USER CENTERED DESIGN ESSENTIALS FOR CONVENTIONAL AND AUTONOMOUS TRUCKS

NİMET DİLAVER

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ABSTRACT

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Dilaver, Nimet

Izmir University of Economics Graduate School

Master Program in Design Studies

Advisor: Prof. Dr. Deniz Hasırcı

Co-Advisor: Prof. Dr. Önder Küçükerman

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Today, autonomous vehicle systems development, that is expected to meet the world's various needs of transportation in the near and far future, is gaining speed. Industrial design, which puts use-centered design at its core, is one of the pioneering steps for this transformation and it will be as crucial as existing vehicles' technological developments, in addition to mechanical and technical equipment specifications improvement. In this study, the "Automotive" sector, which has a wide range of products, will be studied. The conventional "Truck" vehicle notion, based on design and production in commercial vehicle, is discussed in terms of the new generation autonomous vehicles' technological and design-based transformation focusing on truck interior design specific to user-centered design (UCD). The existing research and studies are examined along with literature review in the research methodology. Using interview and observation techniques as research instruments, which are applied to internalize the UCD, and also aimed at revealing the user experience (UX) design contributions on the vehicle design for the study; effective information was obtained from the first users and experts in order to contribute to the study's output. The companies, which are already studying this subject specifically, are examined. The analysis and inferences are done within a scenario for transformation of the Turkish brand, BMC's new truck series "Tuğra" to autonomous vehicle in terms of vehicle interior design.

Keywords: Transportation design, automotive design, user-centered design (UCD), autonomous vehicles, truck design, truck interiors.

ÖZET

GELENEKSEL VE OTONOM KAMYONDA

KULLANICI ODAKLI TASARIM ESASLARI

Dilaver, Nimet

İzmir Ekonomi Üniversitesi Lisansüstü Eğitim Enstitüsü

Tasarım Çalışmaları Yüksek Lisansı

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İkinci Tez Danışmanı: Prof. Dr. Önder Küçükerman

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Günümüzde, yakın ve ileri gelecekte dünya genelindeki birçok ulaşım ihtiyacını karşılaması beklenen otonom taşıt sistemlerin geliştirilmesi hız kazanmıştır. Mevcut araçlardaki teknoloji ile ilgili mekanik ve teknik donanımlardaki gelişmelerin yanı sıra, endüstriyel tasarım da bu dönüşümde kullanıcı odaklı tasarımı merkezine koyarak, öncü adımlardan biri olmaktadır ve olacaktır. Bu çalışmada geniş kapsamlı ulaşım araçlarından, otomotiv sektörü mercek altına alınmıştır. Ticari araçlarda ki geleneksel "Kamyon" araç kavramının, üretim ve tasarım temelindeki varlığının, yeni nesil otonom araçlara dönüşümündeki teknolojik ve tasarımsal değişimleri, kullanıcı odaklı tasarım özelinde, araç iç tasarımı ön planda tutularak ele alınmıştır. Araştırma metodolojisinde, literatür taraması ile mevcut çalışmalar ve araştırmalar incelenmiştir. Kullanıcı odağını çalışma üzerinde özümsemek ve araç tasarımı üzerine etkilerini ortaya koymak adına uygulanan röportaj ve gözlem metotları sayesinde, ilk kullanıcılardan ve uzman teknik kişilerden etkili bilgiler edinilmiş ve çalışma çıktısına katkılar sağlanmıştır. Konu özelinde bu alanda yoğun çalışmaları hâlihazırda yapmakta olan markalar incelenmiştir. Bir Türk markası olan BMC yeni kamyon serisi Tuğra'nın otonoma dönüştürülme senaryosu adına, iç tasarım odağında analizler ve çıkarımlar yapılmıştır.

Anahtar kelimeler: Taşıt tasarımı, otomotiv tasarımı, kullanıcı odaklı tasarım, otonom araç, kamyon tasarımı, kamyon iç tasarımı, kamyon kullanıcı deneyimi

DEDICATION

to My Family…

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LIST OF ABREVIATIONS

UCD:	User Centered Design
UX:	User Experience
IDF:	Interaction Design Foundation
HCD:	Human Centered Design
DDT:	Dynamic Driving Task
ADS:	Automated Driving System
ODD:	Operational Design Domain
DDT:	Dynamic Driving Task
ADAS:	Advanced Driver Assistance Systems
DAS:	Driver Assistant System
ACEA:	European Automobile Manufacturers' Association
SAE:	Society of Automobile Engineers
UNECE:	The United Nations Economic Commission for Europe
ODD:	Operational Design Domain (OD)
OD:	Operational Domain
OEM	Original Equipment Manufacturers

CHAPTER 1: INTRODUCTION

This study aims to reveal the transformation of a conventional transportation vehicle to not only a modern but also technological and innovative vehicle in the light of the user-centered design philosophy. While there are many sources covering UCD, and also UX and usability, which are UCD's supportive comrades, the concept of automotive design, even down to the basic distinction of what constitutes a commercial vehicle, does not have sufficient and qualified sources in the existing literature (Gladkiy, 2018). One of the complementary purposes of this study is being a source to the researchers who want to find comprehensive information about automotive history that is focused on commercial vehicles and the user-centered development of it. The initial stage of the study started with questioning the differences between conventional and modern commercial trucks. The specifications of conventional trucks and their missing or open to improvement points were the crucial enlightening indicators while comparing them with today's new technological autonomous trucks with the focus on UCD. A user-centered approach was the main parser for these examinations, to reach the clean inferences of the study, which is focused on presenting what are the design essentials for conventional and autonomous trucks and also their development process (IDEO, 2015). Existing literature and applications are a significant starting point and guide for this research together with analyzing and interpreting the processes of these sources thanks to professional knowledge and field research according to the user-centered design approach. The main structure will be explained in the following chapters.

1.1. Research Background

The automotive sector of today world's existing circumstances is one of the most demonstrable examples of how technology plays an important role in our lives. Moreover, it also shows us that we are not only dependent on it, but also accept it as part of our daily lives (Jaafarnia, and Bass, 2011).

When it is taken into account, the speed of improvement of automotive technology, which started with the discovery of the wheel and has continued to today's autonomous vehicles in terms of user-centered design, it is not ignorable that the close and far future are going to experience this improvement acceleration more than the standard expectation of the whole world.

The definition of transportation style and solutions has changed from demand-driven to necessity, also product based to user based in the light of user-centered design throughout the previous centuries (Pillkahn, 2011).

This study aims to put forth how this historical evolution and human centered process has taken place, where the commercial vehicles stand in this process, and how this technological development process affects positively or negatively on the design, creation, and production periods. The final aim is to reveal how the truck design changing period and UX adaptation to this process is applied to new products systematically, thanks to every discovery from the past to today (Quesenbery, and Brooks) 2010. In addition, how will this transformation process develop in the future, and what are the expectations would be the supplementary questions that will ensure the integrity of this process.

1.2. Research Objectives

Firstly, it is aimed to make clear existing conventional truck design essentials for this study, after giving the necessary and detailed information about automotive history and its developmental progress from the past until today. UCD, user experience design and usability are the crucial investigative tools for this process. Then, giving reliable data about existing commercial truck brands' autonomously designed vehicles and their concept vehicles in the light of user-centered design becomes another focused subject for this study. Revealing a design proposal for the transformation from the past to today of truck interior design, based on user-centered design, is the last and major aim of this research. There are important questions to be answers or subjects to investigate for finding the best results for this study:

- To show the differences between existing conventional and autonomous truck design history and development process in the light of user centered design.
- Finding out the design essentials of existing autonomous truck interiors in the context of user-centered design.
- To collect user feedback from direct users of trucks for a more user-focused design.
- Creating a design proposal for transformation of a conventional truck to autonomous truck in regards to the vehicle interior in the light of user-centered design.

1.3. Research Question

Main research question:

What can be learned from a user-centered design assessment of autonomous truck interior design with reference to conventional truck design?

Sub-research questions 1:

What are the main differences and similarities between conventional and autonomous truck design in terms of user-centered design?

Sub-research questions 2:

What are the role and effects of design for the transformation of conventional trucks to autonomous structures in the context of user-centered design?

