MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (MII)

THESIS PROJECT

BMW F4x FACELIFTING TO F7x

Author: Ignacio Hernandez Apolinario Fernandez de Sousa

Director: Alvaro Calleja Camara

Madrid

Declaro, bajo mi responsabilidad, que el Proyecto presentado con el título

BMW F4x Facelifting to F7x

en la ETS de Ingeniería - ICAI de la Universidad Pontificia Comillas en el curso académico 2021/22 es de mi autoría, original e inédito y no ha sido presentado con anterioridad a otros efectos.

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Acknowledgments

In first place to Grupo Antolin, to the excellent group of people I had the opportunity to meet and gave me the chance to learn a bit out of the automotive sector.

Then, to my friends, who made my years at ICAI be unforgettable, through good and not so good moments, which hopefully will continue for a lifetime.

And last, and most important, to my family, who have put up with me and my problems all these years, and thanks to them I have had the opportunity to be the person I am today.

FACELIFTING DEL BMW F4X AL F7X

Autor: Hernández Apolinario Fernández de Sousa, Ignacio.
Director: Calleja Camara, Álvaro.
Entidad Colaboradora: Grupo Antolin.

RESUMEN DEL PROYECTO

El proyecto parte de unas modificaciones solicitadas por parte de BMW en los paneles de puerta para dos de sus modelos a Grupo Antolin. El proyecto se ha realizado desde el punto de vista de un ingeniero de producto, tratando los diseños de este mismo y analizando los mismos para obtener el mejor resultado posible. Por último se ha analizado una parte económica del proyecto además de un análisis de los riesgos que el proyecto conlleva.

Palabras clave: automovilismo, BMW, Grupo Antolin, interiores, paneles de puerta

1. Introducción

El proyecto recoge el trabajo realizado durante siete meses de practicas de la mano de Grupo Antolin en Alemania, desde el punto de vista de un ingeniero de producto. Grupo Antolin es un distinguido proveedor dentro del sector del automóvil especializado en la fabricación de interiores del automóvil.

En este caso, el proyecto a tratar consiste en una serie de modificaciones propuestas por parte de BMW en los paneles de puerta interiores de dos de sus modelos. Estos modelos son el BMW Serie 1 (F70) y el BMW Serie 2 Grand Coupé (F74), de los que los paneles de puerta serán fabricados por Grupo Antolin en sus distintas plantas situadas por Europa.

2. Definición del proyecto

La estrategia a seguir definida para el proyecto consiste en desarrollar el producto tratando de minimizar modificaciones futuras que puedan suponer costos más elevados para el proyecto. Para ello, se hará un correcto seguimiento de los planos junto al equipo de CAD en Grupo Antolin India, se revisarán los prototipos para entender su funcionamiento y posibles fallos que estos puedan tener, y por último, un estudio económico en el que se involucrarán las órdenes de compra de las piezas prototipo por parte de BMW.

De este modo, los objetivos del proyecto se muestran a continuación:

- Análisis técnico de las modificaciones presentadas por BMW, comprobando que los planos siguen un camino correcto apoyándose de piezas prototipo y por consiguiente teniendo los planos listos para su producción.

- Definición del producto y sus procesos, con los cambios necesarios presentados en el proyecto, para hacer un posterior estudio de si se pueden producir las piezas dentro de la empresa o externalizarlo a ciertos proveedores.

- Análisis económico que supone este proyecto, considerado a partir de estimaciones debido a los tratos de confidencialidad con la empresa.

- Comparación final entre el proyecto del BMW F4x y el del F7x, analizando si se aplicaron las lecciones aprendidas del anterior proyecto analizando el impacto económico de los mismos.

3. Descripción del modelo y herramientas empleadas

En primer lugar se parte de la descripción del producto a tartar, que tiene una base genérica para todos los proyectos de paneles de puerta interiores en el sector automovilístico. En este proyecto en concreto se desarrollarán las puertas delantera y trasera de dos modelos (F70 y F74). En esta primera fase se estudian las piezas y se hacen las modificaciones necesarias en los planos para que no haya ningún problema a la hora de fabricar el producto final. Para ello se harán ciertos test a las piezas prototipo diseñadas que permitirán hacerse una idea del comportamiento del panel de puerta.

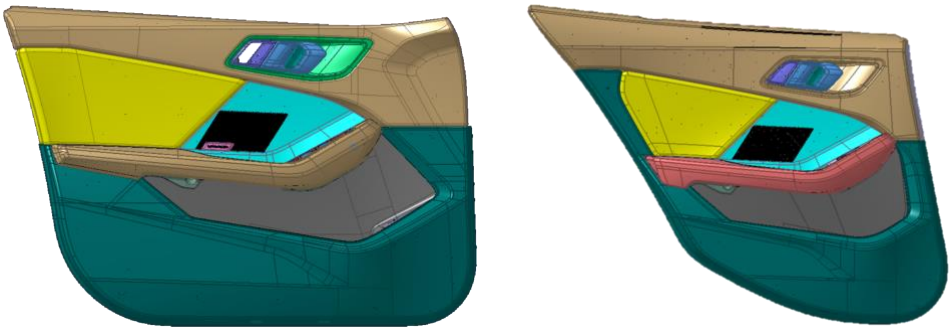

Ilustración 1 – Paneles de puerta del BMW F70 (Serie 1) a desarrollar en el proyecto

Una vez se ha definido el producto y sus modificaciones correctamente, el siguiente paso consiste en analizar la viabilidad de producir este producto dentro de las plantas de Grupo Antolin o si se hará de la mano de proveedores. Esto definirá la estrategia a seguir y por lo tanto, en caso de producir internamente, habrá que definir las plantas de en las que se elegirá producir.

Por último, se hará un análisis económico que ocupará dos partes. Por un lado, las órdenes de compra lanzadas por BMW para las piezas prototipo, teniendo que hacer un seguimiento de estas para poner todo en orden y se puedan realizar los pagos correctamente. Por otro lado, se hará un ejercicio teórico a partir de estimaciones para hacerse una idea de lo que un proyecto de estas características puede suponer para Grupo Antolin.

Para hacer este proyecto posible, será necesario emplear una serie de herramientas. En primer lugar destacar las herramientas que harán posible el desarrollo del producto, en las que se notificarán todas las piezas a emplear (BOM), los requerimientos de compra para buscar proveedores (BPM) y por último los documentos necesarios para hacer el pedido de las piezas prototipo a testear (BANF). Además se ha empleado software 3D para poder visualizar correctamente el producto (Teamcenter).

4. Resultados

El primer punto a analizar será la correcta definición del producto. Para ello, se analizarán las distintas piezas prototipo fabricadas. Estas piezas han guiado correctamente al equipo de producto encargado del proyecto ya que se han ido detectando una serie de problemas que se han podido ir solucionando, sin tener un impacto significativo en el proyecto.

Ilustración 2 – BMW F7x Cubierta del Altavoz ALEV 2.4

En segundo lugar, en cuanto a donde se van a producir las piezas, se ha llegado a la conclusión de que parte de estas nuevas piezas serán producidas en las plantas de Grupo Antolin. Sin embargo, en el caso de la cubierta de los altavoces se ha llegado a la conclusión de que será más beneficioso para el proyecto producirlos mediante proveedores. Por ello, la versión básica la producirá Primas, y para la versión premium, RMIG será el elegido.

Por último, analizando económicamente dicho proyecto, se ha obtenido un margen de contribución cerca del 28%, lo que bajo los estándares de Grupo Antolin significa un negocio rentable. Además se ha realizado un ejercicio teórico obteniendo la cuenta de resultados del proyecto para los próximos años, en los que Grupo Antolin ha sido nominado. Se ha obtenido un resultado positivo, con un EBIT porcentual entre el 5 y el 8%, característico de este sector.

Year	2024	2025	2026
Sales	19.549.927 €	69.194.059 €	30.890.911 €
Variable Costs	14.057.449 €	48.721.783 €	21.787.190 €
Gross Profit	5.492.479 €	20.472.276 €	9.103.721 €
Fixed Costs	2.800.000 €	9.500.000 €	4.750.000 €
Depreciation	750.000 €	3.000.000 €	1.500.000 €
EBITDA	1.942.479 €	7.972.276 €	2.853.721 €
Taxes (34%)	660.443 €	2.710.574 €	970.265 €
Net Income	1.282.036 €	5.261.702 €	1.883.456 €
EBIT (%)	6,56%	7,60%	6,10%

Ilustración 3 – Cuenta de resultados estimada del proyecto BMW F7x

Además, y para cerrar con los resultados obtenidos del proyecto, la administración de las órdenes de compra fue un éxito debido a que BMW pudo recibir todos los recibos del proyecto de prototipos correctamente, haciendo así el pago a Grupo Antolín por este servicio.

5. Conclusiones

Durante el transcurso de este proyecto se ha podido aprender un poco acerca del mundo del automóvil. De este modo, se han tratado diversos temas que contribuyen a la realización de un proyecto de tal envergadura en una empresa referente dentro de dicho sector. Por ello, sería justo decir que las tareas realizadas han cumplido con los objetivos establecidos inicialmente.

En cuanto a la parte puramente del producto, se puede concluir que el trabajo realizado mejora con creces al hecho en el proyecto anterior del BMW F4x, ya que gracias a los errores cometidos y al aprendizaje a partir de estos, se ha podido mejorar tanto en el producto como en los distintos procesos que engloban a este proyecto. Sin embargo, todo producto es mejorable y optimizable, por lo que han de anotarse las lecciones aprendidas de este proyecto para poder aplicar a proyectos futuros.

Todo este trabajo se ve reflejado en la comparación económica entre ambos productos, afirmando rotundamente que el proyecto del BMW F7x va en mejor camino que el de su predecesor. Aun así, debido a la crisis actual y al elevado precio de las materias primas, este rumbo podría variar. Por lo tanto es de vital importancia que para la correcta compleción del proyecto, no se bajen los brazos a la hora de realizar todas las comprobaciones necesaria para evitar cambios futuros que puedan suponer un aumento desmesurado en los costes.

La experiencia en un factor vital en el sector de la automoción, y es por ello que no se debe de dejar de mirar atrás para apoyarse en proyectos pasados y garantizar un proyecto exitoso.

BMW F4X FACELIFTING TO F7X

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Supervisor: Calleja, Alvaro.
Collaborating Entity: Grupo Antolin.

ABSTRACT

The project is based on modifications requested by BMW in the door panels for two of its models to Grupo Antolin. The project has been carried out from the point of view of a product engineer, dealing with the designs and analyzing them in order to obtain the best possible result. Finally, an economic part of the project has been analyzed as well as an analysis of the risks involved in the project.

Keywords: automotive sector, BMW, Grupo Antolin, interior, door panel

1. Introduction

The project is the result of a seven-month internship with Grupo Antolin in Germany, from the point of view of a product engineer. Grupo Antolin is a distinguished supplier in the automotive sector specialized in the manufacture of automotive interiors.

In this case, the project to be dealt with consists of a series of BMW. These models are the BMW 1 Series (F70) and the BMW 2 Series Grand Coupé (F74), of which the door panels will be manufactured by Grupo Antolin in its various plants located throughout Europe.

2. Project definition

The strategy defined for the project is to develop the product trying to minimize future modifications that may involve higher costs for the project. To this end, a correct follow-up of the drawings will be carried out together with the CAD team at Grupo Antolin India, the prototypes will be reviewed to understand their operation and possible failures that they may have, and finally, an economic study in which the purchase orders of the prototype parts by BMW will be involved.

Thus, the objectives of the project are shown below:

- Technical analysis of the modifications presented by BMW, verifying that the plans follow a correct path supported by prototype parts and therefore having the plans ready for production.

- Definition of the product and its processes, with the necessary changes presented in the project, to make a later study of whether the parts can be produced within the company or outsourced to certain suppliers.

- Economic analysis of this project, considered on the basis of estimates due to confidentiality agreements with the company.

- Final comparison between the BMW F4x project and the F7x project, analyzing if the lessons learned from the previous project were applied, analyzing their economic impact.

3. Model description and tools used

First of all, the description of the product to be treated, which has a generic basis for all projects of interior door panels in the automotive sector, will be taken as a starting point. In this particular project, the front and rear doors of two models (F70 and F74) will be developed. In this first phase, the parts are studied and the necessary modifications are made to the drawings so that there are no problems when manufacturing the final product. To this end, certain tests will be made to the prototype parts designed to get an idea of the behavior of the door panel.

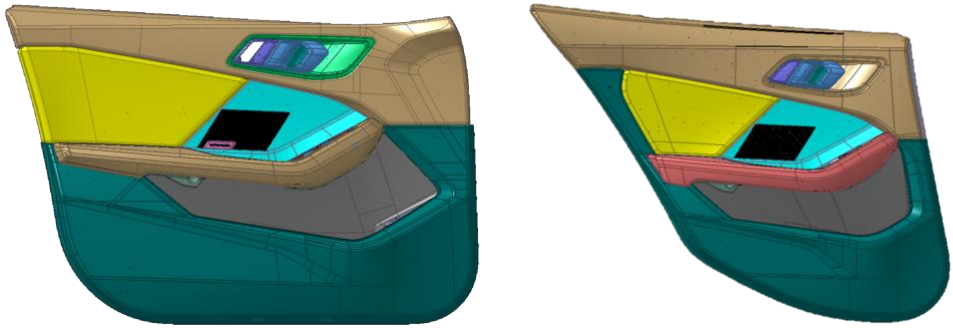

Illustration 1 - BMW F70 (1 Series) door panels to be developed in the project

Once the product and its modifications have been correctly defined, the next step is to analyze the feasibility of producing this product within Grupo Antolin's plants or whether it will be produced by suppliers. This will define the strategy to be followed and therefore, in the case of producing internally, it will be necessary to define the plants where production will be chosen.

Finally, an economic analysis will be carried out in two parts. On the one hand, the purchase orders launched by BMW for the prototype parts, having to follow up on these to put everything in order and payments can be made correctly. On the other hand, a theoretical exercise will be carried out based on estimates to get an idea of what a project of these characteristics could mean for Grupo Antolin.

To make this project possible, it will be necessary to use a series of tools. First of all, it is important to highlight the tools that will make product development possible, in which all the parts to be used will be notified (BOM), the purchasing requirements to find suppliers (BPM) and, finally, the documents needed to order the prototype parts to be tested (BANF). In addition, 3D software has been used to correctly visualize the product (Teamcenter).

4. Results

The first point to analyze will be the correct definition of the product. For this purpose, the different prototype parts manufactured will be analyzed. These parts have correctly guided the product team in charge of the project since a series of problems have been detected and have been solved without having a significant impact on the project.

Illustration 2 - BMW F7x Speaker Grill ALEV 2.4

Secondly, as to where the parts will be produced, it has been concluded that part of these new parts will be produced in Grupo Antolin's plants. However, in the case of the loudspeaker cover, it has been concluded that it will be more beneficial for the project to produce them through suppliers. Therefore, the basic version will be produced by Prisma, and for the premium version, RMIG will be chosen.

Finally, economically analyzing this project, a contribution margin of around 28% has been obtained, which under Grupo Antolin's standards means a profitable business. In addition, a theoretical exercise has been carried out to obtain the project's profit and loss account for the next few years, in which Grupo Antolin has been nominated. A positive result has been obtained, with a percentage EBIT between 5 and 8%, typical of this sector.

Year	2024	2025	2026
Sales	19.549.927 €	69.194.059 €	30.890.911 €
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EBIT (%)	6,56%	7,60%	6,10%

Illustration 3 - Estimated income statement of the BMW F7x project

5. Conclusions

During the course of this project it has been possible to learn a little about the automotive world. In this way, we have dealt with various topics that contribute to the realization of a project of this magnitude in a reference company within this sector. Therefore, it would be fair to say that the tasks performed have fulfilled the objectives initially established.

As for the purely product part, it can be concluded that the work done has improved on the previous BMW F4x project, since thanks to the mistakes made and the learning from them, it has been possible to improve both the product and the various processes that encompass this project. However, every product can be improved and optimized, so the lessons learned from this project should be noted in order to be applied to future projects.

All this work is reflected in the economic comparison between the two products, stating categorically that the BMW F7x project is going in a better way than its predecessor. However, due to the current crisis and the high price of raw materials, this could change. Therefore, it is of vital importance that for the correct completion of the project, no arms are lowered at the time of making all the necessary checks to avoid future changes that may lead to an excessive increase in costs.

Experience is a vital factor in the automotive industry, and that is why you should never stop looking back to build on past projects to ensure a successful project.

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Chapter 1. INTRODUCTION

This chapter introduces this memory remarking how the possibility of doing this BMW project together with Grupo Antolin arose, and therefore briefly introducing the company structure and its main areas of activity. Furthermore, some general details about the customer role in this project will also be introduced.

1.1 PROJECT MOTIVATION

Around the 1860s, the automotive industry was first invented and perfected in Germany and France, pioneering the horseless carriage [1]. Since then, the industry has been constantly growing and innovating until what it is known today. Grupo Antolin started its journey in a small mechanics garage in Burgos, Spain. His story tells how that mechanic from Burgos helped a German truck driver to fix a unique part that could not be found nowhere nearby. Thus, the mechanic made that part with what he had in the workshop. The astonishment of the German driver was enormous, and thus, the workshop of Mr. Antolin grew little by. Today, it has become a reference in the automotive industry for the development, design and manufacturing for components in automobile interiors [2]. The constant urge for seeking new leading technologies is what pushes the company to constantly thrive.

Figure 1 – Grupo Antolin first steps in automotive industry (Burgos, Spain)

Grupo Antolin aspires to be the leading company in automobile interiors while creating value for its stakeholders. In order to do so, there are five important pillars that define the company: contribute to the development of society, stay passionate to always aspire to best quality possible, recognize people as the key to success, have a strong family spirit as identity, and innovate to have the future we desire. These values guide the companies conviction on adapting the automotive sector so it has a place on our futures, by constantly innovate and research for the best solutions, while inspiring others to share the same spirit.

This project arises from the necessity by BMW side to accomplish a restyling of a couple of their running series models. The restyling, or facelift, consists on a series of modifications that will slightly change the car aspect, for which BMW trusts Grupo Antolin to be in charge of the production for the interior door panels. Therefore, and in order to make the most out of it, Grupo Antolin has the obligation to offer the best product possible according their values, with the final objective of maximizing its revenues. However, due to the actual situation of instability, prices for raw materials have skyrocketed. Thereby, Grupo Antolin faces some unique circumstances that must overcome during the course of this project.

1.2 INTERNSHIP ALONGSIDE GRUPO ANTOLIN

The opportunity to carry out this project is the result from an international internship program alongside Grupo Antolin, that expands for over six months working from their headquarters in Munich within the door panel business unit as a product engineer. Grupo Antolin is a Spanish company with global presence belonging the automotive sector, specialized in the design of car interiors such as door panels and cockpits for different clients. The company has several clients throughout the world and, concretely in Germany, they work for car brands such as Porsche, Daimler, Audi and BMW among others. The company headquarters are strategically located between BMW headquarters in Munich and Audi headquarters in Ingolstadt, a small city 80 km north of Munich. These two well-known car manufacturers being two of the most prominent clients of Grupo Antolin.

Grupo Antolin technological leadership, strong commitment to innovation, and extensive industrial experience makes them present in the 10 best-selling cars in the world, being leaders in some of the technologies and solutions on the market. The company is structured into five different business units where different technologies are being developed depending on the requirements and functionality of each section of the car. These business units are divided into overheads, doors and trim, cockpits, lighting and electronic systems, which can be complementary to each other. Each business unit has its own department director, thus forming a pyramidal structure.

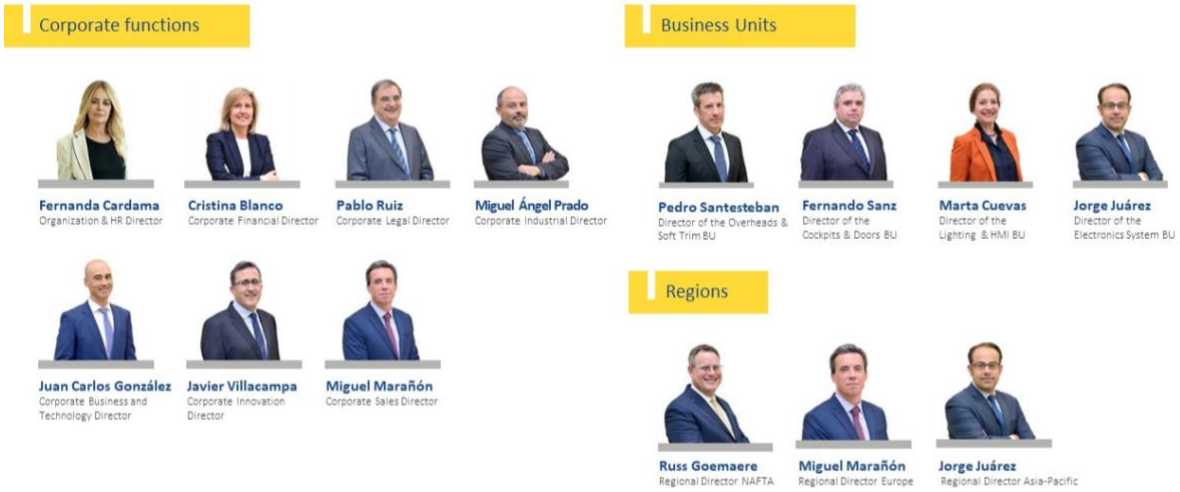

Figure 2 – Grupo Antolin management team

The company's headquarters are located in Burgos, from where the activities of the different international offices are coordinated. Almost in every country that Grupo Antolin develops its activity, there is a company headquarter where the different business units develop their work. Furthermore, each of these headquarters coordinate the production plants in the area, distributing the parts to be produced depending on their capacity and distance to the car manufacturers. Therefore, as an example, if Porsche produces their cars in Czech Republic, Grupo Antolin will give priority to its plant in that country so transport expenses are lower, and in case of any inconvenience, the client can go to the production site. Summarizing, Grupo Antolin has a pyramidal structure to control its international activity, delegating in each region for the control of its closest production plants.

