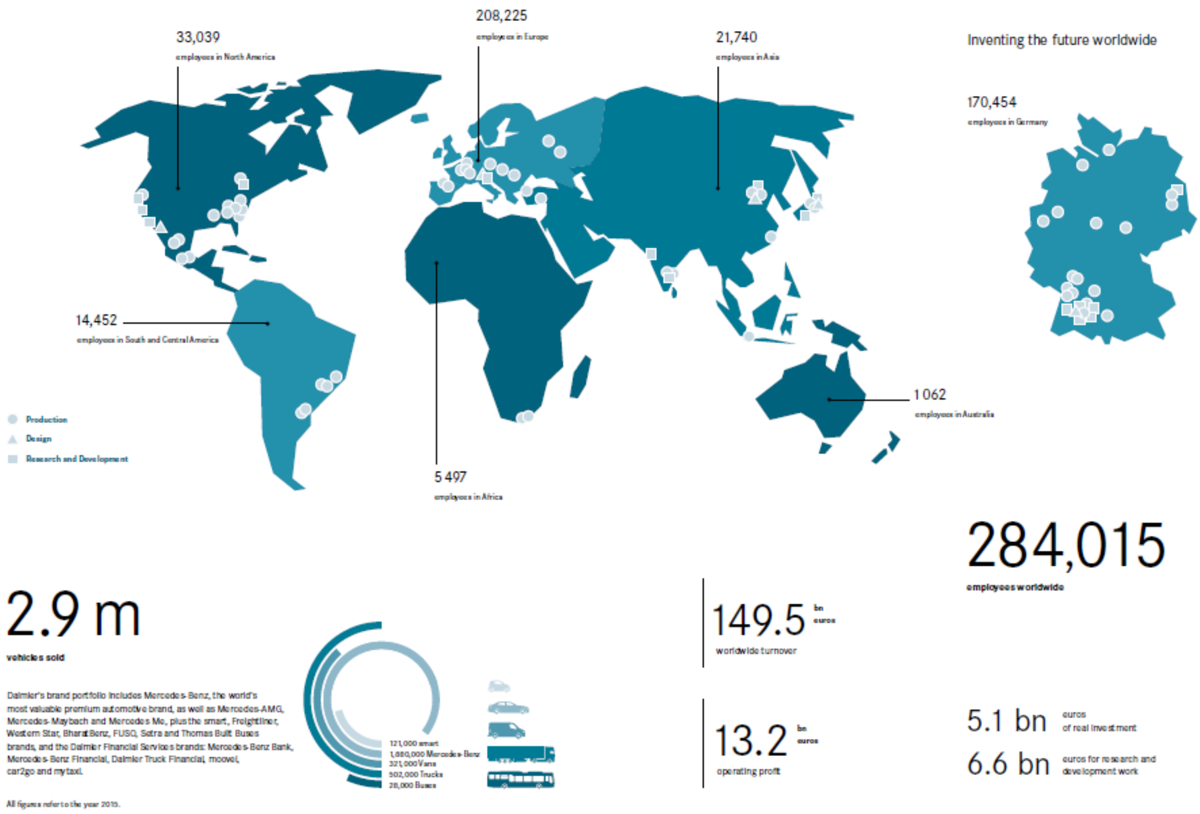


Figure 5: General information of Daimler AG

2.1.1 VAN IT Engineering Department

This thesis is conducted for the Van IT Engineering department. They are responsible for software solution. This department communicates with the VAN BIW department and the software developers. The VAN BIW department makes notice of a problem to VAN IT Engineering. A solution to this problem is developed by the VAN IT Engineering department. The solution is send to the software developers. Those are producing the solution into a software tool. An overview of the communication is shown in figure 6.

Figure 6: VAN IT Engineering overview

2.1.2 VAN BIW Department

The VAN BIW department is responsible for the Body in White of the Mercedes-Benz VAN portfolio, such as Vito and V-class. The result of the thesis could have the most influence on their systems, while their using Siemens NX software. This software is elaborated later. This makes the VAN BIW the biggest stakeholder. At the moment their having problems that the variety of parts is continuously growing. This is due to two reasons. The first is the wish of costumers to personalise and customise the vehicles. The second is known as global market, which means not every country has the same requirements and licensing. For example, the USA has other restrictions than Europe, which has other restrictions as China. Therefore, the VAN department reuses parts by altering them or developing new parts. The overall challenge is to make every variant part fit in the whole assembly. Furthermore, data security is a growing topic. The concurrency is considerable and is not frightened to use data if obtained. This was for long underestimated.

2.1.3 Car BIW Department

Car department is an indirect stakeholder while they are already using the new method, named Create Reduced Part method. They are taken into account with a user interview at the car department Sindelfingen. Their knowledge and expertise on the topic could help to create a better overview of the implementation. It will also gain insights about reasons why they implemented it, such as advantages and disadvantages and all efforts of the method.

2.2 Suppliers

Suppliers are any company which are supplying Daimler with parts, analysis, material, etc. Suppliers can be located all over the world. They use Daimler engineering data for, FEM analyses or part manufacturing. All suppliers are obligated to use the same software packages as Daimler AG. This is obligated while the data transition is not delayed nor transformed. Therefore, Stakeholder will be influenced if Daimler makes a change in their software structure.

3 Analysis

This chapter gives an explanation of the software and methods used in the thesis. First the software will be explained in detail. It will show the data file organization. This will be used to setup the test environment. Furthermore, CAD methods are described. This will give information about the engineering CAD modeling and the methods to make CAD part usable for manufacturing. These methods include the 3D-Master and Create Reduced Part methods.

3.1 Software

This thesis is depending on several software packages. The Engineering Data Management (EDM) software is one of them. The EDM software is described in section 3.1.1. The EDM software has a link with the engineering software Siemens NX. Siemens NX will be elaborated in 3.1.2. Figure 7 shows how the software systems are connected.

3.1.1 Engineering Data Management System

The Engineering Data Management (EDM) system is used as the central database for the development of all vehicles. It functions as organizer and browsing machine for engineering data, such as all CAD models. The linking between the software programs is shown in figure 7. The system makes use of a hierarchical structure, which is based on the Bill of Material (BOM). This is the list with all part needed to build the intended vehicle.

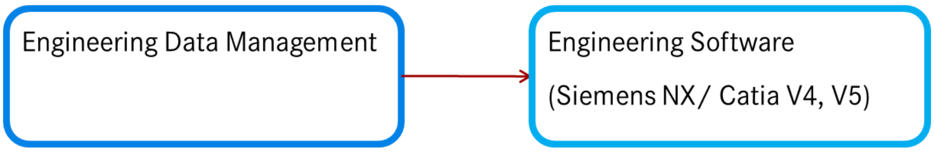


Figure 7: Software connection overview

3.1.2 Engineering software

The current used engineering software package by Daimler is Siemens NX. The software has changed in the recent past. Daimler announced in 2010 to switch from CATIA V5 to Siemens NX. It involved a change in the data structure core of the enterprise. It is a huge risk if the transition would be resulting in a complete disaster. The damage would be severe for the company. Nonetheless, this risk is taken mainly due to compatibility with the EDM software. The transition took time and was fully implemented April 2015.

Siemens NX

NX is the main CAD software used at Daimler. It can be used to construct and model parts. The main difference with other CAD software is that NX makes no difference in solid and surface modeling. Siemens NX is one of the leading players in the CAD software field. Figure 8 shows the Siemens NX interface.

Flexibility

NX has more flexibility to add and create add-ons, which are special functions. This was another advantage to choose for Siemens NX instead of CATIA. Daimler has developed special add-ons for NX. Examples of created add-ons consist out of 3D-master and Create Reduced Part method. These methods are elaborated further in the chapter: 3.2.1 3D Master and 3.2.2 Create Reduced Part.

Increased file size

It became clear the file sizes of parts increased during the transition process from CATIA to Siemens NX. This resulted into a longer loading time and long update/alteration time in NX. The reason why the file sized increased has a direct connection with the feature tree. The feature tree of CATIA and NX differ. NX makes use of a feature tree where every sub-result is created at the step of the intended geometry. This means the geometries are saved twice, once in the feature tree and once as a sub-result.

