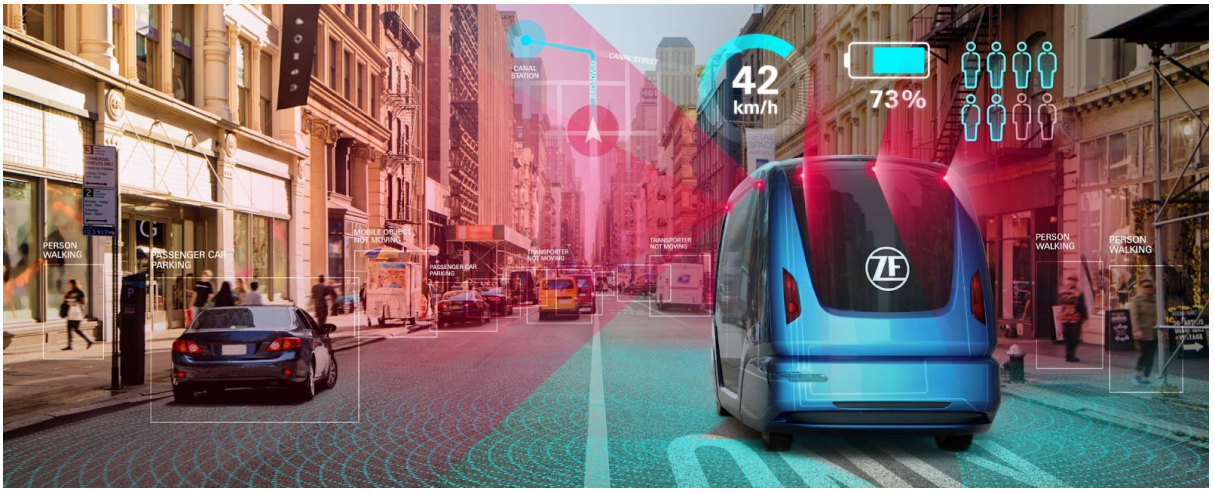
GE 301 TERM PROJECT

Responsible Innovation in ZF : AKC System



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ZF (Zahnradfabrik Friedrichshafen)

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SECTION 1

1. Introduction

Throughout time, technology grows and develops every day which affects society. Since technology grows in every aspect of life, it is also growing in the car industry. We can similarly see technology's growth in the car industry when we look at electric cars and how recently they have entered our daily life. There are several reasons why technology grows in the car industry. Transportation is becoming one of the needs of society. While the world becomes smaller and smaller through communication and transportation, the people in society want to spend less and less time on transportation. For instance, for the USA, it can be seen that the transportation unit variation and the quantity is increasing, and so the money they spend also increases accordingly. Thus, the money and technology that governments use is always increasing [1]**.** Thus, travel in safety and comfort is becoming one of the main focuses of innovations in the car industry and aims to fulfill these needs.

Lots of different innovations and developments are conducted in the car industry and the AKC (Active Kinematics Control) system is one of the innovations that is being developed by ZF. The aim of this project is to increase the safety and comfort of driving. When considering a normal car, the rear wheels follow the front wheels. However, when in a turn, rear wheels are not able to follow the front wheels and that's why, if a driver does not slow the car, the car could slip, get out of the line, and might cause an accident. To prevent such incidents, the driver has to slow the car and increases the turn radius. In ZF's AKC technology, the rear wheels of the cars are able to turn up to 6 degrees (3 degrees to inside, 3 degrees to outside). When a driver turns the steering wheel, the system calculates and adjusts the rear wheels degrees according to the severity. That's why the road grip and the turn performance of the cars increase; the turn radius is decreased and thus, the fuel usage is reduced [Interview 1]. Even for this new technology, some concerns have been raised. In this article, we investigate ZF's AKC technology through Responsible Innovation and evaluate it while considering user and instrumental values, better performance, environmental, and transparency concerns. Even though ZF serves a B-B (Business to Business) relation, ZF still considers end user's values for their safety and comfort as well as the stakeholder's values.

2. Theory

It is undeniable that society and technology are connected to each other and affect each other. It is raising awareness that technological developments require socio-structural values in order to move and grow further [2], while society also grows with technology. To have this mutual relationship, scientists should consider various concerns such as ethical concerns, privacy concerns, and technology & value interactions [3]. During the study, the scientists also find answers for these concerns in order to be successful in society [4]. To answer these concerns, Responsible Innovation is one of the most useful approaches to investigate and answer. With this approach, scientists can analyze the role of values while studying the new

technologies [5]; and as mentioned before, they have to answer these concerns to conduct further studies and further developments [6]. In this article, ZF AKC technology is considered according to Responsible Innovation and values.

Since technological decisions have a huge impact on society, decisions can also have negative effects. Irresponsible decisions can cause many problems such as environmental or social problems [7]. Thus, to have a positive impact Responsible Innovation theory requires several key concepts and mechanisms. To exemplify these concepts/mechanisms, we can simply explain through stakeholders, end-user values; and interactivity [8]. When we first look at ZF's AKC technology, it can seem that ZF has no interaction with end-users, because ZF is a B-B company. However, the interviews show that AKC technology interacts with end-users almost every step of the process. They focused on bringing safety and comfort to drivers (end users). It actually shows their thoughts about what is value and how we can describe them. According to their concerns they try to improve their technologies in different areas such as safety, comfort and reliability and according to the value pluralism approach these are actually final values for ZF. Their manufacturing preferences (material choices and etc [9]) and goals show that AKC technology is starting to implement some of the key concepts of the Responsible Innovation theory to reduce the negative effects of the technology on the environment. The values show that AKC technology starts to acknowledge the Responsible Innovation theory and requires further implementations of the theory. Thus, in this article, we investigate additional Responsible Innovation applications on the development process of AKC technology and additional benefits of Responsible Innovation theory for AKC technology and ZF.