1.3 BMW PROJECT

This facelift project, as previously explained, consists on a series of modifications done to the some actual BMW models where some of the actual designs will suffer small changes such as incorporating new material or developing new parts. Grupo Antolin will only be in charge of the development and production of those designs for the interior door panels. Furthermore, this project will also pursue the goal of analyzing the main differences between the previous and actual project. Not only by doing a deep analysis of the modifications proposed in the facelift, but also analyzing how lessons learned were applied and if as a result, it had a positive outcome.

As previously mentioned, the project focuses on a new BMW "facelift", which consists on a series of modifications made to the actual Series 1 and Series 2 Grand Coupé from BMW catalog. This BMW Series are named internally under F4x (F40 and F44 respectively), that with the new specification will become F7x, which will be referenced throughout the course of the memory.

Figure 3 – BMW Series 1 (F40) and BMW Series 2 Grand Coupé (F44)

During the development of the project, BMW will have the role of project supervisor, being in continuous contact with the Project Manager of Grupo Antolin. In addition, if there is a technical or specific problem of a process or from the product itself, the presence of the affected engineers will be required until said problem is solved. However, BMW will totally give the authority of modifying the drawings to Grupo Antolin, so that the product specifications will be developed and modified in order to meet the objectives.

Grupo Antolin, as an experienced supplier for these brands, has been nominated for the next 2,5 years to carry out the door panels. This means that from mid 2024 to the end of 2026, Grupo Antolin will be in charge of the door panel production. However, it is expected that BMW will keep working alongside Grupo Antolin until 2030. In order to analyze the scope of the project, project specifications will be resolved from the point of view of a Product Engineer. Thus, the scope of this project encompasses everything related to the product and its modifications. However, tasks that correspond mainly to a Project Engineer will be also carried out, such as the control of purchase orders by the client. Consequently, it will be important to understand the economic scope, analyzing the outcomes and comparing them to the previous project, evaluating if all lessons learned have been correctly applied.

Chapter 2. TECHNOLOGIES OVERVIEW

During this chapter the reader will be provided with a series of specific tools with the intention of facilitating readers comprehension during the course of the project. The technologies and protocols described below are needed in order to fulfill with the project objectives, and will be useful to fulfil all steps needed. Therefore, the following protocols are briefly and chronologically described in order to have a better understanding of the project.

2.1 AUTOMOTIVE INDUSTRY KEY CONCEPTS

Clients or car brands are commonly referred to as **OEMs** (Original Equipment Manufacturers). While these manufacturers produce some original equipment, they focus on other tasks such as the car designs, promoting cars, ordering from vendors and assembling vehicles. **Tier 1** suppliers refer to companies that directly supply parts or systems to OEMs. These companies usually focus their activities in a wide range of car manufacturers but they are often tightly coupled with one or two OEMs. **Tier 2** suppliers are companies that supply parts to different companies that end up being assembled in cars, even though these companies do not supply directly to the OEMs. These kind of companies are often experts in an specific domain, but they also support other companies out of the automotive industry. **Tier 3** term refers to suppliers of raw or close-to-raw materials such as metal or plastics. In this way, these company supplies to all levels and can also supply to companies that do not belong to automotive [3].

Grupo Antolin self identifies as a tier 1 although historically they have supplied as tier 2 in some occasions. Main OEMs in Germany would be BMW and Audi, which take up most of the business. Other brands such as Porsche and Daimler are also important clients.

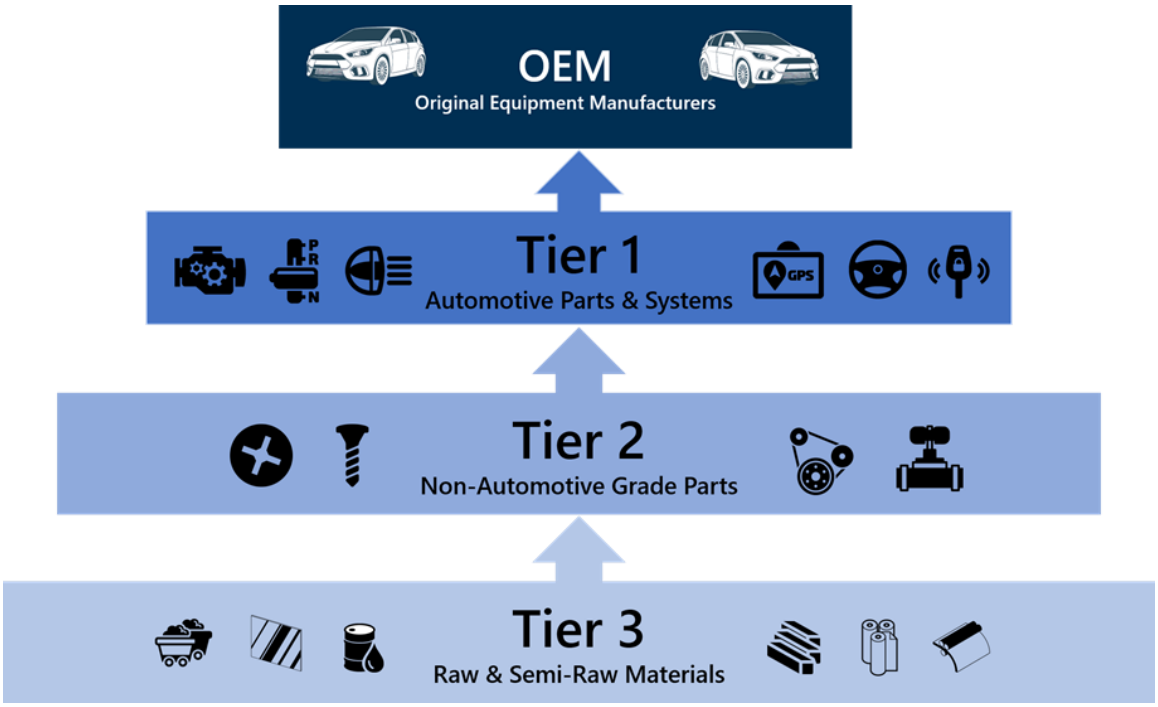

Figure 4 – Automotive industry organized by companies activities

2.2 RFQ (REQUEST FOR QUOTATION)

Every project starts when a car manufacturer decides to produce their car parts externally and look for suppliers rather than producing them in-house. Thus, the process starts by contacting several suppliers that may have participated in previous projects and there is an overall satisfaction with them. These suppliers will have some technical data that the customer provides, so suppliers can estimate the costs of the project. Once the customer has all the costing details from every supplier, they will decide who they will nominate to carry out the project.

As previously introduced, Grupo Antolin works as a Tier 1 company. Therefore, in the same way OEMs request quotation for tier 1 companies, Grupo Antolin will request components and materials to tier 2 and 3 organizations. Besides, other tier 1 companies more specialized in a concrete sector, can provide these parts to Grupo Antolin. From Grupo Antolin point of

view, RFQ is what they get from the client, but when buying services from a third party or supplier, an RFP (Request for Purchase) would be launched.

Once the project is quoted by the costing team, the costs are forwarded to the client through the commercial in charge, who will be responsible of negotiating the resulting price of the project. Every input or doubt that a team may need, will be redirected to the commercial who will be in contact with the client. This lats one, will also receive any input that the client might want to share as further information or in case there are any updated to the initial product.

2.3 BANF SHEET

The BANF is an excel sheet used to formalize an offer made from an RFQ requested by Grupo Antolin to the supplier. It is an internal document used to authorize the purchase of certain products from an external company, where the project data is collected in addition to the specification of the list of products with their respective prices. It also includes the shipping data, which will correspond to the Grupo Antolin plant to which the shipment is to be made, plus the supplier's data, both the contact details of the person responsible for the offer and the company's address. For a purchase to go through, it will require both the approval of the project manager and the department head.

2.4 BOM/BOI (BILL OF MATERIALS/INVESTMENTS)

The first step to follow when a customer launches an RFQ, is to analyze the technical requirements of the project and broke them down into pieces. Thus, in case of having a door panel, all the parts that compose the final part have to be separately described, making a bill of material (BOM). This is an internal document that has to be fulfilled in every project offer phase, where information such as material, weight, dimensions and how many sliders will the injection tool need, will be important to calculate project costs.

Product Engineering team is responsible of filling up this sheet and then send it to costing department, where prices are calculated considering the current market situation. Furthermore, it is important to consider the volume of parts that are expected in order to quote the project. Therefore, there will be a matrix where all product variants are shown and the box will be checked if the part applies with the description or version on top. The result is an excel sheet document that shows a complete overview of the parts to be produced and with which every team that participates in this project (logistics, processes, costing, materials, etc.) will have a clear and detailed picture of the product.

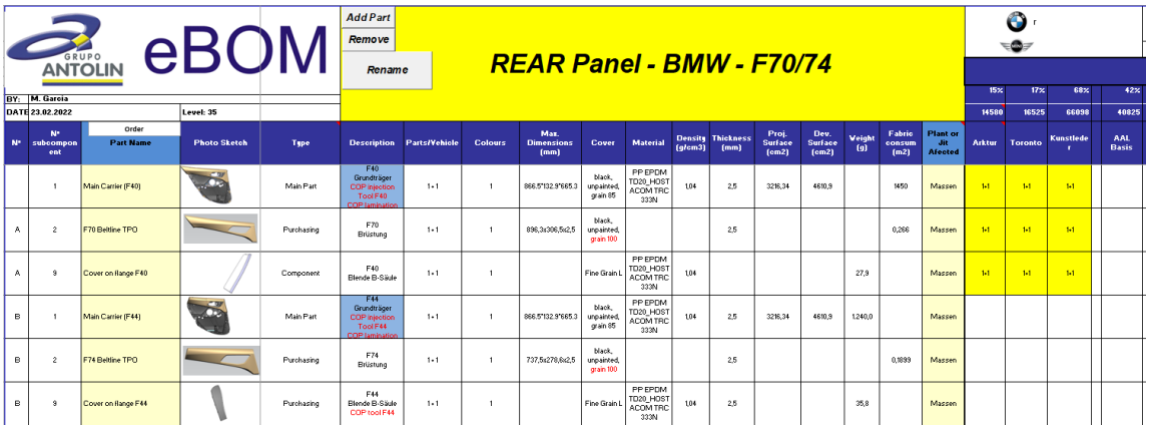

Figure 5 – eBOM example from BMW F7x Rear Panel

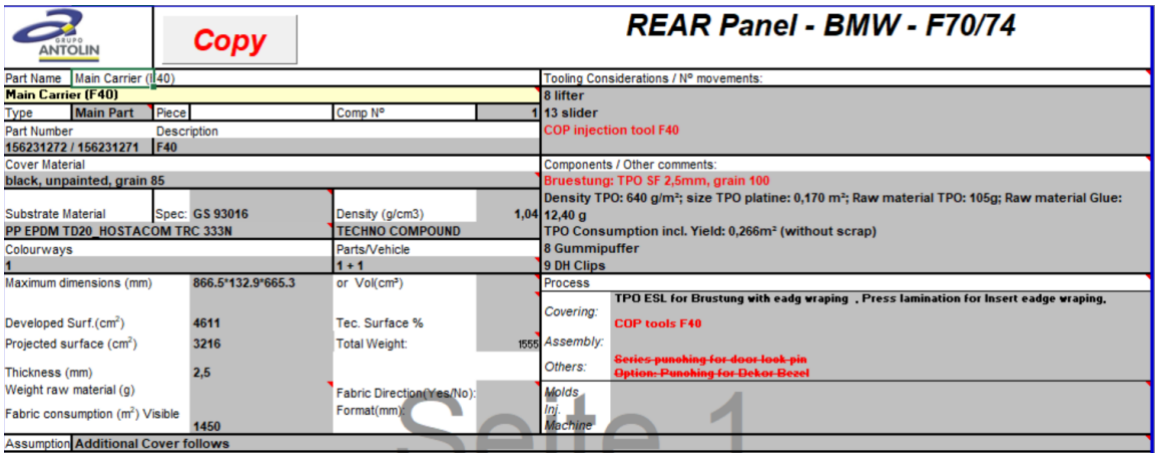

Figure 6 – BMW F7x BOM part specifications

For investments, such as EOL (end of life) tools and molds, there will be another list that will include all the tools necessary in order to produce the final part. However, there will not be an specific document for this section and will only be included in case of an RFP.

2.5 BPM (BUSINESS PROCESS MANAGEMENT)

Once a supplier is nominated for a project, it is time that the company, in this case Grupo Antolin, strategically organizes its production. Therefore, capacity at other plants have to be consulted and other suppliers may be taken into account. Following a similar procedure as mentioned before, Grupo Antolin launches an RFP to some suppliers, and based on costs and further considerations, an election is made. Therefore, the BPM is the internal registration for each part of the door panel that needs to be externally produced. In each BPM details such as name of the participants or part specifications such as drawings or purchase dossiers can be found, and once a supplier is nominated, it automatically sends a message to all people involved.

Therefore this system involves both engineers and the project or commodity buyers. The commodity buyer will be responsible of ensuring that all information that the supplier will need is correctly updated and the product engineer will prepare the drawings for the parts that will be launched for purchasing. Furthermore, all parts and tools will be including in the BOM/BOI section, with important information such as tool price or price per part and yearly volumes.

All these BPM system is registered in Buyone, which is a Grupo Antolin internal software used to store all the projects of the company. This software offers multiple functionalities for different projects, but access is denied unless it is specifically granted for your project, For a purchase to go through, it will require both the approval of the project manager and the department head.

BOM

Selector for sourcing			SAP Code	Label	Eng. Level	BPM Number	Commodity Buyer	Commodity Manager	Consumer Site	PPY
☑	🗑	✎	186044162	F70/74 SZT Bezel FR LH LHD	C		Hof Sebastian	Hof Sebastian	MAS	117,425.00
☑	🗑	✎	186044161	F70/74 SZT Bezel FR RH RHD	C		Hof Sebastian	Hof Sebastian	MAS	50,325.00
☑	🗑	✎	186044172	F70/74 Fensterheber Bezel FR LH RHD	C		Hof Sebastian	Hof Sebastian	MAS	50,325.00
☑	🗑	✎	186044171	F70/74 Fensterheber Bezel FR RH LHD	C		Hof Sebastian	Hof Sebastian	MAS	117,425.00
☑	🗑	✎	186044182	F70/74 Fensterheber Bezel RR LH	C		Hof Sebastian	Hof Sebastian	MAS	167,750.00

BOI

Selector for sourcing			SAP / ICT Code	Label	BPM Number	Budget Item	Commodity Buyer	Commodity Manager
☐	🗑	✎	338055131	F7x; Gripper Bezel Passenger LHD tool (2cav)			Hof Sebastian	Hof Sebastian
☑	🗑	✎	R00006069	Checking gauge - Alev 1.1 Vo Hi LH	BPM004188	Y21177PLNMAS	Pedde Sophie	Hof Sebastian
☑	🗑	✎	R00006070	Checking gauge - Alev 1.1 Vo Hi RH	BPM004188	Y21177PLNMAS	Pedde Sophie	Hof Sebastian
☑	🗑	✎	R00006058	Painting jigs - Alev 1.1	BPM004188	Y21177PLNMAS	Pedde Sophie	Hof Sebastian
☑	🗑	✎	R00006059	Pre-treatment jigs - Alev 1.1	BPM004188	Y21177PLNMAS	Pedde Sophie	Hof Sebastian

Figure 7 – Buyone BOM/BOI section with parts and tools main details for BPM creation

2.6 TEAMCENTER

As product engineers, it is necessary to have a tool that allows you to visualize the parts to be processed in a 3D environment. Teamcenter is used for this purpose, which allows you to visualize the parts of the product but will not allow you to make modifications. Thus, if it is necessary to make any modifications to the designs, you will have to contact Grupo Antolin's CAD team in India, who will be in charge of making such modifications using the CATIA program, which is widely used in the automotive sector.

However, this program is very useful because it enables to analyze the product in detail, which will be necessary to determine its technical specifications. It also allows to obtain technical data such as maximum dimensions of the product or its weight, which will be very useful to complete technical data sheets of each part within the BOM.

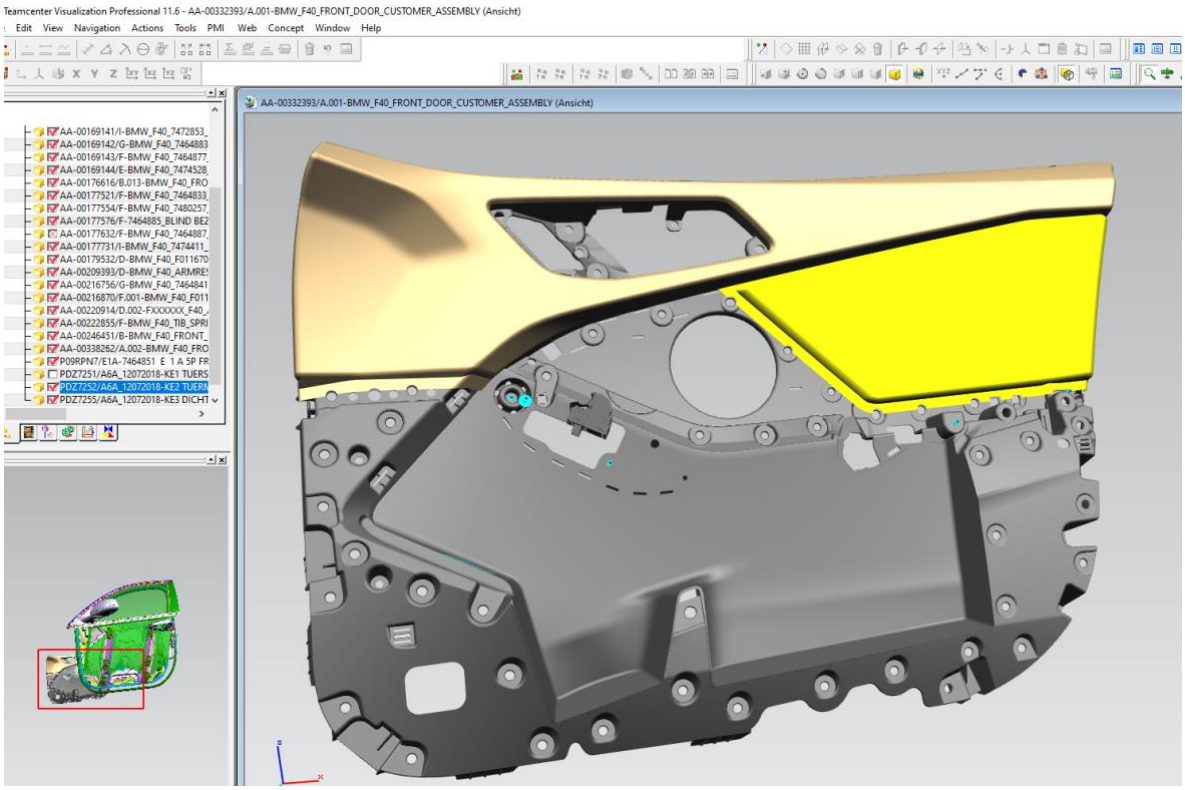

Figure 8 – Teamcenter visualization of BMW F40 front door panel

Chapter 3. CURRENT STATE OF THE QUESTION

In this chapter the intention is to show some previous projects that served as a guideline to develop this project. Therefore, some examples of previous door panels projects manufactured by Grupo Antolin will be shown, analyzing how they affected in the design of the F7x and doing a final comparison to the most similar project which is on actually being produced, as it is the F4x. Consequently, this will lead to understand the purpose of this project, leading to the following chapter.

In the first place, as an experienced manufacturer, Grupo Antolin has a large experience in door panels. Therefore, some other door panel projects carried out by Grupo Antolin may lead this project by using them as reference. However, every project is unique and will basically depend on its costs and quality. Thus, having BMW as a client, the references to be taken should be from similar brands, as being a more luxurious option it would not have similar materials or components as Renault, for example.

3.1 AUDI AU426 Q5

As a first reference example, the Audi Q5 AU426 door panels are being produced by Grupo Antolin since 2016. Besides, the new Audi Q5 AU436, which will be the new Q5 model, Grupo Antolin has been also nominated to start its production by 2024, which means that Audi Q5 project will have a similar background to BMW F7x project. The main characteristic of this project is that it will be produced in Mexico, more concretely in Grupo Antolin Tlaxcala plant, as Audi production plant will also be placed in Mexico, in San Jose Chiapa. Furthermore, the door panel principal parts will be injected in plastics and grained or covered with other materials, which also makes it a good reference to follow for the new BMW project.

The results obtained from this project were very good overall. The designs were correctly designed, avoiding further modifications to the tools and the quality was to the customer's

liking. As a result, Grupo Antolin was awarded for their efforts by being nominated for the project successor. However, despite the efforts to follow a continuous line in the design and development of the new model, the current situation has caused the prices of materials to rise exorbitantly, thus putting the benefit of this project at risk. Therefore, this will be an important point to consider during the project.

Figure 9 – Audi Q5 AU426 reference project

3.2 BMW G1X SERIES 8

Secondly, it is interesting to analyze other projects carried out with more luxurious models, as for this F7x project there will be a premium version where it is interesting to understand how to deal with these higher class concepts in greater detail. Accordingly, the BMW G1x Series 8 will be a good reference as how to integrate high quality materials and processes in the door panel production. Also, these parts are produced near the factory where BMW produces this model, which is a good point to take into account for the F7x project as it will follow a similar concept.