Sub-research question 3:

What is the feasibility of a relationship between existing sectoral factors and planned truck transportation development in the future?

1.4. Research Strategy

In order to clarify and manage to reveal the true creation and development path of the automotive industry and commercial vehicles' division, the study starts with a summary of the main developments in automotive history. The subject's details are researched specifically for commercial vehicle and truck design requirements.

To provide an effective study, truck design is examined with its structural details such as exterior and interior design features, with the focus on user experience design. Moreover, the homologation criterion, which is decisive for the vehicle's main design volume to driver's use area's ratio, is examined.

To better understand the effect of the contributions made by User-Centered Design, User Experience and Usability to the whole development process of transportation and as the main subject of the study, they are explained in separate parts (Novoseltseva, 2011).

Design of autonomous vehicles and questioning its contribution to transportation systems in general as well as to truck specific examination is detailed in the ongoing process of the study.

Market research of existing companies is analyzed in the light of UCD and UX, to discover the main strategies and criteria for transformation of a conventional truck structure to an autonomous one. While creating this deduction the first users of trucks are get involved in the subject.

Finally, user-centered design recommendations for both conventional and autonomous trucks are provided, and further implications regarding how the study can be advanced for researchers as well as designers are offered.

CHAPTER 2: AUTOMOTIVE DESIGN HISTORY

The requirement of humankind to constantly develop themselves mediated it to being creative and analytical to think about any deficiencies then after that designing and creating the solution and developing it day by day and year on year, acting upon the existing term's necessities.

The primal requirement of needing to transport passengers from point A to point B, inspired the invention and continual improvement of passenger cars. Then the secondary aim of finding a solution to carrying a load from point A to point B was considered a problem and was solved. That brought along the development of light and heavy commercial vehicles throughout the years. All this research and production started with the invention of the engine and improved day by day.

2.1. Automotive Design History

Gasoline engines, invented in the 1860s and 70s, are accepted as the major innovation within the automotive industry; although steam engines were the predecessors of them (Encyclopedia Britannica, 2018). Before World War 1, nearly all the automotive manufacturers had low production capacities, which were based on manual labor. The categories of the producers could be classified as bicycle producers, horse-drawn vehicle producers and machinery producers (See Figure 1).

Figure 1. The first vehicle built by Carl Benz in 1886 (Source: Knoll, 2014)

The desire for innovative progress even with the world's harsh conditions at that time saw Gottlieb Daimler and Carl Benz put a signature to the automobile invention with their uniquely designed engines, even though they were not clearly influenced by each other's (Pillkahn, 2011).

Each category was based in various countries but mostly Britain, Germany and United States were leading this enterprise. The decision about the choice of energy used by producers was a critical milestone at that time. The success of electric and steam powered automobiles was compared with gasoline ones throughout the improvement of these discoveries. The different power types have advantages and disadvantages against each other; for example, while controlling and designing electric automobiles, the technical hardware was easier to implement than the others but its energy storage and efficiency became an insoluble problem (Clark, and Whitall, 1989). On the other hand, while steam powered engines were easy to control, it tolerated less load on the total body. Therefore, gasoline powered automobiles took a lead over the others during the 1920s (Encyclopedia Britannica, 2018).

The automotive industry has become one of the most innovative sectors from the past to today. As a production discipline, it requires fundamental and solidly founded development and application methods. The United States was the major player for creating this standardization and applicability. The "Mass Production" roots were taken by Americans in the early 1900s which resulted in the ability to use different vehicles parts on different vehicles, a system that is known as "the American System" (Rychtyckyj, 2007). Over the course of this period, European manufacturers improved their skills and tried to invent various technical capabilities.

While the Ford Company under Henry Ford was known as the master and creator of 'Mass Production', Ransom E. Olds was actually the first applicator of mass production principles in automotive production with his "Curved Dash Automobile" in 1901. However, the required specifications of the automobile lent itself more to "the American System" that allows interchangeability of product parts. In the ongoing process, Ford invented the most famous car, "the Model T", in 1908 (See Figure 2).

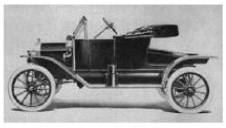
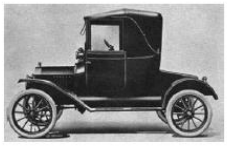
Model T – Type	Picture	Year of Production	Model T – Type	Picture	Year of Production
Touring		1909–1927	Sedan		1915–1923
Touring Fore-door		1912–1916	Sedan Fordor		1924–1927
Coupé		1909–1911, 1914, 1919–1927	Tudor		1925–1927
Runabout		1909–1927	Torpedo		1910–1912
Town		1909–1917	Coupélet		1915–1918
Tourster	–	1909			

Figure 2. Types of Model Ts in Ford's catalogue built and produced from 1908 to 1927 (Source: Alizon, F., Shooter, S. B. and Simpson, T. W., 2009)

The main aim of the car was to meet the primary needs of its users while having a solid body, quality technical parts and also be easy to repair in the case of any breakdown circumstances. The car proved itself over the years, and throughout this period Ford developed the production line and eliminated any deficient open-ended steps of more successful manufacturing methods. Work distribution between employees is the one of the best methods to approach non-disruption on the production line (González-Crespo, and Vazquez, 2017). This and derivative solutions allowed Ford to offer a reduction in the price while enhancing the quality of production of the cars (Gill, 2014).

Competitor enterprises and companies started to compete against Ford, once the sector has enlarged and, as a result, he fell behind the requirements of the day.

William R. Morris and Herbert Austin became famous in Britain, while Andre-Gustave Citroen and Louis Renault were doing the same in France.

Until the end of World War 1, Ford was the master of the automotive sector together with its competitors. The leading position the company held was taken over by GM (Houghton, 2013), which was founded in 1908 by William C. Durant in Michigan (Encyclopedia Britannica, 2018). The economic crisis had a major effect on GM until the 1920s when the company took on a new lease of life. Thanks to Walter P. Chrysler, who is the third member of the automotive circle, the giants of the industry were complete (Wren, 2013).

While technical and engineering developments were continuing in the American market, European companies, which were not so big and comprehensive as their competitors in the United States, were improving their capabilities not only on the engineering side, but also in design. This versatility brought with it lots of contributions for these industries (Vosta, and Kocourek, 2017). There were various pioneers in Britain, France, Germany, and Italy. Each company had powerful strengths, but capacities were not the same as in the American market for various reasons, such as production capacities, low purchasing power, the economic crisis, and the World War. All through World War 2, between 1940-1945, both the American and European automotive industry were only focused on being loyal supporters for their countries (Smith, 2002). Even though the automobile production facilities were not directly suitable to transferring to military vehicle or aircraft production; they contributed with both their technical capacity and manpower.

After World War 2, each country started to adapt to the current conditions and increased production to meet the demands (Townsend, and Calantone, 2013). While the United States improved its production, European countries also did not fail to develop and increase their capacities and numbers. The leadership of the sector by the United States was continued until the 1980s. While European countries and the United States were developing themselves, Japan came to the front with its admirable rate of growth and took first place in leading the automotive industry. Between 1980 and 1994, the Japanese continually held the leadership in the automotive industry, until the United States again took over the title in 1994 (Toyoda, 1997).

By the end of World War 2, the United States' automotive production was remodeling from the military vehicles structure to automobile technical requirements. Lots of attempts occurred to get a share of the big cake, but the rooted companies would not allow this. The trend was for the bigger and smaller companies to work together in this period of the American sector. This bidirectional action was beneficial, not only for the small scaled companies by saving themselves from bankruptcy but also was a contribution to large-scaled companies by allowing them to enlarge their production facilities and technical capabilities. The Rambler was one of the first results of this conglomeration. It was the first compact car from the American automotive industry.

While Rambler was a bicycle producer between 1878 to 1900, thanks to its owner Thomas B. Jeffery's personal interest and curiosity, the company managed to produce a car prototype, which had important features, such as having a steering wheel and front mounted engine in its structure, unlike its competitors. This new innovation brought a new impulsion to the company but in those days it could not proceed because of family issues. Throughout the years Rambler continued with its production and improvement of the car. Until his death in 1907, Jeffery managed to build different dimensioned and styled cars. After his death, his son Charles headed the company from 1910 (Motor Trend, 1963).