3. Background Research

1. **History and importance of car**

The first motorized road vehicle in history is known as a three-wheeled, slow, and impractical vehicle invented by the French inventor Nicholas-Joseph Cugnot in 1769. In 1805, Oliver Evans is considered to be the first American in history to invent a motorized road vehicle, but this machine was also designed to be slow [10]. The first modern motor car, known as the basis of today's modern vehicles, was a Mercedes car designed in 1901 and was designed by Wilhelm Maybach [11]. From the beginning of the 20th century, the British, Americans, and Italians also joined the automobile industry and began to occupy a large area in the sector. Two of the prominent companies in the automobile industry at that time were Rolls-Royce from England and Ford from America because these companies were established by partners who combined engineering competence and business skills [12]. In this context, we can evaluate the reason why Ford stands out in the industry, in terms of combining engineering with business skills, the methods in the design and production process. Production methods were the main focus during the production of Henry Ford's Model T, which is very famous in the car industry. In 1913, a system called "moving assembly

line” that enables simultaneous production was introduced in order to reduce the cost of production, and Ford made the car production style customer-oriented by paying attention to customer demands [10]. At this point, in the early production of cars of Ford, because Ford has taken into account the demands of its customers, which has enabled society to shape technology in the car industry.

In the automobile industry, it was inevitable to see an increase in the use of cars in society as a result of mass production and customer demands are taken into account. At this point, competition has emerged between automobile manufacturers. At the same time, with the increasing use of automobiles and reducing the cost of production, it has become necessary to find new foci. The increase in the number of cars naturally brings about an increase in automobile accidents. In this context, safety takes an important place for itself. One of the important factors for safety has been a risk issue. In order to meet social responsibility, companies aimed to minimize risks in terms of safety. Thanks to continuous improvements for vehicle safety, the protection of society in terms of life health can be increased [13]. Companies should try to minimize risks by making these improvements continuous. The road holding and braking system of cars are one of the most important factors in preventing accidents and is at the forefront of safety. In addition, as evidenced by the history of the automotive industry, companies that stand out in this industry are seen as those who take into account customer demands and provide customers with a good experience (Henry Ford's T Model). For this reason, comfort has been an important issue for the automotive industry from the past to the present.

Safety and comfort have been one of the important factors to be considered throughout the history of the automotive industry. In addition to safety and comfort, being able to continue production during the COVID19 process has become one of the most important issues today. Many companies serving the automotive industry changed their working patterns and had to switch to a new working order.

2. COVID19’s Effect

The coronavirus has caused changes in the car industry as it touches every aspect of life and causes great changes. It affects the automobile industry from different aspects such as consumer demand and ongoing projects where stopping of production can cause great harm to companies.

Long-term lockdowns because of the global pandemic can affect the global economy and it can cause a global recession. Because of this probability of recession, there are lots of problems between the customer and the companies. According to Deloitte, this problem is seen as a threat to the automobile industry. They said, “various lockdown scenarios may spark a global recession, leading to widespread loss of consumer confidence,

significantly impacting automaker revenues and profitability" [14]. According to statistics, in Europe, while in lockdown car sales were reduced by 27% and in the USA it is 17% [15]. Although, after lockdowns, there is an increase in car sales, still in the USA and Europe, car sales are not as high as before the pandemic. Also, according to experts, the progression of the pandemic can be worse because future waves are highly possible, flu season can be a problem to flatten the curve, and broad vaccine availability and deployment not likely until mid-2021 [15]. Therefore, unfortunately, it seems that customer demands will not increase in the near future.

Because the automotive industry is one of the biggest industries, there are projects which can not be stopped unless there is a very unexpected situation. However, now, the whole world is affected by a pandemic. There are lots of unfinished and delayed projects due to this pandemic. Because governments take lockdown decisions all around the world in order to reduce the effect of the pandemic on people, unfortunately, required projects cannot be finished and delayed. Also, because the demand and production are strongly and positively correlated with each other, when the demand reduces because of the pandemic, production reduces, too. Due to this pandemic, sales of new cars fell by 72.4% in Russia [16]. Also, "The Association of European Enterprises states that production has slowed down and sales have almost completely stopped" [16]. As a result, although the car industry experienced a 6% decline just before the pandemic [17], because the pandemic exists and affects every aspect of people's lives, the car industry is still getting smaller.