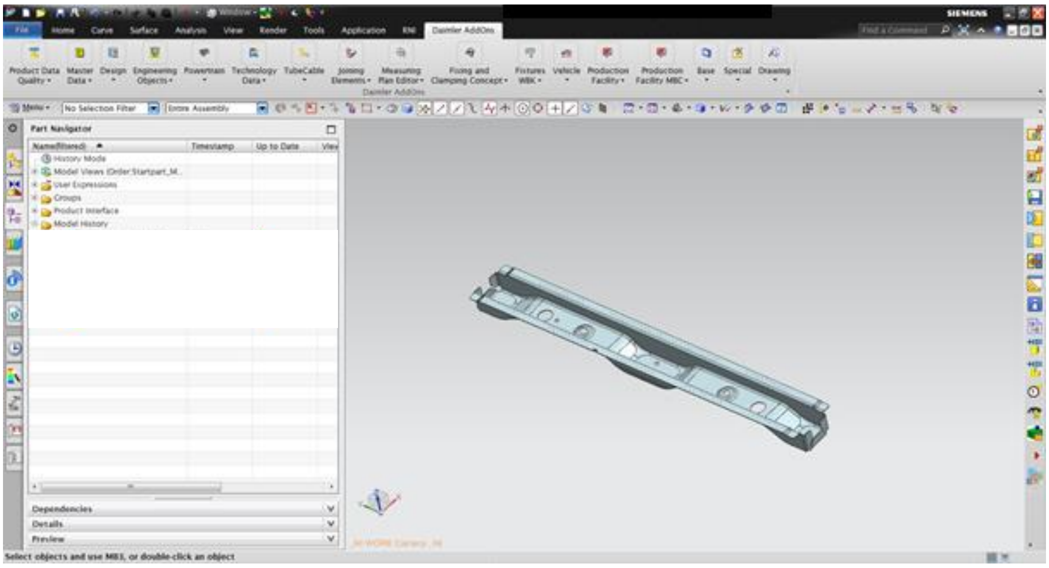


Figure 8: Interface Siemens NX

3.2 CAD Methods

CAD method differs from company to company. It depends on the industry the company is operating. The method to make such parts is depending on the material and the production method. An injection moulding company works with plastic parts and has therefore, a whole other CAD modeling approach in comparison to Daimler VAN BIW department while they are working with pressed metal parts. Therefore, the CAD modeling structure is very specific at Daimler. At Daimler every part of a vehicle has a CAD model. The use of CAD has the advantage that all the engineering requirements are transferred to a digital prototype. Those can be used for several tests such as, finite element method. The model needs to be changed if any engineering requirement is altered. CAD models have the advantage to be modified rapidly. Therefore, the CAD models are constructed according to a specific guide to keep the flexibility to adjust the part for e.g. engineering or manufacturing. The guide provides every part with the same structure and modeling consistency. It makes the part organized and readable for every employer in every department. The design of a CAD part begins with a Daimler start part in Siemens NX. The modeling methods of CAD parts are explained in chapters 3.2.1 and 3.2.3. The methods will be explained according to the pressed production process. Examples of pressed parts exist out of doors and hoods. These methods will be compared with each other in the thesis.

3.2.1 3D-Master

3D-Master is the CAD documentation method used at VAN BIW. It holds all the parametric geometry data with manufacturing conditions and process documentation (Daimler AG, 2016). At the moment the CAD part holds every geometry features and bodies for the manufacturing process. The different manufacturing states are shown in figure 9. The steps are organized and numbered in the order of the production process. It begins with the rough part. It is cut into the right form after that part is manufactured. This is indicated in step two and three. Afterwards the holes are cut out of the part at step four: All these steps result into the final part, presented at step five and six. In order to manufacture the CAD model, Product Manufacturing Information (PMI) is required (Daimler AG, 2016).

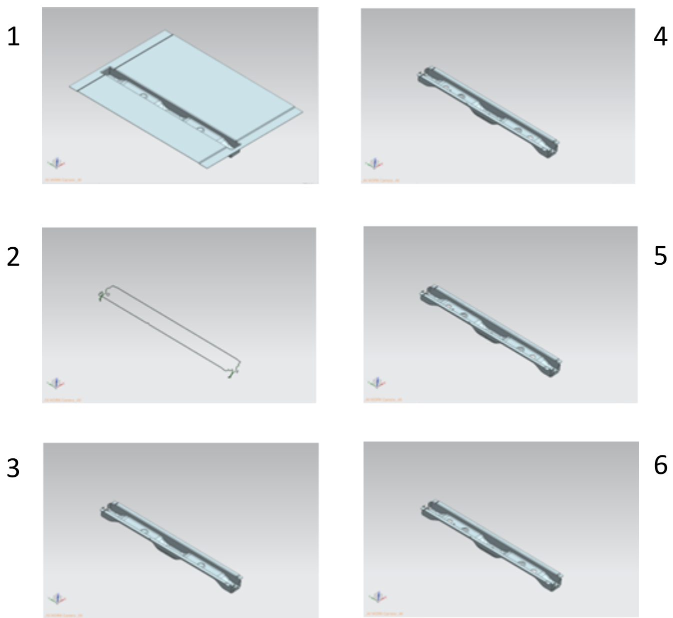


Figure 9: 3D-Master geometry process overview

3.2.2 Product Manufacturing Information

Product Manufacturing Information is information which ensures the produced part will fit in an assembly and is usable in the manufactured product. Theoretically the part should be precisely produced as modeled in any CAD software. Unfortunately, deviation of production machine processes makes the part slightly differ from the intended model. Therefore, a permission able deviation is documented at which the part is considered to still fit into the whole assembly. The fast majority of manufacturers are making use of technical drawings. Technical drawings are used for the production process. Therefore, the drawing consists out of parametric data, tolerances and material at different sections and views. Documenting this precisely is very important. Otherwise the part is interpreted wrong which could ultimately result into an error in the production process (Daimler AG, 2016).

Product Manufacturing Information

The CAD part itself already exists out of parametric information. It is inefficient to make technical drawings from the CAD part. The geometry and dimensions are already present in the CAD model. Therefore, they use the CAD model and implement all lacking information. Implementing the information reduces time to make the part ready for manufacturing and makes technical drawing redundant. Furthermore, it enhances the different user to interpret the tolerances correctly. PMI is a special tool in the CAD modeling software Siemens NX. PMI's are added to the CAD model after the modeling is finished. They exist out of the regular used tolerance symbols also used in technical drawings. The symbols are specified per characteristic such as holes, lines, surfaces, points, etc. An example of a CAD part with PMI is shown in Figure 10. PMI can be recognized by the circle, rectangle and note connected with the geometry.

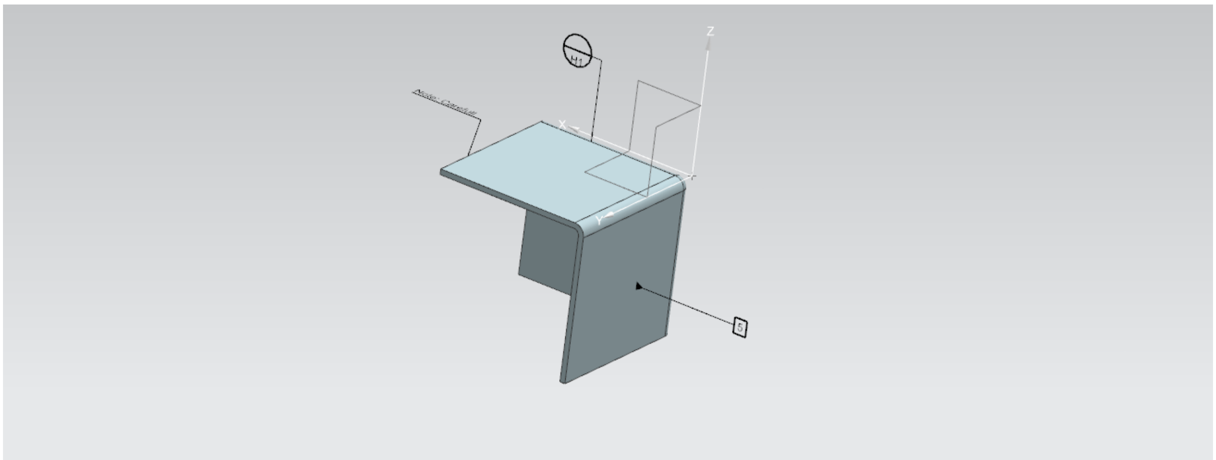


Figure 10: Geometry with added PMI's

3.2.3 Create Reduced Part

It is another possibility for documentation of the part. This method is used and developed by the car department. The method exists out of a template and a reduced form of that part, named the component part. Component part means all native features are not present anymore. It exists only out of bodies. This means all features will be converted into a fixed geometry that cannot be changed. Therefore, the CAD parts information is reduced. The PMI's are added on the component CAD geometry. Furthermore, the component part has a link to the original template part. The link is established in order to update the component part. The tool to do this needs to be executed after every alteration. The flowchart of the creation of a CRP is shown in Figure 11.