While Rambler was continuing its path, The Hudson Motor Company started its work in 1909. Hudson climbed the success ladder rapidly compared to Rambler and produced near 5000 cars per year (Motor Trend, 1963).

Not only these two well-known companies but also all sized facilities served their countries during World War 2. After the reconstruction period started, each company put forth their innovations to the market.

The sector developed throughout the years in the States; during these years lots of companies had economic crises while some of them were taking governmental support like Chrysler (Curcio, 2000). It could be clearly observed that there were four essential companies AMC, Chrysler, Ford, and GM in the United States which were directing and moving the automotive sector forward.

European and Japanese companies opened different facilities in the United States but some of them closed after determined inefficient periods, (Triebel, 2017). This trend led to starting joint ventures between local and foreign companies, and again this method became a learning opportunity for both sides. Japanese Toyota was the most active company playing its cards in a daring way (Toyoda, 1997).

It could be said that after World War 2, the automotive industry tried to reshape and adapt itself to the sector's requirements. The main duty of the companies was getting back on track, rather than achieving any new and pioneering innovations in automotive design. For most regions design came into prominence through time, with technical improvements also continuing.

During the ongoing process after World War 2, the European automotive sector was reforming itself too. All sizes of companies were following the road of merger to empower not only their production capacities but also their production and technical capabilities and companies such as Leyland and British Motor Corporation were founded as a result (Encyclopedia Britannica, 2018). Furthermore, the British Government attempted to support national companies so as not to lose their value, but it did not prevent the British companies from having tempestuous ownership stories compared to the world's other automotive giants.

In addition, the German automotive industry was writing another history in its own right, and later for the whole of the world. After World War 2, nearly all the facilities of German producers were in ruins (Koshar, 2001). In a short space of time, under the leadership of Volkswagen, leading industry representatives managed to be born out of the ashes. The German government was attaching importance to being national for its industries so that against all of the challenges the required support was given to the automotive sector too (Triebel, 2017).

The Italian side of the automotive industry was based on more hand workmanship until the 1950s although they had the culture of both design and technical capabilities. In contrast, the French industry was led by four major companies which were Citroën, Peugeot, Renault, and Simca. These leading companies were trying to reshape and be productive for France after World War 2 (Casalino, 2010).

Above all other countries and their efforts, Japan wrote the success story that has stuck in people's minds since the 1950s and it has continued for nearly thirty years. The prominent companies of the country, Honda, Toyota, Nissan, and Mazda, were sources of pride for the Japanese community with their international status. Each company developed themselves and increased production capacities and exports. Over time, these companies opened various facilities around the world to avoid logistical expenditure and abide by the production plans.

An automobile has been defined by Chris Dowlen, in his research that studied the history of the automobile as;

> *"An automobile is generally taken to mean a privately owned self-propelled road vehicle, usually with four wheels and an internal-combustion engine (Dowlen, 2013)."*

Although research about the automotive industry like Dowlen's exists, it has mostly remained restricted to automobiles. Dowlen (2013) handled automobile history from the viewpoint of design milestones that were developed according to users' desires. On the other hand, what could be a reason for the categorization of the automobiles from the past to today? How much has the automobile's technical, structural, and styling features gained importance within the parameters of its historical progress? These are the questions or subjects that are waiting to be answered or researched following on from Dowlen's and similar research.

On the other hand, company-based research has been a frequently encountered subject for the existing literature on automotive history. For example, Eiji Toyoda did his research on Japanese Automotive Technology (Toyoda, 1997). Country based desires, interaction between competitor brands as well as interaction between different nations' automotive producers have been major topics for Toyoda.

As it has been shown with quantitative data, the number of motor vehicles produced in the United States increased from 8000 to 26.5 million between 1900 and 1929, and then 26.5 million to 230 million between 1929 and 2001 according to Pellerito (Pellerito, 2006).

These numbers prove to us how the automotive industry is open to development and innovation for our century as it was for past centuries.

Humankind's desires and requirements increase and diversify, and in parallel with these improvements, the pace of innovation and the efficiency in the automotive industry increase. Due to the increase in the demand, in time the vehicles' features and specifications are altered in order to meet these needs (Dowlen, 2017).

2.2. Commercial Vehicle Division and Truck History

The reasons for inventing different categorized vehicles have been varied according to not only their user profile but also their structural features, capacities, and usage purposes in the beginning of the diversification of today.

During the World Wars, military supplies as well as munitions were the basic loads for commercial vehicles. Agriculture and freight transportation was the most popular area of demand for the automotive inventors after the World Wars. Steam powered engines were the first leading mechanical vehicle developers to respond to this demand early in the nineteenth century (Smith, 2002). The new inventions were in line with the users' demands like Dowlen mentioned. These boundless expectations are the major source for the development of the automotive industry not only for commercial vehicles but also for racing cars, aircrafts, or even electronic products too (Dowlen, 2017).

> *"Any type of motor vehicle used for transporting goods or paid passengers (ISO, 2016)."*

> *"Motor vehicle, which, on account of its design and appointments, is used mainly for conveying goods and which can also tow a trailer (ISO, 2014)."*

These definitions are the basic explanations for the commercial vehicle as a noun. As it is mentioned above, the technical features and capacities are the important determinants for classifying the vehicles. This basic classification is shown clearly in Figure 3 below (See Figure 3).