3. Safety

The developing automotive industry brings innovations to its customers. The most prominent of these innovations are in the field of safety because the biggest risk factor in automotive use is the safety of people. Thousands of people are killed or injured each year due to car accidents. According to research, 1.35 million people die due to crashes occurred on the road and 3.700 people die on the road every day [18] Considering these numbers, preventing accidents and minimizing the damages in accidents becomes one of the most important points for companies serving in the automobile industry. Car accidents can be caused by things drivers make while driving (like acceleration and steering control). At this point, it is important for automobile manufacturers to make the necessary improvements for safety, and ZF company focuses on this because it is the responsibility of the companies to ensure the safety of customers and minimize risks. Companies need to research to understand what developments to focus on. For example, according to research, more than 94% of car accidents occur as a result of drivers' errors According to data from 2017, almost 30% of accidents occur as a result of acceleration [19]. At this point, car manufacturers focus on safety in terms of innovations for cars to prevent accidents that may occur as a result of acceleration or minimizing risk factors. AKC (Active Kinematics Control) technology developed by the ZF company increases vehicle stability and enhances the road holding of vehicles. In other words, AKC tries to prevent cars from skidding and accidents thanks to its

road holding [20].In order to minimize the risks of acceleration, the focus is on the handling and suspension systems of the cars. Thanks to its road holding, AKC works to prevent cars from being thrown and accidents. Thanks to the suspension system, the car is kept stable on the roads with bumps and holes, and in a way prevents it from falling over and making an accident [20].

4. Comfort

In the automotive industry, one of the points that are important to make a difference in the competition is comfort, and companies that want to keep their competitive power also consider a comfortable ride in the design of their cars. At this point, the important point is to understand the expectations of customers in terms of comfort since if companies design cars in terms of responsible innovations, they can make a difference in their products, stand out in the industry, and become more in demand. In addition, when companies think about comfort in terms of driving, they have started to pay more and more attention to suspension technology, which supports road holding as one of the most important points and enables cars to move on the road without swaying because the suspension system is seen as a necessity for a comfortable journey [20]. Suspension technology increases the friction between the intermediate tires and the road, thereby making the vehicle fixed to the road, in other words, reducing the vibration of the car during driving [20]. With the reduction of these jolts caused by dents or bumps while driving, a comfortable journey is provided and customer satisfaction increases. In addition to the suspension, the AKC (Active Kinematics Control) technology developed by the ZF company provides stability to high-speed vehicles and provides maneuverability to the drivers in addition to increasing road-holding. Thanks to AKC, drivers who do not have difficulty in handling and maneuvers have increased the comfort of driving [9].

5. Stakeholders involved in the Automotive Industry

The process Automotive Industry has several stakeholders. According to Jahishankar who is Toyota's DMD - purchase & technical, the primary stakeholders of an Auto manufacturing company include Customers, Dealers, and Employees [21]. Therefore, according to our interview with Mr. Erdogan, their main stakeholder is customers which are end-users. Because using AKC technology, reactions of the car is totally changed and they let this technology to particular professional drivers. Using their feedback, they change the design process of technology. Moreover, according to ZF, It gives more confidence at higher speeds on curved roads and increases vehicle stability at very high speeds. That is why this suspension technology is a revolution in the Automotive Industry; it is different from traditional car models and customers will like it. Therefore, their main stakeholders are customers.

In addition, the Mercedes S-class which is the flagship of the Mercedes Automotive Industry [22], uses this technology and canvassed it. Some

popular magazines say that this feature excited us [23]. There this situation shows that in AKC technology the main stakeholder is customers.

Engineers which are responsible for this AKC project, taking the risks in the design process. Therefore in order to reduce them, they simulated products and analyzed them. That is why they are also stakeholders as well [24].

In addition, dealers that sell cars are other stakeholders. Because dealers mention this AKC technology to the customers and make this technology sold. To sum up, all stakeholders have different roles in this technology and responsible innovation. Because they make societies' life easier.[25]

Dealers in this sector spend a big proportion of money on testing and analyzing feedback in order to protect and increase the place of Final Values such as safety and their customers' health. Both dealers and engineers work hard in order to produce new technologies which increase human wellbeing and sustainability of their products. As a side note, even the importance of the software has increased a lot in the last years, and the necessity of software testing skyrocketed[26].

6. Solutions

The suspension systems have been widely applied to vehicles from the horses to the cars today [27]. These systems are highly effective on customer comfort and safety. In order to develop better suspension systems, there are ongoing developments. Active Kinematic Control (AKC) systems are one of the most popular, useful and qualitive one in this technological area. Still, these technologies are developed by R & D departments of automotive industries because of the importance of suspension technologies in automotives. As we know, because of Covid-19 , there are lots of obstacles occured in every aspect of industries. Fortunately, regardless of all these negative impacts of pandemic, the role of R & D departments in industries gain importance and their work has been increasing.

4. Method

We decided on our subject depending on some background research about global industries, machine learning, artificial intelligence, automotive industry, etc. Then, depending on our research we decided to progress with the automotive industry because the automotive industry is so big and comprehensive rather than other topics. After deciding the topic we searched for different companies that are related to the automotive industry. We wanted to select a company that has lots of projects, is competent in their fields, and has innovations for the industry. Because we have been in the covid-19 pandemic, we didn't attach importance to the city where the company is. Therefore, we decided to select ZF (Zahnradfabrik Friedrichshafen) which has lots of factories in different countries. Because ZF has a factory in İzmir we decided to contact ZF İzmir. Fortunately, they gave positive feedback to us about interviews. ZF is a car parts maker, that is, they produce car parts such

as driveline technologies, chassis technologies, axis systems, software for cars, diagnostic systems, precision plastic technology, lubricants, etc. Also, they have lots of Research & Development projects for these car parts to optimize them.