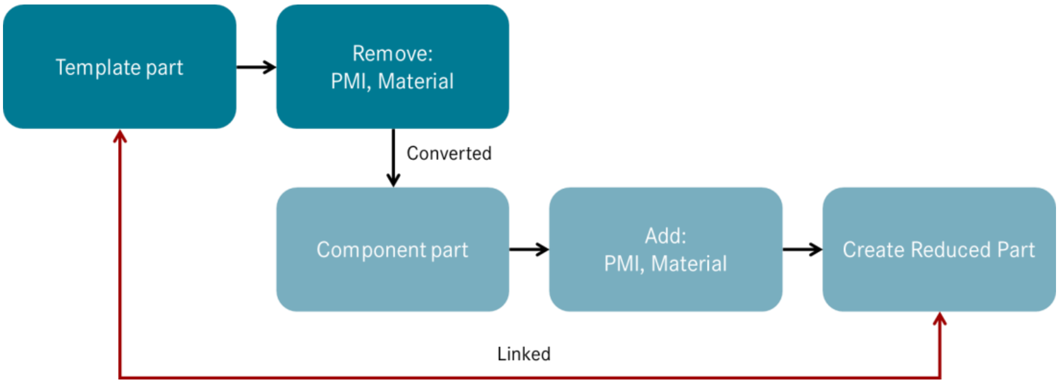


Figure 11: Template part to Create Reduced Part process

3.2.4 Difference 3D-Master/ Create reduced Part

The 3D-Master model includes all information. This makes the model hard to handle when it comes to adjusting or altering the models information. It is 'Updated-to-end' when a change is made. These changes could exist out of geometry information, PMI or material features. It means that all features and additional information are updated as well. This takes time, especially when small changes are made on complex part because small changes do not have much connection with other features within that part.

The Create Reduced Part method has another approach to handle information. It consists out of fixed geometry when the component is created. This also reduces the data size of the model. After the creation the material, help geometry for tolerances and tolerances are added.

4 Thesis Process

The full process of the thesis exists out of several steps. They are divided over chapters 5, 6, 7, 8, 9 and 10. First the assignment will be elaborated in chapter 4.1 . The full approach to conduct the thesis is described afterwards.

4.1 Assignment

The assignment is to research if the Create Reduced Part method making a substantial difference compared with the current 3D-Master method, currently used method at VAN BIW. The substantial difference will be based on conversion to CRP, time spend to implementing change in parts and data size reduction. Those are stated at below. Furthermore, influences which come with the new method will be taken into account such as the EDM structure, Stakeholders and further processes.

- Time spent to:
  - ➢ Conversion to Create Reduced Part
  - ➢ Implement changes
- Data size reduction;
  - ➢ Reduction of size in the part used to release for manufacturing.
- Consequences for;
  - ➢ EDM system structure
  - ➢ Stakeholders

4.2 Approach

The first step to execute the thesis was to know the ins and outs of the required software for the tests. Also the current state of VAN BIW department was important. This was explained in the previous chapters such as the required software exists out of the EDM software and Siemens NX. Then the theory behind the 3D-Master and Create Reduced Parts are learned. Afterwards, the complete tests to compare the 3DM and CRP method can be conducted. The complete steps to approach the thesis are shortly described in Figure 12. Also the chapter number can be found in the right corner.

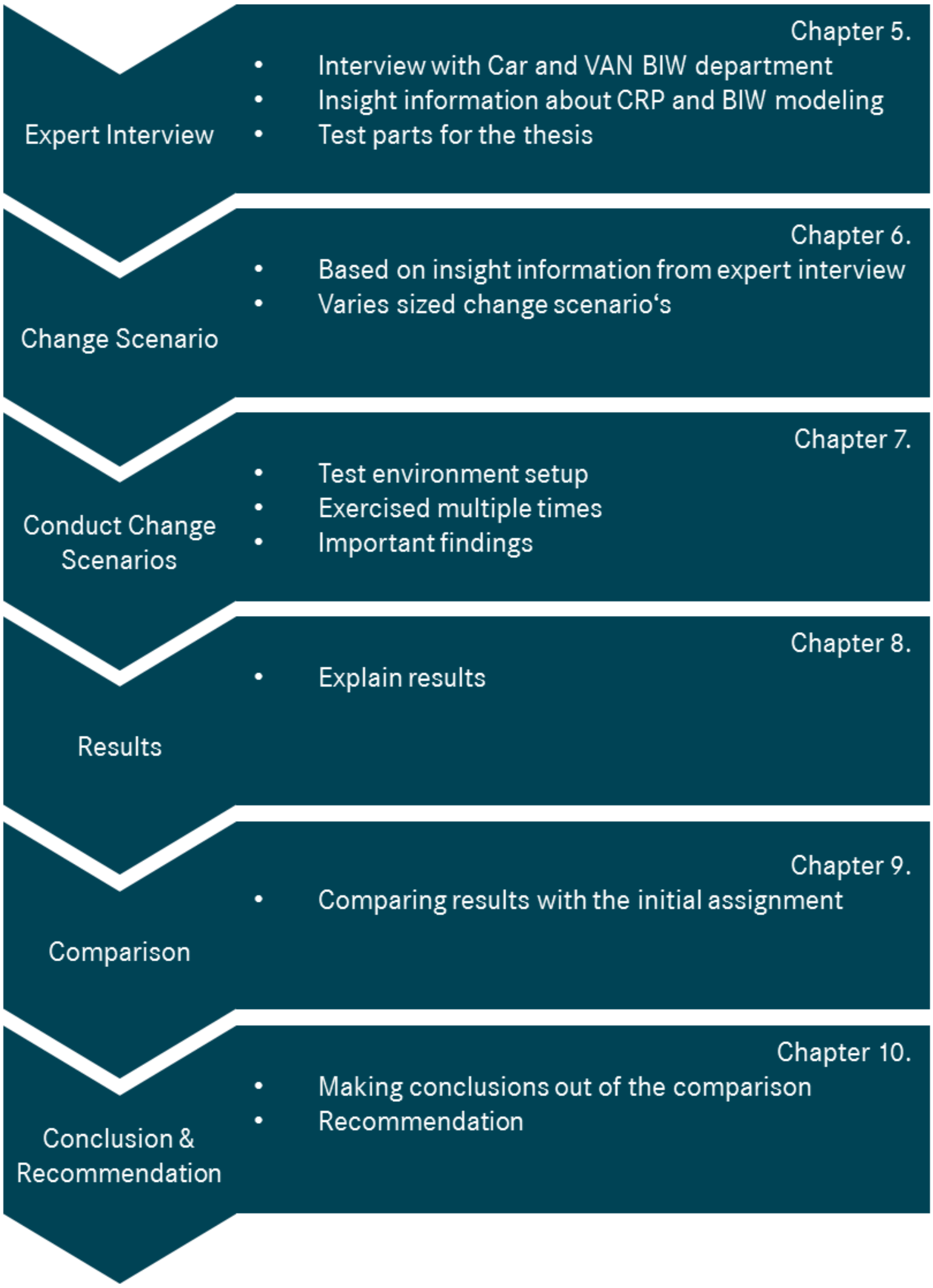


Figure 12: Process of the conduction of the thesis

5 Expert Interview

The expert interview was conducted in order to get insights of the Create Reduced Part and to setup the test environment. Two interviews were held with the car department and the VAN BIW department. The interview with the car department was conducted to get more insight on CRP method. They explained that the reasons to implementation of the Create Reduced Part methods could be different from the reasons of the VAN department because the situations in the car department in comparison with the VAN department are not similar. Therefore, the differences are also researched. The reasons for the implementation and differences can be found at the end of this chapter. Furthermore, the CRP method is more than just converting parts. A parallel hierarchy structure needs to be designed and created in the EDM structure. This structure is required and it is considered the most effort while the naming of each object must be agreed and understood. The parallel structure must be created while the template parts are linked with each other. Figure 13 shows an example of the parallel structure. The component parts are linked with the BOM data. This results in the separation between CAD design data and BOM data. The CAD design data is available for design engineers and internal processes. Though, internal processes do not require the CAD design data. The component part data is available for suppliers and can be used by further processes.