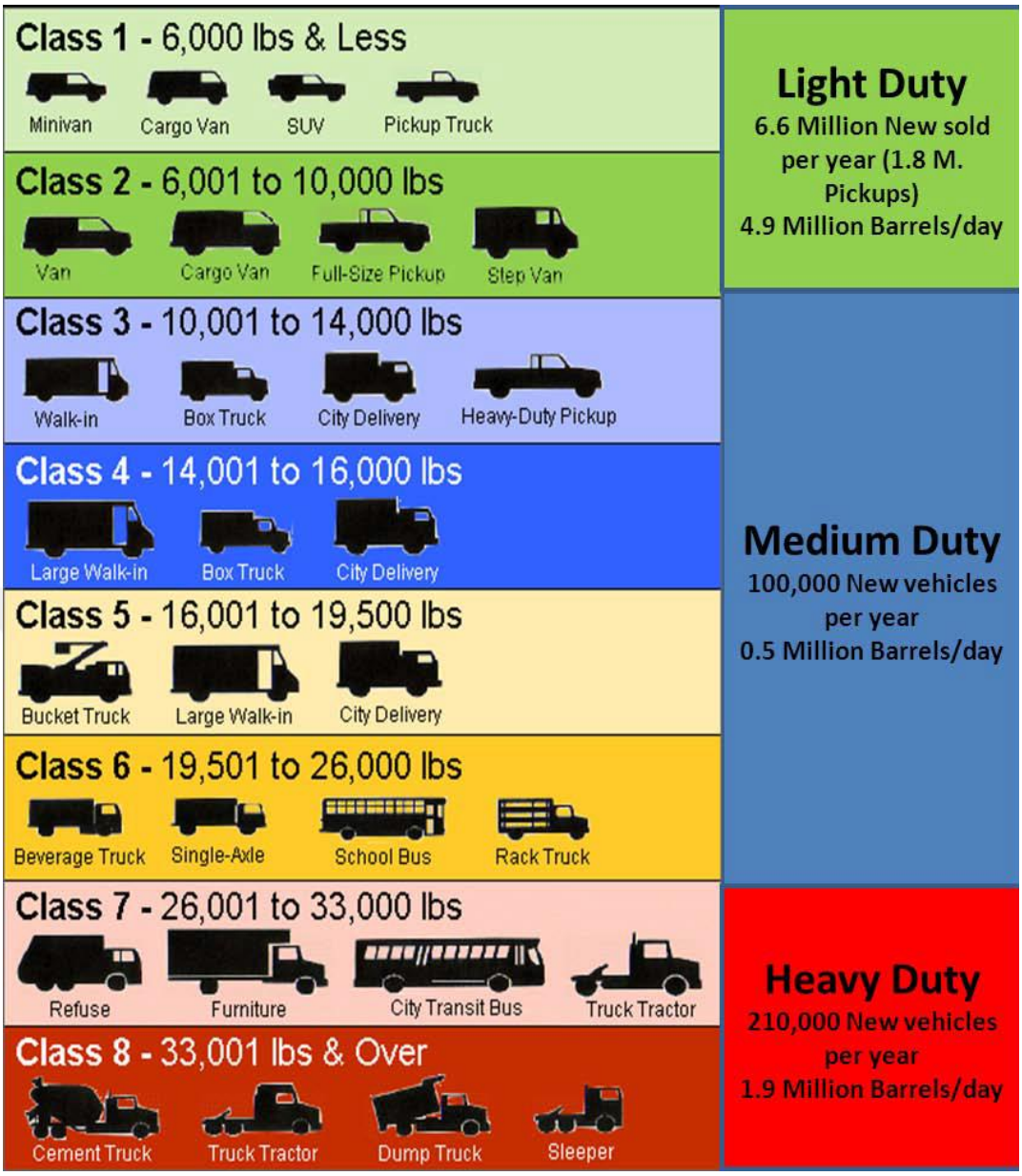


Figure 3. Truck Classification by the U.S. Department of Transportation's GVWR and Vehicle Inventory Use Service (VIUS) Categories (Source: U.S. Department of Energy, 2013)

The U.S. Department of Energy's illustration shows the main differences between vehicles classes and their capacities. Moreover, it can be observed that the variation of the vehicle types is also according to its usage area.

Usage area, vehicle structural specifications, vehicle dimensions and freightage limit are the crucial topics for the commercial vehicles as Lumsden (Lumsden, 2004) showed us with the vehicle length below (See Table 1).

Table 1. EU Directive 96/53/EC (2019) Information About Commercial Vehicles

12 m	Motor vehicle
12 m	Trailer
16, 5 m	Articulated vehicle (semitrailer combination)
18, 75 m	Road train (rigid truck with trailer) combined with a regulated

These dimensions show variations from country to country, due to national limitations and road structures which are effective for this issue. Mass capacity is the second major criteria for commercial vehicle after length specialties (See Table 2).

Table 2. EU Standards 96/53/EC (2019) About Gross Vehicle Weight and Gross Combination for Commercial Vehicles

3,5 tons	General definition "heavy vehicle"
7.5 tons	Limit for some driver's license
12 tons	Limit for Euro vignette and upcoming German road fees
16 tons	Limit for heavy trucks in some official statistics
18/19 tons	Limit for single two-axle trucks (depending on national regulations)
26 tons	Limit for single three-axle trucks
40 tons	Limit for trucks generally in Europe
44 tons	Limit for vehicles carrying a 40 ft ISO container as a combined transport operation.

When this information is researched in detail, it can easily be interpreted that the main aim of the creation and production of commercial vehicle product families is to support and provide all nations in the world with an opportunity to improve their societies.

As mentioned in Lumsden's report:

> *"Transport is a prerequisite for economic growth in society. Historically, there has been a correlation between transport growth and GDP growth" (Lumsden, 2004).*

According to the given information about the classification requirements of commercial vehicles, it is easy to see that defining the usage purpose of the vehicle and specifying carrying capacity or weight of tow are the crucial key subjects for true and safe transport. Trucks are going to be the subject of this study, which will be explained in detail in the following chapters.

CHAPTER 3: TRUCK DESIGN

The requirement for transportation started and increased depending upon the needs of mankind. The transformations of society's demands have been shaped in direct proportion to social change and development since the early ages to today (Nedham, 2013).

Companies, entrepreneurs, and inventors focused their studies on answering this necessity. As is should be remembered, special circumstances always force human beings and encourage them to be creative and analytical during harsh condition, such as during the World Wars.(Jaafarnia, and Bass, 2011). During this time, the definition and assignment of alterations to the transportation vehicles and their capabilities were gaining importance for mankind in order to meet each situation's requirements.

The Commercial Vehicle segmentation and product tree has gone through changes according to the market and users' demands throughout the course of time. Trucks are one of the members of this extensive product family (Khan, and Machemehl, 2016).

The types of commercial vehicles show differences according to their dimensions and load capacity. There are several explanations and classifying definitions for this automotive discipline. According to The European Categorization System, which is seen as being reliable throughout the global environment, trucks are defined as;

> *"..motor vehicles with at least four wheels, used for the carriage of goods. They have a mass of more than 3.5 tons*"

> *"Under this system, trucks are either classified in the N2 category (weighing more than 3.5 tons) or N3 (weighing more than 16 tons). N3 vehicles are also referred to as 'heavy trucks' or 'heavy commercial vehicles'* (ACEA, 2017)."

Truck structures have changeable features according to the vehicle's usage and also the weight of the freight that it is going to be transported.

The term "body on frame structure" is used to describe this mechanical specialty. Thanks to the vehicle's mechanical form, the structure of trucks is sufficient for different transport or hauls.

As it mentioned by the U.S. Department of Energy Vehicle Technology Office:

> *"Unlike passenger cars, which are categorized by the size and weight of the vehicle, trucks are grouped according to their carrying capacity or Gross Vehicle Weight Rating (GVWR), which includes the combined weight of the vehicle and cargo (US Vehicle Technology Office, 2013)."*

According to this essential and important information, when the subject becomes the 'design' of a truck, not only aesthetical notions come into prominence but also, function, safety, aim of usage, social benefit and global climate responsibility are all main subtopics which should be taken into consideration, for a sustainable and user-centered design; a design that is contemplated for everyone (Schaller, 2010).

3.1. Truck Design Essentials

When a truck design is considered as a creative project, whose progress is going to be followed from starting point to final product, it should be remembered that the vehicle's design philosophy should not be constituted from a minority group; it should be designed for everyone (The International Transport Forum, 2019).

As a transportation vehicle, a truck that is a member of a commercial vehicle family differs from passenger cars in various ways. Even with the differentiations about the classes, features and sales potentials, as well as changing regulations from country to country, the demand for trucks increases in general depending on the societies' augmenting consumptions. The rate of this acceleration is changing direction according to the requirements of the markets, which is reflected in the design and features of the trucks too.

The design criteria are derived according to not only the market requirements but also users' needs, demands and developing technological innovations. The most effective approach for designing a new truck should be based upon the direct users. The design community has researched various style approaches and methods for addressing this issue productively that will be explained in detail in the following chapters of the study. However, consequently it should be appreciated that being user focused is the most important key factor for designing an effective truck, which is continuously interacting with its users. Environmental factors, market and business requirements, technological improvements adaptation and expectations about this

topic are also further effective contributory factors for this issue. There are some determined and clear criteria about the legal requirements about a vehicle, which are controlled by international regulations and homologated standards. The relationship between trucks as a transportation vehicle and regulative requirements will be examined in next part of the study.

3.2. Homologation and Truck Design

Homologation consists of an extensive range of approval tests and any other confirmation documentation that allows a vehicle to freely circulate from country to country and enter the different markets. When Original Equipment Manufacturers (OEMs) and Tier 1 companies partake in international business, not only for exporting but also importing, they should have homologation approval and the required reports too (Martins, 2010). There are several beneficial factors for having required homologation certification. While various countries' regulations show differences from country to country, the importance of international standardization to this situation cannot be understated for the following reasons (UL, 2020). According to TÜV SÜD:

"*- Gain legal access to target markets to generate higher revenues,*

- Ensure rapid delivery of your product to consumers,

- Avoid costly penalties and fines for non-compliance or costly recalls,

- Boost brand reputation among consumers and regulators by ensuring vehicle safety (TÜV SÜD, 2014)."

These significant features are guaranteed thanks to the valid regulations.

The standards serve as approval evidence for a vehicle or a sub-component which is planned to enter a new country or a market. This main focus of these standards is to advance the "active and passive vehicle safety" also "environmental protection" while providing and controlling "product and production quality" (Luxcontrol, 2020). The product and production quality can be called "components" and "systems" according to another source (Bank Bazaar, 2021).