In order to make an efficient interview with ZF and get useful information for our term project, we did some background research about cars, car parts, and the history of ZF. All interviews were conducted via recorded phone calls and Zoom. These interviews helped us to understand the automotive industry and its importance. Other than this, during the interviews, some important concepts of responsible innovation were also mentioned and we have learned how these concepts like the comfort of users and safety by design are applied to the Research & Development projects of ZF, whether the ethical values are concerned or not and whether they take into account the society while designing their projects. After the interview is done, we divide the interviews into sections and subsections. We have coded our interviews by using the QDA Miner lite program. It helped us to code and analyze our interviews based on STS concepts easily. Then we did the job distribution about coded interviews equally. So, everyone involved in the background research and analysis parts of the project.

5. Findings

Table 1: Company

Company	Area	Quotation

	Technical	We are developing a new technology **AKC (Active Kinematics Control) that leads the user to 100% better performance during driving the vehicle.** [Interview 1] We are working **on disability reduction and transition to automation**.[Interview 2] In our system, we use **mechanical parts with electronics and software together**.[Interview 1] To determine all the risks before starting serial production, **we have FMEA (Failure Mode Effect Analysis) studies during the project phases of new products.** [Interview 1] Normally, the steering system in vehicles is on the front axle. **When we turn the steering wheel, it makes some rotational movement** [Interview 3]
	Costs	We cannot do prototypes right away because creating **prototypes is a much more overcosting job**. [Interview 3] Just like keeping the **foundation solid while building the building**, we need to make our foundation solid, otherwise big problems may occur. [Interview 2]

	Design Process	The adjustments between **the components are perfect and because of this harmony.** [Interview 1] **Just like keeping the foundation solid while building the building, we need to make our foundation solid, otherwise big problems may occur**. [Interview 2] I**nstead, we analyze and simulate, and model them with some programs. As a result of these, we take the useful ones to the next stage and start making products and test them** [Interview 3] The sound may come from the vehicle, if we get feedback such as any gap or contact or vibration **after certain speeds in your new product, we make changes in the design or process**. [Interview 3] **That's why we minimize these risks by doing all our tests.** [Interview 3]

In ZF there are 3 main areas. Technical, cost, and design process. They are manufacturing a suspension technology named AKC and they use many different technologies and engineers for this purpose. Therefore from quotations, it can be said that they use many technical methods. Also, they want to develop their technology with minimum cost and maximum efficiency. According to Mr. Şanlı, its main job is to make the landing with maximum robotic systems and Lights-out manufacturing for this purpose. Therefore the cost is another main instrumental value in ZF. Lastly, because of manufacturing, they have a design process that includes several steps. The most important one is feedback. With respect to this feedback, they analyze their projects and change their design. According to Mr. Yildiz, Until reaching perfect results, the design changes, and further tests never stop. When the test team is satisfied with the results then we send the product to customers together with our test results. Therefore, it can be referred to that from all quotations given above, the design process is another main Instrumental Value in ZF.

Table 2: Instrumental

Instrumental	Effects of Covid-19	The coronavirus has no impact on our products but on our working style. At the moment most of the teams are working at the home office and have virtual team meetings. Of course, working in the plant and face-to-face meetings are more effective but we have to adapt to the new reality of the world. **[Interview 1]** **Corona is good for me, actually**. For something, I have to pry the line, take measurements, and stop the operator. Sometimes I had to stop the machine for half an hour, sometimes for 1 shift. While things are going well, it is very difficult for me to stop the loom, **but now it has become easier for me to buy looms and do R&D work because production is very low now.** But there were difficulties in running things. Adequate yields cannot be obtained on platforms such as zoom and teams, and we will get used to it. **[Interview 2]** I cannot say that it directly affected a complete project. But in general, it had an automotive effect. Namely, the projects we could do were certain, and the budgets allocated for them were also determined. There were places that closed when people could not buy a car during this time, so budgets fell. Not only in this project, but in all projects, there was a delay of at least 6 months. **[Interview 3]**

	Future Plans	The future technology is autonomous cars and more fun in cars. But this needs better performance in the steering and suspension systems of the vehicles. We call this new technology “flying carpet”. **[Interview - 1]** Industry 4.0, digital transformation, we do this kind of work. **[Interview 2]** The Dark Factory is our main application. We make applications such as unmanned factories, robot lines, cartesian loading systems, or unmanned any manually made system. **[Interview 2]** While I expect much more efficiency, we suddenly improve the process or turn it into automation. **[Interview 2]** I think these technologies will hyperloop the future point. I think fast transportation is among the technologies of the future. Technology is at a very advanced level, robots started to do the work we used to do with artificial intelligence. Start using artificial intelligence even in human resources. Even any incoming document makes the necessary classification with artificial intelligence. While the factory works like this, I think the transportation part will go to the hyperloop. **[Interview - 2]** This technology is currently not available in my own vehicle. Probably, there is no one in our vicinity who uses this technology. Currently used in the 2020 model Mercedes s-class. But technology is gradually descending into lower segments. Currently, this technology is not an expectation by end-users because it is unknown. But after 5 years, it seems to me that there will be a public opinion about whether a vehicle that cannot be returned in this way will be taken. It will be like an automatic gear. After 30 years, vehicles can fly, there may not be a road, but if there is a road, there will be flying carpet and fully independent suspensions. I think 30 years from now people will read your book or watch your movie in the back. But they

		will never feel the road. But I think the road will probably disappear after 30 years. **[Interview 3]**

In the pandemic, ZF changed their working styles. Most of the teams started to work from home using online meeting applications such as Zoom, Microsoft Teams, etc. According to the first interview, although face-to-face meetings are more effective than online ones, ZF optimizes online meetings to make those meetings as effective as possible. Also, as pandemic has bad effects all over the world, in ZF some projects were delayed at least 6 months. In addition to that, because the global economy was affected by the pandemic, car sales and demands reduced. Although the pandemic had bad impacts on ZF, there are some positive impacts on the Research and Development department. Because production was delayed in the pandemic, according to the second interview, the R & D department had more privileges to design projects.