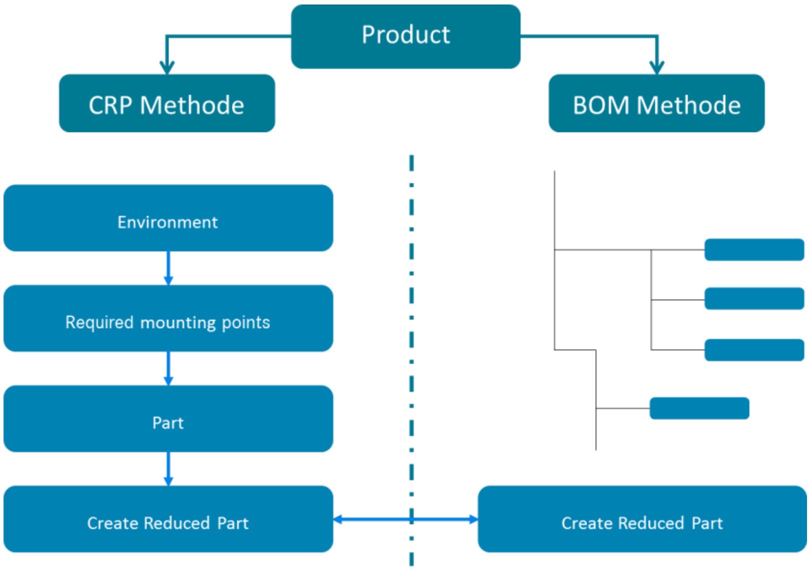


Figure 13: Parallel documentation structures for the Create Reduced Part method

Nonetheless, several test needs to be conducted in order to know if the creation of the parallel structure is worth the effort. Therefore, an interview with a design engineering expert of VAN BIW was asked for a test part to conduct the tests with. He was also asked for common changes in the CAD parts. Change scenarios were made out of this interview.

Different reasons for the car department to switch to CRP method:

- Modular design
- Variant construction
- Less data size for BOM

Differences Car department and VAN department:

Car department

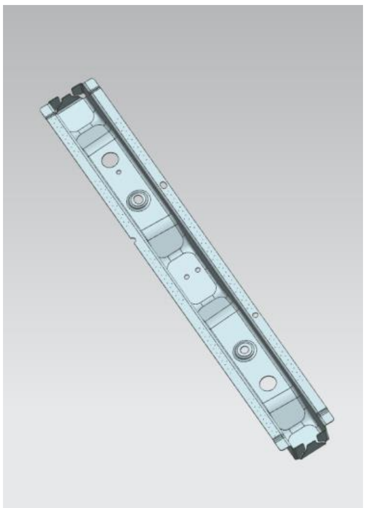
- Many departments
- NX parts
- Template and BOM structure

VAN department

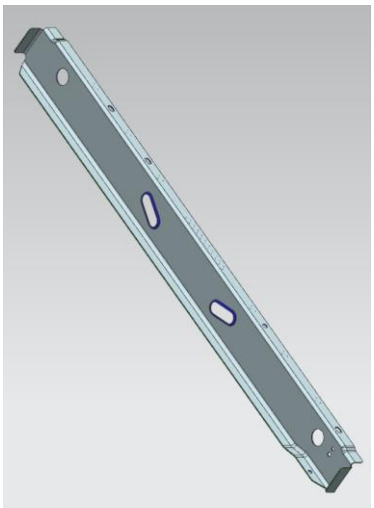
- One department
- V4,V5, NX parts
- BOM structure

5.1 Test Parts

The test part needed to fulfil certain requirements. First of all the test parts needed to be a Siemens NX part with construction features. The test part required to have construction data of average complexity. Also the part required to have around 10 – 20 PMI's. This way the test part has the flexibility to change geometry structure. Also the changes of the PMI position can be validated. These requirements were send to a design engineering expert. The part numbers are substituted for a name. This makes it easier to differentiate them. The parts which met the requirement for the thesis are two crossbeams. Both crossbeams differ slightly from each other. Figure 14 shows both crossbeams with their naming in the thesis.



Part Bowl



Part Foil

Figure 14: Test parts

6 Change Scenarios

Change scenarios are created for the crossbeam test parts. The insights acquired with the design engineer expert interview will be used to create fitting change scenarios for both parts. The test parts have much in common. Therefore, the different steps included in the change scenarios are identical. Though, the execution of one step can be slightly adapted to the specific test part. The change scenarios are divided into three different complexities: Complex, Medium and Simple. The scenarios are created according to associated changes, the amount of changes, complexity of changes and consequences for the component part.

Complex exists out of three associated changes and consequences for component part.

- Extend mid surface/ adding a cavity
- Move one hole
- New mounting point

Medium exists of creating changes in geometry.

- Add multiple reinforcement geometries

Simple change scenario exists out of a deleted geometry and one change.

- Remove little knobs
- Extend side

All scenarios will be exercised in front of the tests. The exercises are meant to gain experience with the parts and change scenarios. This way the test results can be better compared with the time a design engineer expert would spend on the change scenarios. Furthermore, the change scenarios will be tested with both the CRP method and the 3DM method. This means all change scenarios will be conducted twice. First the change scenarios and different including changes will be described shortly. The start and end result are shown at the end of the descriptions.

6.1 Part Bowl

The change scenarios for part Bowl are described with a small description. The change scenarios are described in the following order: Complex, Medium Complex and Simple Complex. The descriptions will have a link with the models in Figure 15. Furthermore, the original model is shown in order to see the differences.

Complex

The complex change scenario is shown in the left corner of Figure 15. The complex change scenario of part exists out of:

- Extend mid surface

The middle surface of the part will be extended. This feature is one of the first features in the feature tree. It makes it a good option to alter while the total part will be different in the calculation. It is also helpful for the latest alteration. New mounting points can be added in the extended surface.

- Move one hole

This hole will be used in production as a fix point for other parts. The hole will be moved outwards. This hole has PMI's. The PMI's are located at the origin of the part. Therefore, it will also be tested if the PMI's are moving to the new place.

- New mounting point

This step will require new mounting points in the middle of the part. Adding a new mounting point require a new origin. The newly placed origins need to be placed also in the Create Reduced Part (Daimler AG, 2016).

Medium Complex

The medium complex change scenario is shown in the lower right corner of Figure 15. The medium complex change scenario of part exists out of:

- Add multiple reinforcement geometries

The medium scenario exists out of adding multiple reinforcement geometries. The part is symmetric through the middle. Therefore, two reinforcement geometries are added on one side. The two reinforcements will be mirrored. The alterations are reinforcing the stiffness of the part. This scenario shows that altering the overall geometry will function.

Simple Complex

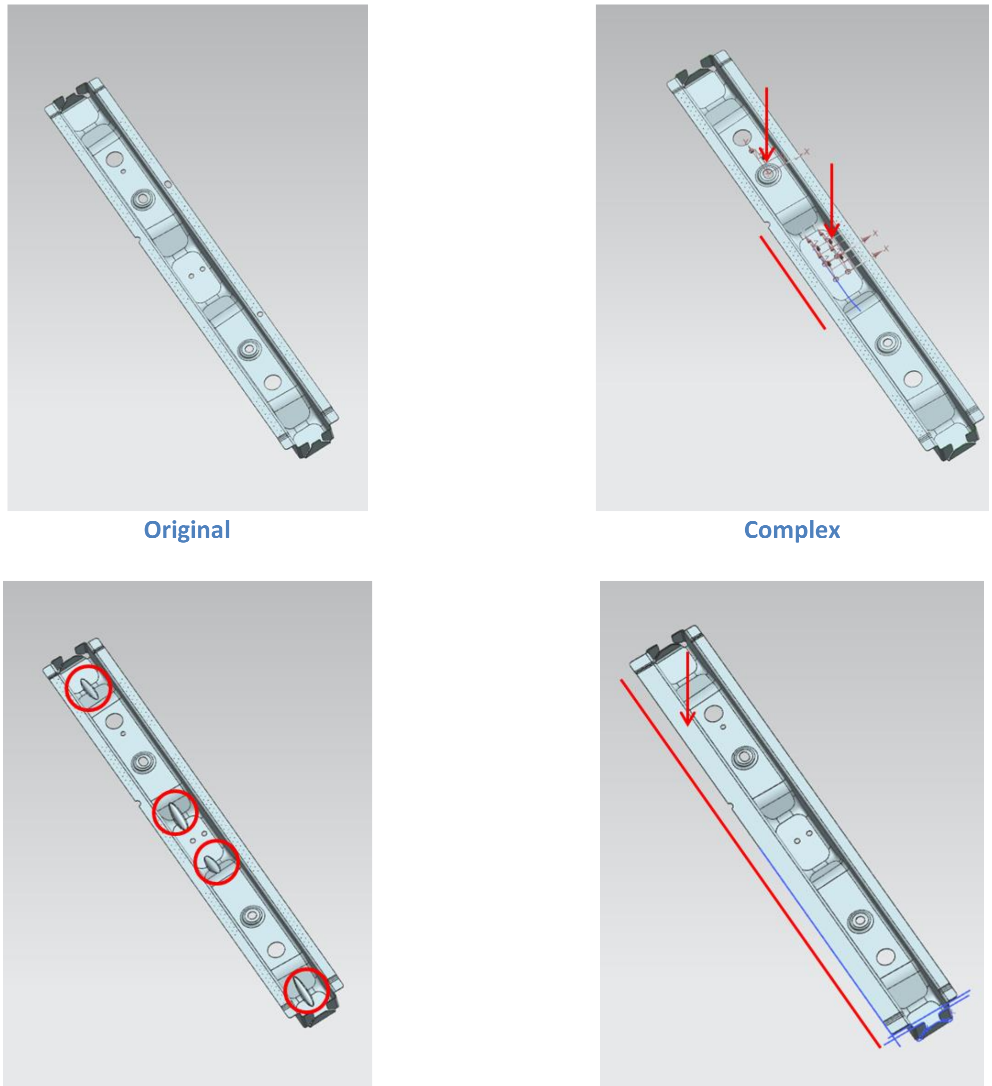
The simple complex change scenario is shown in the lower left corner of Figure 15. The simple complex change scenario of part exists out of:

- Remove little knobs

These knobs are functioning as extra material for laser welding. They are located at the top sides of the part. The knobs are removed while this would be considered a variant of the original part. It gives also the ability to connect the part with other tools.

- Extend side

This alteration has a connection with the previous one. Removing the knobs and the extension of the side gives the opportunity to change the connection machining from welding to glue. The extended geometry will then function as a glue stip.



Original

Complex

Medium Complex

Simple Complex

Figure 15: Overview of all results of change scenarios part Bowl

6.2 Part Foil

The change scenarios for part Foil are described with a small description. The change scenarios are described in the following order: Complex, Medium Complex and Simple Complex. The descriptions will have a link with the models in Figure 16. Furthermore, the original model is shown in order to see the differences.

Complex

The complex change scenario is shown in the left corner of Figure 16. The complex change scenario of part exists out of:

- Adding a cavity

Adding a cavity is substituted for extend mid surface. This is substituted while the middle of the part cannot be extended without making the part longer. It will then result to a not fitting part in the vehicle. The part is also symmetrical in the middle. Therefore, the added cavity is modeled only once and mirrored to the other side.

- Move one hole

The hole with the blue line is moved. It has moved outwards. The other hole did not move.

- Add new mounting points

The mounting points are added in the middle. These could be used for wiring of the vehicle.

Medium Complex

The medium complex change scenario is shown in the lower right corner of Figure 16. The medium complex change scenario of part exists out of:

- Add multiple reinforcement geometries

Two reinforcement geometries are constructed into the part. The geometries are mirrored through the middle of the part. The geometries are preventing that sides will bend back to its original form.

Simple Complex

The simple complex change scenario is shown in the lower left corner of Figure 16. This change scenario is the same as the Simple Complex change scenario of part Bowl. Therefore, it has the same reasons for the changes. Removing the little knobs and extend the sides are converting the part into a glued part instead of a welding part. The simple complex change scenario of part exists out of:

- Remove little knobs
- Extend side

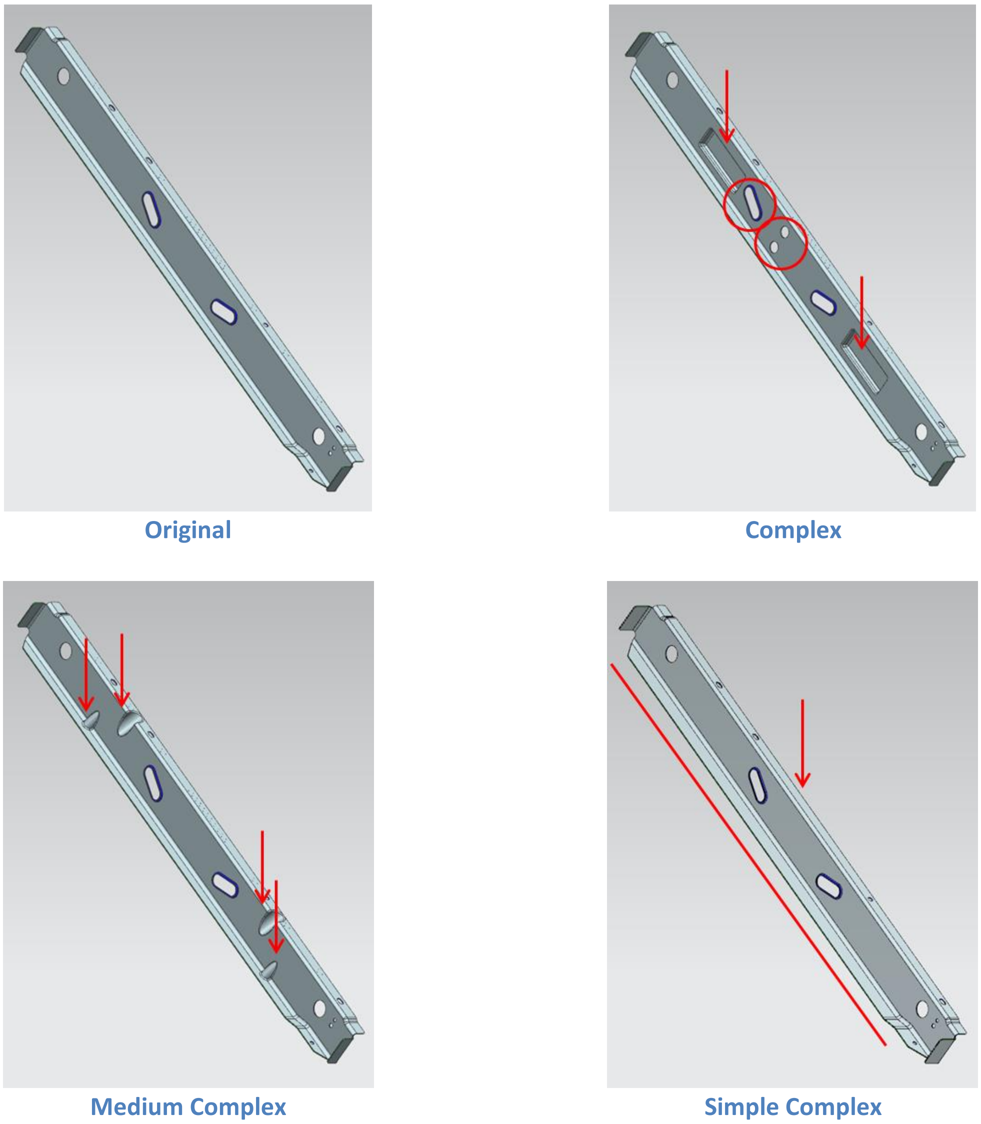


Figure 16: Overview of all results of change scenarios part Foil

7 Executing of Change Scenarios

The EDM structure needed to be created before the change scenarios could be executed. This is necessary to know if synchronising between Siemens NX and EDM software works with the CRP method. It provides a test environment for the thesis. Afterwards the change scenarios for the test parts can be conducted. The approach is explained in figure 17.