This G1x project is a reference for Grupo Antolin in terms of delivering a solid product while investing in technology, successfully fulfilling with technical requirements. Although for the

most premium version that was offered in this model was a complete success, for basic versions it supposed some losses to Grupo Antolin. As a consequence, the project resulted in an almost inexistent profit despite the great quality delivered, meaning that BMW was satisfied with the work but Grupo Antolin would have expected a more profitable project.

Therefore, the G1x project will be useful as a reference as the premium materials and concepts will be very similar to F7x project for the fact that they share the same OEM. However, processes and basic versions will be reviewed in order to optimize its production and try to avoid losing money on these versions.

Figure 10 – BMW G1x 8 Series premium reference project

3.3 BMW F4X SERIES 1 & SERIES 2 GRAND COUPÉ

Last, the most faithful reference for the BMW F7x project would be its predecessor, the BMW F4x Series 1 and Series 2 Grand Coupé. Although it was not as good as expected economically speaking, from its technical point of view it is not very far from what constitutes its new version. Its management will be analyzed during the project with the aim of obtaining the maximum knowledge possible so as not to repeat the same failures. Lessons learned from this project, will be of huge importance to understand the reasons why this

project was a complete failure economically speaking, as they will pave the way on how to overcome those mistakes by making a good prevention strategy.

Although this project was not a good project for Grupo Antolin, it is fair to say that BMW considered that quality requirements for the final product were correctly fulfilled apart from other important points such as logistics, production timing or product quality.

Furthermore, this project expands over three different Grupo Antolin plants, all in Europe (GA Massen, Germany; GA Valplas and GA Aragusa, Spain), which are giving constant support to BMW main production plants in Germany. However, the new facelift will only be produced in Leipzig as a result of the current economic crisis. This model has been in production since 2019, and will share some years of production with the new facelift definition.

Figure 11 – BMW F4x Series 1 & Series 2 Grand Coupé reference

3.4 CURRENT SITUATION OF THE AUTOMOTIVE SECTOR

The expected result from every project is maximize the profit while taking care of the relationship with the different stakeholders. Due to the current situation of uncertainty, on many occasions projects are being taken in which no profits are generated, since greater importance is given to the relationship with the client. For example, in past projects, plastic materials for injection parts were quoted at an initial price of 2,3 €/kg. As a result of the recent Russian invasion to Ukraine, materials have risen over 3 €/kg, making projects very hard to quote and as a result making Grupo Antolin have a big uncertainty on whether projects will be profitable or will make the company not to grow.

Starting from this solid base, this project has a great internal experience to face this new project, which, used in the correct way, will make this project a great success. However, falling into misinformation and making mistakes similar to previously carried out projects added to the current difficult situation, would mean a loss of money, and therefore, a failure for the company. Also, it is important to emphasize that the magnitude of this project, being a facelift, is much smaller than the scope of the projects discussed above. This means that the figures will be lower, and therefore the profit will be lower in comparison.

Having put on the table the different projects that will serve as a guide for the realization of this project, it is time to move on to the next chapter, where the reason for the project will be justified and its scope will be analyzed.

Chapter 4. PROJECT DEFINITION

The magnitude and scope of the project will be analyzed during this chapter by carrying out a brief justification on why this project is being developed, listing the different objectives that are necessary to complete the project, and analyzing the methodology to follow during the course of the project. The intention is to clearly define the boundaries of the project so it can have a clear structure to follow

4.1 JUSTIFICATION

Even though Grupo Antolin has been already nominated to carry out this F7x facelift project by BMW, this section will explain the different reasons why it could have been decided to carry out the project with Grupo Antolin instead of with other suppliers.

Before entering into details of why Grupo Antolin is the perfect supplier for this project, it is important to understand why this project is important to Grupo Antolin. As BMW occupies a great part in Grupo Antolin Germany portfolio, it is crucial for the company to keep the relationship as alive as possible. Therefore, and because of doing the previous project for BMW, Grupo Antolin has the know-how for the project and as a result, it will be the cheapest and best quality option for BMW. However, this time Grupo Antolin expects a better payed project in return. So much so that some foundations were established in which both parties were favored, and further in the memory, this part will be explained in detail.

As previously referenced, some of the past projects that will be used to prepare the foundations of this project where briefly analyzed to discuss whether or not the outcome was successful. However, what all this projects share is the reason for which Grupo Antolin was nominated, which leads us to the question, why Grupo Antolin? Therefore, the answer will be divided into points referring to Grupo Antolin's principal strengths.

4.1.1 GRUPO ANTOLIN BROAD EXPERIENCE

Although experience is not everything, it would be fair to say that it is a crucial differentiator when deciding between two competitors with similar characteristics. Experience can be obtained in two different ways: over the years and accumulating completed projects, or buying that experience from other companies. Grupo Antolin is one of the leader companies in the automotive sector largely due to this facet. The following two examples show how Grupo Antolin expanded its horizons and gained the experienced needed through the years to be on top of the market.

4.1.1.1 Purchase of Magna Interiors

In 2015, Grupo Antolin acquires Magna Interiors from Magna, which is a mobility technology company and one of the largest automotive suppliers in the world. With this acquisition, Grupo Antolin assured the following key points:

- Grupo Antolin becomes one of the largest players in car interior market internationally, doubling its size with sales over 4€ billion.
- All projects and customers that belonged to Magna where directly transferred to Grupo Antolin list.
- The employees in charge of these projects became part of the ranks of the company, completing a total workforce around 28,000 employees.

Thanks to the purchase of Magna, Grupo Antolin positioned itself as one of the main suppliers for the brands, increasing confidence in these [4].

4.1.1.2 Relationship with BMW

Another example would be the relationship between Grupo Antolin and BMW. Due to the broad experience over the years that the company shares with the car manufacturer, a relationship of trust has been developed. Thanks to the correct execution of the different projects in which Grupo Antolin has been nominated, BMW keeps counting on the company for future projects, as they possess the know-how and specifications preferred by the OEM.

Apart from that, as F4x project was also produces by Grupo Antolin, some of the tools to make the final parts for the door are already manufactured and in the possession of the company. This is a key factor, as tools are one of the most expensive parts to be produced, which gives Grupo Antolin a huge advantage against their competitors.

4.1.2 INNOVATIVE SOLUTIONS

Grupo Antolin is characterized for constantly seeking for innovative solutions that can be applied and serial produced in the automotive sector. There are many revolutionary discoveries that that due to their inability to apply them to the production line of a vehicle remain as mere discoveries. However, Grupo Antolin is constantly developing these technologies and also working closely with companies that offer these technological solutions with the objective of integrating it in the manufacturing lines. To explain the scope of technology development by Grupo Antolin, the following examples used in other projects that could be of interest to BMW are set out below.

4.1.2.1 Heating mates integrated in car interiors

These surfaces consist on a lamina integrated on different parts of the car interior, usually the armrest, as a way of reducing gas consumption for air conditioning. The heating technology will depend depending on technology developed on each company, but the most extended will be a heating lamina connected to the electrical part of the vehicle that will be included in the part lamination.

Anyway, these solutions are often used for premium models and have higher costs. As mentioned before, in the BMW G1x project this heating armrest was already implemented on series. However, as this is a new tendency there are several applications in the market to be chosen, and Grupo Antolin studies which solutions fit best for each project. These kind of solutions are interesting for BMW as it seems that car interior trends tend towards this stream of heated interiors systems and could be of great use in future versions of this project.

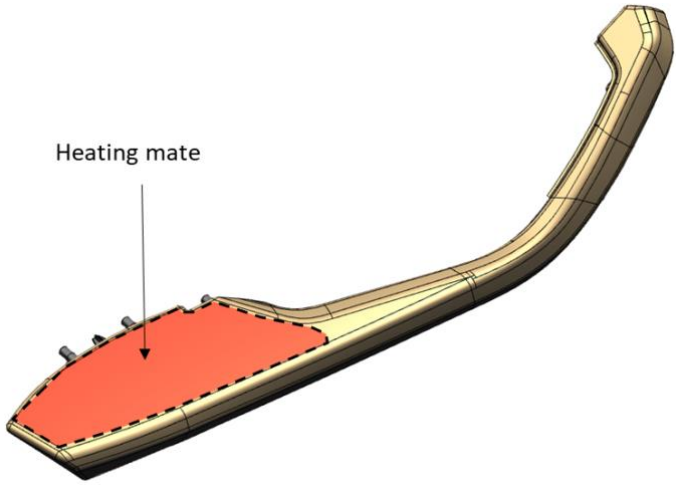

Figure 12 – Heating mate simulated in BMW F7x Armrest (not real)

4.1.2.2 NFPP Materials

Due to climate change, the current trends tend to reduce the amount of plastics used in car production. Knowing that the majority of parts in the automotive interior sector are plastic parts, there are new options to reduce the consumption of plastics. This is the case with the NFPP (Natural Fibers + Polypropylene), which is increasing its influence exponentially as a green option. It consists, as its name suggests, on a compound of natural fibers mixed with a plastic, greatly reducing its use. It also provides properties such as low weights, which also helps reduce fuel consumption, or in the case of electric cars, these are materials that counteract the high weight of batteries.

Grupo Antolin, committed to the fight against climate change, is committed to this type of solution to facilitate the transition. For this reason, it began to incorporate this technology several years ago in its portfolio of projects as options for car manufacturers. Thanks to its advancement in this technology, many OEMs opt for these solutions and trust Grupo Antolin to deliver the best result. Although the F7x project does not have any parts with this material, car manufactures find this tendency of huge importance due to recent restrictions that are imposed mainly in Europe against climate change.

Figure 13 – Grupo Antolin project with NFPP material used

4.1.2.3 ESL (Exact Shape Lamination) process

One of the most advanced features of Grupo Antolin is an special process used to reduce processes and material consumption when covering a plastic material. The process consists on cutting the covering material with the exact shape of the part plus some millimeter to do the edge wrapping. The innovative part is that the part is covered and wrapped through the edges in only one process, by using some sliders that will fold the material once the part is covered. However this process will not work for all parts. The process works as follows:

- Firstly, the substract or plastic part is taken to the lower tools that has the shape of the part, where the coverstock or covering material will be shaped into the part.
- The coverstock adheres to the substract using an adhesive and applying pressure. Then, the adhesive is activated with heat.
- Once the parts has been covered, the are some sliders on the tool that give the form to the resting material and glues it to the interior of the part, obtaining the final result.

This process will be of great interest to BMW as it will be used by Grupo Antolin to do the covering for an important part of the door panel. It was firstly introduced for F4x project and will continue working for F7x project.

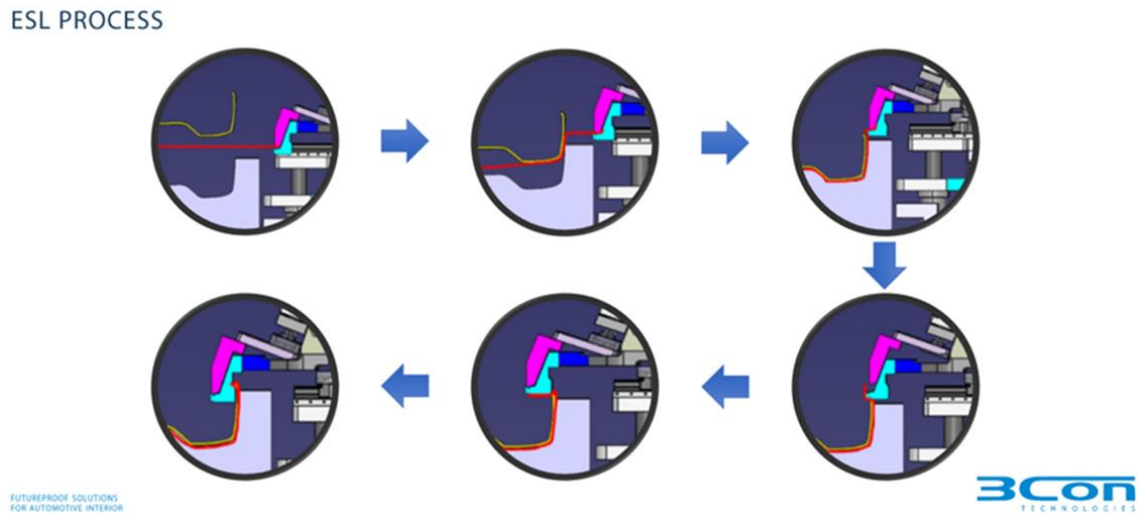

Figure 14 – ESL process from 3CON used by Grupo Antolin in BMW F4x project

4.1.3 PRODUCTION CAPACITY

Last but not least, it is important to highlight the production capacity that Grupo Antolin is able to support in its production plants. Thanks to its internationalization, it has multiple production plants all over the world, with special emphasis on its activity in Europe. With a presence in more than 10 countries in Europe, with multiple plants in many of them, Grupo Antolin finds one of its pillars in its great capacity to accept projects from the main OEMs in Europe. In addition, the proximity to the factories of these customers is a key factor to consider, since the main customers in the automotive sector demand this proximity in case any inconvenience arises.

On the other hand, in addition to the confidence that a company with a large production capacity can give to its customer, there is the factor of the decision of where the parts will be produced. This allows Grupo Antolin to obtain lower prices, since it can study the best option between producing in-house or outsourcing production to suppliers. Thanks to this negotiation capacity, the customer will benefit from Grupo Antolin's very competitive offer, thus adding another strong point to be taken into account.

4.2 OBJECTIVES

Taking into account the strengths of Grupo Antolin defined in the previous section, it will be important to set a series of objectives that facilitate the organization of the project. Therefore, this objectives will mark a series of milestones throughout the project, with the main intention of guiding it and ensuring its success. The goals of the project are defined as follows:

- The technical analysis of the modifications requested by the customer for this facelift project. A deep understanding of the drawings and proto parts created, will be needed in order to have all drawings ready for production.

- The definition of the new product and process changes necessary in order to obtain the new product in the production plant and sub suppliers. Consequently, it will be important to study whether these parts can be produced in-house as a way of saving money.

- Economic analysis of the engineering changes, considering the selling price and the costs inquired to Grupo Antolin for the development, tooling and part price that these changes requests.

- Final comparison between the previous and actual project, analyzing how lessons learned were applied and how them affected to the overall project.

Following these goals will ensure a correct path for the completion of the project. Although these objectives might slightly change due to confidential reasons, the idea is to give the big picture so the reader can have a clear idea of the magnitude and scope of this project.

Furthermore, the project will be carried out by a project engineer point of view, which means that economical aspects will discussed from a technical point of view. However, a more deep analysis of the company strategy, discussing concepts such as the contribution margin and how does this value affect to Grupo Antolin will be also discussed in a final stage of the project.

4.3 METHODOLOGY

The path to follow during the project will be structured into milestones, that divided into tasks and organized through time, will be the key to achieve the project objectives. It is important to highlight that the aforementioned milestones are not necessary the project objectives. However, these milestones are structured through time in order to facilitate the objective completion. Consequently, all these events are chronologically placed in a Gantt Chart (see below) considering that the completion of this project was proposed at the beginning of February and with the target of finishing it by mid-July, with approximately a total of 24 weeks to work on the project.

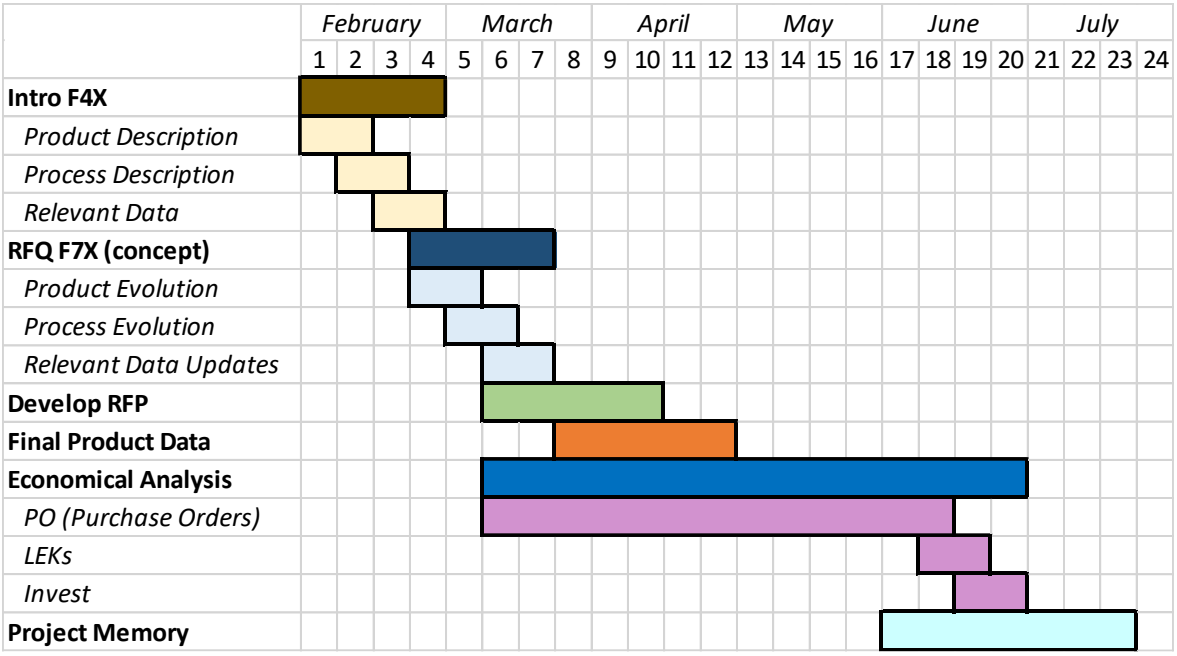

Table 1 - Gantt Chart designed to face the different goals of the project

Once the direction of the project has been established, there will be three different phases that will constitute the methodology of the project:

1. The first step consists on gathering all the relevant information about the previous project and understanding how the new modifications will be implemented. Apart from reviewing all the documentation available, it will be of huge importance to

physically analyze the product, having a deeper understanding of the door panel as a result. Therefore, thanks to the proto parts manufactured for this purpose, it will give some notions on how the design works and if there is any problem with it.

2. As follows, once all the technical data is on the table, it is time to study whether it is more convenient to nominate a supplier to produce some of the parts, or if it is better to produce in-house, using one of the production plants available from Grupo Antolin. Analyzing the marginal cost of the plant will clarify which option will be the best one. However, this study will be conducted by purchasing team that will communicate their answer by the notification of the BPM, either if there is a supplier that has been nominated or the final decision of producing in-house.

3. Last but not least, an economic analysis will be carried out in order to study how lessons learned from the previous project were applied. Therefore, the strategy to follow for the F7x project will be analyzed to compare the final results. Furthermore, these economic analysis will also include the purchase orders made from BMW, that have to be processed to get the payments from the customer.

To ensure the success of the project it is important to follow a clear path completing the different tasks successfully. Therefore, the product engineer in charge of this project, will be responsible for periodically reviewing the progress of the project by organizing meetings where the work done to date will be exhibited. All the feedback gathered on these sessions will be important to stay on path.

Moreover, the project director proposition, Alvaro Calleja, is to set a clear route plan at the beginning of the project by making a presentation of the tasks to be done. Once all feedback has been received, every doubt that may appear during the course of the project will be resolved by project director. The last step will consist on the project presentation to the whole team, receiving feedback and making the necessary changes to hand in the memory of the project.

4.4 PLANNING AND ECONOMIC ESTIMATION

As for the timing of the project, every door project at Grupo Antolin has several phases that must be completed. Firstly, there are the first pieces, with which the client can check if the proposed designs are as expected. Following these parts, there are up to four phases of prototype parts, which, as shown in the graphic below, would be the BBGP4. Next are the last revisions for each model, which are the VS0 and followed by crash tests. Finally, once it has been correctly checked that all the parts have been manufactured without problems and as expected, the last phase would be the SOP (Start of production), which as its name suggests will be the beginning of mass production. In addition, all tasks to be performed will be indicated on the left side, closing all open topics and distributed by weeks throughout the year, in order to have a clear guide of what to do in each moment.

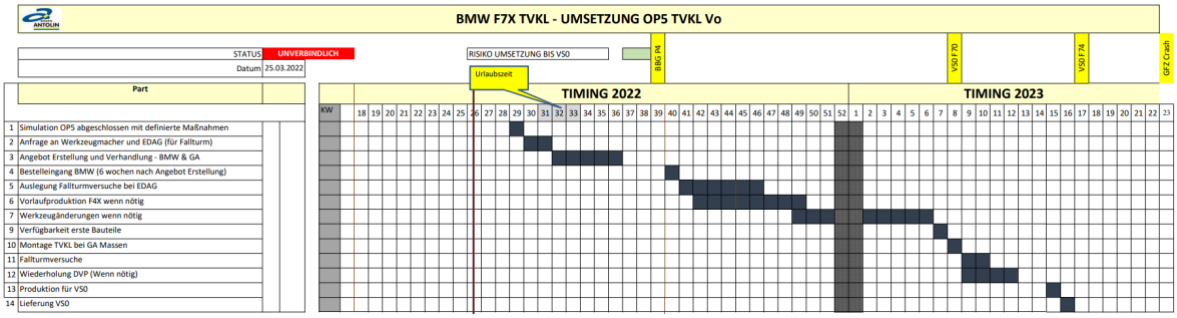

Table 2 – BMW F7x Door panel timing

The project is a facelift to a previous BMW model, which means that it is a smaller project than starting a new model or a new design line. This is why the economic estimates that may come out of this project may not be comparable to a larger project. However, as these figures are confidential, it is not possible to give real data on this project. For this reason, at the end of the report an economic study will be carried out making some estimations of what a project of these characteristics could mean.

Chapter 5. DEVELOPED MODEL

This chapter includes the development of the project, taking a tour to understand what the product offered to BMW consists of, what processes must be completed to obtain the final product, and finally the modifications proposed by BMW to develop the new model will be studied.