The segmentation of essential Homologated items would be clearly classified like this:

*"**Passive safety***

- *Passenger protection. It is verified by a crash test,*
- *Child restraints,*
- *Working on seat belts.*

Active safety:

- *Steering system,*
- *Brake system.*

Components and systems:

- *Field of vision of the driver and screens and wipers,*
- *General lighting in the vehicle,*
- *The horn of the vehicle,*
- *The mirrors in the vehicle,*
- *The warning triangle,*
- *The tires of the vehicle,*
- *The tank of the vehicle,*
- *The rear-view system.*

Environment:

- *Amount of fuel consumed by the vehicle,*
- *The amount of pollution emitted by the vehicle,*
- *Noise emission,*
- *EMC (Bank Bazaar, 2021)."*

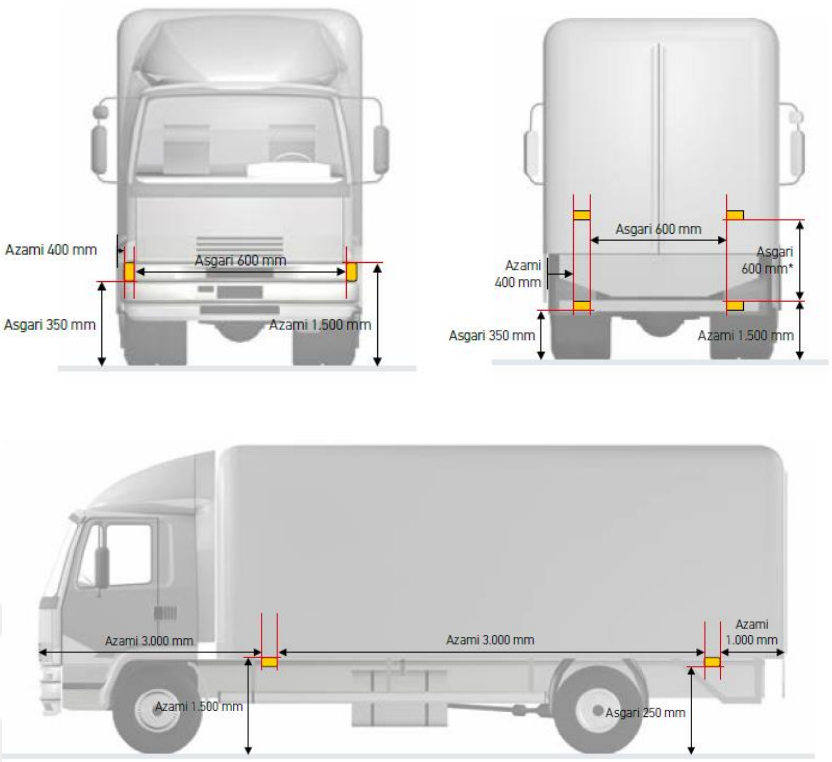


Figure 4. Exterior Signal Lamps Homologation Criteria (Source: Hella-ECE 48, 2020)

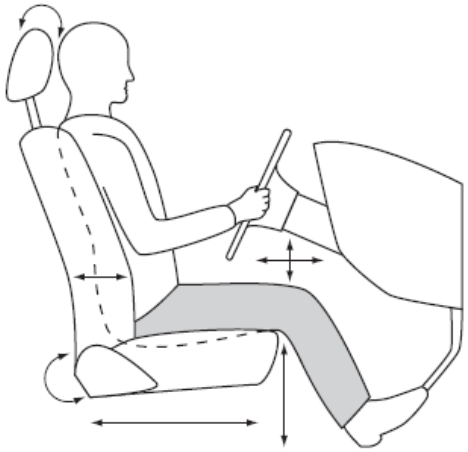


Figure 5. Diagram to Show Interior Optimum Seated Posture and Adjustments (Source: Gkikas, 2013)

As is mentioned above, the regulations show differences according to the country and also the type of vehicle (See Figure 4 and Figure 5). While the layout of a truck trailer's dimension limits is mentioned in Figure 4, Figure 5 shows the critical

measurements of a driver seat and its position between the wheels. The European vehicles endorsements directly follow the explanations from the Directive of the European Parliament 2007/46/EC from September 5th, 2007 (CEW, 2020).

3.3. Truck Accidents

There are several contributory factors for designing action to produce more reliable, safer, and current products. When the product is specified as a transportation vehicle such a truck, "accidents" would be an unavoidable topic to investigate.

A truck has not only an interaction with its' driver when it is used, it also has a relationship and interaction with its environment as well as other external factors, such as pedestrians, other vehicles, and their users', and motorcycles or bicycles.

According to the Volvo Trucks Accident Investigation Team (2007) figures, is can be clearly shown how the damage can be harmful for innocent people (See Figure 6).

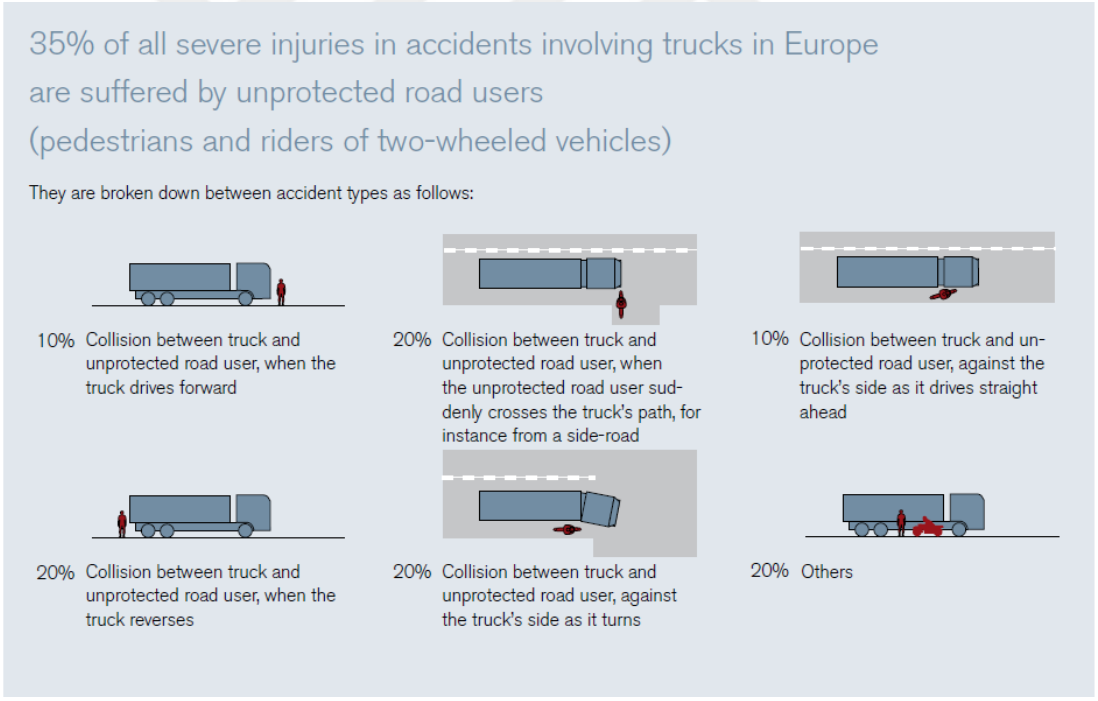


Figure 6. Volvo's Database of Parameters Such as Accident Types and The Kinds of Injuries Suffered in Accidents (Source: Volvo, 2007)

The improvement studies for trucks provide design inputs as creative items of the briefs. While pedestrians or other vehicles included accidents provide these

contributions, also the driver or vehicle sourced crashes give data to the designers or engineers (Woodrooffe, and Blower, 2015).

The regulative and homologation required tests also provide different perspectives to the innovators. Examination of what should be done to prevent these crashes' effects brings about new, fresh ideas that should be tried as design and engineering inputs (Woodrooffe, and Blower, 2015). As Küçükerman mentioned these kinds of findings would be useful as an activator for an iterative design research period (Küçükerman, 2014).

The active and passive safety system which are going to be explained in the further chapters have become the most solution-based suggestions, while other innovative solutions are also being studied (Wismans, 2016).

CHAPTER 4: USER-CENTERED DESIGN, USER EXPERIENCE DESIGN and USABILITY IN RELATION TO TRUCKS

Designers use several investigation tools to collect and contribute to their research, products, and services. This process remains similar, even if the final outcomes are different from each other.