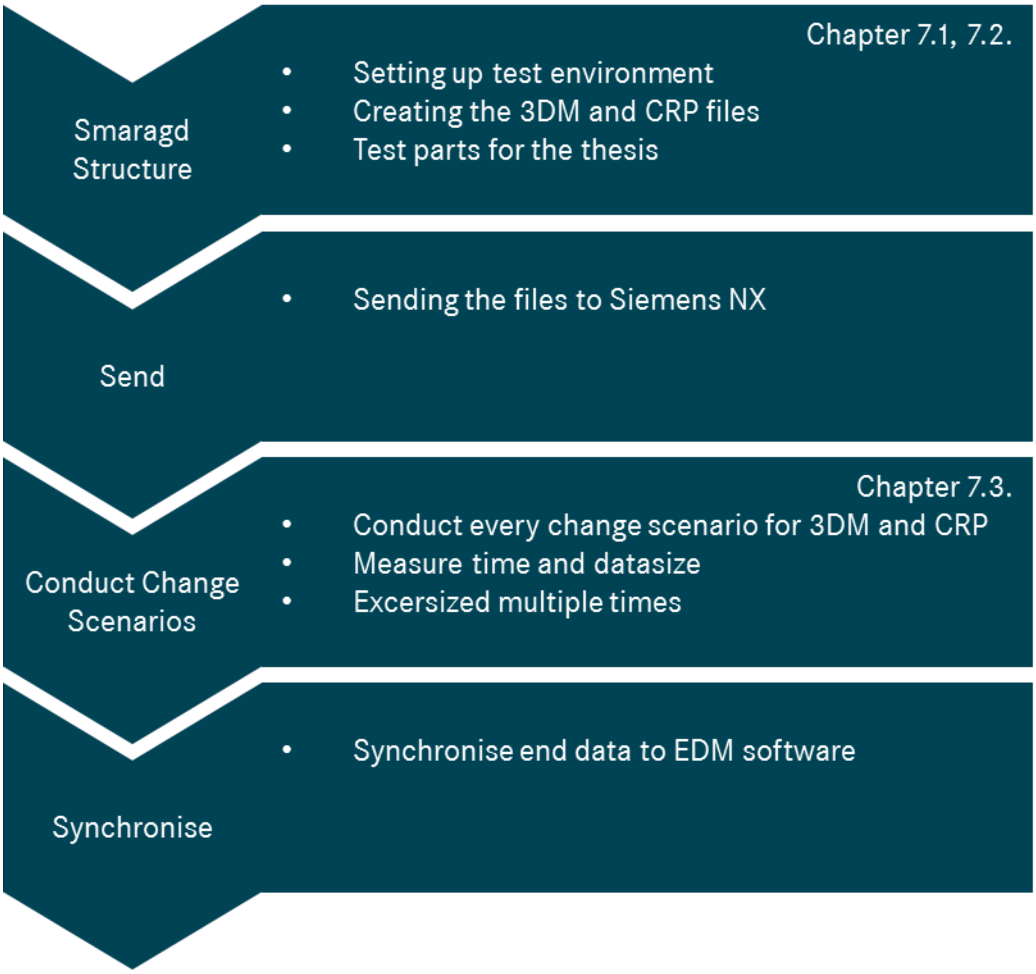


Figure 17: Process overview of change scenario execution

7.1 First EDM Structure

The first attempt to setup the test environment in the EDM system was a real challenge. It took place before the expert interview with the car department. At that moment organizing the structure needed to be estimated. There is made use of Arrangement objects in the first estimated structure. The arrangement object is used while it can be created with no special authority rights. It also has links with the EDM structure. The disadvantage is that the object is unable to be implemented in the BOM. This means the arrangement is not available in further processes such as the final testing. It is often used to conduct research and tests on a small assembly. The Arrangement objects can be linked between each other and are holding the CAD data files.

The template and component part of the CRP method were separated in the first attempted. This resulted into a confusing structure. The separation showed the different reduced and template parts. It made it difficult to know which part was the reduced and template part. This structure failed as soon as the different scenarios would be implemented. It was hard to find the specific parts for a scenario. Therefore, the synchronizing of data did not function well. Sending the data to Siemens NX was hard while the template and component part were separated. Therefore, another structure was established.

7.2 Second EDM Structure

A proper EDM structure became known after the expert interview with the car department. They developed the method based on research and experience. First of all they used the EDM object: Internal Part. One Internal Part object holds a template and component part.

The second test environement resulted in both methods are differing in quantity of Siemens NX files. 3D-Master is holding two objects. This is the template part with PMI and a documentation file. Create Reduced Parts objects are holding two Siemens NX files and the documentation file. The two Siemens Nx file consists of one template part and one component part with PMI. The full EDM structure devided into CRP and 3DM data. Both methods are created multiple times, one original and all change scenario data.

A error occurred with the creation of the different Siemens NX files within the Internal Parts. This was due to the link between template and component part in the Create Reduced Part process. It was expected to be only a matter of copying the parts or naming the parts differently. After serveral attempts with different approaches the solution to the problem was considered to be rooted deeper in the software.

The establishment of the original CRP part was no problem at all. Though, a problem emerged when the template and component part were copyed. The problem is that the original template part link is copyed to the new copy of the component part. Meaning the new component copy is linked with the original template part. Therefore, the template copy has no link or conncetion with the component copy. Furthermore, naming the part differently also did not make any differnce, while the name of the newly named parts was not transitioned to the 'original part'. This is shown in Figure 18. The connection lines are presenting the links. The black lines are established links, whereas the red line represents the link which would be desired.

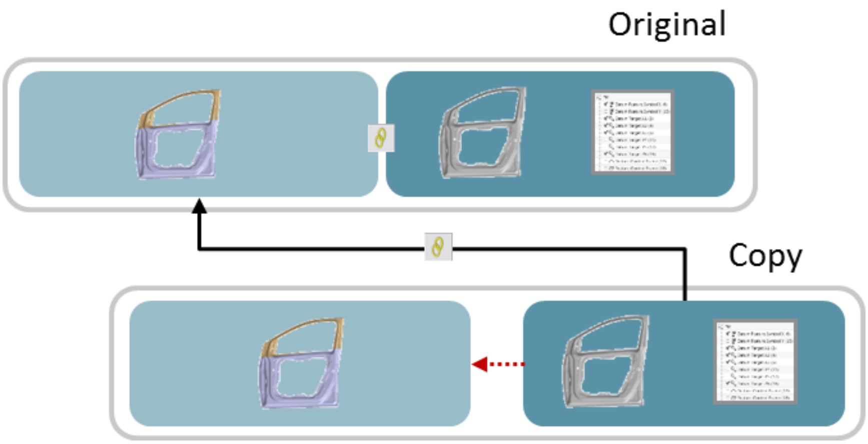


Figure 18: Failure in linking of component part copy

The original part is required to update the component part. Errors occurred when this part could not be found. It results in a part which can not be used. Therefore, the link to the right 'original' template part is vital.

In order to get the results on time. There is chosen to create the Create Reduced Parts seperatly for every scenario. This desciscion resulted into creating the origininal and three scenarios for each method, 3DM and CRP. Furthermore, it also resulted into one start condition for every scenario. The creation of every Create Reduced Part was important in order to know if all PMI information moved into the right position. The time spend on the creation of every Create Reduced Part is measured. This would give an indication of how long it could take to create a reduced part. Escpecially, adding the helpgeometry for the PMI's.

7.3 Execution of Change Scenarios

After the whole setup of the test environment was done the change scenarios were executed. The conduction went without any problems. This was because all other programs and tools functioned well such as, EDM software, NX and CRP tool. The scenarios were exersized a few times in front. This gives an indication of how the test were executed in the different change scenarios. Exersizing the scenario in front would make the spend time comparitive with the time a real expert would take to make the same alterations.

The time spend to make each alteration in a scenario is clocked in minutes. There is chosen to measure in minutes because the methods were estimated to differ more than a few minutes with each other. The time was started at the same featrure tree position in Siemens NX. It is important to set the feature tree in the same position. A false position in the feature tree would influence the measurement. This starting position is shown in Figure 19.