In addition, the tasks carried out in each section of the project will be detailed, giving importance to the work carried out by the product engineer. Note that in this chapter no economic analysis of the project will be detailed, but will wait to comment on it in the next one, once all the information has been correctly detailed.

5.1 PRODUCT ANALYSIS

As described throughout the report, the product to be dealt with in the project are the door panels of the BMW 1 Series and 2 Series Grand Coupé models. These are the front and rear doors of both models. While the front door is the same on both models, the rear door differs due to the difference between the two models. For this reason, in this section the product will be presented in detail, differentiating the different parts that conform a door panel. Additionally, as door panels will be manufactured also for right driven countries, the produced volumes will be vary, being LHD (left hand drive) door panels different to RHD (right hand drive), only having this exception in the front row of the car.

The objective of this section is to understand the different parts that conform the door panel, reserving the analysis of the differences between F4x and F7x for further points. Therefore, this section will separately describe the general parts of this door panel, giving some general details such as materials for injected parts, materials used for all covering variants and how will they be manufactured.

5.1.1 MAIN CARRIER

The Main Carrier is the main structure of the door panel, where all the parts will be assembled. It is injected in plastic and there are only two parts of it that will be covered, the Beltline and the Insert, that will be described later. Furthermore, the different parts that conform the door panel will be welded with plastic domes.

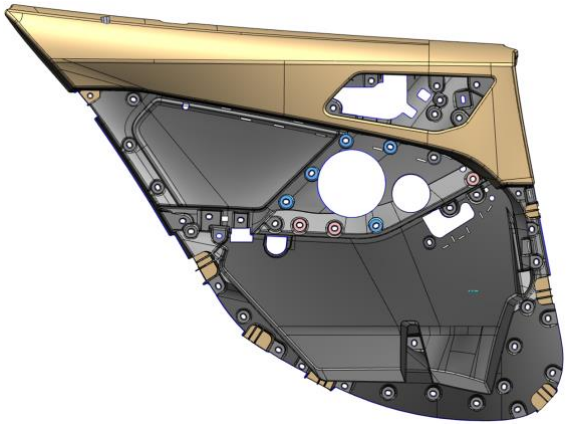

Figure 15 – BMW F70 Main Carrier from rear panel

5.1.2 BELTLINE, INSERT & WEATHER STRIP

As previously mentioned, the Beltline is the upper part of the Main Carrier. This part will be covered with a TPO (Thermoplastic Polyolefin) material using an ESL process with edge wrapping in the same process.

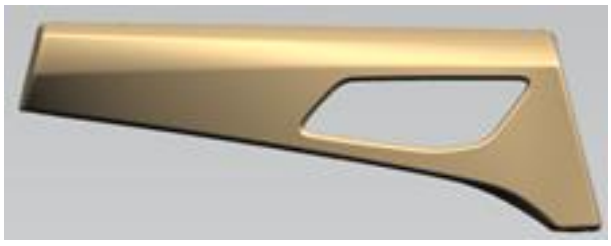

Figure 16 – BMW F74 Beltline from rear panel

The other part that conforms the Main Carrier is the Insert. This parts is characterized for being laminated with a PUR foam, making it a thicker part with a softer touch. Furthermore, there will be three variants depending on the version. For basis version, there will be two

textile options with the following commercial names, Arktur and Toronto; for premium version, artificial leather will be used, and it will also be sewed with a stitching line. These parts, regardless of the covering material used, will be covered using press lamination.

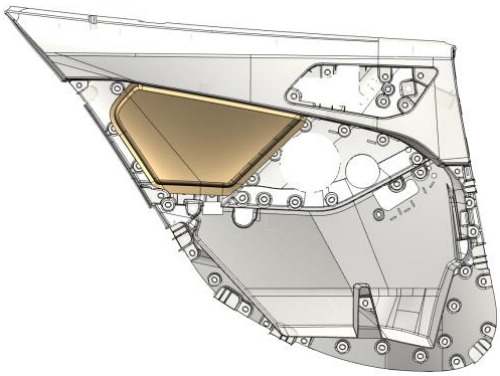

Figure 17 – BMW F7x Insert from rear panel

Last, the Weather Strip is a injected plastic part that goes in the B side (hidden side) of the door panel. This part will be welded to the Main Carrier, so that it does not form part of the Main Carrier whole.

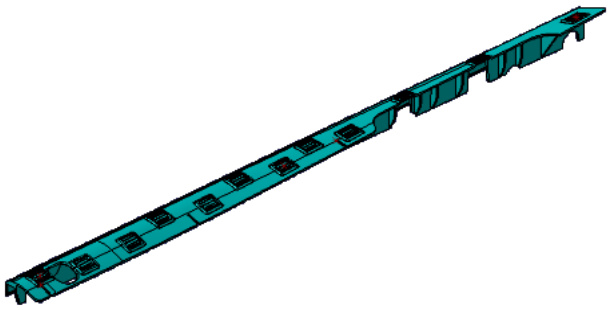

Figure 18 – BMW F70 Weather Strip from front panel

5.1.3 ARMREST, GRAB HANDLE & SWITCH BEZELS

The arm resting zone is formed by three differentiated parts. Firstly, the Armrest, which offers two versions, basis version using a PVC material, and premium version with a sewing line and made out of artificial leather. Both versions will have a foam and then covered using vacuum covering plus an edge wrapping process. The second part that belongs to this

structure would be the Grab Handle, which is a plastic injected part that gives robustness to the Armrest. The last parts that complete this zone are the switch bezels, which are responsible of fitting the switches for windows and trunk switch. Its geometry will vary depending on the door panel they are placed and will also be plastic injected.

Figure 19 – BMW F7x Armrest, Grab Handle & Rear Switch Bezel (from left to right)

5.1.4 MAP POCKET & DOOR OPENER ASSEMBLY

The Map Pocket is used to give the door panel some storage space, where the driver can place its personal belongings. It is injected in plastic and grained, for after welding to the Main Carrier.

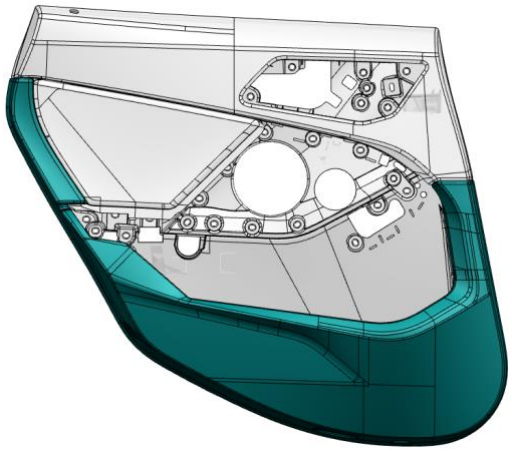

Figure 20 – BMW F74 Map Pocket from rear panel

Then, the door opener assembly is formed out of several parts. Again, depending there a two versions available, with or without SMS (Seat Memory Switch). Furthermore, there is the

Lever, which will be used to open the door of the car, and then the Doorlock Switch in the front seat to lock or unlock the doors.

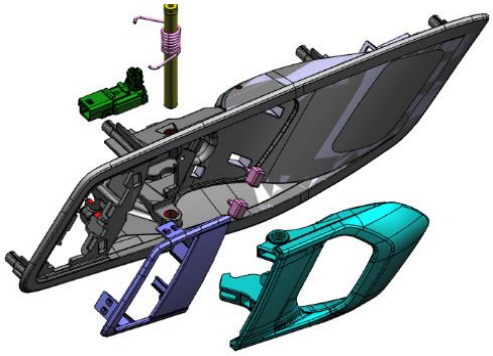

Figure 21 – BMW F7x Door Lock Assembly front door panel

5.1.5 SPEAKER COVERS

This part consists on the plastic or metal cover, depending on its version, of the speaker. There are two versions, basis which offers a plastic part with two options, grained or painted, and the premium version which consists on a metal grill with some lighting of the sound supplier.

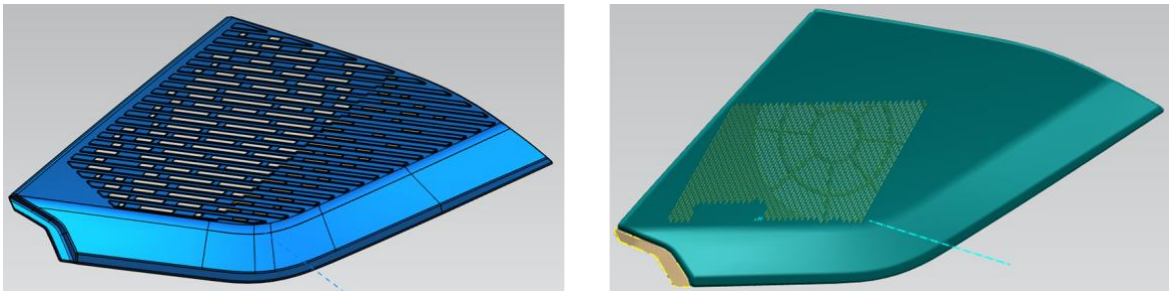

Figure 22 – BMW F7x Speaker Grills basis and premium version (from left to right)

5.1.6 OTHER COMPONENTS

To end up with, the are many components that conform the door panel in its whole, making possible the assembly of all the parts. The following table gathers the components in charge of sticking all parts together and attach it to the BiW (Body in White), which is the car

structure where door panels will be mounted. It also contains decorative components such as LED lights to illuminate the car interior.

Part Name	Photo	Description	Parts/Vehicle Front Panel	Parts/Vehicle Rear Panel
Plastic Clip		Plastic clips in charge of clipping the door panel to the BiW.	8+8	9+9
Rubber Bumper		Reduce noise and friction when assembled to BiW.	7+7	8+8 / 6+6 (F70/F74)
Flock Profile		Rubber part placed in the side of the door panel to reduce squeak and rattle.	1+1	1+1
Door Step Lighting		Light turned on when door opnes.	1+1	1+1
Screw Dome Cover		Plastic trim to hide screws.	1+1	1+1
S-Clip		Clips used in Door Opener Assembly.	2+3	3+3
LED Module		LED module that will generate light to then guide it through the fiber optic.	2+2	2+2
Fiber Optic Guide		Light will be conducted throught this part to the Grab Handle.	1+1	1+1
Metal clip		Metal clips used to attach Switch Bezels into the Gran Handle.	3+1	1+1
Screw 4x12 Delta PT40		Assembly of door panel to BiW.	4+4	1+1
Screw 4x30		Assembly of door panel to BiW.	1+1	-
Foam Pad		Reduce noise and friction.	2+2	1+1 / 2+2 (F70/F74)
Door Panel Cables		Cables needed to electrify all components, such as switches or LED modules.	1+1	1+1

Table 3 – BMW F7x Components front and rear panels

5.1.7 DOOR PANEL ASSEMBLY

Once all parts have been listed, it is time to assemble them to make the final door panel. Therefore, there will be different fixations such as welding points, screws and clips that will make all the parts stick together. The different steps to assemble the door panel are as follows:

1. The Main Carrier will be the base of the door panel, and where all the different components will be attached to.

2. Once Main Carrier is ready, other main parts such as Map Pocket, Weather Strip, Speaker Grill and Door Opener will be welded into the main carrier with their respective welding domes.

3. To end up with, the Armrest plus the Grab Handle will be assembled. Once these parts are mounted, Switch Bezels will be clipped in their holes, making the complete door panel.

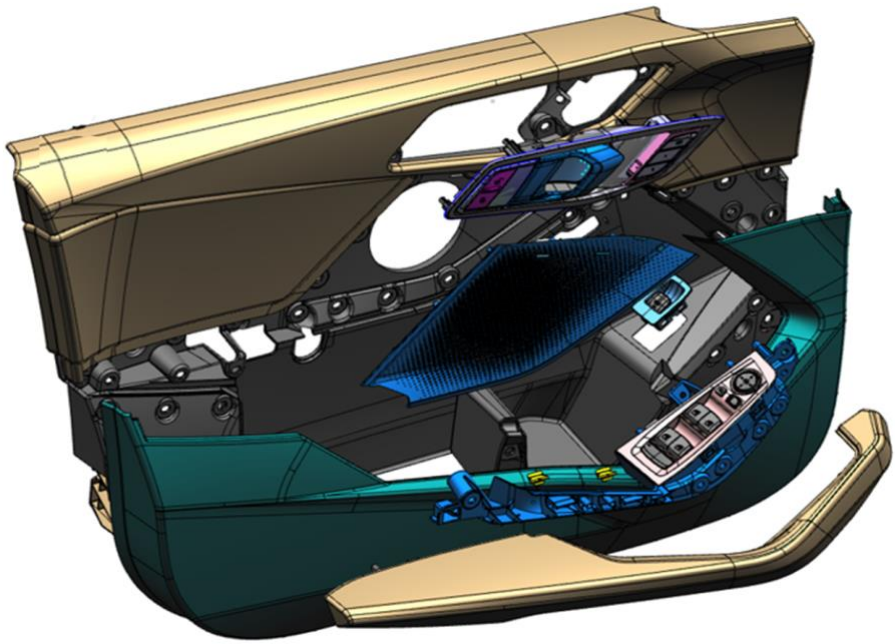

Figure 23 – BMW F7x exploded view of the assembly

5.2 PROCESS ANALYSIS

The objective of this section is to understand the process that BMW F4x undergoes in order to be produced. Although product processes may belong to process engineers area of work, it is important that product engineers fully understand these processes so that in case of detecting a problem in the part, it can be directly related with the process. Furthermore, the importance of understanding the path that the different part follows through the Grupo Antolin production plants is primordial as product engineers will have to go and visit these plants in order to make sure all parts are produced as expected. Last, BMW F7x processes will stay the same, slightly adapting injection tools to new parts by creating new molds.

5.2.1 PROCESSES

The first point is to understand that all plastic parts will be injected, using molds and injection machines. Once parts are injected, there are some that will be covered in different materials, such as the Beltline or the Map Pocket. These materials will be different depending whether it is a premium or basis version. Lamination with other materials such as foams will make the technology used to cover plastics vary. When doing a lamination process there are three different parts that conform the final part:

- **Substrate**: made by injection molding and usually made of ABS, ABS+PC or PP. In this project, plastic parts will be injected in PP with TD20 (talc 20). There can also be added a series of additives depending on the specific optimization of the material properties that may be required (glass, talcum powder, carbon black). Variation with injection molding parts with foamed areas or foaming agent. Alternative where is manufactured in a fiber press process, usually made from natural fibers plus black injected PP elements (NFPP).

Figure 24 – BMW F7x Main Carrier injected in PP TD20

- **Coverstock**: material used to cover the plastic that can go from a TPO foil or other plastics for basis versions to artificial leather, leather or Alcantara for premium versions. In this project basis material will be some textile material named Arktur and Toronto, and for premium version artificial leather will be used, which is formed from a PVC material. Furthermore, these materials may be laminated with foam

materials depending on the part of the door panel. For example, the Beltline will have less foam than the Insert, which will offer a softer touch.

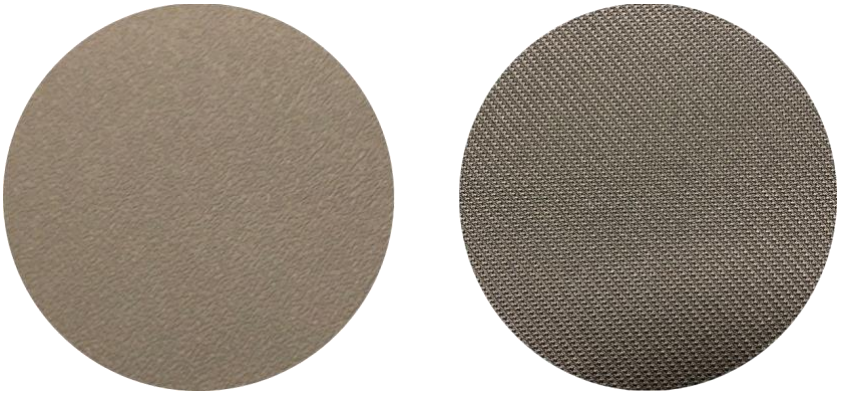

Figure 25 – Artificial Leather (left) and Arktur textile (right) materials fro BMW F7x

- **Adhesive**: it is the surface treatment in order to improve the adhesion of both parts, as low surface tension results in low adhesion. There are different adhesive types, such as water based dispersion, solvent glue, PUR Hotmelt or POR Hotmelt. The application methods for this adhesive may be: spraying, painting or roller coating. Once the adhesive is applied, the glue will be activated with heat in order to join both parts.

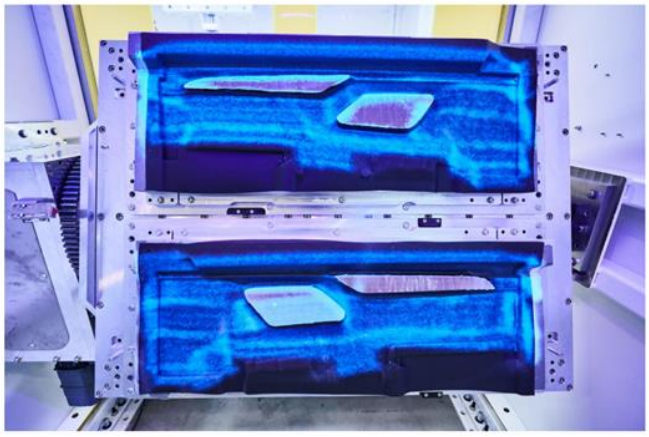

Figure 26 – UV additive added to visualize the adhesive application in the area

For these different combinations, there are some process parameters to take into account when covering the plastic parts:

- **Temperature**: in order to activate the glue temperature is needed. Once the substrate is joined to the coverstock, the demolding temperature will be useful to take the part out of the mold.

- **Pressure**: to obtain a good adhesion result, pressure will be applied uniformly through the mold to obtain the best result possible.

- **Time**: last but not least, the heating time plus press time is of huge importance so that the adhesive gets enough time to adhere to both sides. Once the part gets out of the mold, it is important to consider the cooling time so there are no imperfections in the final result.

Once the materials are chosen, there are a couple of lamination possibilities that can be used depending on the material used and the difficulty the part may suppose. All these processes named below are part of the production of the BMW F4x interior door panels, that will vary depending on the part.

5.2.1.1 Press Lamination

Depending on the complexity of the geometry to be laminated, this process can be divided into two different options [5]:

- **Negative lamination**: or female, is when the substrate is placed in the upper tool and the coverstock is in the lower tool. Once placed on the cold tool, they are heated before applying pressure. The outcome would be the part already together. It is mostly used for 2D blanks (cut to shape). Stable process for easy geometries that can be flat protected.

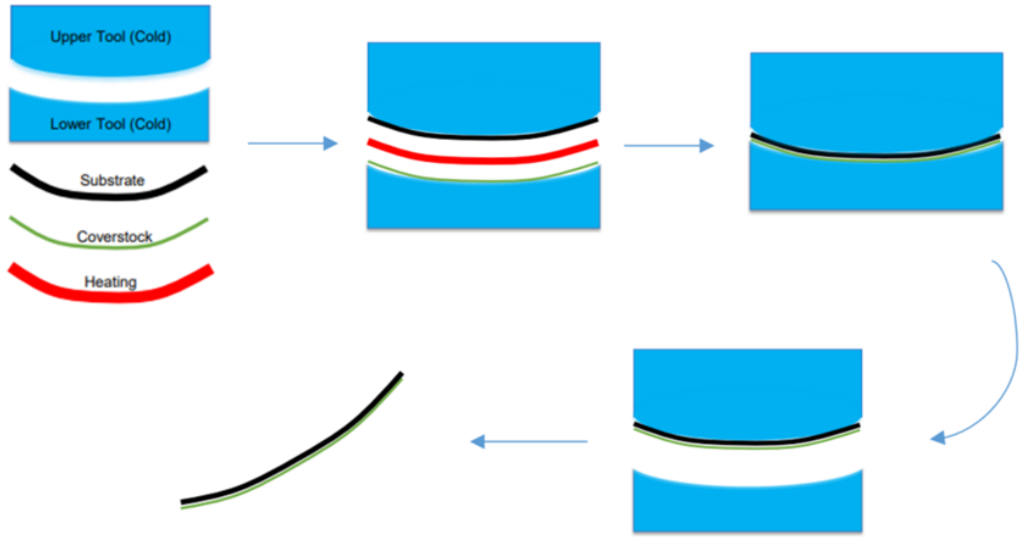

Figure 27 – Negative lamination process scheme

- **Positive lamination**: or male, in this case there will not be a heating process as the Upper Tool will be hot once the pressure is applied. The coverstock will be placed on the substrate, and both on the lower tool. The pressure is applied until the Upper Tool cools down. This technique is mostly used for Cut & Sew skins due to complex geometries. Stable process for complex parts to correct smaller issues.