When a truck is considered as a vehicle which is going to be improved and designed by its creators, it would be beneficial to search contributory tools, to reveal better products.

It is aimed to transfer how design research and its variations are effective factors for product development and discovery progress. While the trucks are considered as this study's main theme, the interactions between the drivers and the drivers' requirements are also demands which have become actual outcomes for the designer's research topics.

UCD was selected as the main approach for researching into truck design and its progress; not only for discussing design recoveries between past and current models of vehicles, but also the irrepressible development between conventional and autonomous trucks with the guidance of today's and future technology (Teisman, 2019).

The design approaches or methodologies vary according to the designers' main purpose of a product, service, or a system. UCD, as a design approach, is selected for this study to explain conventional and autonomous trucks design essentials. While UCD differs from other topics, thanks to its inclusive treatment of a subject, it would not be logical to not take into consideration UX design and Usability when investigating the subjects in greater detail. As will be explained in detailed in this chapter, each approach or notion has a very similar aim for a product (Buurman, 1997). It is acceptable to think that UCD and other notions can be viewed under the same approach's umbrella; they are all aimed at researching the users' actual needs and demands. While UCD is defined as the leading approach for this study; UX, Usability and also HCD have a supportive role in providing a valuable contribution.

4.1. User-Centered Design

The term "User-Centered Design" was first used by Norman and Drapper in two scientific research laboratories in 1986 at the University of California San Diego and after the publication of "*User-Centered System Design: New Perspectives on Human-Computer Interaction (Norman & Draper, 1986*)", the book written by the duo, the term UCD consolidated its authority in the design community (Teisman, 2019).

When a designing process is accepted as an analytical action and period, "User-Centered Design" becomes leading edge,

> *"...philosophy that puts the user in the center of the design and development process (Kirstin, 2013)."*

There are many ways, methods, and research approaches derived throughout the designing processes. The reason of this creation is influenced by the need to collect different resources for user-product interaction. Furthermore, finding and observing obvious reasons for why an innovation or a reformation is required for the product or the service is vital. Efficiency, which is obtained by an interdisciplinary working style, provides more contributions than expected to design disciples. UCD is the final achievement of the co-operation between designers and computer specialist's that was started in the 1980's (Gladkiy, 2018).

The essential aim of UCD is to research for better design, not only for a few people but also for the extensive determined community (Gasson, 2003). This way of finding design solutions to a problems, comes from the UCD's approach, which will be explained in the next part of the research.

4.1.1. Introduction to User-Centered Design

The whole aim of design philosophies is to add value through various research and approach capabilities which bring about creative and benefit focused solutions to the whole of the discipline (Abras, Maloney-Krichmar, and Preece, 2004).

> "*User-centered design (UCD) is an iterative design process in which designers focus on the users and their needs in each phase of the design process. In UCD, design teams involve users throughout the design process via a variety of research*

and design techniques, to create highly usable and accessible products for them (IDF, 2020).”

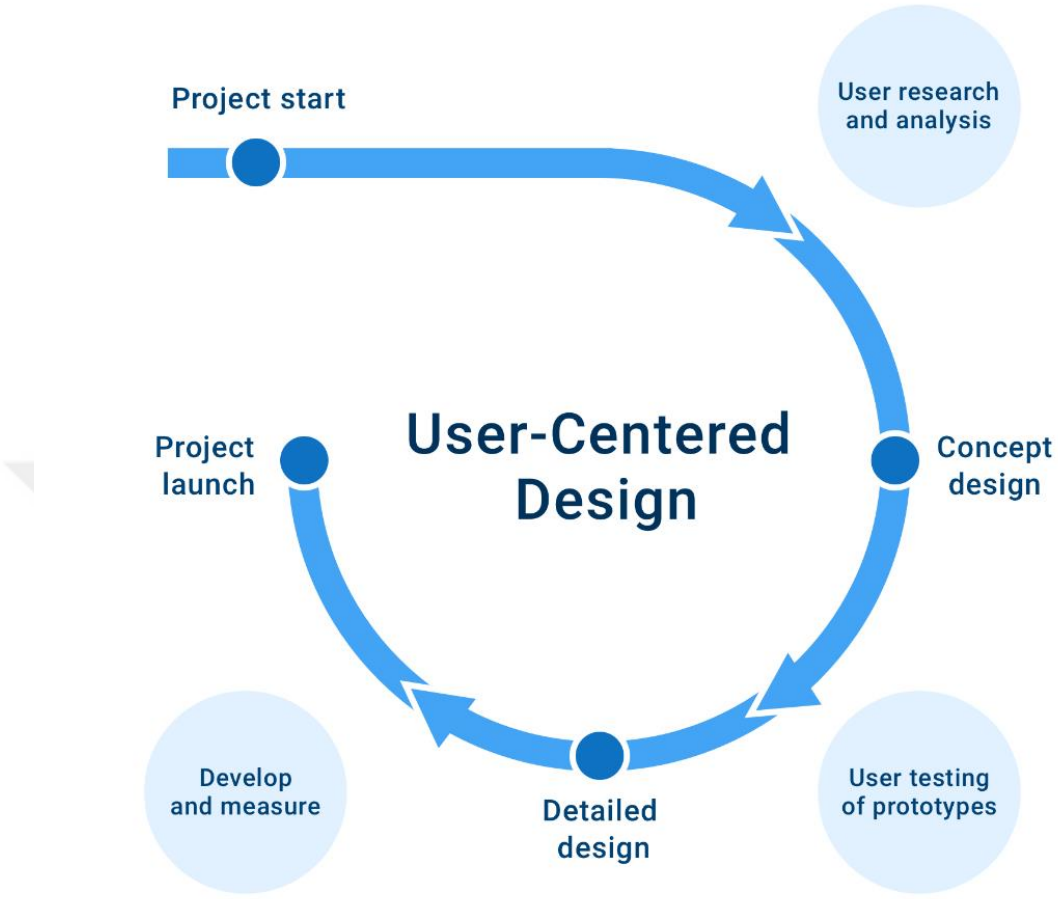


Figure 7. UCD Development Structure (Source: Gladkiy, 2018)

UCD aims to design what is focused on users’ needs and wants (See Figure 7). The title is adapted to several design area such as software design, graphical design, medical design, transportation design and construction environment etc. (Ågerfalk, 2001), and producing optimal solutions for each different area is the most important duty for UCD according to its’ philosophical approach.

Designers generally apply several research methods in UCD. These methods allow the researcher to investigate the users’ demands from the most common ones to the most detailed ones.

According to Norman, who is known as the father of UX design, UCD provides opportunities for designers to work directly with users to produce innovative, desire-focused products according to its serving area and usage conditions (Gladkiy, 2018).

To create more beneficial products or services, research method cooperation would be understandable for each design approach (Buurman, 1997). To serve this aim UCD, mostly takes support from “UX” and “Usability”, which is going to be explained in the next part of this study (Bordac, and Rainwater, 2008).

