Internship at Dr. Ing. h.c. F. Porsche AG

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Preface

For my study mechanical Engineering at the University of Twente I have done an internship at the engineering department of Dr. Ing. h.c. F. Porsche AG. The placement is been carried out in the team responsible for all the front and rear development of the Porsche sport cars. Working for a longer time in an engineering department of a car manufacturer gives me a good impression in all the things that are going on at an engineering department. This report will show what I’ve learned during the internship and also one project will be treated. I will special thank my supervisor at Porsche for his time he invested in me, to support me during the internship. Also I will thank the whole engineering team for working together. Finally I can say that one of my dreams comes true to work at the engineering department of Dr. Ing. h.c. F. Porsche AG. And that it has exceeded all my expectations.

Bart Oude Luttikhuis

Summary

This report is a summary of my work done during my 6-months placement at Dr. Ing. h.c. F. Porsche AG as an internship part of my study Mechanical Engineering at the University of Twente. Porsche is one of the famous car brands which builds luxury and sport cars. The placement is been carried out at the team responsible for all the front and rear engineering of all the Porsche sport cars (911,Boxster,Cayman); including front and rear bumpers, air channels, crash boxes, wheel guards and bottom plating. During this internship there was not one subject to work on, but different smaller exercises are done. Mostly the exercises have something to do with creating concepts, constructing in CATIA V5 and making overviews. A few exercises are picked out and will be explained in this report. First the CATIA V5 course will be treated in which a comparison is made to SolidWorks (The used CAD software at the University of Twente). Special attention is given to constructing a CAD model in a structured way. As an example; creating a CAD model of a license plate holder will be used to explain how a CAD model can be build up. One of the exercises is picked out and will be explained in this report. In this exercise is tried to optimize a Park Distance Control sensor holder. Park distance control (PDC) is a system that supports the driver parking his car. It informs the driver about the distance between his car and objects. First the working principle of a PDC sensor is explained also the positioning of the sensor will be explained. Thereafter a new concept is worked out and compared to the existing concepts. Finally this concept will be tested in the prototype phase; to make a good comparison to the existing concepts.
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Introduction
In this part the company Dr. Ing. h.c. F. Porsche AG will be introduced. As introduction the philosophy and products of this company will be explained. Thereafter the department in which the internship is done will be introduced. Further the different exercises done during the internship will be listed and explained.

The Porsche philosophy
The Porsche Principle is our Magna Carta. It is based on values and philosophies that together create our added value. The Porsche Principle is about a company that consistently goes its own way. In public life because we not only decline subsidies. In society as a whole because – despite our exclusive products – social acceptance is paramount for us. On the labour market, because to secure our long-term success we don’t eliminate jobs, we secure and create them. On the business base issue, because we are committed to Germany and are a constant reminder to others that one can succeed here too.

Porsche models

The Porsche 911
The Porsche 911. ‘Icon’, ‘Legend’, ‘Benchmark’, others rave. For Porsche, it is simply the Eleven. A success formula for more than 40 years. With every new generation, it is a few rpm ahead of its time. That’s how to stay timeless. And yet Porsche has never changed it. Basically. Naturally Porsche equip every generation with absolute state-of-the-art technology. Meaningful technology, of course. And its design is advanced with sensitivity and restraint. Because Porsche remains wholeheartedly committed to the basic principle. The Eleven is the quintessence of intelligent evolution. And Porsche has never questioned its basic character: rear-engine, rear-wheel drive. Nobody today builds such a car – except Porsche. It comes as Coupé, Cabriolet, Targa and, available since 1988, with all wheel drive, in two engine versions and as Turbo. But it is always a 911.

The Porsche Boxster
Introducing: the Boxster. Unveiled at the 1993 Detroit Motor Show. In the land of the roadsters, but Made in Germany. It has inherited a bit from its great grand-daddy, the legendary 550 Spyder. Featuring above all the uncompromising mid-engine concept known in racing for its agility and performance. The Boxster and Boxster S – available with soft or hard Turbo, but popularly driven with the roof down – is widely considered an entry-level model. But it is one thing above all: a full-fledged sports car, a genuine Porsche. It makes the brand younger,
without sacrificing its purist attitude. It gives the brand new power, and lets the driver sense it too. Via a motoring feeling that is, in the truest sense of the word, moving.