Engineers in ZF consider some probabilities about future technology and design their projects and technologies depending on these considerations. For example, because there is an autonomous car trend, they found that in the future the importance of performance in steering and suspension will increase. Also, they know that their project designs shape the future and society, and these changes also will shape their production and their R & D.

Table 3: Final Values

	Area	Quotation
Final Values	Comfort	**While cornering and parking, we make the maneuvers with the commands from the front axle and the front wheel movements.** [Interview 3] **In this technology, we will move the wheels that are normally straight to the road at a certain angle to the direction of movement or vice versa. Not only the front wheels but also the rear wheels will assist in turning.** [Interview 3] **These can be comfort-oriented, crash tests, durability tests.** [Interview 3] Because when I get the vehicle, **I park much more easily when the rear wheels turn.** [Interview 3]
	Safety	This means the rear side of the vehicle is not passive and not just following the front side of the vehicles but helps the vehicle's rear side to turn with **better performance without skidding** and reduce the fuel usage. [Interview 1] **In this technology, we will move the wheels that are normally straight to the road at a certain angle to the direction of movement or vice versa. Not only the front wheels but also the rear wheels will assist in turning.** [Interview 3] **These can be comfort-oriented, crash tests, durability tests.** [Interview 3]

		For example, the driver's experience changes at high or low speeds, when cornering or parking. [Interview]
	Reliability	...but because of the adjustment problems of different supplier's components, the **performance never reaches ZF AKC performance.** [Interview 1] **The adjustments between the components are perfect and because of this harmony, the product performance reaches 100% and increases the driver's safety.** [Interview 1] **Until reaching perfect results, the design changes, and further tests never stop.** [Interview 1] **Our work is trying to increase the efficiency of production and make production unmanned.** [Interview 1]

ZF takes final values into account for their design process and they try to achieve user-friendly, reliable, safe, and comfortable products. In the comfort area, they mainly focus on AKC technology in order to solve some issues about comfort when a customer is faced while parking or maneuvering. The same technology will help them to increase the safety of traveling with a reduction in skidding. Their products will be used for many long years, therefore reliability is a very important category for their work and they are hardworking in order to increase performance while saving the level of efficiency and harmony between components in a high standard.

Table 4: Stakeholders

Stakeholders	Dealer	Only on some luxury cars, the car manufacturers supply some components of similar systems from different suppliers and assemble them on the vehicles **[Interview 1]** We evaluate the end user's feedback and we perform the product test evaluations mostly together with OEM development teams. **[Interview 1]** our partner's expectations **[Interview 3]** Currently used in 2020 model Mercedes s-class **[Interview – 3]**
	Consumer	customer expectations **[Interview 1]** customer's **[Interview 1]** he end-consumer in the market **[Interview 3]**
	Engineer	In our system, we use mechanical parts with electronics and software together. **[Interview 1]** That is why our design teams have very close contact with the development teams of car manufacturers **[Interview 1]** Our customer is the production itself **[Interview 2]**

ZF is interacting with different stakeholders while producing their car part products. There are different stakeholders both inside and outside of the company. They have about 260 locations in some 41 countries [28]. Also, they work with different companies such as Mercedes, Volkswagen, Audi, etc. as dealers. They also have engineers and consumers as stakeholders such as end-consumers in the market, engineers who have knowledge about car parts, etc.

Table 5: Risks

	Quotation
Risks	In all new technologies, there are risks. To determine all the risks before starting serial production, we have **FMEA (Failure Mode Effect Analysis) studies during the project phases of new products.** All the tests in ZF and in customers are **performed to avoid risks** before reaching the products to end-users. [Interview 1]
	The risk I take is a decrease in production efficiency. [Interview 2]

	It causes a serious increase in loss. [Interview 2]
	There is a risk in every technology. Anything newly made is risky. Some can be predicted, some cannot be seen. But we are not doing anything to put human health at risk. [Interview 3]
	Risks may occur in the production area. [Interview 3]

The automobile sector is a really tough sector and even a small mistake can lead to lethal consequences. Therefore risk factors should be minimized in both development and production steps. In order to reduce risk in these steps, they conduct a lot of critical tests. They made a special analysis in order to detect different failures in the different phases of new products. In the production step, ZF developed special designs and products in order to minimize these risks. In AKC technology, the risks of developing the product and testing the product have several risks. They are working for minimizing the risk and offering a better road hold for automobiles.