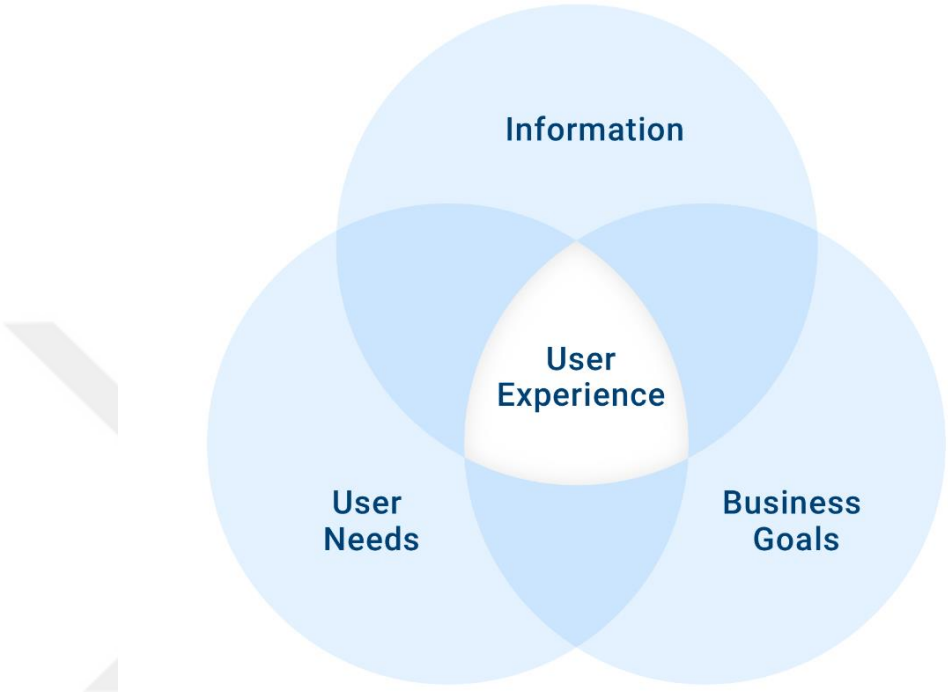


Figure 8. UCD Information Structure (Source: Gladkiy, 2018)

UCD uses the above structure as a main design process resource (See Figure 8). All individual sets and their intersection sets present several goals for the designers to achieve the desirable products for their defined users.

Designers should apply several methods and questioning styles to the specific problem that has been perceived as a user problem and work towards finding a solution to it (Deane, Langdon, and Clarkson, 2010). To manage this primal step, there are different methods to support their research (See Figure 9).

Method	Cost	Output	Sample size	When to use
Focus groups	Low	Non-statistical	Low	Requirements gathering
Usability testing	High	Statistical and non-statistical	Low	Design and evaluation
Card sorting	High	Statistical	High	Design
Participatory design	Low	Non-statistical	Low	Design
Questionnaires	Low	Statistical	High	Requirements gathering and evaluation
Interviews	High	Non-statistical	Low	Requirements gathering and evaluation

Figure 9. Popular user-centered design methods (Source: Inviqua, 2006)

Thanks to the different outputs of these investigative methods, designers receive various sources, which have specialties different from each other, for their design subjects. UCD and its comprehensive approach to the design problem would be identified as "a new example of a problem-solving method" (Gladkiy, 2018).

As a contribution to these circumstances, according to Eason, user-centeredness has two conceivable implications which are being 'Designed for users' and 'Designed by users' (Eason, 1995). As a supporter of Eason's approach, it would be accepted that;

> *"Participatory Design: is characterized by its emphasis on cooperation between the researcher and users.*
>
> *Co-Design: a more recent version of UCD goes even further by engaging users more actively in all stages of the design process as co-designers (Eason, 1995)."*

Today's fast changing consumption society needs more and uses up resources faster than ever before. The interaction with a product, a service or a digital experience has more specific, personal and users focused expectations compared to before. According to this approach;

"User-centered design requires deeper analysis of users – your target audience. It is not only about general characteristics of a person; it is about particular habits and preferences of target users to come up with right solutions for specific problems (Novoseltseva, 2011)."

Thanks to this division UCD is differentiated from Human Centered Design.

At this stage of this study, it would be beneficial to mention about the Human Centered Design, which is commonly confused with UCD.

According to ISO Standardization HCD is;

"Human-centered design is an approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, and usability knowledge and techniques. This approach enhances effectiveness and efficiency improves human well-being, user satisfaction, accessibility and sustainability; and counteracts possible adverse effects of use on human health, safety and performance (ISO 9241-210, 2019)."

UCD and HCD design approaches or "philosophies", another commonly used terminology, have almost the same definition when they are researched in their basic forms. The difference between these two approaches is elusive but can be construed after focusing on the meanings and researching case studies in detail.

There are some valuable and experienced design communities around the world, which are aimed at not only designing products or services as a money-making enterprise, but are providing contributions to societies thanks to their undiscovered potential. IDEO is one multicultural design team which is known as a master of the HCD approach. IDEO describes HCD as,

"...a creative approach to problem-solving that starts with people and ends with innovative solutions that are tailor-made to suit their needs (Usertesting, 2018)."

The company publishes informative books and sources on digital platforms that provide a means to reach accurate and experienced-based information easily. According to the *"Field Guide to Human Centered Design"* book that IDEO published in 2015,

"When you understand the people you're trying to reach and then design from their perspective, not only will you arrive at unexpected answers, but you'll come up with ideas that they'll embrace (Usertesting, 2018)."

As experienced HCD experts, the company shares seven adopted mind-sets as a guide to other designers or any researchers who are seeking to discover the communities' common design-based problems.

These seven HCD mind-sets are:

"- Empathy,

- Optimism,

- Iteration,

- Creative Confidence,

- Making,

- Embracing Ambiguity,

- Learning from Failure (IDEO, 2015)."

Each topic of the HCD approach that has been recognized by IDEO and has been developed by lots of other designers, is supposed to increase the users inclusion in each phase of the designing, evaluating and improvement process of products or services.

Similar to the contribution made to these factors by IDEO, Norman (2019) has explained *"The Four Principles of Human-Centered Design"* according to his valuable experiences:

"1. Understand and Address the Core Problems.

2. Be People-Centered.

3. Use an Activity-Centered Systems Approach.

4. Use Rapid Iterations of Prototyping and Testing (Norman, 2013), (Norman & Spencer, 2019)."

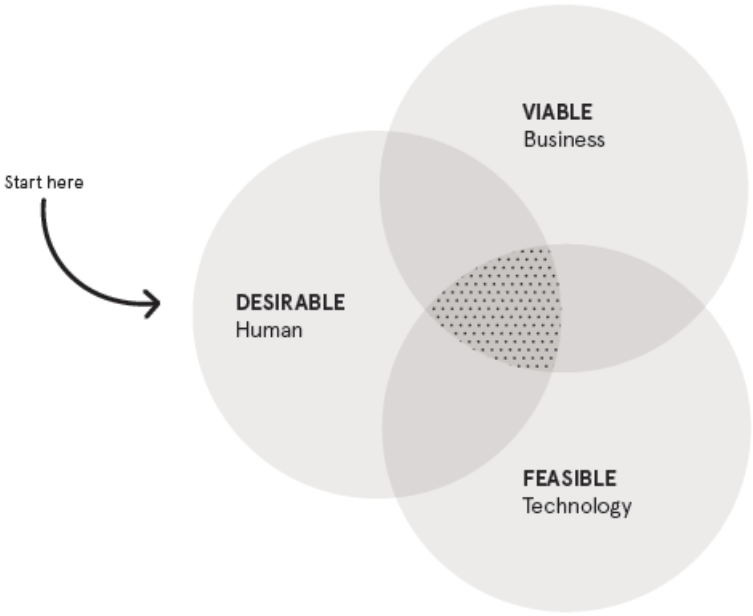


Figure 10. Human Centered Design Problem Context (Source: IDEO, 2015)

According to several experts of HCD, it can be clearly seen that observing humans, defining the core problem, researching, and designing according to their expectations, desires and needs, trying it and getting feedback and trying again and again meets the requirements of the iteration action (See Figure 10).

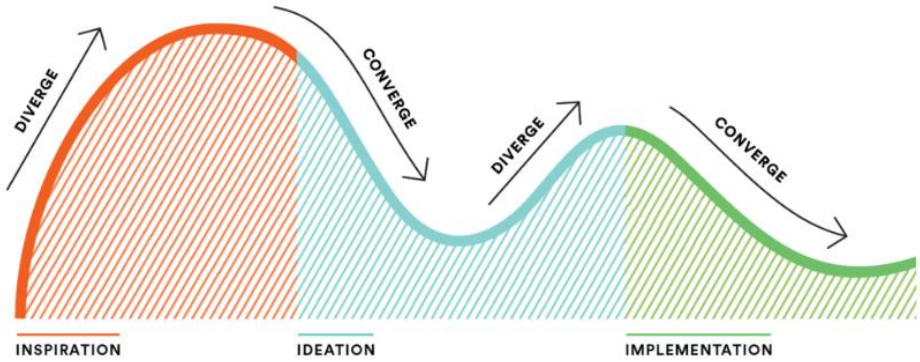


Figure 11. Human Centered Design Process (Source: IDEO, 2015)

Experimenting lots of times and producing more innovative products or services keeps alive the HCD and provides an opportunity to keep it as a dynamic approach (See Figure 11). The temperature and density of the HCD process could show

differentiations against the acquired data throughout the progress. It would be a representation of interactive evolution of a design problem and its solution finding duration.