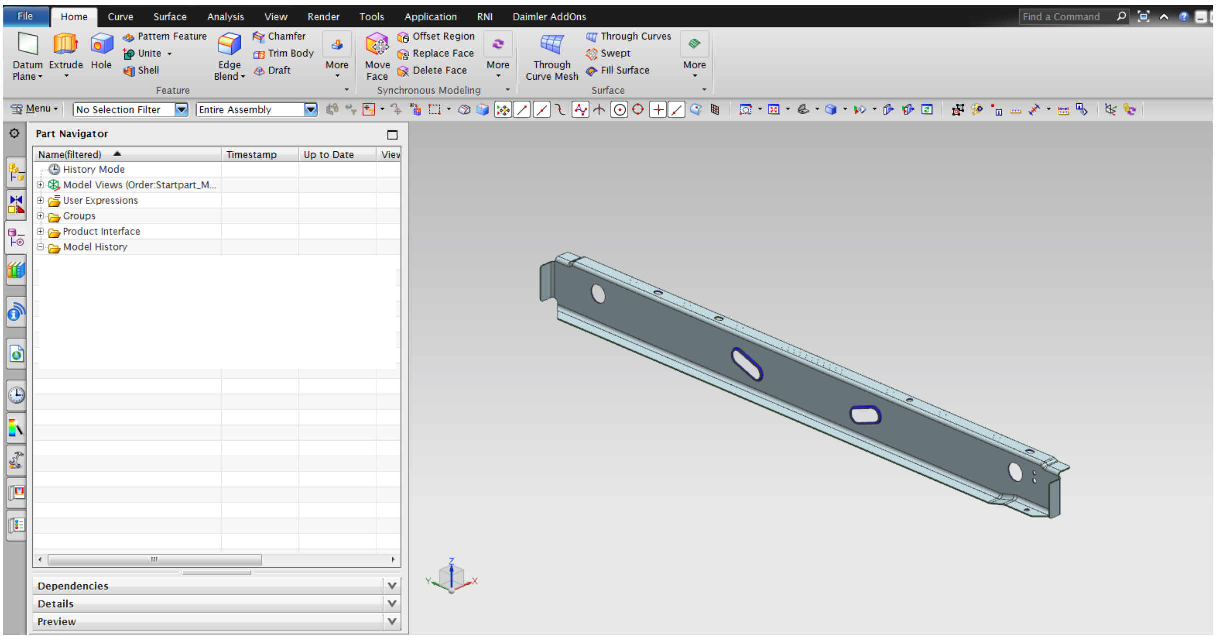


Figure 19: Start position of every test

The data size of parts is measured in Mb. The total is based on the data which will be used in further processes. The 3D-Master parts are used in further processes at the moment. Therefore, the data size is copied.

7.4 Possible Flaws

Possible measure deviations are taken into account. These could influence the results, such as the time measurement. It was estimated that the difference in time spend on the scenarios was larger. Unfortunately, this was not the case. Nevertheless, measuring in minutes is still considered the right unit. Measuring in seconds would give a better understanding of the time it took to make the changes. Though, clicking wrong also costs seconds. This is something any one can happen. It does not make difference whether you’re an expert or not. Therefore, seconds could also give a wrong indication while this could be considered to precise. Furthermore, failures in the test are reduced while tests were executed again if a fault influenced the time much. The test was then considered not accurate enough. That is why some tests were done multiple times. It enhances the comparability between the results.

8 The Results

The results exist out of three measurements: Conversion to Create Reduced Part method, Change Scenarios and Data Size. It is shown in the same order as the tests are executed.

Conversion to Create Reduced Part method

Referring back section 7.2 the CRP method did not allow copying the parts. There is chosen to make every CRP manual. The conversion of the test parts to the CRP method is measured. This process would also be conducted if the new method was to be implemented. The creation results are stated in Table 1.

Part Bowl

Scenario:		Original	Scenario 1	Scenario 2	Scenario 3
Add (min):	10 help geometries	10	13	6	6
	21 PMI's	7	10	10	6
	Material	3	1	1	1
Finished upset	Total (min):	20	24	17	13

Part Foil

Scenario:		Original	Scenario 1	Scenario 2	Scenario 3
Add (min):	14 help geometries	10	10	10	8
	6 PMI's	5	11	5	4
	Material	1	1	1	1
Finished upset	Total (min):	16	22	16	13

Table 1: Creation of the original and the different CRP scenario test parts

Change Scenarios

Both parts results of each scenario are stated in Table 2 and Table 3 . The scenarios are conducted in each method. The end results are shown in Figure 20: 3D-Master and CRP total time of part Bowl change scenarios and Figure 21: 3D-Master and CRP total time of part Foil change scenarios. Above the left row the method is stated. The steps in the change scenario are separately measured and particularities are noted. The total time was the most important. Also the graphics are comparing the total time of both methods. Furthermore, the update time is taken into account. This is a tool which must to be executed in order to calculate the part from begin to end status.

Part Bowl

Scenario 1			CRP Time (min)	3DM Time (min)
Changes template:				
Extend mid surface			0	1
Move one hole			2	2
New mounting point in mid surface			4	4
Update			1	1
Total			7	8
Note*	No failures	PMI adjusted New CSYS		
Scenario 2				
Changes template:				
Add multiple reinforcements			10	10
Update			1	1
Total			11	11
Note*				
Scenario 3				
Changes template:				
Remove little knobs			4	5
Change left side length			1	1
Update			1	1
Total			6	7
Note*				

Table 2: Results of change scenarios of part Bowl

Part Foil

Scenario 1			CRP Time (min)	3DM Time (min)
Changes template:				
Extend mid surface			2	3
Move one hole			1	1
New mounting point in mid surface			3	4
Update			1	1
Total			7	9
Note*	No failures	PMI adjusted New CSYS		
Scenario 2				
Changes template:				
Add multiple reinforcements			6	7
Update			1	1
Total			7	8
Note*				
Scenario 3				
Changes template:				
Remove little knobs			0	0
Change left side length			1	1
Update			2	1
Total			3	2
Note*				

Table 3: Results of change scenario part Foil

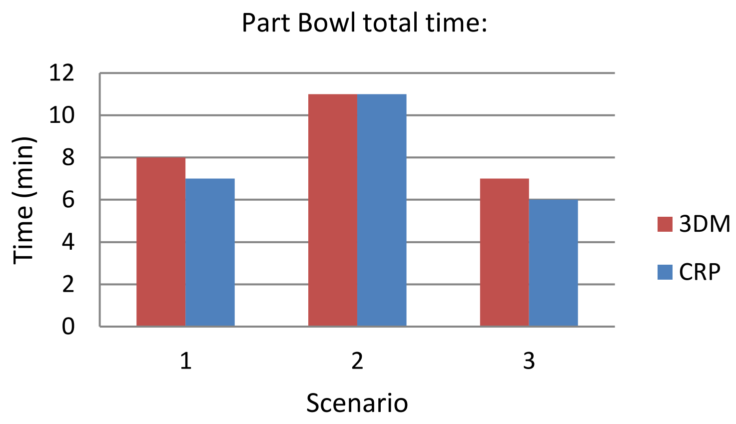


Figure 20: 3D-Master and CRP total time of part Bowl change scenarios

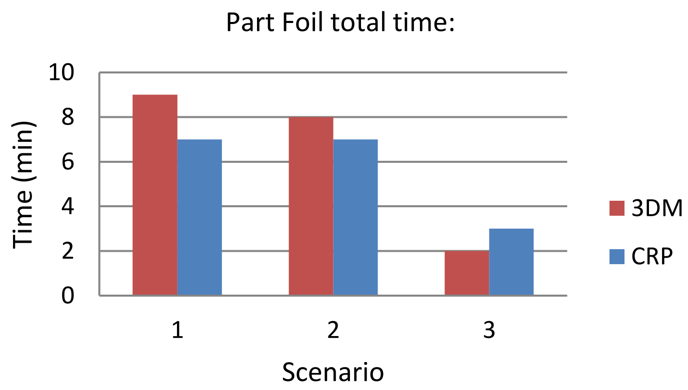


Figure 21: 3D-Master and CRP total time of part Foil change scenarios

Data size

The data sizes of each change scenario and method are recorded after the change scenarios were finished. The CRP has two parts, template and component part. The total size what will be used by further processes is the component part and the documentation. Therefore, those are calculated as total data size. Table 4: Data size of originals and change scenarios and Table 5: Data size of originals and change scenarios part Foil show the results. Figure 22: Total data size part Bowl and Figure 23: Total data size part Foil show the comparison

Part Bowl

3D-Master

	Template (Mb)		Document (Kb)	Total (Mb)
Original	28,80		82	28,88
Scenario 1	22,02		81,5	22,10
Scenario 2	23,40		81,5	23,48
Scenario 3	20,02		81,5	20,10

Create Reduced Part

	Template (Mb)	Component (Mb)	Document (Kb)	Total (Mb)*
Original	22,8	12,54	89,5	12,36
Scenario 1	24,13	15,59	89	15,67
Scenario 2	26	17,68	89,5	17,77
Scenario 3	21,29	14,21	90,5	14,3