Table 6: Solutions

	Area	Quotation
Solutions	Environmental	**...to turn with better performance without skidding and reduce the fuel usage** [Interview 1]
		For example, we do not use **any plastic parts that will rot nature,** **or we do not have a situation that increases any carbon emissions, so we do not risk** **human health in any case**. [Interview 3]
	Feedback	**Understanding customer expectations and learning the complaints of the customers are** **the first steps of the design phase.** [Interview 1]
		We evaluate the end user's feedbacks and we perform the product test evaluations mostly **together with OEM development teams.** [Interview 1]
		...**we sent the product to customers together with our test results.** [Interview 1]

		If they will have any concerns, then **we will make the necessary design changes and this cycle will repeat again**. [Interview 1]
		All the tests in ZF and in customers are **performed to avoid risks before reaching the products to end-users**. [Interview 1]
		Of course, **their feedback is very important to me.** If this does not happen, I always score a goal from where I did not consult. [Interview 2]
		We **receive feedback either on our own standards, customer expectations, or the comments of the end-user**. These can be comfort-oriented, crash tests, durability tests. [Interview 3]

It can be seen that ZF has already started to implement different solutions in the light of the Responsible Innovation framework. They are focused on several concerns and try to reduce these concerns. For instance, they try to reduce the negative environmental concerns. From feedback, we see that in the process of the AKC technology, ZF considers the end user's feedback and focuses on solving those problems, even though they are a B-B company.

6. Analysis Conclusion

6.1 Analysis

6.1.1 Instrumental Values

Three main Instrumental Values are included in ZF. Technical, Cost, and Design Process.

Firstly the Technical area is one of the most used areas among all 3 interviews. Because ZF is a manufactory and they have many engineers working. Therefore it is expected that they have a technical area. ZF uses electronics and software together in AKC technology and this work is a technical issue. Also, in order to determine all risks, they have Failure Mode Effect Analysis that studies during the project phases of new production. Normally the steering system in vehicles is on the front axle, however, This is achieved by turning the rear wheels in the opposite direction.[9] Thus, this is the technical description of the project. They are all engineers and they sell their products to OEM so their job is technical as expected.

Secondly, Cost is another instrumental value in ZF. They cannot do prototypes right away because creating prototypes is a much more costly job. Therefore it can be referred that cost is a very important instrumental value for ZF. Also, Cost estimation is a significant topic in the automotive industry [29]. Therefore Lights-out manufacturing is one of the big goals in ZF. Last year, there was no pandemic so ZF's work was better. Therefore, ZF could not stop an operator for R&D purposes because it is costly. Thus, it can be said that one of the main Instrumental values in ZF is cost. They support R&D work, however, considering the cost balance.

One of the last main Instrumental Values in ZF is the design process. They have a big manufacturing area and they manufacture some important items for cars such as

suspension technology. Also, they are leading these technologies [30] so they have a detailed and feedback-based design process. ZF's components are perfect because of the harmony. Thus, ZF produces a unique technology for new cars and sells them to luxury car companies, that is why they have a significant and complicated design process.

To conclude, as we expected, this manufacturer has 3 main areas which are Technical, Cost, and Design Process. Therefore, their manufacturing system includes these topics as an Instrumental value. We expect these because if a company manufactures some product, the company should consider these concepts.

6.1.2 User Values

ZF is working hard to keep this system of high quality. The main values considered in this quality definition are "Comfort", "Safety" and "Reliability". All of them are highly associated with users, customers of their product. The main reason for this is behind today's trends. Today, there is a growing recognition that providing superior value for users is instrumental for business success [31]. In order to achieve this business success like other companies, ZF tries to achieve a multilevel improvement on user values with AKC technology. AKC provides a 3-level of freedom to rear wheels while the car is turning and it increases the general movement abilities of the car. It increases the easiness of maneuvering with the car from the perspective of a user. This shows that a technological improvement in the interior parts of a car can affect a users' comfort highly due to its value. In order to achieve this improvement in the Comfort area, ZF makes comfort-oriented tests for their products. If we look at ZF from the safety and reliability perspective, we will see that they try to achieve perfection. As a result, it will return as user satisfaction and customer happiness. In parallel to Safety and Comfort, ZF must improve their reliability too in order to maximize user values for their products. The feedback of the increase in efficiency will be increased in reliability and as a result, it will improve overall customer happiness at the end of the day.

6.1.3 Responsible Innovation

ZF has already acknowledged the Responsible Innovation theory and according to Responsible Innovation, they have already taken some actions. Thus, they avoid making irresponsible decisions. They know that the end-user will be the key reviewer and their opinion is much more important than the stakeholders. Therefore, they are focused on the feedback of the end-user as much as the stakeholders' feedback. They start the design phase with their stakeholders' expectations and after that, they use end user's feedback to evaluate the product and repeat this step until end users are satisfied. Moreover, even though they focused on using the end-user feedback, it is seen that their priority is still the satisfaction of the stakeholders and OEM team. ZF must acknowledge that the end user's expectations should also be their priority in order to develop more successful technologies and easier acceptance by society. Moreover, ZF started to acknowledge some environmentally friendly decisions such as reducing plastic usage in order to reduce carbon emission. Even though that's a good start, they can still accept further environment-friendly decisions. They can take further actions to help the environment. Finally, it can be seen that ZF and AKC technology perform several tests to see the risks of technology. The AKC team focuses on reducing the loss of technology in every step possible and studies the risks. The risks are high in this sector and to prevent these problems they have to work more because they want to reshape their process in order to avoid those risks in the first step.