**The Porsche Cayman**

If anything else fits in between the 911 and the Boxster, it’s the Cayman. It links the two sports cars as members of the same family, and interprets them in its own distinctive way. As forceful as the sway of its hips are its inner values. An all-star athlete when it comes to power; an aesthete as regards appearance. And a Porsche, as expressed in quality and versatility. An all-new definition of a very classic concept: that of a thoroughbred sports coupé.

**The Porsche Cayenne**

Basically, the Cayenne is a Porsche that nobody could imagine. A sporting multi-purpose vehicle – a term which itself took some getting used to. And, on Turbo, with a front-engine configuration plus enough space to comfortably accommodate five persons and loads of luggage. The sports car world was shocked. Then came the second bombshell: from zero to 100,000 vehicles sold in less than three years. The world applauded. The Cayenne conquered all-new terrain. And all those who wanted safety, comfort, transportability one size bigger than in the 911 or the Boxster. Who find an SUV chic, but want a sporty interpretation. The Cayenne comes in three differently powered versions.

**The Porsche Panamera**

One, two, three. And four. Four seats, four doors. The Panamera, rolling out in 2009, completes our quartet. Following the 911, Boxster/Cayman and Cayenne, the fourth series will be a sports coupé of the premium class and a genuine Porsche. Guaranteed by performance, sporting spirit, exclusivity. And by Weissach, Zuffenhausen, Leipzig. The Panamera shows in principle what holds true for all Porsche vehicles: not one ounce too much, not one horsepower too little. Basically, we were never interested in building a car whose dizzying specifications are felt to best advantage in the car registration papers. Porsche horsepower are felt on the road. (Porsche, 2011)
The department EKS 1

The internship is done at Dr. Ing. h. c. F. Porsche AG in the EKS1 department. EKS means in German: (Entwicklung-Karosserie-Systeme und Sicherheit). Translated to English this means: (Development-Body Systems and Security). This department is responsible for all the front and rear development of all the Porsche sport cars (911, Boxster, Cayman) including front and rear bumpers, air channels, crash boxes, wheel guards and bottom plating as shown in Figure 1. EKS1 has the full responsibility of the complete product development process, from creating concepts till the implementation in series production. Furthermore the pendulum tests are the responsibility of EKS1, which will test the minor damage. The EKS1 department has also a lot to deal with the regulations in the different countries and the intern Porsche safety requirements.

Figure 1: Overview of the EKS1 parts

In Figure 2 a diagram is given which displays how the EKS1 is integrated in the EKS department. The EKS2 and EKS3 are also responsible for the front and rear systems but for the other Porsche models (Cayenne and Panamera). EKS 4 is responsible for all the other security aspects like; airbags, Child security and seat belts. The departments EKS5-EKS7 are responsible for all crash tests.

Figure 2: Overview of the EKS department
Exercises
During this internship there was not one subject to work on, but different smaller exercises are done. Mostly the exercises have something to do with creating concepts, constructing in CATIA V5 and making overviews. A few exercises are picked out and will be explained in this report; further an overview of the most important exercises is given below.

*Changing the 3D model of the 911 Turbo intercooler air duct*
- Optimizing the CAD model to make it producible by injection moulding.
- Changing the model to fit it to the surrounding components.
- Trying to enlarge the cross section of the air duct

*Constructing a new licence plate holder for the 911 in China*
Constructing a licence plate holder which fits to the rear bumper of the 911 TURBO. The global design should be the same as the licence plate holder used for the 911 C2.

*Researching the possibility of using the VW towing eye for the 911*
Making a comparison between the towing eyes used by Porsche and VW. (Dimensions, Geometry, Functionality etc). Further a summary of advantages and disadvantages of the towing eyes is made. This was done for looking if it is possible to use VW towing eyes at Porsche.

*Researching the difference between Porsche models (Fachreferate) (towing eye hole, headlight washer)*
Making a comparison of the towing eye hole and headlight washer used at the different Porsche models (911, Boxster, Cayenne, Panamera). The comparison is made based on: Geometry, Functionality and Practical tests.

*PDC-Sensor Holder*
- Creating a global model of the PA-Sensor housing integrated in a lamella.
- Creating a minimal space model for the design of the PA-Sensor housing.
- Constructing a new concept for the PA-Sensor holder and housing which is based on the minimal space model.