* = Component + Document

Table 4: Data size of originals and change scenarios

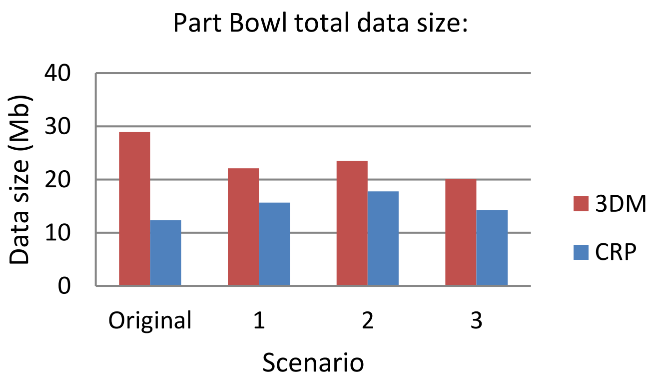


Figure 22: Total data size part Bowl

Part Foil

3D-Master

	Template (Mb)	Document (Kb)	Total (Mb)
Original	5,47	78,5	5,55
Scenario 1	6,49	78,5	5,57
Scenario 2	6,89	78,5	6,97
Scenario 3	5,34	78,5	5,42

Create Reduced Part

	Template (Mb)	Component (Mb)	Document (Kb)	Total (Mb)*
Original	5,35	4,76	86	4,84
Scenario 1	7,13	7,27	86	7,36
Scenario 2	6,55	6,62	86	6,71
Scenario 3	5,7	5,53	86	5,61

* = Component + Document

Table 5: Data size of originals and change scenarios part Foil

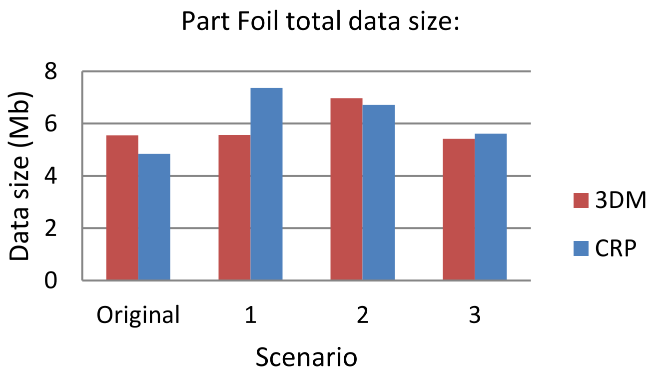


Figure 23: Total data size part Foil

9 Comparison:

During the conduction of the thesis it became clear the main question can be approached in two ways. One way would be to approach the difference form the method itself and the other one would be for the whole implementation. At first the intention was to only focus on the method itself. Though, this was not sufficient while the whole implementation could not function without incorporating the EDM structure. First the method itself will be evaluated. Afterwards, the implementations in the EDM system will be evaluated.

9.1 Change Scenarios

The change scenarios are compared within the CRP and 3DM method. It is based on the analysis and results of both change scenarios. The making of the CRP part, results of change scenarios and data size is discussed in the same order.

Creating the CRP

Creating the CRP parts was not difficult. It took time to add the auxiliary geometries, which hold the PMI's. The auxiliary geometries are copied to the same position as before. This operation took the most time. The whole CRP method then exists out of a template and component part with part documentation, instead of only a template part and documentation. Therefore, the overall data size is bigger than 3D-Master. Creating the CRP part for each part needs to be conducted only once if this method is to be implemented.

Results of change scenarios

The individual results of the alterations in the scenarios are showing a moderate reduction in time. Though, the time reduction is noticeable in the total time spend. Average time reduction is about 1 minutes. Furthermore, the car department is using the CRP method. They could give direction to make this process run smoother. Also optimizing the CRP method is for them a priority. Further development of Siemens NX the time to make alterations and data size could be even further reduced in the future.

Data Size

The data size is showing a reduction in the component parts. The average reduction in the test parts has a factor of respectively 1.6 and 0.97 times the original size. Even more complex parts shall be reduced even more. Despite the bigger template parts size, the steps to calculate the model are less than the current template model. The times to calculate and alter the models are, therefore, resulting in reduction in the time.

9.2 Implementation

To implement the new CRP method a few aspects needs to be created. First of all parts need to be converted to the new method. Adding the auxiliary geometry information and adding the PMI's costs the most time of this operation. Secondly, a new parallel EDM structure needs to be added. This requires clear agreements, especially concerning the naming and partitioning of the structure. The car department gave notice this operation is costing the most time, even more time than the conversion of parts. After all parties involved agree with the structure the creation of the structure is no problem. The advantages must be heightened against the disadvantages in order to know if the implementation is worth it.

Advantages/ Disadvantages

Implementing the CRP methods takes a lot of effort before it really can be used properly. First of all the partitioning of the EDM system needs to be agreed. Afterwards, this structure needs to be created. Furthermore, all the parts need to be converted. Though, all this effort must to be depleted once. The process is shown in Figure 24.

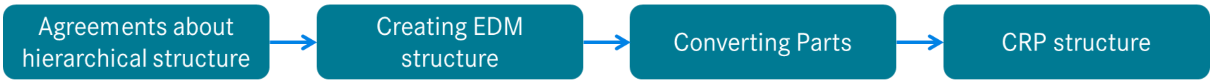


Figure 24: General implementation process Create Reduced Part method

A few things are notable when looking at the results of the change scenarios. First of all the differences between the times spend on the alterations are modest. After the creation of the component part, the reduction in the scenarios differs from 1 to 2 minutes. It was expected to be reduced more. Nonetheless, the test parts are considered middle complex parts. The reduction indicates that altering even more complex parts could have a larger time reduction. Those parts exist out of more features. The data reduction is considerable 1.6 and 0.97 times the original part size.

10 Conclusions & Recommendation

The outcome of the thesis is positive towards the implementation of CRP method. An impact forecast can be estimated by using the average time reduction of about 1 minute per change scenario. Referring to the interview with a design engineering expert. All these alterations will be applied around 40 times a year. Therefore, 40 minutes can be spared a year for medium complex parts. More complex parts are not taken into account in this thesis. It is estimated more time reduction can be saved with those parts.

Furthermore, the CRP method influences more than only reduction of parts. The tests of parts are influenced while the data is reduced. This is estimated to reduce the calculation time in large assemblies. It is important the majority of employees at VAN BIW are convinced about this method. They are most influenced by the change, while they must handle two Siemens NX parts. Every advantages summed up outweigh all disadvantages. Also the disadvantages require only a one time effort.

It is recommended to first obtain enough support of employees and employers for further implementation. This is an aspect which is not to be underestimated, while it involves people. The majority need to accept the new EDM structure. Some people will instantly recognise the benefits, but still some people need to be convinced. Afterwards, the designing and developing of the new EDM structure can begin. There must be clear agreements to be formulated about the naming and hierarchical structure. Also the connection with the current structure needs to be taken into account.

EDM structure specific

The copying of the CRP was difficult while the 'original' part could not be found. This was a problem in conducting the thesis. It can be imagined copying is needed for variant management. This is considered a problem. The possibility to solve this problem could be found in the car department.

Besides this, they have experience with the switch to CRP. During the interview they responded positive on the possibility of the VAN department switching to CRP. Asking them for help would be a benefit for both parties. The car department knows what are the possible flaws in the new system and can help to overcome then quickly. Both departments can learn from each other after the VAN department is switched to the new method. This is an advantage for the car department.

10.1 Further processes

Further process would exist out of convincing the department to switch to CRP. Another visit to the car department would make a benefit. Also testing of smaller and bigger parts is required to get a better overview. This will be conducted in the following months. The results could be presented to design engineers. This will make them aware of the possibilities and advantages of the new system. At the same time questions that will arise can be taken into account.

11 Reflection

The CAD modeling and CAD methods on a professional level differ from that of the University. It did surprise me how much it differed, although a little difference was expected. Also the connection with an EDM system was new. After a short training I could navigate through all systems. Then the current 3D-Master and Create Reduced Part methods were studied. This was very complicated at first. The Create Reduced Part looked like a method which only affected parts. The parametric data could be better protected. Further processes are using only the geometric data while their do not require the parametric data. Though, it became clear to me the Create Reduced Part was more than parts after the meeting with the car department. The topic affected also the EDM system, which needs a new structure. Without this structure the Create Reduced Part method cannot function. This was not expected but it did help in further conduction of the tests. The parallel structure made it clear why the Create Reduced Part method is an asset for the CAD design engineers

The results of the change scenarios are promising though to convince others the results are not sufficient. It must be clear the effort to create the CRP method is worth the effort afterwards. Though, the protection of parametric data and enhanced variant management are, for example, are considered equally valuable. At the moment I think the CRP method could be a real asset to the VAN department. I will assist the VAN IT Engineering department for two more months. Therefore, in the next two months I will conduct further research on more parts.

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