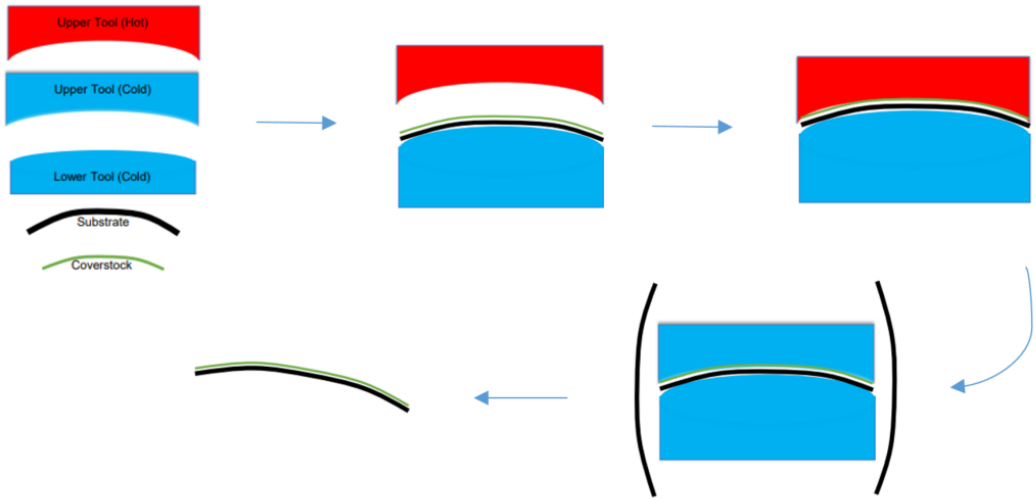

Figure 28 – Positive lamination process scheme

5.2.1.2 Vacuum Lamination

The vacuum lamination machine function is to fix the decorative layer or coverstock (PVC, TPO or TPU) over the visible surface of the part and even start the edge wrapping in some required areas. Of the materials used in both conventional vacuum processes, substrate material and covering material are defined by the customer. The adhesive will be the only material chosen or defined by Grupo Antolin and the coating process will be defined based on this choice. The adhesive will be applied in a previous process to the vacuum covering and it will condition some of the characteristics of the machine and tooling.

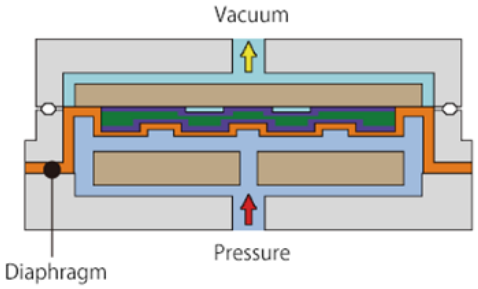

Figure 29 – Vacuum lamination process function scheme

5.2.1.3 Exact Shape Lamination (ESL)

The Exact shape lamination (ESL) is a negative lamination process with servo-controlled movement of the clamps. Is a combination of lamination and edge folding in the same tool. Dedicated for stretchable 2D materials, and allows the production of parts with higher complexity and makes possible stronger stretch areas.

Figure 30 – BMW F7x Beltline covered with ESL and edge wrapped on the right

5.2.2 LOCATIONS INVOLVED IN THE PRODUCTION

The BMW F4x production is divided into four different plants that spread along Europe. The idea consists on producing some of the door panel parts in other countries such as Spain or Slovakia, while the assembly of the final product will be in Germany, close to BMW production plants. Therefore, the production in Grupo Antolin production plants are organized as follows:

- **Trnava (SK)**: this plant receives the artificial leather in rolls already laminated by the suppliers and consequently prepares the Cut & Sew formats for the armrest to send them to Valplas.

- **Valplas (SP)**: in this plant located in Valencia, the armrest is injected and foamed. Then formats for premium version arrive from Trnava, consequently preparing the armrest by press covering. For basis version, armrests will be covered with a TPO foil using vacuum covering. Once all parts are ready they will be send to Germany, for final assembly.

- **Aragusa (SP)**: in Burgos, the weather strip is injected and prepared to send it to Massen production plant in Germany.

- **Massen (GE)**: this plant is located in a small city to the north of Dresden. It is strategically situated close to the BMW production plant in Leipzig and Regensburg, so in case there is any problem, the response capacity is high. Therefore, in this plan the Main Carrier is injected, and the insert and beltline are covered. Also the Map Pocket is injected and punched to get the final part. The final arrivals, such as purchase parts from suppliers and other parts from Grupo Antolin plants arrive to the plant. Welding, assembly and sequenced of the door panel will follow, having as a result the door panel ready to delivered to BMW.

Figure 31 – Grupo Antolin production plants for BMW F4x project

These BMW door panels offer over 600 variants depending on the combination of materials. The final version of the requested door panels will depend completely on the final customer choices, making this a difficult task for the plant as combination may vary constantly.

The BMW F7x production plants will suffer some changes due to the new project configuration. As there are more parts that will be produced in-house, more Grupo Antolin plants must be in disposition to hold the production. Therefore, all previous production plants will keep their planning production but the following additions will be added to the following plants:

- **Silesia (PO)**: new change will be that Switch Bezels instead of buying them from a supplier they will be injected in Grupo Antolin Silesia, which is a plant located in Poland. Again, once parts are finished, they will be delivered to Massen.

- **Massen (GE)**: this plant will maintain its status of final production plant for Grupo Antolin plant, but Grab Handles will be added to its production. This means that these parts will no longer be purchased to suppliers. It is also important to highlight that from BMW side, the plant in Regensburg (south Germany) will no longer be part of the production process, only leaving the deliveries to Leipzig.

Figure 32 – BMW plants evolution from F4x to F7x project

The tasks carried out for the correct functioning and checking of the different production activities, consisted on, as a product engineer, visiting Massen facilities production plant. These visits have been made approximately once every two months, with the intention of getting to know the processes and machines involved in the production chain, and on the other hand, getting to know the members of Silesia production plant team due to their recent incorporation. Some other topics such as first parts production timing and how logistics were going to be treated during the project were also discussed.

5.3 FACELIFT CONSIDERATIONS

The BMW F7x is the result of the modified BMW F4x door panels. Therefore, this section will explain which were the modifications done to the door panel, how these modifications were treated during this project and how proto parts were built in order to fully understand the behavior of these parts, and a final point where BPM creation for new parts were studied to decide whether produce parts internally or by other suppliers.

5.3.1 DOOR PANEL MODIFICATIONS

The changes listed below are the modifications to each part or material done to the actual BMW F4x:

- **Beltline**: this part will change its material grain, from a TPO Foil of 2,5mm with grain 80 to a TPO Foil of 2,5mm with grain 100. This modification will not change anything in the production line, the only relevant change will be from the supplier.

Figure 33 – Comparison between F4x grain 80 (left) and F7x grain 100 (right)

- **Insert**: there will also be a change on the material used. On one hand, basis version material will change to new Arktur and Toronto textiles. On the other hand, premium version material, artificial leather, will change its grain 75 to a grain 100, making grains look smaller.

- **Armrest**: again, changes in material will be the main topic, having for basis version, PVC based material, a change in the grain 80 to gran 100, and on the other side, for premium version having a sewed artificial leather, grain will change from 75 to 100.

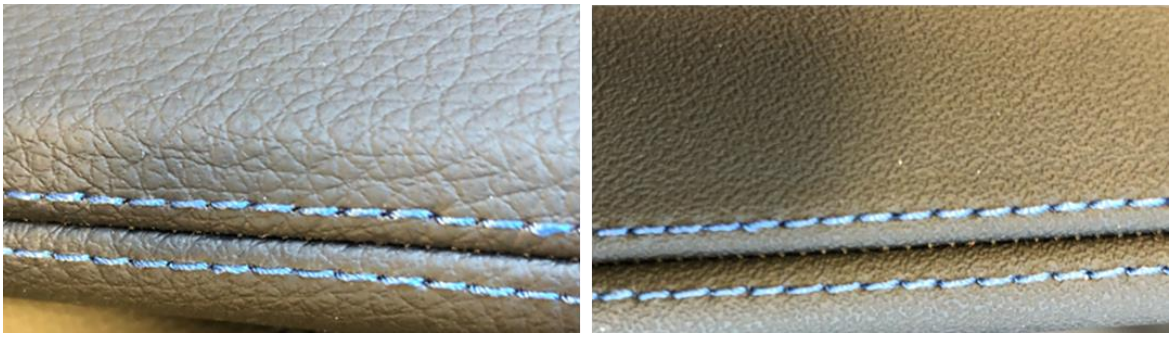

Figure 34 – Comparison between F4x grain 75 (left) and F7x grain 100 (right)

- **New switches design**: the new buttons design will mainly affect to the following group of parts:

    - **Switch Bezels**: new switches, such as window or trunk buttons, will mainly affect the design of the plastic parts that will hold these parts.

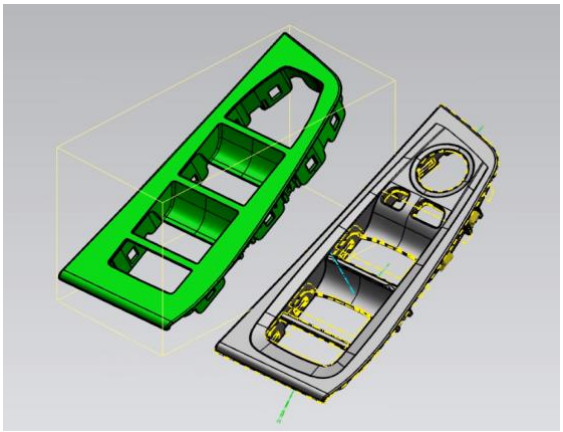

Figure 35 – New F7x Driver Switch Bezel on the left compared to F4x on the right

    - **Grab Handle**: due to the integration of these new Switch Bezels, this plastic part design will also have to be modified to integrate the new front Switch Bezels. As rear Switch Bezels will maintain its shape, the only parts affected will be front Grab Handles, which are not symmetrical.

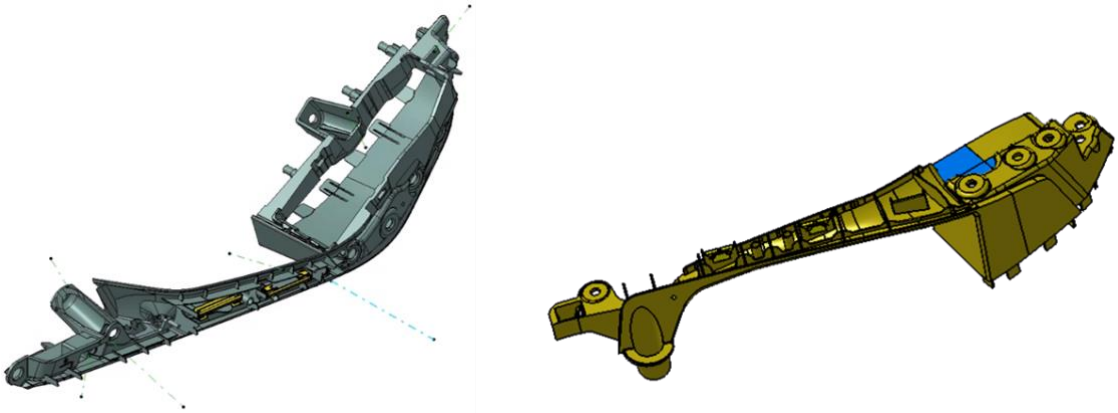

Figure 36 – F7x driver Grab Handle (right) and passenger Grab Handle (left)

- **Speaker Grill ALEV 1.1**: this speaker grill is a new version from F4x Speaker Grill ALEV1.2, with a new holes design for front and rear speakers. It will be offered to the final client as basis version and there will be two different versions, one that will only be grained and another one that will be painted in Darkchrome color.

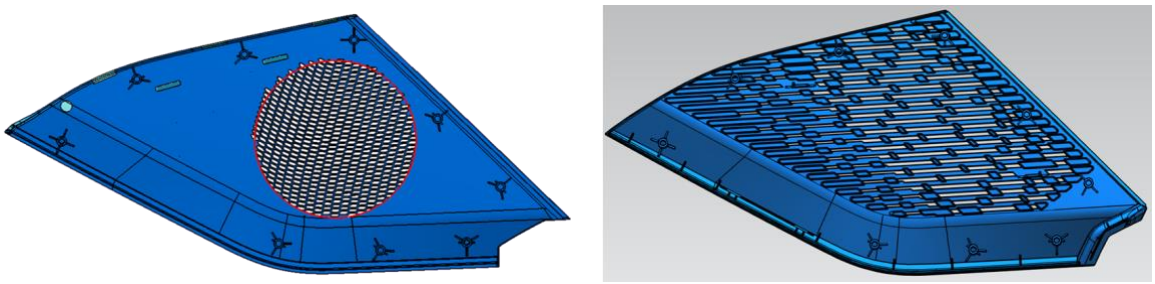

Figure 37 – Comparison between ALEV 1.2 (left) and ALEV 1.1 (right) Speaker Grills

- **Speaker Grill ALEV 2.4**: is the evolved design from F4x ALEV 3, offering a new patter of holes. This is a higher quality version offered as premium, which includes Harman Kardon branding illuminated with a LED module in the back of the part. Furthermore, compared to basis version, it consists of three different parts: one plastics carrier that gives the shape to the part, a foam as a mid-layer to improve the sound, and finally covered with a metal grill.

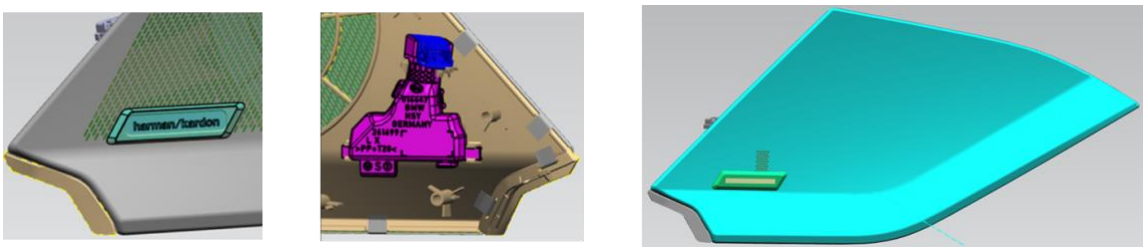

Figure 38 – F7x Speaker Grill ALEV 2.4 new design

- **Decorative line**: this was a part used to decor the inside of the car, and it would have some light inside when entering a dark place. This part will be eliminated from the new project.

Figure 39 – F4x Decorative line that will be removed highlighted in red

- **Door lock bezel**: this part will also be eliminated for F7x project, keeping the Beltline intact and reducing a step of punching process.

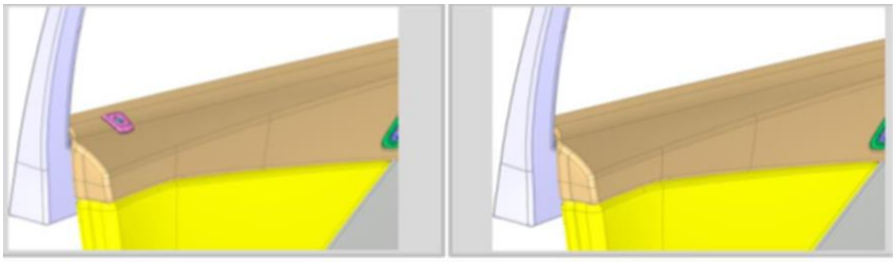

Figure 40 – On the left F4x version, and on the right F7z version without bezel

The rest of the parts that conform the door panel and have not been mentioned will be COP (carry over parts), which means that they will keep the same specifications as the F4x project. This is a very important point for BMW, as all molds created for F4x project can be used in F7x project, reducing the project budget a lot.

5.3.2 TECHNICAL DRAWINGS

All the changes and modifications done to the door panel suppose a big effort from the whole engineering team. Concretely, product team will be in charge of monitoring these changes and simulating these new parts in order to determine whether new changes are needed or not. To do so, product team will count with CAD team help, which it is located in Grupo Antolin Pune, in India. This team will be in charge of modifying the drawings according to the product engineer specifications.

These drawing modifications could be of various kinds, and were communicated to the CAD team by creating Power Point presentations, analyzing and correctly describing the changes needed in the drawings. Product team has access to the drawings and CAD but they are not allowed to modified them, making CAD team responsible for these changes. Some of the issues treated consisted on correcting some of the control points that appeared in the drawing so that when the part was produces, checking gauges (measurement machines) would check either the part was correctly manufactured or not. This is a very important step as if the part is not correctly measured and then because of that dimension problems appear, the part might not be tight enough in its place. Due to confidentiality issues, only drawings pre modified from F4x project will be displayed in ANNEX II.

Once drawings are already checked by product team, CAD team receive a notification of approval in order to validate the drawings for production. This means that the drawings are ready to be used and send them to suppliers so that the part can get quoted. To do so, these drawings are entered in Buyone platform where the commodity buyer will be able to create the BPM for these parts, starting the process to find the best fitting supplier. Furthermore, to test these parts it will also be needed to build some of them so that product team can visually inspect them, and to do so, the proto part supplier will need the final drawings.

5.3.3 PROTOTYPE PARTS

Prototype parts are manufactured in order to allow the product engineer to evaluate how the part is designed and whether it has any manufacturing or assembly errors. During this project there have been many proto parts that have helped guide the team's thinking, as in the case of the Grab Handle or the Switch Bezels. In addition, proto parts give the whole team a good picture of the project scope plus the extra boost of motivation from seeing the part of the work accomplished.

Figure 41 – BMW F7x Speaker Grill ALEV 2.4 proto part example

To place an order for this type of parts, the following actions must be performed:

1. The first step is to evaluate the need to make a prototype part and what purpose it will serve once it is manufactured.

2. Then, once the parts that are needed to be tested by product team are decided, supplier will be contacted requesting quotation. The supplier will create an offer for the parts and send it to the product engineer.

3. When the quotation has been received, the product engineer is in charge of filling in the BANF, which is the form with all the information concerning the order that has to be approved by the project manager.

4. The last step will be that once the purchase of these prototypes is approved, the supplier's offer will be accepted and the transportation of the parts will be arranged.

However, the results of prototypes are not always good. As an example, during the development of the project, a roll of material was requested to cover some Armrests to evaluate the performance of the new material. Once the material had toured the various Grupo Antolin plants and was prepared for final assembly at the Valplas plant, it was confirmed that there was a big difference between the materials used in the two different projects. Analyzing the process with the material supplier, it was concluded that the material used was not the correct one. As a result, the material to be used was clarified, thus avoiding much more costly unpleasant surprises later on.

Another important case to evaluate would be the logistics of the product. When ordering a prototype part, the route that the part will take and the transports it will need are established. Taking the same example used earlier, the material to become the final part had to travel several kilometers to reach Massen's plant. This is so because the part began its journey in Central Europe, at the supplier's headquarters, being transferred to the Trnava plant, which, once the material was formatted, was sent to Spain, to the Valplas plant. Once the necessary tests were determined, the finished parts were sent to Massen where the product was evaluated during product team visits to this plant. The problem with this complex process is that it is easy for something to go wrong. It is therefore important to evaluate what problems have occurred during the trips and to make a count of the parts and their condition in order to finally evaluate how good the result is. All this will help to reduce expenses once the serial production begin.

5.3.4 BPM COMPLETION

Having explained the product and the process involved in this project, it is time to discuss in this section how to decide where the parts of this project that have not yet been defined will be produced. Thus we have three sets of parts whose production plant is not yet known, so in principle it will be decided to make an RFQ to different suppliers to produce these parts. These sets of parts will be Grab Handles, Switch Bezels and Speaker Grills. In order to do

so, a series of steps must be followed to help determine who will be in charge of producing these parts:

1. The product engineer will list all the parts that need to be produced in an excel sheet in order to create the SAP references. These references are crucial as it will be the way of identifying the parts along the project and within all internal software. Therefore, this list may contain some basic information such as the name of the part both in English and German, the family that the part belongs to (in this case belongs to injected plastic parts), whether it is left or right door panel and the measurement option (each, meters, square meters...). Once all this information has been completed, the file will be sent to the Grupo Antolin Corporate team, who will be in charge of creating these codes.

2. Once parts SAP references have been created, it is time to enter them into Buyone software, under F7x project. By doing this, parts will be entered under BOM section allowing them to be fulfilled to create the BPM. The information to be added will basically consist of the estimated quantity of parts to be produced, the price per part and the target price for which the supplier will manufacture the part, thus making a market estimate.

3. The next step is to communicate to the project buyer that the information is complete in order to create the BMP. In this process, all potential suppliers will be incorporated, informing them to prepare an offer to be studied by the purchasing department.

4. As the suppliers prepare their offers, technical questions are expected to arise and a meeting will be scheduled to discuss these matters. This meeting will be attended by the project manager, the purchasing manager and the product engineer. This last one, will be crucial to answer technical questions about the drawings provided to the supplier. In addition, the supplier will make a brief presentation including what production capacity and previous experience from other projects possess.

5. When all the offers arrive, an economic study is carried out to determine which will be the best option for Grupo Antolin. Among these options, the one for producing in a Grupo Antolin plant that has available capacity is also considered. If, on the other hand, it is decided to nominate a supplier, they will be informed as soon as possible so that they can start manufacturing their molds and there will be no problem when it comes to delivering the parts to BMW.

After completing this process, the conclusions shown below about where these parts will be produced are as follows:

- **Grab Handles**: these parts were decided to be produced in-house, as no supplier offered a significantly comparable cost to the one that resulted in Grupo Antolin. Therefore, these parts will be produced in Massen plant as previously mentioned.

- **Switch Bezels**: after concluding with the same ideas as for the Grab Handles, it was decided to produce these parts at the Grupo Antolin Silesia plant, due to the availability and capacity of the plant.

- **Speaker Grills**: these parts were the only ones that were decided to be produced by a supplier, but dividing the strategy into two versions available:

    - **Speaker grill ALEV 1.1**: this part has the grained and painted version, and will be all carried out by supplier Prisma.

    - **Speaker Grill ALEV 2.4**: for this part there will only be one supplier which is RMIG, although the final part is made out of several subcomponents.

5.3.5 PURCHASE ORDERS FROM BMW

The last section that completes the development of the project is dedicated to the purchase orders launched by BMW to test the new prototype doors in its production line. This work has been based on solving an existing problem within the door panel department due to a change in production plants at the beginning of the orders. In addition, due to inaccuracy and

disorder on the part of Massen plant, the shipping notes sent were not correct, so the problem had to be solved from the root.