*911 TURBO hoses*
- Making concepts for mounting hoses in the front area.
- Constructing the hose positions.
- Changing the Wheel house (RHS)

*Constructing new ribs for alignment of the front lights*
In order to get a better alignment of the front lights additional ribs are constructed. These ribs are constructed on the housing of the front lights and on the front bumper.
Course PDMU/CATIA V5

In the Porsche Engineering department the CAD software CATIA V5 is used for all construction work. This software is used in combination with the data management system PDMU (Porsche Data Management Unit), which is based on the ENOVIA V6 software. Because it’s important to work properly during the internship with this software, Porsche gives a special course with a duration of one week. The main aspects of these courses will be explained in this part to make clear what is learned during this course.

PDMU course

During two days of the course the PDMU system is explained and some practice exercises are made. In this part the important aspects of PDMU will be explained. The PDMU software is used to manage and store all the CAD data which is needed for the engineering. Further a lot of processes are integrated in PDMU like: Package, the release process, calculations and used materials. A big advantage of the PDMU software is that it can generate every specific car combination without saving every combination in the system. This is very important, because there are a lot of combinations like different rims, interior, engine, etc. Without such a system a lot of space is required to store all the combinations, and it’s difficult to keep a good overview of all the combinations.

The following topics are treated during this course:

- Creating objects
- Infrastructure of CATIA V5 and Navigator
- Q-Checker
  Q-Checker is used to check if the CAD-data which is constructed in CATIA is acceptable to store in the system. The CAD data will be proven on different aspects.
- Revisions
- Structure used in PDMU

CATIA course

Introduction

The target of the CATIA course was to learn how to construct a CAD model in a structured way. It was not the goal to make a lot of CAD-models; it was namely assumed that this knowledge was already known. At large companies like Porsche AG it is important that the CAD-models are constructed in a structured way so other persons “intern or extern” can also understand and change the CAD data. During the course the following subjects are threaded:

- CATIA overall: Licenses, Users, Settings, Structure
- Data names
- Construction methods, Norms, start model
- How to construct CAD-models in a structured way
- Part design: solid construction, shape design
- Product design: Constraints
- Drawing creation
Example (Constructing a new licence plate holder)

To explain how a CAD-model can be constructed in a structured way one of the internship exercises is used as an example. The exercise is constructing a new license plate holder for the new 911 Turbo. First is tried to make small changes to the 911 C2 licence plate holder to fit on the 911 Turbo, but the differences were too big. So a new license plate holder is constructed. The licence plate holder will be made out of Polypropylene and will be produced by injection moulding. Therefore it is important to keep the specific injection moulding rules in mind; like using an equal wall thickness, direction of draw, using a draft angle, etc. Further in this report design rules of injection moulding will be explained in more detail.

Porsche Start model

Porsche uses for every CAD-model the same Start Model, in which a structure is predefined. This structure is based on the EVA-principle. (Eingang, Verarbeitung, Ausgang), in English translated: (Input, Processing, and Output).

The Porsche start model is shown in Figure 3. It contains the three bodies:

- Import Information (Import Informationen)
  - Under this body all the information is placed from other CAD parts which are used to construct the new part. It can be information like; conditions, package data, geometry of other parts, etc.
- Part description (Bauteil Beschreibung)
  - The complete geometry of the part will be build under this body.
- Export Information (Export Informationen)
  - This body consists all the information which is important for other parts, like position of holes, outer dimensions etc. The information in this body must be published to make it usable in other parts.

Import Information (Import Informationen)

The position of the licence plate for the 911 Turbo is already defined, so this information can be imported in the license plate holder part. The imported geometry is placed under Import Information and is shown in Figure 4. Where the yellow plane is the geometry of the rear bumper, and the orange part is the licence plate for China both in the right position.
Part description (Bauteil Beschreibung)
When building a structured CAD model it is important to avoid serial linkage between sketches or features. This can be avoided by creating all the points, lines, planes and sketches who defining the geometry at the top of the model under the body “Steering (Steuerung)” as shown in Figure 6. Further this steering body is placed under the body “part description”. Now all the created features in the different bodies can be linked to these elements. When something has to change on the model it can all be done by changing the geometrical information in this steering body. It is also important to keep in mind that points, lines and planes are the most stable operators, and that referencing to points, edges and planes of solids must be avoided. Therefore in the body “Part Description” the sketches are made which are used to control features which are defined later. These rules are schematic explained in Figure 5, in this picture there are two bodies which are both controlled by the two left planes, which are together with the sketches positioned in the Steering part. So when now the planes are changed, both bodies (blue and red) will change. It isn’t allowed to link the blue part to the red part (Serial linkage). The right way is to link the blue part also to the planes which define the dimension of the bodies.