6.1.4 Covid-19 and Solutions

Because of the covid pandemic, ZF is affected both negatively and positively. For example, in ZF, because of lockdowns and the spread of the virus, they had to delay the ongoing projects at least 6 months later. Also, because face-to-face meetings are more effective than online ones, there existed some efficiency problems in the meetings. Other than that, because the whole global economy is affected by the pandemic and lockdowns, the car sales and demand for cars reduced so that the production was reduced. However, because ZF is an institutional and developed company, they could manage the problems with minimum effort. From a positive perspective, because production was stopped for at least 6 months, these delayed times were filled with research and development. So, engineers who work at the R & D department at ZF had more privileges and more flexibility. Therefore, although, as every aspect in the world, the pandemic is still affecting the ZF about their ongoing projects, productions, the efficiency of meetings, etc. ZF companies could manage those problems with an effort also some departments could be positively affected by this pandemic.

Additionally, in the interviews that we made, we understand that design of the engineers both affects the development of technology and is affected by these developments. For example, ZF started to design more efficient steering and suspension systems for autonomous cars which can be an example for how developments affect produced technology in ZF. Also, some of their developments such as AKC using AI lead to connection between artificial intelligence, machine learning technologies and car parts.

As a result ZF company is affected by environmental factors such as pandemic, lockdowns, technological developments etc. and also affects the developments in technology, production of new products etc. However, thanks to ZF's R&D studies, ZF has turned this challenging process into its own advantage and carried its AKC technology to an advanced level.

6.2 Conclusion

In this project report, we examined and analyzed ZF and one of its innovations, the AKC (Active Kinematic Control) system. Based on our interviews and background research, we carried out our project by basing our analyzes on Company, Instrumental, Final Values, Stakeholders, Risks and Solutions. First of all, we made a short introduction and determined our theory. Then we did a background research. The specific points we focused on for background research were the History and Importance of Cars, Safety, Comfort, User Design, Stakeholders Involved in the Automotive Industry and COVID19's Effects. After collecting data by conducting background research on these issues, we completed our interviews with company employees and combined the information we obtained from this interview with the information we obtained from past research.As we learned from research and interviews, safety and comfort is an important issue in the automotive industry. In this respect, AKC technology developed by ZF plays an important role in providing safety and comfort in cars. In order to develop a successful product in the automotive industry, it is important to consider customer demands in design. For this reason, it is an important point to determine the focal points in the design process. Stakeholders are involved in the process from this point on, and they have a place in the process. Product users determine their demands for the product and these demands are taken into consideration. Engineers look at these demands, are innovative, responsible, and consider risk factors and come with a

solution. In other words, there is a process that consists of thinking of stakeholders as a whole

7. Credits

Ümit Yiğit Başaran: Covid19, Conclusion, Findings and Analysis parts, Background Research

Murat Angın: Methods, Background Research, Conclusion, Findings and Analysis parts

Elif Özer: History and importance of Cars, Safety, Comfort, Conclusion, Findings and Analysis parts

Muhammed Emre Yıldız: Interview conducting, Translation and transcription, Stakeholders, Conclusion, Findings and Analysis parts

Abdullah Can Alpay: Developing Introduction and Theory part, Background Research, Conclusion, Findings and Analysis parts

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9. Appendix

First Interview (Tamer Yıldız)

1. Please tell us about the technology that you are developing.

We are developing a new technology AKC (Active Kinematics Control) which led the user to 100% better performance during driving the vehicle.

In the conventional systems; when the driver turns the steering wheel, the front wheels turn left or right to change the direction of the vehicle. But the rear wheels just follow the front side of the vehicle. They neither turn left /right or have an angle in the horizontal direction. That is why the turning radius of the vehicles are bigger and the rear side of the vehicles skid in the counter side of the turning direction.

In our new system, when the driver turns the steering gear, this data comes to our system assembled onto the rear axle of the vehicle. Our product lets the rear wheels move up to 3 degrees in the horizontal direction. This means the rear side of the vehicle is not passive and not just following the front side of the vehicles but helps to vehicle's rear side to turn with better performance without skidding.

2. What are the main applications for the technology in your project?

Conventional vehicles are not equipped with this kind of a system. Only on some luxury cars, the car manufacturers supply some components of similar systems from different suppliers and assemble them on the vehicles but because of the adjustment problems of different supplier's components, the performance never reaches ZF AKC performance.

In our system, we use mechanical parts with electronics and software together. The adjustments between the components are perfect and because of this harmony, the product performance reaches 100%.

3. Do you consult end-users at any point during the design process

At ZF we mostly produce and develop parts for car manufacturers (OEM). Understanding customer expectations and learning the complaints of the customers are the first steps of the design phase. That is why our design teams have very close contact with the development teams of car manufacturers. We evaluate the end user's feedback and we perform the product test evaluations mostly together with OEM development teams.

4. Do you make any adjustments in response to user feedback during the design process?

After our initial design, prototypes of the new products are tested in the ZF Test departments. Until reaching perfect results, the design changes, and further tests never stop. When the test team is satisfied with the results then we send the product to customers together with our test results.

The customers also perform their tests and inform us about their results. If they will have any concerns, then we will make the necessary design changes and this cycle will repeat again.

5. Are there risks associated with the technology?

In all new technologies, there are risks. To determine all the risks before starting serial production, we have FMEA (Failure Mode Effect Analysis) studies during the project phases of new products. All the tests in ZF and in customers are performed to avoid risks before reaching the products to end-users.