First of all, it is important to know where the problem comes from. To do so, it is necessary to go back to the creation of the RFQ launched by BMW, for which Grupo Antolin obtained the nomination. At that time, the prices of the prototype parts are negotiated between both participants determining a purchase price. Once established, BMW places the orders it needs under the agreed price, launching for each order a purchase order (PO). Once Grupo Antolin plant in Massen receives this order, the requested products are prepared and shipped to BMW creating a delivery note. In parallel, the product managers at Grupo Antolin's headquarters are responsible for preparing, together with the PO and the delivery note, the invoice to be sent to BMW through the financial department. Once the invoice has been sent, it is expected that BMW will make the payment to Grupo Antolin within approximately one month.

Once the problem was detected, the task was to determine, both with Massen plant and with BMW, how many parts had actually been shipped. In order to perform this task correctly, an excel sheet was used, where each purchase order was recorded with its indicator, detailing information such as the price to be paid for the parts, the content of the order and the current status of the consignment note. For better appreciation, the excel table has been attached in ANNEX III.

Finally, periodic meetings have been held with the financial department to follow up on these POs. In the event that there was a problem with the acceptance of the invoices by BMW, the process consisted of verifying that it had been denied by BMW and requesting the correct version of the shipping notes.

5.4 ECONOMIC STUDY

In this section an economic study of the BMW F7x project will be carried out. This will provide the project report with an approach to the scope of the product and what it means for Grupo Antolin. For this, it will be necessary to know the estimated number of doors that will be supplied to BMW during the three years of the project. As an aside, in order to break down the calculations, the project will be estimated to last 3 years instead of the actual 2.5 years. The average annual estimate of BMW F7x units to be produced is shown below.

	Yearly average volume	*Yearly maximum volume*	*Maximum capacity per week*
F70	100.818	120.981	2.520
F74	67.268	80.721	1.682

Table 4 – BMW F7x expected production units

Taking these units as a starting point in this study, the number of doors required for each car will be calculated, thus allowing Grupo Antolin to make a total estimate of annual sales.

$$F70\ door\ panels = Yearly\ avg.volume\ x\ 4 = 100.818\ x\ 4 = 403.272\ door\ panels$$

$$F74\ door\ panels = Yearly\ avg.volume\ x\ 4 = 67.268\ x\ 4 = 269.072\ door\ panels$$

These calculations make a total of 672.344 BMW F7x door panels that have to be produced by Grupo Antolin and delivered to BMW. The following table shows the average prices for front and rear door panels for both models and versions.

BASIS	*Front average price*	*Rear average price*
F70	71,31 €	67,73 €
F74	74,54 €	69,21 €

Table 5 – BMW F7x basis version door panels prices

PREMIUM	*Front average price*	*Rear average price*
F70	88,30 €	83,12 €
F74	92,47 €	85,80 €

Table 6 – BMW F7x premium version door panels prices

Furthermore, it is important to understand the percentage of each basis and premium version in each model in order to calculate the total sales from the door panels.

	Basis version	*Premium version*
F70	32 %	68 %
F74	11 %	89 %

Table 7 – BMW F7x basis and premium version take rates

With the price per door and each version take rates, an estimate can be made of what Grupo Antolin's total annual sales will be for this project, resulting from the following calculations:

$$F70\ (\frac{€}{dp}) = \frac{[0{,}32 * (71{,}31 + 67{,}73) + 0{,}68 * (88{,}30 + 83{,}12)]}{2} = 80{,}53\ €/dp$$

$$Anual\ sales\ F70\ dp = 80{,}53 \frac{€}{dp} x\ 403.272 \frac{dp}{year} = 32{,}48\ M€/year$$

$$F74\ (\frac{€}{dp}) = \frac{[0{,}11 * (74{,}54 + 69{,}21) + 0{,}89 * (92{,}47 + 85{,}80)]}{2} = 87{,}24\ €/dp$$

$$Anual\ sales\ F74\ dp = 87{,}24 \frac{€}{dp} x\ 269.072 \frac{dp}{year} = 23{,}47\ M€/year$$

$$Total\ sales = 32{,}48 + 23{,}47 = \mathbf{55{,}95\ M€/year}$$

The total number of doors sold by Grupo Antolin to BMW amounts to a total of 55,95 million euros per year. Although this figure gives a slight indication of the size of the project, it will be important to take into account the costs in order to obtain the profits of the project.

In order to analyze the costs related to the project, it is necessary to differentiate between two types of costs, variable and fixed. These costs will be those that Grupo Antolin need to disburse so that the company can guarantee its operation. Fixed costs will have a determined periodicity, while variable costs will not only increase or decrease, but will also be paid according to different work cycles, such as distribution, packaging or raw materials.

Firstly, variable costs are considered, which in this case, belonging to the automotive sector, will be the variable costs derived from the materials to be used, the labor necessary for the realization of the product and finally the logistics related to the project. Taking as an example a generic BMW project, it is considered that in a 7-year project, the production will vary over the years, being higher in the middle of the project. Therefore, the cost will vary with respect to the volume of doors produced per year, having to buy more materials in the peak year, and likewise employ more workers and a greater number of trucks to transport the goods. Although this project is initially nominated for the first two and a half years, the total project duration is expected to be 6 years (2024-2030). Therefore, a curve of the estimated volumes can be estimated for the years in which the door panels of this project will be produced.

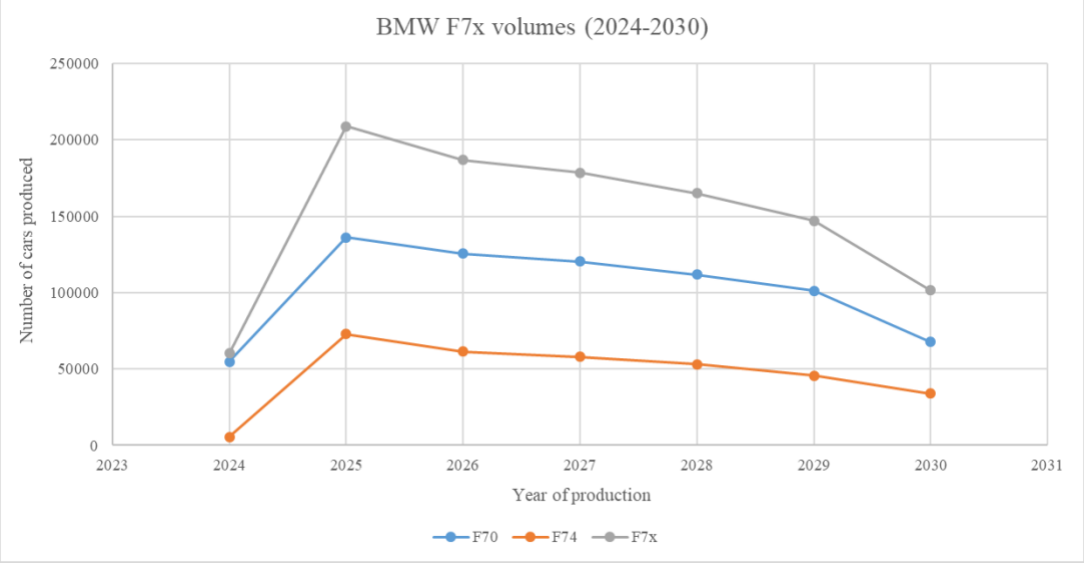

Figure 42 – BMW F7x expected production volumes until 2030

Knowing that total revenues exceed 50 million euros, it is known that the variable cost per door panel, taking into account all the points mentioned, is a estimated price of 58,35 euros. This price represents the average volume estimated for the three first years of the project, and has been handled by costing department. Thus, taking into account that of the total parts produced, 3% of the total will be defective, the total variable cost can be estimated:

$$Total\ variable\ costs = variable\ part\ price\ x\ total\ units\ produced$$

$$Total\ VC = 58{,}35\frac{€}{dp} x\ 672.344\ dp\ x\ 1{,}03 = \mathbf{40{,}41}\ \boldsymbol{M€/year}$$

Grupo Antolin's priority is to achieve the objectives set and to ensure that adequate profits are obtained. To this end, the contribution margin is used as a measure to determine whether a project is worthwhile or not. The contribution margin is the result of subtracting variable costs from the selling price. In other words, it is the excess of revenue over variable costs. This surplus must be sufficient to cover both the fixed costs and the expected profit [6]. The following formula represents the marginal cost:

$$Contribution\ margin = \frac{Total\ sales - Variable\ costs}{Total\ sales}$$

For Grupo Antolin, the limit that determines whether a project is profitable or not is 22%. Therefore, by means of the marginal cost it will be possible to determine whether the project is in the company's interest or not.:

$$Contribution\ margin = \frac{55{,}85 - 40{,}41}{55{,}85} = \mathbf{27{,}78}\ \%$$

The purpose of calculating this variable, as the name itself indicates, is to know how much the production of a given service or product contributes to the stability of a company in economic terms. Thanks to this calculation, it is possible to know precisely to what extent it can be profitable to continue producing that item. Analyzing this result, it can be deduced that the project meets Grupo Antolin's conditions for the expenditure to be worthwhile and profitable.

In addition, there are fixed costs related to the project, which include employees' salaries and plant rental among others. Although there are some fixed costs exclusively related to this project such us the molds used to prepare the plastic parts, most of the fixed costs will be shared with Grupo Antolin projects. As an example, we take any Grupo Antolin production plant. This plant is within the fixed costs to be considered, but if this plant is not being used at one hundred percent of its capacity, it will represent a loss. Therefore, the objective will be to try to reach the maximum capacity of the plant to maximize its performance, which is why several projects distribute these total fixed costs. It would be the same with a product engineer working on two or three projects instead of just one.

As for depreciation, something similar will happen as with fixed costs. The machines used to manufacture the product will be of a generic nature, serving to carry out multiple projects. It is also worth mentioning the case of tooling, which will have an associated depreciation and will be unique to the project.

To demonstrate the application of these examples, it has been decided to develop a small example in which the net income will be roughly estimated. Thus, the numbers implemented will be made up for a theorical purpose, since for confidentiality reasons, real values with greater detail level cannot be exposed. The analysis will be carried out for the first three years of the project for which Grupo Antolin has been nominated. In addition, estimated fixed costs of 8.5 million euros and a depreciation of 2.2 million euros are considered, distributed equally over the three years. However, as the first and last year of the project will not be the whole year, fixed costs and depreciation will be considered proportionally. In addition, being a Spanish company, taxes of 34% are considered.

Finally, EBIT as a percentage will be added, which will be the percentage of net income compared to total sales. In addition, the net present value (NPV) will be calculated, determining the total profits that the project will yield. The interest rate considered is 8%, which is the usual rate used in the projects developed by Grupo Antolin in Germany.

$$EBIT\ (\%) = \frac{Net\ Income}{Total\ Sales}$$

Year	2024	2025	2026
Sales	19.549.927 €	69.194.059 €	30.890.911 €
Variable Costs	14.057.449 €	48.721.783 €	21.787.190 €
Gross Profit	5.492.479 €	20.472.276 €	9.103.721 €
Fixed Costs	2.800.000 €	9.500.000 €	4.750.000 €
Depreciation	750.000 €	3.000.000 €	1.500.000 €
EBITDA	1.942.479 €	7.972.276 €	2.853.721 €
Taxes (34%)	660.443 €	2.710.574 €	970.265 €
Net Income	1.282.036 €	5.261.702 €	1.883.456 €
EBIT (%)	6,56%	7,60%	6,10%

Table 8 - Theoretical exercise of the income statement of the BMW F7x project

$$NPV = Net\ income_1 + Net\ income_2 * \left(\frac{1}{(1+r)^1}\right) + Net\ income_3 * \left(\frac{1}{(1+r)^2}\right)$$

$$NPV = 1{,}28 + 5{,}26 * \frac{1}{1{,}08} + 1{,}88 * \frac{1}{1{,}08^2} = \mathbf{7{,}76\ M€}$$

The NPV determines whether the project forecast is profitable or not. Thus, a positive NPV means that it is a profitable project, because if after measuring the flows of future income and expenses and discounting the initial investment there is still some profit, the project is viable [7]. In addition, reasonable EBIT percentages have been obtained, since knowing that in the automotive sector this percentage is between 5 and 8%. It would be prudent to state that the theoretical exercise carried out above gives an idea of what the income statement of a company such as Grupo Antolin would be like.

Finally, it should be noted that this is merely an economic exercise, as these costs are extremely complicated and are not accessible due to confidentiality issues. In addition, the degree of detail of the costs is much higher, as would be the case of tooling, which would have a completely different interest rate than the rest of the machinery. This exercise is a mere example of the numbers applied in the world of motorsport, and will also serve to make a future comparison between the F4x and F7x projects.

Chapter 6. ANALYSIS OF RESULTS

This chapter will cover the important task of analyzing whether the tasks and objectives of the project have been performed correctly. It will review the issues that failed in the previous BMW F4x project and what actions have been taken to avoid the same results. Furthermore it will be discussed whether these results are on the right direction or whether new solutions have to be implemented.

6.1 LESSONS LEARNED

As discussed throughout this report, the BMW F4x project was an organizational disaster on the part of Grupo Antolin. This was due to the fact that when Magna Interiors was acquired, a number of projects were added to the Grupo Antolin portfolio, the BMW F4x being one of them. The conditions negotiated by Magna and BMW for the project were not adequate, leaving Grupo Antolin with a project with a contribution margin much lower than the company's standards. This, added to the enormous pressure from BMW to meet the established deadlines, made the project a failure. The following sections will analyze which points have been strengthened with respect to the previous project and what exactly is expected of them.

6.1.1 PRODUCT RESULT

The first step is to determine the quality and feasibility of the product to be manufactured. To do this, the prototype parts made throughout the project will be analyzed, analyzing the failures in their production and logistics as mentioned above. As for the prototype parts, it is worth noting the great usefulness of these parts, since they not only serve to test the product and see the visible results on the part, but also help to check the logistical issues involved in the process.

First of all, in terms of visual testing, the parts are inspected by product engineers, trying to look for flaws in the manufacturing of these parts, just as plant operators will do once production starts. During these tests it is worth mentioning problems found as problems in the materials used, finally determining that the material chosen was the wrong one, as in sizing errors, since when assembling certain sets of parts, it was observed that there was a gap between parts that could not be admitted due to the noise that these could generate. These problems were solved thanks to the modifications proposed by the product team, which were again tested with a positive result.

In addition to being visually tested, these parts were subjected to computer simulations to determine their behavior with use and the passage of time. The result was notorious, since due to the new configuration of parts, the Map Pocket suffered a lot when the driver leaned on it, causing cracks to appear in the part. To fix this problem, it was proposed to add some small plastic ribs that made this problem disappear. Thus, this problem was solved leaving the simulated part for use in closed weather.

The last point related to the testing of prototype parts is related to a mandatory test to be performed in the automotive sector, such as the crash test. This simulates an accident of the complete car observing the results of the same one. As for the doors, there was only one interesting thing, and that was that the Armrest came off the door and was screwed halfway. In the crash test all components should stay in place to avoid injury. It was determined that the problem was a defective part that had nothing to do with the design, so the process side solved this problem.

Finally, we must mention the important role of logistics for the product, as it will ensure that everything arrives on time and in optimal condition. For this reason, when testing these parts, the transport of these parts is also tested, which is carried out by means of an internal Grupo Antolin transport line. These parts have always been shipped correctly once the package has been correctly loaded into the transport. The problems arose when it was time to load these goods onto the trucks. As an example, there was a problem of this nature due to the fact that when the package was made, the correct indicators were not placed, leaving the box in

oblivion. To avoid this problem, all the boxes were labeled correctly, indicating the destination and the contact details of the engineer in charge of the order. In addition, Grupo Antolin has a system where boxes are placed in different places according to priority, so these procedures were applied to the F7x orders. Since then, there has never again been a problem in the shipment, leaving this problem aside.

Comparing the current moment of this project with respect to the product, it is important to clarify that it is a very similar product since there have been no major structural changes. In any case, the prototype phase is a very important phase of the project, because even if it does not seem so, it is necessary to dedicate as much time as possible to reduce the problems once the parts start to be produced in series. Therefore, analyzing this same phase of the F4x, it should be noted that not all the necessary prototypes were made. Moreover, it was a totally new product, since it started with a new line that was a breakthrough compared to its predecessors. In the case of the F7x, the modifications are minimal with respect to the previous project and with a much more solid base.

Therefore, it would be fair to say that in this project things are being done with greater consistency, and that thanks to what was learned during the F4x project, an important effort is being made to prevent later changes that could be more costly, as in the case of the mold modifications that will be discussed in the following section. This starting point is making the F7x project characterized by its robustness in the product in the sense of design checks, which will result in much less losses in the future.

6.1.2 MOLD EXPECTATIONS

This section will be crucial for the future of the project, since the F4x project is where the biggest losses occurred. The molds are a key part in the manufacture of the product, as they are responsible for shaping the various parts. These have high manufacturing costs and in this project they are requested to external suppliers to make them. Normally the tooling is the property of the OEM in question. However, any modifications that need to be made to these will be the responsibility of the supplier, since if there has been a problem in the design it is understood that this error is the responsibility of Grupo Antolin.

The strategy to follow consists of making molds with zero modifications. To do this, the team is motivated to make all the necessary investments during the project, both in prototype parts and in simulations, to determine that there are no structural or visual problems in the final product. The molds are very sophisticated parts, usually made of steel to withstand as many injections as possible. In a project of this nature, tooling is in the region of five million euros, with modifications that can be devastating to project management.

Analyzing the progress made so far and comparing it to the F4x project, it would be fair to determine that the project is on a better path than the previous one. However, it is important not to be complacent and not to trust that the parts will be manufactured without any problem from now on, as any small modification in these molds can have a big impact on the project. Therefore, several series of prototype parts are being made to check that all the parts are the same and do not have any defects.

6.2 ECONOMIC ANALYSIS

The economic exercise, which is included in the final part of the project report, gives an estimate of the quantities treated within the automotive sector. However, this project is a Facelift, which means that it will be a smaller project than starting a new model from scratch. Therefore, even if the treated figures are lower, which translates into a potentially lower NPV, percentages will be obtained that are around common figures in this sector.

Therefore, on the one hand, we have a contribution margin for the F4x project of around 21%. This means that the project did not initially meet Grupo Antolin's requirements. This was due to the fact that the project was accepted by the company Magna Interiors under their own judgements, which was obtained by Grupo Antolin. On the other hand, there is the F7x project, which has been estimated to have a contribution margin of nearly 28%, which far exceeds the limit imposed by Grupo Antolin. Thus, it can be clearly determined that the new project is off to a better start than its predecessor.

Furthermore, analyzing the EBIT estimate obtained, assuming standard conditions in the automotive sector and similar to the F4x project, it can be seen how the F7x project results

in a quite reasonable EBIT percentage for a project of these characteristics, being within the range between 5 and 8% of EBIT typical of this sector. This allows us to calculate the net present value, which will be the total earnings of the project. Comparing this value of 7.76 M€ for the F7x project with the negative NPV value obtained in the F4x project, it can be firmly determined that the tasks to be performed in this project have been correctly directed pending confirmation that there are no problems with the molds in the future months.

However, as the project has not yet been completed, an analysis of the risks that may still arise during the course of the project will be carried out. This will give value to this economic study, analyzing the feasibility of the pending tasks during the project.

6.3 RISK ANALYSIS

The idea of this analysis lies in the ability to anticipate problems that may arise during the rest of the project in order to prevent them from occurring. This will help to save time and waste money, with the objective of maximizing the benefits of the project. These risks are identified as the uncertainty of an event occurring due to a potential cause. In addition, their consequence would have a negative impact on the project, differentiating between these the amount of impact. Therefore, the focus should be on preventing these risks rather than solving them.

To control these risks, the first step is to identify them. Starting in the initial phase of the project, these risks are identified and updated during the course of the project. However, as the project is in the middle phase, the risks to be analyzed will be those in the middle and final part of the project. In addition, there will be two types of risks, known risks, which can be identified, analyzed and planned for, and unknown risks, which cannot be proactively analyzed. These risks have important factors such as the probability of occurrence, the impact they may have on the project, when they may occur and how often they occur [8].

First of all, a brainstorming process will be carried out to obtain the following list of all the risks that may affect the project:

	N°	Risk
Timing	1.1	Designs are not ready for production on time
	1.2	Molds do not get to Grupo Antolin from suppliers when specified
	1.3	Imposed parts do not get to Grupo Antolin from suppliers when specified
	1.4	Purchasing parts do not get to Grupo Antolin from suppliers when specified
Logist.	2.1	Transport delays when delivering final parts to client
	2.2	Packaging problems that affect the parts
Suppl.	3.1	Suppliers bankruptcy
	3.2	Cost overruns for modifications
Client	4.1	Change of designs
	4.2	Excessive pressure
GA Management	5.1	Change of strategy
	5.2	Not enough engineers in the project
	5.3	Inadequate cost estimates
	5.4	Mold modifications

Table 9 – Risks list for BMW F7x project completion

Once the risks have been listed, it is time to perform a qualitative analysis of them. To do this, these risks will be classified according to their impact and probability, with a score from 1 to 5. To obtain the risk, a probability/impact matrix will be made, where the risk will be obtained as the result of the multiplication of impact and probability. Finally, this risk will be classified as high (>15), medium (≤15, >5) and low (≤5).

Color	Range	Category
Red	[16-25]	High
Yellow	[6-15]	Medium
Green	[1-5]	Low

Table 10 – Risk categorized by levels and colors

Once the risk has been measured, it will be placed in the risk matrix to show graphically where each risk is located. In addition, this matrix will be very useful to understand where the risk has to evolve, thus focusing on the aspect that has to be reduced.