After the “Steuerung” Body in which all the important geometric information is placed there are three separate bodies (Haupt frame, Loch oben, Loch_oben_2) in which a solid is constructed, as shown in Figure 7. These bodies are based on the information in the “Steuerung” body. The body “Haupt frame” contains the main geometry of the license plate holder which is based on an extrude feature and cutting this by the imported geometry of the bumper and license plate (Yellow). The other two bodies (Loch_oben/Loch_oben_2) contain the geometry of the three holes. This geometry is constructed as a positive solid (Extrude feature). These bodies are operated by Boolean operators to create the geometry of the licence plate holder. This is done in a separate body called “Kennzeichenhalter”, as shown in Figure 7. The used Boolean operators for the holes are CUT; this is because the Holes are constructed as a positive body. Thereafter in this body a shell operation is used to
get the needed geometry which can be produced by injection moulding. Chosen is to use a wall thickness of 2.5 millimetres. Also the draft angles of 5 degree which are needed for making this part producible are performed in this body as well the needed radii.

Figure 7: Part description

Export information
In this cad model there is no export information defined. But it should be possible to define the positions of the three holes. These positions of the holes could be used for positioning the Screws which are used to mount this license plate to the rear bumper.

Draft analysis
Because this part is produced by injection moulding a draft analysis in the direction of draw is made to check the needed minimum draft angle of 5°. The draft analysis is shown in Figure 8. Where green means that there is a minimum draft angle of 5° in the direction of draw. Further means blue that the draft angle is less than 5°. When checking both sides it becomes clear that the required draft angle of 5° will be fulfilled. Further the mould release line can be found in Figure 8 where it is represented by the line between the green and blue part.
Conclusion

During this course it becomes clear that CATIA V5 differs a lot compared to the used CAD software at the University of Twente (SolidWorks). The biggest difference comparing CATIA to SolidWorks is that CATIA parts can be build up out of separate bodies (which contain features like pad, cut, revolve etc), which can be operated with Boolean operations like, assemble, add, cut etc. The advantage of using these separate bodies is that very complex parts can be constructed easier and also more structured. Also a good function of these separate bodies is that they can be copied very easy. The advantage of copying bodies is that it is very easy to use bodies or faces from other parts as reference in its own part. This is for example not possible in SolidWorks. When working on simple parts copying bodies isn’t important. But when the models become complex with for example double curved surfaces it is important to use other parts as reference. Therefore it must be possible to copy these bodies. Further it was very interesting and helpful to learn how to construct a CAD-model in the right way, which should be useable for all the construction jobs in the feature. Normally when models aren’t very complex the structure isn’t that important, but during this course it becomes clear that it isn’t possible to construct complex parts well without a good structure. Problems will occur when the model has to be changed or colleagues have to work with the model. Finally it can be said that SolidWorks is more user-friendly compared to CATIA. But CATIA has more advantages when working on complex models. The PDMU course has learned how to work with this software in combination with CATIA V5. During this course it becomes clear that a good data management system is very important when working on complex systems.
Park Distance Control-Sensor holder

Introduction
Park distance control is a system that supports the driver parking his car. It informs the driver about the distance between his car and objects. Actually it is used to prevent collisions to objects when parking. The system informs the driver about the situation by using beeps, the different frequencies of these beeps gives an indication of the distance to objects, where a higher frequency means closer to an object. It is also possible that the distances are displayed on a screen as shown in Figure 9. In this report the abbreviation PDC will be used which means (Park Distance Control).

![Figure 9: Park Distance control (Google Pictures)](image)

Problem description
For the 911 turbo a PDC sensor holder must be designed which can hold and cover the PDC sensor. The challenge is to construct it as small as possible because the PDC sensor is in the vision range and should be good looking. Further the holder should be stiff enough to fulfil the requirements for a good functioning PDC system.