6. Has the coronavirus had an impact on your innovation practices?

The coronavirus has no impact on our products but on our working style. At the moment most of the teams are working home office and have virtual team meetings. Of course, working in the plant and face to face meetings are more effective but we have to adapt us the new reality of the world.

7. What is the future for technology?

The future technology is autonomous cars and more fun in cars. But this needs better performance in the steering and suspension systems of the vehicles. We call this new technology a “flying carpet”.

Second Interview (Can Şanlı)

We are working on the initiative of AKC's systems in the production and manufacturing phase. Industry 4.0, digital transformation, we do this kind of work. We are working on disability reduction and transition to automation.

The Dark Factory is our main application. We make applications such as unmanned factories, robot lines, cartesian loading systems, or unmanned any manually made system.
Our work is trying to increase the efficiency of production and make production unmanned. Our customer is the production itself. Because my job is to support production. Of course, their feedback is very important to me. If this does not happen, I always score a goal from where I did not consult.

There is a process flow and an operator loads a part on the machine and assembles it. It loads the components on the machine and retrieves them automatically. I want to put a robot there instead of an operator. But at that stage, the operator has solved some problems that the operator made there, but he should not have done, and actually adopted it. There is a problem intervening there and it has become part of a process. If I don't know this point, these parts come back to me unassembled. I just put the robot there and when I say let's do it, I'm doing something very wrong. I have to fix the background mistakes too.

The risk I take is a decrease in production efficiency. While I expect much more efficiency, we suddenly improve the process or turn it into automation. Sometimes we double the efficiency, but if we do not see some risks, we suddenly become unable to get parts from there. It causes a serious increase in loss. Just like keeping the foundation solid while building the building, we need to make our foundation solid, otherwise big problems may occur.

Corona is good for me, actually. For something, I have to pry the line, take measurements, and stop the operator. Sometimes I had to stop the machine for half an hour, sometimes for 1 shift. While things are going well, it is very difficult for me to stop the loom, but now it has become easier for me to buy looms and do R&D work because production is very low now. But there were difficulties in running things. Adequate yields cannot be obtained on platforms such as zoom and teams, and we will get used to it.

I think these technologies will hyperloop the future point. I think fast transportation is among the technologies of the future. Technology is at a very advanced level, robots started to do the work we used to do with artificial intelligence. Start using artificial intelligence even in human resources. Even any incoming document makes the necessary classification with artificial intelligence. While the factory works like this, I think the transportation part will go to the hyperloop.

Third Interview (Ender Erdoğan)

Normally, the steering system in vehicles is on the front axle. When we turn the steering wheel, it makes some rotational movement. While cornering and parking, we make the maneuvers with the commands from the front axle and the front wheel movements. In this technology, we will move the wheels that are normally straight to the road at a certain angle to the direction of movement or vice versa. Not only the front wheels but also the rear wheels will assist in turning.

It is very important to find the idea first. For a good idea, first of all, marketing research, the end consumer in the market, or our partner's expectations and technical requirements are very important. By taking all of this and making a brainstorming, we form the ideas of competent or non-competent people. Then we take what worked for us from these ideas. Then the designs start. We cannot do prototypes right away because creating prototypes is a much more overcosting job. Instead, we analyze and simulate, and model them with some programs. As a result of these, we take the useful ones to the next stage and start making products and test them. We receive feedback either on our own standards, customer expectations, or the comments of the end-user. These can be comfort-oriented, crash tests, durability tests.

Especially in solutions that affect the end-user. For example, AKC technology affects. Because when I get the vehicle, I park much more easily when the rear wheels turn. In fact, the center of rotation of the vehicle is normally at the rear, now it is towards the middle of the vehicle. This obviously changes the way the driver uses it. For example, the driver's experience changes at high or low speeds, when cornering or parking. Of course, we get competent drivers and certain driver candidates to test them and get feedback. This feedback is very important to us.

For example, sound may come from the vehicle, if we get feedback such as any gap or contact or vibration after certain speeds in your new product, we make changes in the design or process.

There is a risk in every technology. Anything newly made is risky. Some can be predicted, some cannot be seen. But we are not doing anything to put human health at risk. For example, we do not use any plastic parts that will rot nature, or we do not have a situation that increases any carbon emissions, so we do not risk human health in any case. Risks may occur in the production area. That's why we minimize these risks by doing all our tests.
I cannot say that it directly affected a complete project. But in general, it had an automotive effect. Namely, the projects we could do were certain, and the budgets allocated for them were also determined. There were places that closed when people could not buy a car during this time, so budgets fell. Not only in this project, but in all projects, there was a delay of at least 6 months.

This technology is currently not available in my own vehicle. Probably, there is no one in our vicinity who uses this technology. Currently used in 2020 mode Mercedes s-class. But technology is gradually descending into lower segments. Currently, this technology is not an expectation by end-users because it is unknown. But after 5 years, it seems to me that there

will be a public opinion about whether a vehicle that cannot be returned in this way will be taken. It will be like an automatic gear. After 30 years, vehicles can fly, there may not be a road, but if there is a road, there will be flying carpet and fully independent suspensions. I think 30 years from now people will read your book or watch your movie in the back. But they will never feel the road. But I think the road will probably disappear after 30 years.