	N°	Risk Prompt	Cause	Effect	Risk Measure	Prob.	Imp.	Risk
Timing	1.1	Designs completion	Incomplete drawings from GA side	Increased time and client dissatisfaction	Time	2	3	6
	1.2	Molds delay	Molds are not manufactured when needed	Increased time and client dissatisfaction	Time	2	4	8
	1.3	Imposed parts delay	Imposed parts are not manufactured when needed	Increased time and client dissatisfaction	Time	2	2	4
	1.4	Purchasing parts delay	Purchase parts are not manufactured when needed	Increased time and client dissatisfaction	Time	2	3	6
Logistics	2.1	Transport delays	Not correctly organized	Urgent deliveries	Cost	2	2	4
	2.2	Packaging	Pacaking condition not optimal	Damage on final parts	Cost	2	5	10
Suppliers	3.1	Suppliers bankruptcy	Insufficient study on suppliers by GA	Find a new supplier	Time/Cost	1	5	5
	3.2	Cost overruns	Conditions not reviewed carefully	Increased cost than expected	Cost	4	4	16
Client	4.1	Change of designs	Uncertain client thoughts	Increased time to adapt new designs	Time/Cost	2	5	10
	4.2	Excessive pressure	Bad managing of the project by GA	Errors in calculations	Cost	3	3	9
GA Management	5.1	Change of strategy	Plant inefficiency or better options	Increased time to deliver parts	Time/Cost	2	4	8
	5.2	Insufficient engineers	Too many projects in GA portfolio	Increased time and client dissatisfaction	Cost	4	4	16
	5.3	Cost estimates	Economic study not correctly done	Increased costs by wrong planning	Cost	2	5	10
	5.4	Mold modification	Parts produced are not well	Increased costs in modifications	Cost	4	5	20

Table 11 – Risk analysis list of the project with risk levels

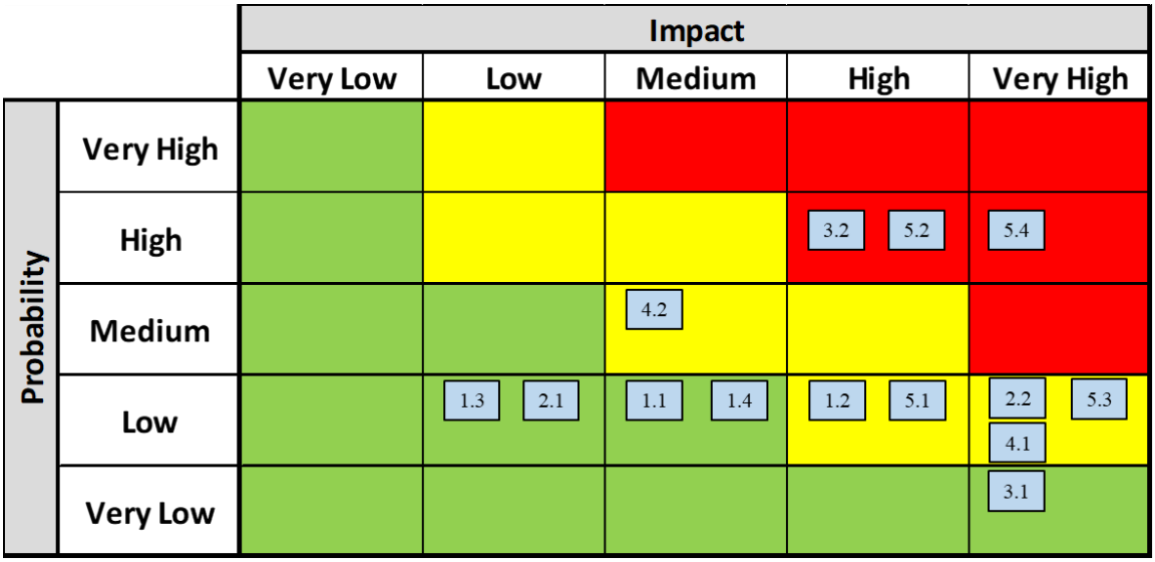

Table 12 – Probability Impact Matrix applied to BMW F7x project

Now it is time to analyze and act on these risks according to their position in the matrix. To do so, there are different risk response strategies that can be employed, such as risk avoidance, risk mitigation, risk exchange or risk acceptance. These strategies must be adapted according to the importance of the risk, and they must also be profitable and realistic with respect to the proposed solution. Below is the analysis carried out for each risk of the project with the strategy to be followed, and therefore what the application of this strategy will mean for the level of risk.

	N°	Risk Prompt	Risk Response	Effect	Risk Measure	Risk	New Prob.	New Imp.	New Risk
Timing	1.1	Designs completion	Mitigate	Prepare final revisions way before production phase	Time	6	1	3	3
	1.2	Molds delay	Transfer	Give all responsabilities of delay to mold manufacturer in case of delay	Time	8	2	3	6
	1.3	Imposed parts delay	Accept	There is no big effect on the project	Time	4	2	2	4
	1.4	Purchasing parts delay	Transfer	Transfer responsibilities to supplier in charge of sending the parts	Time	6	2	2	4
Logistics	2.1	Transport delays	Mitigate	Prepare transport for previuos weeks	Cost	4	1	2	2
	2.2	Packaging	Avoid	Renew packaging and avoid bad functioning	Cost	10	2	4	8
Suppliers	3.1	Suppliers bankruptcy	Accept	Very remote possibilita, may happen to anyone due to actual crisis	Time/Cost	5	1	5	5
	3.2	Cost overruns	Mitigate	Review conditions to be negotiated with suppliers reducing possible problems	Cost	16	4	2	8
Client	4.1	Change of designs	Transfer	Accord that this will be BMW responsibility	Time/Cost	10	2	3	6
	4.2	Excessive pressure	Avoid	Discuss terms and conditions for taking this project	Cost	9	2	2	4
GA Management	5.1	Change of strategy	Avoid	Review conditions from the beginning, use more time	Time/Cost	8	1	4	4
	5.2	Insufficient engineers	Mitigate	Foresee project scope and employ more assets	Cost	16	3	3	9
	5.3	Cost estimates	Avoid	Dedicate more time to review the income statement estimated for the project	Cost	10	1	5	5
	5.4	Mold modifications	Transfer	Clearly state if there are modification because of client, all responsability is theirs	Cost	20	3	3	9

Table 13 – Risk contingency plan to mitigate risks

Once the possible risks that could have an influence during the course of the project have been analyzed and neutralized, the risks are put back into the matrix to evaluate their evolution.

Probability \ Impact	Very Low	Low	Medium	High	Very High
Very High					
High		3.2			
Medium			5.2, 5.4		
Low		1.3, 1.4, 4.2	1.2, 4.1	2.2	
Very Low		2.1	1.1	5.1	3.1, 5.3

Table 14 – Probability Impact Matrix with risks updated

In conclusion, it can be determined that the risks related to this project are as important to analyze as completing the rest of the tasks. Without analyzing these risks, many of the tasks could not be completed. By carefully understanding these risks, the project can anticipate the problems that may arise. The detection of these will be mainly thanks to the lessons learned from different projects, and especially from the F4x project.

However, these risks will always exist, and although most of them can be detected and analyzed to avoid these problems, there will be certain unknown risks that cannot be foreseen. This type of risk should be treated as sensitively as possible and noted to avoid the same problem in future projects. In this way, certain documents are prepared to guide Grupo Antolin engineers with lessons learned. This set of notes makes Grupo Antolin have a robust and long experience, attractive to the different customers in the automotive sector.

Chapter 7. CONCLUSIONS AND FUTURE PROJECTS

The last section of the project will consist of concluding with the most relevant points during the course of the project. The project was based on a part of the project carried out by Grupo Antolin for BMW, consisting of modifications made to the 1 Series and Series 2 Grand Coupé models. In addition, the project was carried out from the point of view of a product engineer, thus analyzing the main points of the product and the process that will make its production possible. However, a series of tasks that would correspond mostly to a project manager have also been carried out, such as the analysis of the purchase orders by BMW and a final analysis of both the economic and the risks involved in the project.

First of all, it is important to highlight the work done in the product development phase. This phase focused mainly on the modification of the drawings of certain parts of the product in order to improve the design and avoid future problems. In addition, other tasks have been carried out such as the assembly of prototype parts for physical testing of these drawings. It is important to emphasize the importance of this phase as well as its duration, since it is very important to have a robust design in order to avoid structural problems with the product. Even so, there are parts that do not always come out as expected for other reasons related to the process, so it will be necessary to be aware of any possible failure. Regarding this point, all the necessary drawings have been completed in order to have the product parts ready. However, there is still work to be done for the creation of drawings for the materials that will cover these parts, which will have both dimensional information and the type of materials that correspond to these parts. Finally, it should be noted that the CAD team in India was in charge of the design changes, since the product engineering team did not have these licenses to modify the parts.

Secondly, special mention must be made of BMW's analysis of purchase orders for prototype parts. These parts are used so that the customer can get an idea of how the whole car will work without the need to have molds prepared for series production, thus being cheaper. The work in these tasks concentrated on putting some order to the mess that had mounted with

the orders of these parts, since as mentioned during the project, no control was kept on these orders. In an initial phase it was complicated to determine each order correctly, but little by little a method was proposed to check each purchase order, leaving everything little by little more orderly. Although along the way there have been some misunderstandings caused by this disorder, it has been possible to solve this issue. However, the negative point to highlight during this process was that the customer had to be contacted on several occasions to verify which products had arrived and which had not, which does not give Grupo Antolin a very good image. Finally, everything was in order and the payments for these parts could be made correctly.

Another important point during the realization of this project was to create the necessary documentation for the different requirements of the project. This is the case of the creation of the BOM or all the documents needed to launch a BPM. These documents are of vital importance to create a solid foundation and help both the costing and purchasing teams to extract the optimal information to obtain the best possible offers for both customers and suppliers. However, this is a very tricky task because not all the technical details are always available and there is a lot of guesswork involved. These estimates obviously improve with experience, and the fact of having to produce your first documents without the help of third parties is a complicated job, not always obtaining the best possible result. Even so, it is a good learning process because although these documents affect the project, you can prepare several versions until you reach the optimal one.

Finally, to conclude with all the above points, it is important to make a special mention to the automotive sector, and more specifically to Grupo Antolin. This sector is strongly developed in Germany, thanks to the different OEMs it owns. This generates a large market for the different companies that belong to this sector at all levels. In particular, Grupo Antolin has a great importance within the major automotive brands, supplying a large percentage of the interiors in the sector. The great success of Grupo Antolin is largely due to the human factor of this company. During the course of this project it has been possible to verify the good execution of the values that the company holds as its flag, highlighting above all that of the family. Thanks to the union that exists between all the members of the team, and the

interconnection between different teams, it has been possible to see firsthand how all the projects, thanks to the experience and participation of different people, have been successfully completed. Therefore, it would be fair to conclude that Grupo Antolin has the formula for success, justifying it with its growth and the good work that it leaves in the mouths of its many customers.

To conclude the report, future work on this project will be discussed. This report only covers the work of seven months within a BMW project. However, as has been discussed throughout the report, these projects usually take about one to two years to come to fruition. Thus, once the prototype parts are finished, it is time to start making the molds that will be used for the mass production of these models. The first units to be produced will be responsible for guiding the operation of the designs and that there is no problem, so that in such a case the molds can be modified, as a last option. Once these parts have been verified and the model is ready for mass production, production will begin. From then on, it will be necessary to adjust the quality and logistical issues that may arise during the course of the project.

This report represents a small part of what is a project in the automotive world. The intention was to illustrate the work done during seven months of internship with Grupo Antolin in Germany, which is possibly one of the best examples to learn a little more about this great industry. However, as mentioned above, it is impossible to cover all that takes place in the automotive world, in relation to car interiors, in a single report. This is why each project is a world unto itself, and the technologies that are being applied to this sector are truly innovative, thus trying to encourage the reader to discover more in depth about some of the proposals mentioned in this report.

So, it would be fair to conclude that this is a small part of the automotive interiors, more specifically of the door panels, in which we analyze a project made for a specific customer such as BMW. Therefore, it is hoped that you will find this information useful to know a little more in depth the ins and outs of the great sector that is the automotive industry.

Chapter 8. BIBLIOGRAPHY

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ANNEX I

Grupo Antolin aims to be the reference business in automobile interiors, creating value to all its stakeholders. Its success resides in a unified and familiar spirit that is constantly seeking for the most innovative practices with determination and passion. However, it is clearly stated inside the group that the key of success is the people that makes Grupo Antolin always push forward, thus contributing to the development and prosperity of society. This leads us to the first Sustainable Development Goals (SDGs) that stand out amongst the others when analyzing this project:

- **Decent work and economic growth (8)**: Grupo Antolin is a big and solid business with presence in 26 countries all around the globe, with over 30.000 employees. Regardless of the country a company member operates, everyone has the opportunity to be measured equally by their talent and progress shown. Furthermore, this project is being developed in three different countries, all having same possibilities to develop their talent and skills and their salaries accordingly growing with their success.

- **Industry, innovation and infrastructure (9)**: the determination to be on top of the industry makes Grupo Antolin to constantly seek for new technologies that will not only make processes more efficient, but also reduce materials and other resources. Digging deeper into the project, there are some processes in which innovative machines are used, having the parts ready in one process instead of two. In addition, they allow to reduce the use of material used.

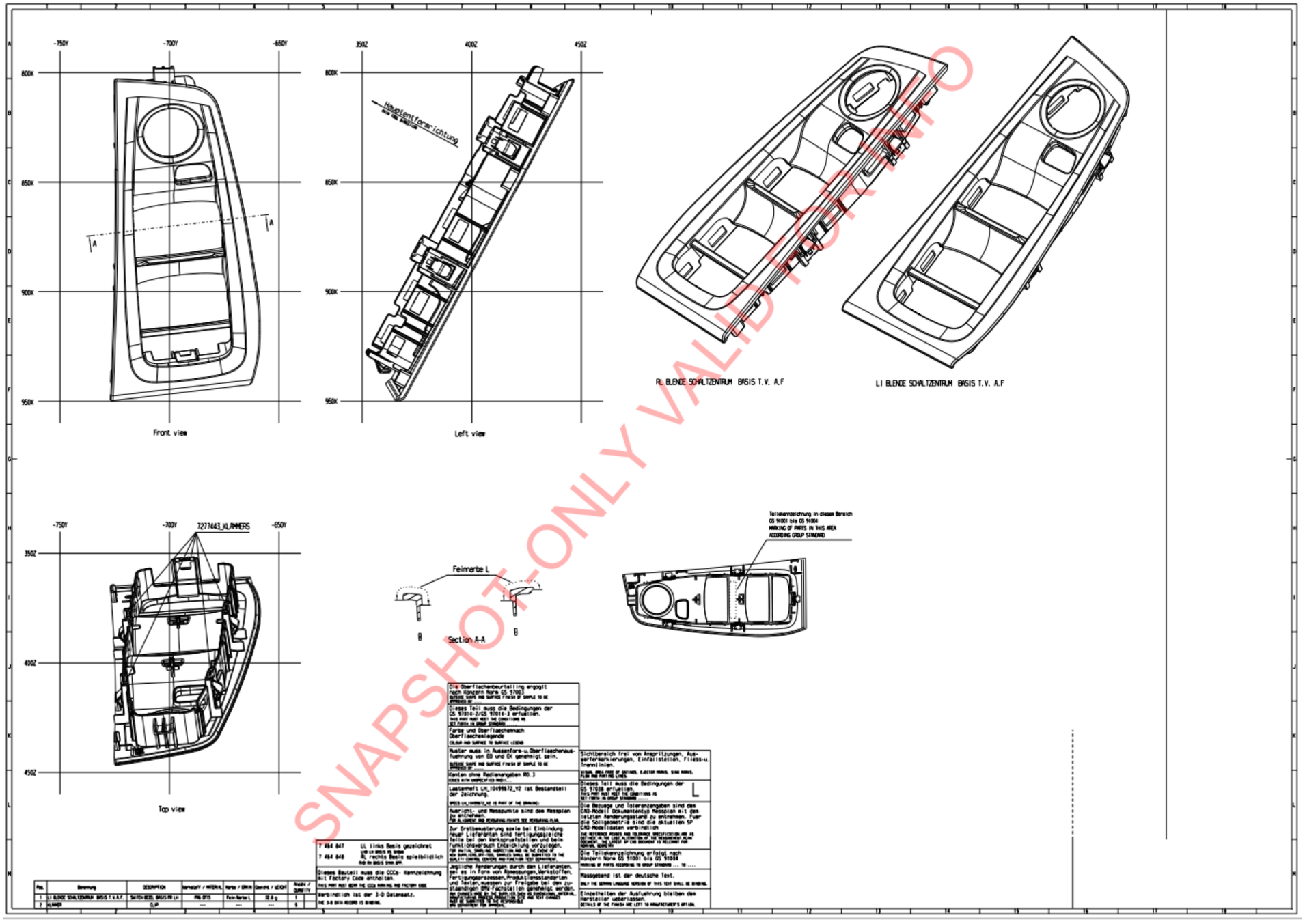
- **Responsible consumption and production (12)**: accordingly to the previous point, it is important to highlight the reduction of resources used in the project. Furthermore, there are other measures such as returnable packaging that aspire to achieve the company mission of cero CO2 footprint.

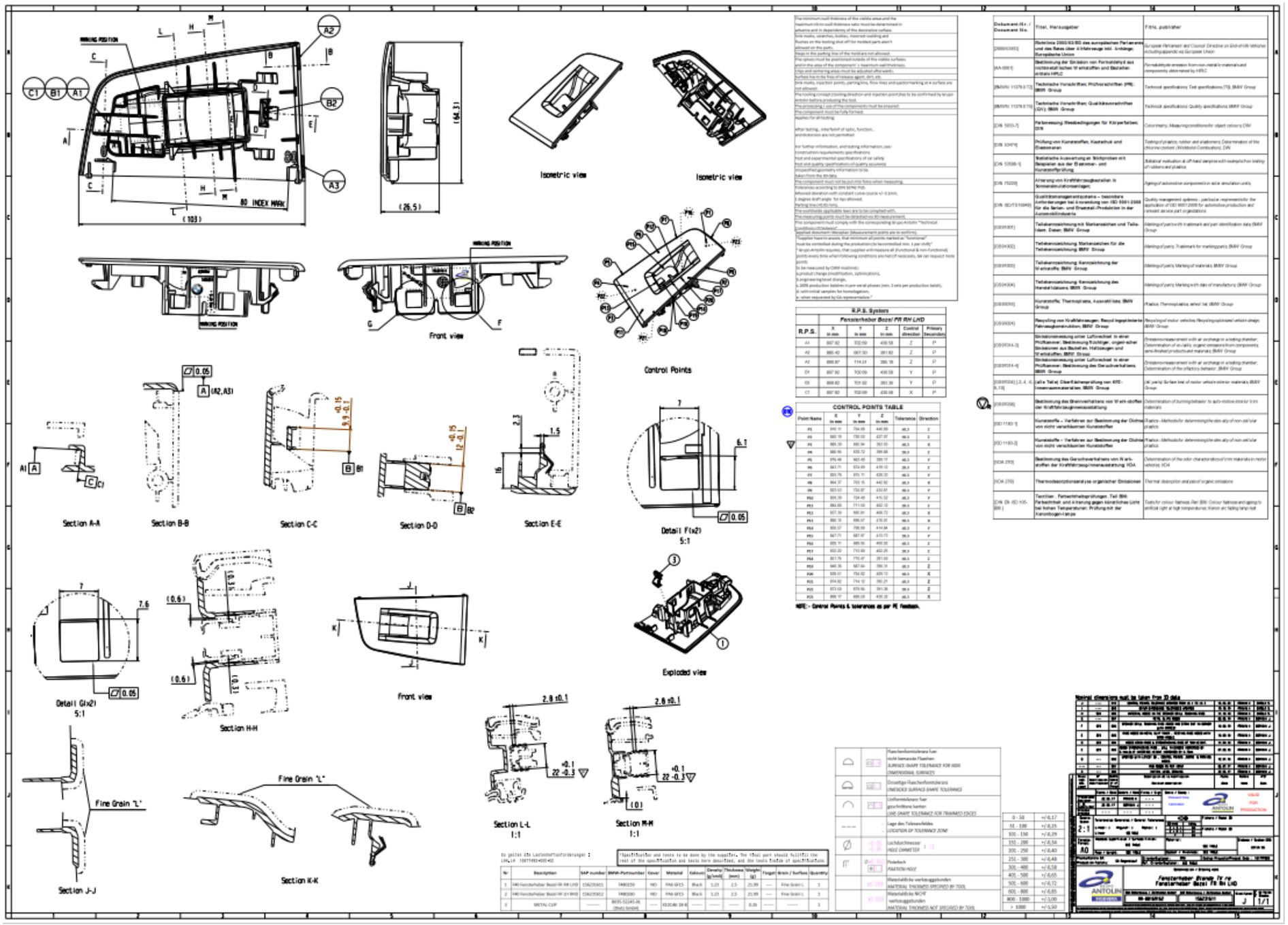
Figure 43 – SDGs aligned with BMW F7x facelift project

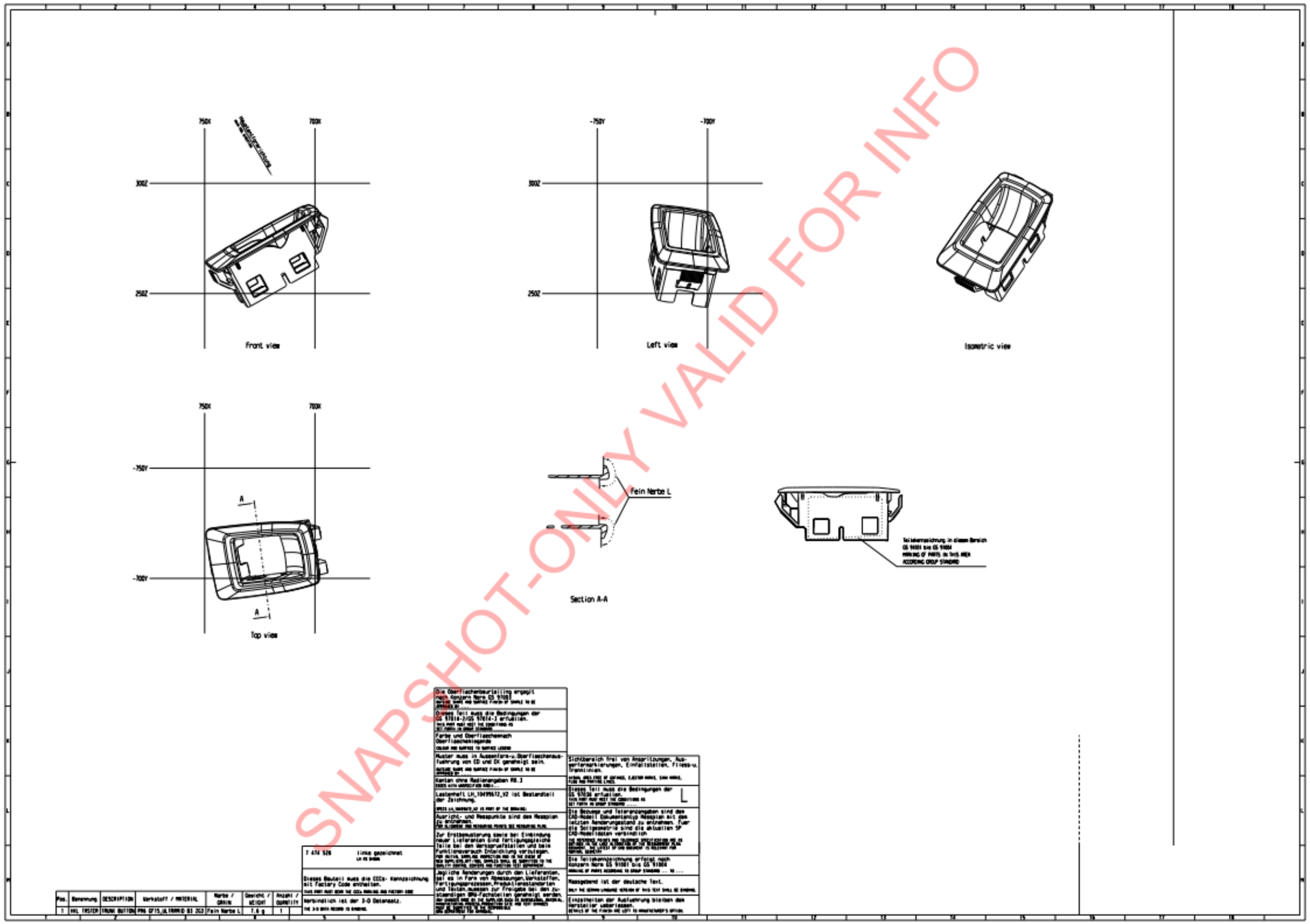
These are the most relevant examples in which this project contributes directly with the SDGs. However, Grupo Antolin Assures to contribute indirectly to 1, 2, and 14 and directly to the remaining 13. This sustainability plan aims to consolidate a sustainability culture inside the whole company, giving response to everything related with the automotive industry and society [9].