Explanation of the working principle of a PDC sensor
The used PDC sensor is a combination of a PDC and PLV sensor. This sensor works as sender and receiver. Objects will be determined with the Pulls-Echo-principle, which is explained in Figure 10. A combination of sensors at the front and rear side of the car will together recognize all kind of objects.

The main element of the ultrasonic sensor is the piezo Ceramic part. This part sends sound waves. If somewhere in the range of the sensor an object is placed, these sound waves will be reflected and the Piezo Ceramic part receives these waves. Thereafter this signal will be translated into an electric signal.

In the measure phase an amplifier will calculate the time between the sand and the received sound waves. With this calculated time between sending and receiving a sound wave the distance can be calculated with the following equation: \( d = \frac{c \cdot t}{2} \). Where \( d \) is the distance to the object (in meters), \( c \) is the sound wave speed (in m/s), and \( t \) is the time (in seconds) between sending and receiving the sound waves.

![Figure 10: Explanation of the Pulls-Echo principle (Wikipedia)](image)
Defining the PDC sensor positions

To get an optimal performance of the sensors, it is very important to define the sensor positions in the right way. Therefore some standardized positions are defined in relation to the road height. These positions are also dependent on the angle of the sensors. In Figure 11 an overview is given for the right height of the sensor in relation to the sensor angle.

<table>
<thead>
<tr>
<th>Height</th>
<th>Angle of attack (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>0 till +1</td>
</tr>
<tr>
<td>480</td>
<td>0 till +2</td>
</tr>
<tr>
<td>440</td>
<td>+2</td>
</tr>
<tr>
<td>400</td>
<td>+4</td>
</tr>
<tr>
<td>360</td>
<td>+6</td>
</tr>
<tr>
<td>320</td>
<td>+8</td>
</tr>
<tr>
<td>300</td>
<td>+10</td>
</tr>
</tbody>
</table>

Figure 11: PDC sensor position in vertical direction

Used PDC sensor

The PDC sensor which will be used for the 911 Turbo is shown in Figure 12. Further the dimensions are given in appendix A.

Functions of the sensor
A: Connection to the connector
B: Decoupling ring, used to seal the PDC sensor.
C: Sensor side which may not covered by anything.
D: Poka-Yoka rib for checking if the right sensor is used during assembly
E: Clip which can be used to clamp the PDC sensor.

Figure 12: Used PDC sensor
Decoupling ring
A mechanical decoupling ring between the bumper and sensor housing is needed for well functioning of the PDC sensor. The decoupling ring must connect to the sensor membrane over all its faces. This is important because the view of the sensor to the sensor hole must be covered.

PDC Holder
For this PDC sensor the supplier has already a PDC holder defined which can be found in Figure 13. This prescribed PDC holder will be used for the idea how the PDC sensor holder should be fixed, but the challenge will be to create another design which will be smaller.

![Figure 13: PDC holder defined by supplier](image)

Requirements
For the PDC sensor holder there are several requirements which are listed below.
- Using minimal outside space for PDC-Sensor holder
- View range of the PDC-holder should be made of a good looking plastic
- No grooves in vision range
- Producible by injection moulding
- Easy to assemble
- Possibility for disassembly
- High stiffness
- Construction consist of few parts

Concepts
For this problem already two solutions for covering and holding the PDC sensor are created. First these two concepts will be explained; thereafter a new concept will be introduced. As already explained the idea of the new concept is that it is smaller than the existing solutions. Further the stiffness is an important aspect because the sensor holder must be stiff enough for well functioning.
**Concept 1**

A schematic sketch of this concept is made and can be found in Figure 14 and Figure 15. In this schematic overview the connector of the PDC sensor is neglected. This concept uses 3 parts to hold and cover the PDC sensor. The red part is the frame which is connected to parts of the car. The blue part is the sensor holder in which the PDC sensor will be fixed. This PDC holder is partly based on the suppliers prescribed holder, as already explained in Figure 13. The PDC sensor will be fixed in this holder by the two clips (1) on the PDC sensor. Furthermore this sensor holder with the sensor in it, is fixed to the cover (green) by clipsing (2) it to the cover as explained in Figure 15. Finally the cover “with holder and sensor in it” is connected to the frame by using two clips (3).

![Figure 14: Concept 1 Z-Intersection](image)

![Figure 15: Concept 1 Y-Intersection](image)
Advantages and disadvantages

The advantages and disadvantages of this concept are listed in Table 1, and will be explained. The first advantage “good stiffness” is among others due to the used PDC sensor holder, which is made of a stiff and strong plastic. An important fact is that this plastic can’t be used for the cover and frame because the surface quality is not good enough for a part in the vision range. Another advantage of this concept is that it is easy to assemble and disassemble. But due to the additional PDC holder the complete unit will be larger for about 5 mm’s in diameter. Also this concept has a seam between the frame and cover in the vision range; normally this should be prevented. Further in this concept three parts are used which is in this case good for the stiffness, but worse for the manufacturing and assembly costs.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good stiffness</td>
<td>Large cover</td>
</tr>
<tr>
<td>Easy to assemble/disassemble</td>
<td>Seam between frame and cover in vision range</td>
</tr>
<tr>
<td></td>
<td>3 parts used</td>
</tr>
</tbody>
</table>

Table 1: Advantages and disadvantages of concept 1
**Concept 2**

A schematic sketch of this concept is given in Figure 16 and Figure 17. The idea of this concept was to construct a smaller PDC cover by integrating the functions of the PDC holder in the PDC cover. Therefore the cover can now be constructed much smaller. The PDC cover is now for about 5 millimetres smaller in its diameter and looks much smaller. In this concept the PDC sensor will be clipped directly to the cover as further explained in Figure 18. The two clips which are used to fix the sensor are now integrated in the cover. Also the stop surfaces which are needed to fix the sensor are integrated in this cover. This is in contrast to concept 1 where an additional PDC holder is used for these functions. The connection between the frame and Cover is in this concept the same as in Concept 1; by using two clips.
Advantages/Disadvantages
The overview of advantages and disadvantages is given in Table 2. The main advantage of this concept is that the cover is smaller in comparison to concept 1. Also this concept uses just two parts instead of three, which can save costs for production and assembly. But a disadvantage of integrating the function of the holder in the cover is the worse quality of keeping the sensor in its position. The reason for this is that in this concept the stiff PDC holder which is made of a good quality plastic is skipped. Now the sensor will simply hold by the stiffness of the cover which isn’t that large. Further the Clips which are used for the connection between the sensor and cover will be visible, as shown in Figure 18. There is no possibility to cover these clips within the building space for this concept. Also there will be still a seam between the frame and cover, like concept 1.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small PDC cover</td>
<td>Lower stiffness</td>
</tr>
<tr>
<td>System consist out of 2 parts</td>
<td>Clip between cover and sensor in vision range</td>
</tr>
<tr>
<td>Easy to assemble</td>
<td>Seam between frame and cover in vision range</td>
</tr>
</tbody>
</table>

Table 2: Overview of advantages and disadvantage of concept 2
**New Concept**

In this new concept is tried to get an optimal construction which is stiff and small looking in the vision range. A schematic overview can be found in Figure 19 and Figure 20, in this sketch the connector of the PDC sensor is also taken into account in contrast to concept 1 and 2. This concept consists of two parts; the green part is the cover and the red part the frame. The function of clamping the PDC sensor is now done by both the cover and frame. The idea of this is that the frame presses the PDC sensor against the cover to fix the PDC sensor, as explained in Figure 20, by the orange arrows. Further is tried to get rid of the seam between the cover and frame which is in the vision range at concept 1 and 2. This is done by covering the frame by the cover in the view range; the view range is also shown in Figure 19. The connection between the cover and frame is done by using two clips on the left and right side. The clip on the left side has the same construction as in concept 1 and 2. The clip on the right side is constructed in a different way; the clip is now connected to the frame in contrast to concept 1 and 2. This is done because now it’s possible to get rid of the seam between the cover and frame within the vision range. Also the clip will not be visible in the view range.