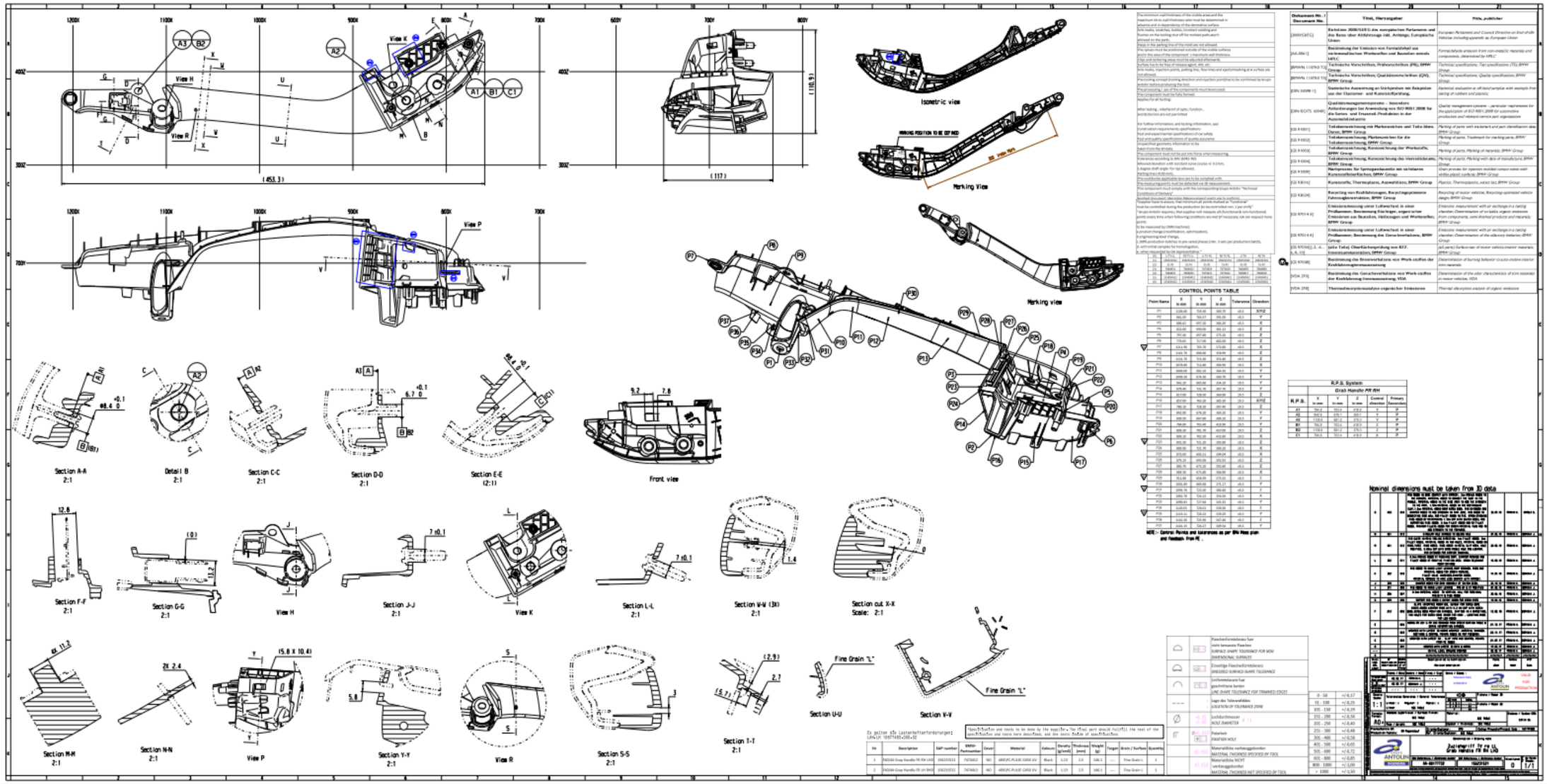
ANNEX II

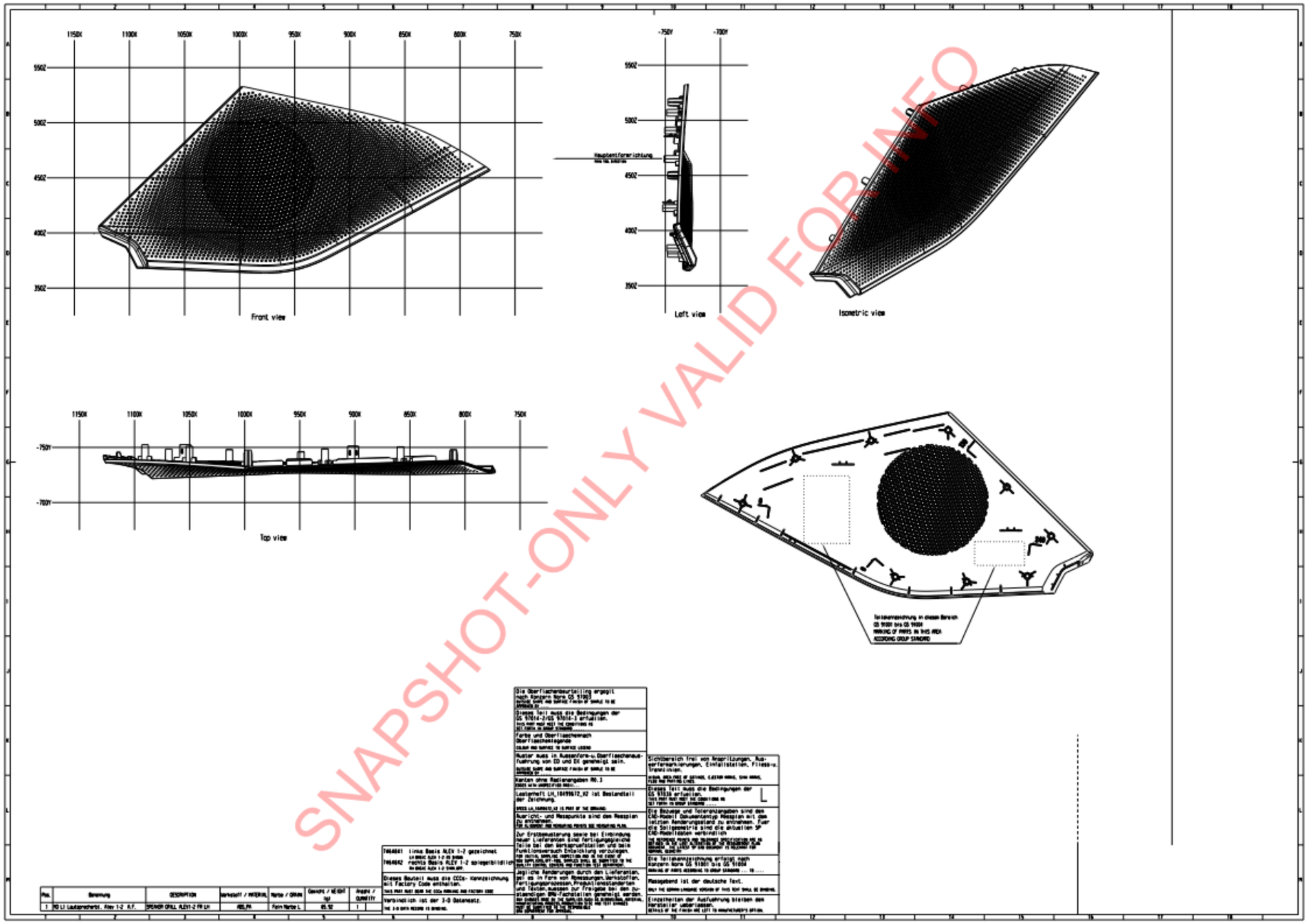
The following drawings show the main parts modified as an example of how drawings are treated in Grupo Antolin. This drawings lack of any information that may damage Grupo Antolin confidentiality and are acting as a mere example. Although the drawing quality is not the optimum, the objective is to provide the reader with some visual examples of the parts treated during the project, as the information displayed will not be object of the project.

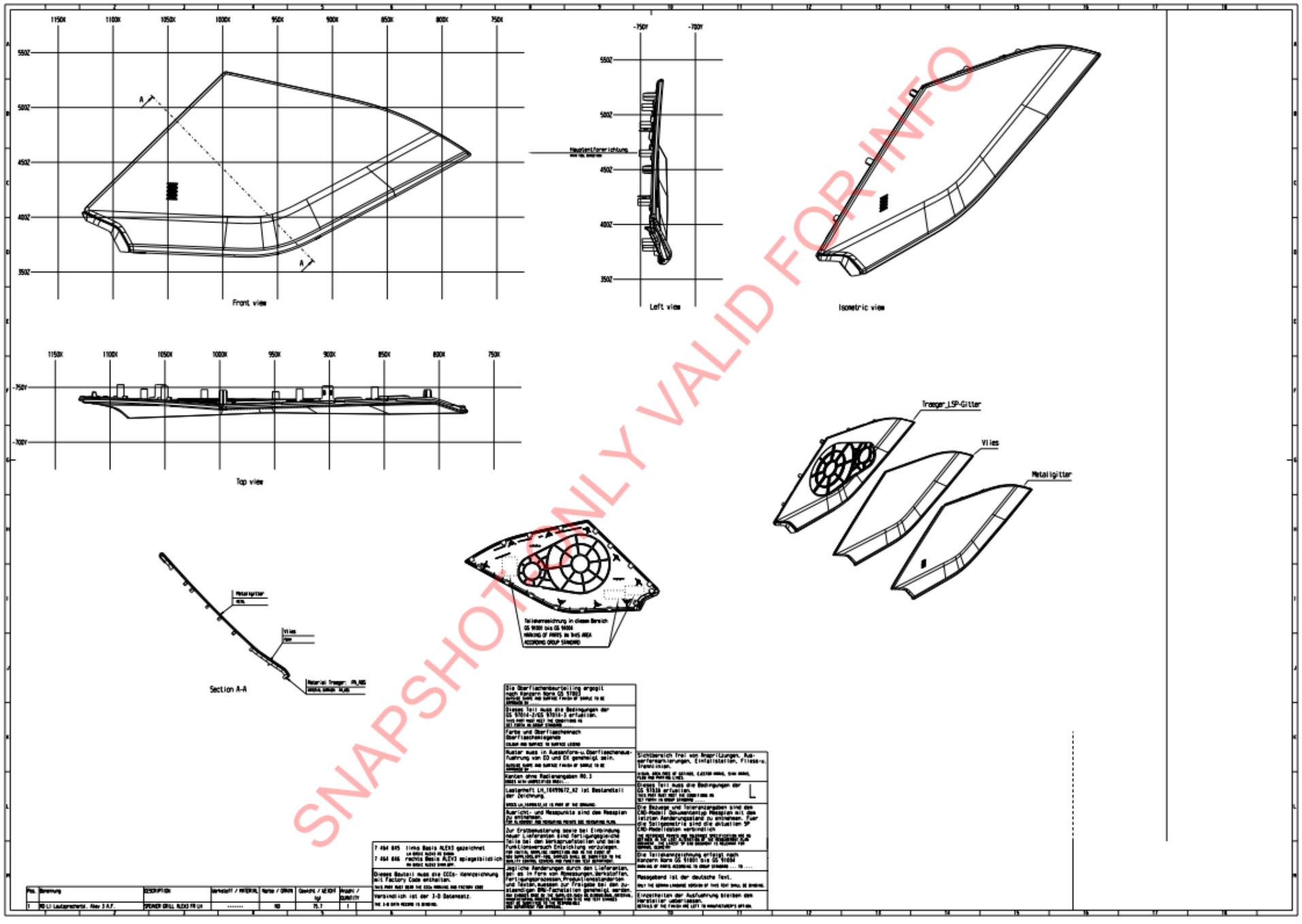



Isometric view
Isometric view
Front view
Control Points
Section A-A
Section B-B
Section C-C
Section D-D
Section E-E
Detail F(x2)
5:1
Detail G(x2)
5:1
Section H-H
Front view
Exploded view
Section J-J
Fine Grain "L"
Section K-K
Section L-L
1:1
Section M-M
1:1
R.P.S. System
Fensterheber Bezel FR RH LHD
CONTROL POINTS TABLE


750X
700X
300Z
250Z
front view
-750Y
-700Y
300Z
250Z
Left view
Isometric view
750X
700X
-750Y
-700Y
A
A
Top view
Fein Narbe L
Section A-A
SNAPSHOT-ONLY VALID FOR INFO


Isometric view
Marking View
Marking view
Front view
Section A-A
2:1
Detail B
2:1
Section C-C
2:1
Section D-D
2:1
Section E-E
(2:1)
Section F-F
2:1
Section G-G
2:1
View H
Section J-J
2:1
View K
Section L-L
2:1
Section M-M
2:1
Section N-N
2:1
View P
Section Y-Y
2:1
View R
Section S-S
2:1
Section T-T
2:1
Section U-U
Section V-V
Section cut X-X
Scale: 2:1
CONTROL POINTS TABLE
R.P.S. System
Grab Handle RR RH
Nominal dimensions must be taken from 3D data


Front view
Left view
Isometric view
Top view
SNAPSHOT-ONLY VALID FOR INFO



ANNEX III

Pos	Beschaffertext	Bestellnummer	Bestelldatum	Material	Kurztext	Anforderungsmenge	Lieferungen (ab/bis)	Kommentar	Preis	Lieferschein Status	Kommentar LS	LS Nr.	LS €	LS Date	Abrechnung (Invoice n°)	Invoice Date	Payment
1	F74	F3NJVMK	14.06.2021	4A1BE33-01	ZB LI TVKL VO F74 (BBG)	32	13.07.2021	Left front door	6.720,00 €	NO		?	6.720,00 €				
2	F70	F3NTM4V	22.07.2021	4A1DE57-01	ZB TVKL VORNE F70 N100 + ARKTUR(FEASECU)	4	30.08.2021	Front door (Arktur)	2.200,00 €	NO	ok	ok	4.520,00 €		RN-17014420	-	YES
					SNR: 4A1DE57-01 WKZ - Kosten				2.320,00 €								
3	F74	F3NYF9T	11.08.2021	4A1BE33-01	ZB LI TVKL VO F74 (BBG)	40	27.08.2021	Left door for front and rear	8.400,00 €	NO	ok	ok	12.600,00 €		RN-16945020	-	YES
				4A1E221-01	ZB LI TVKL HI F74 BASIS (BBG)	40			4.200,00 €								
4	F70	F3PK3TW	15.10.2021	4A1E233-02	ZB LI TVKL VO F70 HKL (BBG)	2	24.01.2022	Driver door HKL version	870,40 €	YES	ok	2022-027	870,40 €	10.01.2022	22-ALH-03-025	17.05.2022	
5	F70	F3PK9GH	18.10.2021	4A1E233-01	ZB LI TVKL VO F70 HKL (BBG)	1	19.11.2021	Left front door panel HKL	435,20 €	YES	will be invoiced in week 23	2021-01	435,20 €	29.03.2022			
6	F70	F3PK9GK	18.10.2021	4A1E427-01	ZB LI TVKL VO F70 HKL+SSM (BBG)	2	29.11.2021	Left front door panel SSM	945,88 €	YES	ok	2021-01	945,88 €	29.03.2022	22-ALH-03-011	17.05.2022	
7	F70	F3PK9GQ	18.10.2021	4A1E427-02	ZB LI TVKL VO F70 HKL+SSM (BBG)	1	25.01.2022	Left door front	4.729,40 €	YES	ok	2021-01	4.256,46 €	10.12.2021	22-ALH-03-010	17.05.2022	
						9	16.02.2022				ok	2022-009	472,94 €	10.01.2022	22-ALH-03-009	17.05.2022	
8	F7x	F3PK9H7	18.10.2021	5A44B41-01	LI BLENDE FENSTERHEBER T.H.	25	25.11.2021	Left and right fensterheber	225,00 €	YES	will be invoiced in week 23	2021-01	750,00 €	11.12.2021			
				5A44B42-01	RE BLENDE FENSTERHEBER T.H.	25			225,00 €								
				5A44B70-01	BLENDE FENSTERHEBER BFS LL SCHWARZ	25			300,00 €								
9	F70	F3PK9HH	18.10.2021	4A1E431-01	ZB LI TVKL VO F70 SSM (BBG)	4	01.12.2021	Left front door panel SSM	2.109,56 €	YES	will be invoiced in week 23	2021-01	2.109,56 €	29.03.2022			
10	F74	F3PK9HM	18.10.2021	4A1CA91-01	ZB LI TVKL VO F74 (BBG)	2	18.01.2022	All four door panels	1.145,88 €	YES	ok	2022-001	6.200,00 €	10.01.2022	22-ALH-03-022	17.05.2022	
				4A1CA92-01	ZB RE TVKL VO F74 (BBG)	7			3.934,00 €								
				4A1CA93-01	ZB LI TVKL HI F74 (BBG)	7			2.373,00 €		ok	2021-015	3.625,88 €	16.12.2021	22-ALH-03-020	17.05.2022	
				4A1CA94-01	ZB RE TVKL HI F74 (BBG)	7			2.373,00 €			2021-015					
11	F7x	F3PK9J4	01.02.2022	5A44B41-01	LI BLENDE FENSTERHEBER T.H.	26	02.02.2022	Blende fenterheber	234,00 €	YES	ok	2022-006	750,00 €	10.01.2022	22-ALH-03-023	17.05.2022	
				5A44B42-01	RE BLENDE FENSTERHEBER T.H.	26			234,00 €	NO	missing parts	?	270,00 €				
				5A44B70-01	BLENDE FENSTERHEBER BFS LL SCHWARZ	46			552,00 €								
12	F74	F3PK9J9	18.10.2021	4A1CA91-02	ZB LI TVKL VO F74 (BBG)	5	11.01.2022	Left front door panel	2.864,70 €	YES	will be invoiced in week 23	2022-002	2.864,70 €	10.01.2022			
13	F70	F3PK9JG	18.10.2021	4A1E431-02	ZB LI TVKL VO F70 SSM (BBG)	8	20.01.2022	Left front door panel	4.219,12 €	YES	ok	2022-010	2.109,56 €	11.01.2022	22-ALH-03-018	17.05.2022	
											ok	2022-019	2.109,56 €	20.01.2022	22-ALH-03-024	17.05.2022	

Table 15 – BMW F7x Purchase Order excel sheet example

Overview		
1. Amount of POs BBG F7x BMW		**36**
- Potential Income		**234.707,73 €**
2. Amount of delivery notes		45
- Total invoiced (not payed)		**105.125,05 €**
- Total already payed		**17.120,00 €**
3. Amount of invoices pending		
- Ready to invoice		**75.245,96 €**
- Easy to correct and invoice		**13.697,95 €**
- Not ready to invoice		**35.906,94 €**

Table 16 – Purchase Order overview of all the project proto parts