![Figure 19: Concept 3 Z-intersection](image1)

![Figure 20: Concept 3 Y-intersection](image2)
Advantages/disadvantages

The advantages and disadvantages of this concept are listed in Table 3. As can be seen some disadvantages of concept 1 and 2 are now solved. The challenge to get a smaller and better looking PDC holder will be fulfilled. Now the function of the PDC holder is integrated in both the cover and frame. Further the system consists just out of two parts, which can safe costs for manufacturing and assembling. Finally there is no seam anymore between the cover and frame as in concept 1 and 2. This seam between the cover and frame will now placed out of the vision range. Also the idea that the frame is totally out of the vision range has some advantages because when this system should be painted only the cover has to be painted. This can also safe some costs. The stiffness of this concept can be a problem because no additional PDC holder is used as in concept 1, but the concept has enough possibilities to get a stiffness which is good enough. The stiffness of this concept should be an important point of improvement in the elaboration of this new concept.

<table>
<thead>
<tr>
<th>Advantages</th>
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</thead>
<tbody>
<tr>
<td>Small PDC cover</td>
<td>Lower stiffness</td>
</tr>
<tr>
<td>System consist out of two parts</td>
<td></td>
</tr>
<tr>
<td>No seam between frame and cover in vision range</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Advantages and disadvantages of concept 3
Elaboration of the new concept

The new concept has as already explained some extra advantages compared to concept 1 and 2. The main advantages are a smaller design and no grooves in the vision range. But the feasibility of the new concept has to be proven. In this part is tried to elaborate this concept and check the feasibility. Special attention will be given to the stiffness, manufacturability, design and disassembly.

Functioning

In Figure 21 the elaborated concept is shown, in this model the cover is not shown but the orange dashed line represents the cover. The principle is the same as already explained, but now an additional part (light blue) is added which is needed to guarantee a well fixed PDC sensor.

![Figure 21: Overview of sensor fixing method](image)

In Figure 22 a section view is shown to support the explanation of fixing the PDC sensor. The idea of fixing the PDC sensor is that it will be clamped between the frame and the extra fixing part. As already told the extra fixing part and frame will be pressed together by the cover. Firstly the connection between the cover and frame is done by using a clip on the right and left side, the clip on the left side is shown in Figure 21. The extra fixing part will stay in his position because the outside surface of the extra fixing part lays to the inside of the cover.
The inside geometry of the extra fixing part is the same as the holder defined by the supplier as shown in Figure 13. In this part the sensor stop surfaces are also constructed to get a stop surface for the sensor. Also the Sensor type indication surfaces are integrated to get a poka-yoka assembly. It was not possible to integrate these functions in the cover therefore this separate part is constructed.

The ribs constructed on the frame as shown in Figure 21 has the function of extra clamping and centering the PDC sensor. How this is functioning is explained by a section view in Figure 23. The PDC sensor will be clamped and centered by the three sections of the frame which has the possibility of light bending. On each part of the frame one rib is constructed. These ribs have a larger outside size compared to the inside diameter of the cover and therefore the cover will press the frame segments to the middle point. So the PDC sensor will be clamped and centered by the frame segments as shown in the right picture of Figure 23.
**Manufacturability of the Cover**

The cover of the PDC holder will be produced by injection moulding. A schematic sketch of the cover is shown in Figure 24 to explain how the cover will be produced. In this sketch the used moulds are also shown. The Blue part is the mould on the injector side and will form the outside of the cover. To form this part an additional slider is needed because the clip can’t be formed in the direction of draw. Therefore an additional slider is used, as explained in Figure 24. When opening the mould, first the green slider will move in the direction of draw (1). Thereafter the red slider will move to the right “perpendicular to the direction of draw” (2). Finally when the red slider is far enough moved to the right side it will move also in the direction of draw.

![Figure 24: Schematic overview of the moulds used for producing the cover](image-url)
**Manufacturability of the Frame**

In this part the manufacturability of the frame will be explained. Because the part will be produced by injection moulding it is important to take the directions of draw, drafts and wall thicknesses into account. The top and bottom view of the frame are respectively shown in Figure 25 and Figure 26. Firstly the direction of draw is defined; the direction is chosen perpendicular to the top view. Further is the mould release line shown in Figure 26, by the red line. Further all the ribs of this part are constructed in the direction of draw and have a specific draft angle. Also is tried to keep the wall thickness equal. The clip is designed in such a way that no additional sliders are needed. The bottom part of the clip will be formed by the injection mould and the top side of the clip by the ejector mould.

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**Figure 25: Top view of PDC sensor frame**

**Figure 26: Bottom view of PDC sensor frame**
**Assembling the PDC holder**

In Figure 27 an exploded view is shown to explain the order of assembly. First the PDC sensor will be placed in the frame (1), the clips of the sensor must be between the grooves of the frame. Thereafter the extra fixing part will be placed over the sensor (2). And finally the cover will be clipped to the frame (3). Disassembling the PDC holder is in reverse order. Further the clip between the frame and cover can be declipsed by using a small plastic tool.

![Figure 27: Assembling the PDC holder](image)

**Conclusion**

Finally it can be concluded that the new concept has some advantages compared to the other concepts. The requirement of small and good looking can certainly be fulfilled, because this concept is for about 5 millimetres smaller in its diameter compared to concept 1. Concept 2 has also a small diameter but has the big disadvantage of the visible clip in the vision range. So compared to the other concepts this new concept will actually be the smallest and best looking. Also this concept has no grooves in the vision range which is a big advantage compared to the other concepts which have both a groove in the vision range. The manufacturability by injection moulding of the parts shouldn’t give problems, and no complex moulds are needed. The number of used parts for fixing the PDC sensor is three which is the same as concept 1 but one more than concept 2, which isn’t a big problem. Regarding to the stiffness of the PDC holder there isn’t enough analyzed to say something about this.

**Recommendations**

To create a functioning and working design extra engineering is needed. Compared to concept 1 and 2 this new concept is just worked out as a concept. The other concepts are already fully developed and are proven as a possible solution. In the next part this concept will be optimized.
Creating the design for the first prototype

The elaborated concept which is treated in the previous part will be optimized. The goal is to make a fully functioning and producible design which can be tested in the prototype fase to compare it to concept 1 and 2.

Clamping the PDC sensor

Compared to the elaborated concept now the extra fixing part is skipped. The PDC sensor will now be fixed only by the frame (blue part). It will be fixed by using four clips on the left and right side as shown in Figure 28 and Figure 29. The function of the ribs to centre and clamp the PDC sensor is still used and will function as already explained in Figure 23.

![Figure 28: PDC holder for the first prototype front/outside view](image)

![Figure 29: PDC holder for the first prototype front/inside view](image)

Connection between cover and frame

The idea of clipsing the cover to the frame is roughly the same as in the elaborated concept. The clip on the outside of the frame is shown in Figure 28. This clip has changed a bit because it’s now connected in a different way to the frame. Further the part of the clip which is positioned at the cover hasn’t changed. The clip on the outside is also constructed and can be found in Figure 30 and Figure 31.
Conclusion

The constructed PDC sensor holder is now fully worked out and a prototype can be made. In theory this construction should work but in the prototype phase it must be tested in praxis. Now it can also be compared to the other concepts. But the expectations are very well because this design has a lot of advantages as already explained; small PDC cover, construction consists out of two parts and there is no seam between the cover and frame in the vision range. An important aspect which should be tested is the stiffness of this concept.
Looking back

The internship done at the Front and rear development department at the Porsche development centre has fulfilled all my expectations. During the period of my internship I have learned a lot but it was also a very nice period of my life. I formed a clear overview how it is to work as a Construction Engineer. During the first weeks of the internship I learned a lot of how to work with the software tools (CATIA V5, PDMU) used at Porsche. Also it becomes clear what all is going on at the development centre. Thereafter I worked on some very interesting projects. During these projects I was very good involved with the projects. Finally I will thank all my colleagues of the EKS1 department, I really enjoyed to work together with them. Especially I will thank my department head Mr. Nennemann which makes this internship at the front and rear development department possible. Also I will thank my mentor Christian Wirth, for all the support during my internship.

Bibliography

Wikipedia. (n.d.).
Appendix A

991 TOP SENSORS HI BST 1

Comparing old VS new

1. Extra rib will be used for coding the type of PA Sensor (PA/PLA).
2. Extra rib without a function
3. Same connector
4. Extra rib

Housing

Comparing dimensions

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</tr>
<tr>
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<td>J</td>
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<td>K (angle)</td>
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Table: Dimensions of old and new sensors.
Decoupling ring

Vergleich

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Source: Porsche AG

Date: 11/11/2019

Sheet: 3