Finally, the “chair case” would be an informative example to present the difference between HCD and UCD. When a designer come across the need to design a chair, researching a chair, its basic and final expected function, market analysis, comparing products, creating personas, and trying to design it so humans can use it in an ergonomically suitable and comfortable way meets the HCD requirements. While the expectations are defined more specifically in the UCD method; for example, the designer will know who is going to use this chair, is there any unique position which is required for this chair user, the usage duration information for the product, is there any special material selection etc. All of these direct designers to make their design research in more detail. This approach would find answers via UCD (Doran, 2020).

As shown by this basic example and explanations of differences in design approaches, it should be mentioned that defining the best suitable path would be beneficial to improve both user and market satisfaction from the product or service (Digital Adoption Team, 2020).

UCD is like a harmonic finalization of the designer’s investigations, market realities, design iterations and is the final solution to what a user wants or requires to use the product or service more effectively.

When it is considered from the market side, after the application of UCD to any design, expectations of product fulfillment, competence, user interactions and user-friendly experience are expected to be increased (Novoseltseva, 2011).

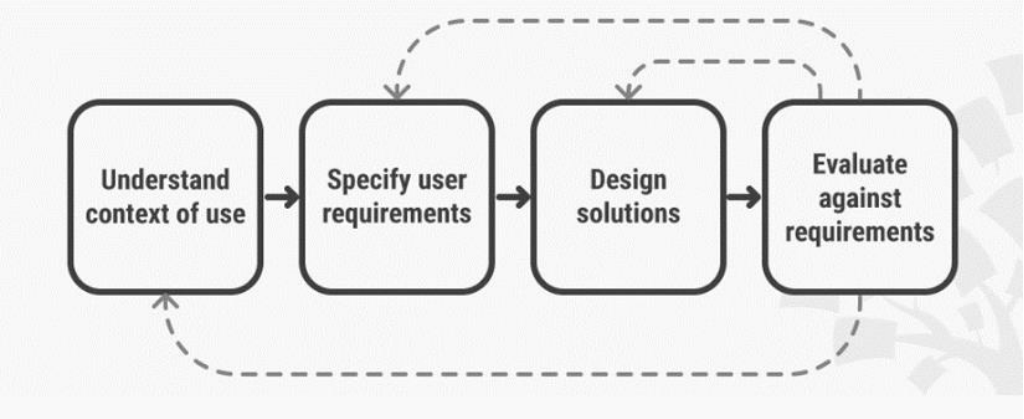


Figure 12. UCD Iterative Process (Source: IDF, 2020)

Searching for fresh vison and trying to find different experiences from the product are supposed to be reached thanks to this iteration way of UCD (See Figure 12). However, the only goal for this philosophy is not only to present the most effective, desired, useful, or aesthetical final product or service, but also to meet the business requirements and aims too (Kirstin, 2013). Bringing a balance between users' desires and market's expectations would be a successful application of UCD to the product design process.

Not only are designers applying UCD to their designs, but also the world's biggest companies have realized the contribution that the UCD's design philosophy can have on their long term profit (Silva, and Marques, 2020). Earning increased profits has not become the only objective for these huge companies; they also want to be remembered as pioneers of different innovations, which will provide them with a priceless corporate advertisement (Lundberg, 2016).

4.1.2. Principles of User-Centered Design

To obtain consistent sources, progress and output as a designed product either physical or digital, UCD should be applied by the book. There are several research projects about UCD and design experts who have used UCD in their projects. According to the generally accepted evidence, UCD has six essential principles.

"*Specify the use context and users' needs;*

Specify business requirements;

Build design solutions from rough concept to finished design;

Evaluate designs with usability testing;

Implementation - develops and delivers the product;

Deployment - the final product is evaluated, as consumer needs change (Gladkiy, 2018)".

Each of these principles has their specific requirements for the expected creation. The mutual aim of these six steps starts with composing equipped, convenient, and improvable solutions to the problem. After this step comes the clarification period, which is focused on users' wants and desires, market requirements, the project's expected gains and provides a lot of advantages to both the designers and market (Barnum, 2011).

While the essential principles of UCD are focused on how to improve product or service value, Küçükerman's (2014) approach and statements in 'Designing Industrial Products in 100 Steps' differs in that he is considered as a supporter of proving the interaction between different disciplines' common aims of how to reach better product or services (Küçükerman, 2014).

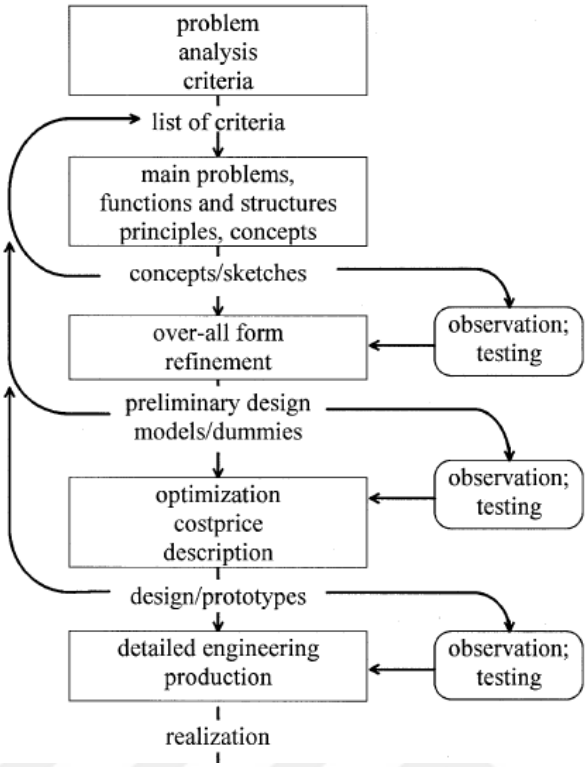


Figure 13. The process of user-centered design (Source: Marinissen, 1993)

Figure 13 visualizes Masinissen (1993) approach to the UCD principles. Thinking from the starting point to the final product and mapping out a progression path provides a secure zone for the designer. Testing the existing product and collecting different feedback becomes like fresh blood for the designer to develop his or her project at this stage. Contribution becomes a key element at this stage, which is continued to the finalization of the project. After the refinement process, the final product is ready for user and market.

Similarly, Ågerfalkuse used UCD as the basis of his research in 2001; his terms cover various paths such as: participatory design, co-design, space syntax and usability of buildings (Ågerfalk, 2001).

It would be acceptable as proof of UCD's rallying and interrogatory approach to building design to quote his two questions:

"1. How users are incorporated into processes of designing and redesigning space,

2. How users' experiences and existing practices can be used to inform design activity (Ågerfalk, 2001)?"

4.2. User Experience Design

Various disciplines, methods or intermediaries have come into existence together with the era of developing production and consumption (Vermeeren, Roto, and Väänänen, 2015). This improvement process has searched and derived these tools to create and obtain more effective and solution-based products and services (Knight, 2019). User Experience (UX) is one of these valuable design disciplines that is not only focused on the users' benefits but also on the market and the business too. Interdisciplinarity became one of the most influential specialties for the 'design' term. The discipline, which is aimed at presenting more user friendly, useable, and efficient products, is adaptable for each design area, not for only interface design as opposed to popular belief but also any scenario that is open to meaning with having a contribution to design (Quesenbery, and Szuc, 2012). According to the Interaction Design Foundation, where lots of precious academicians and professionals share their journals and research, UX design is:

"User experience (UX) design is the process design teams use to create products that provide meaningful and relevant experiences to users. This involves the design of the entire process of acquiring and integrating the product, including aspects of branding, design, usability and function (Interaction Design Foundation, 2020)."

UX Design is a comprehensive discipline that aims to create more beneficial and value-added products. It is also aims to contribute not only to the final products or services but also the creation and improvement process too. Having an interdisciplinary method in addition to a multicultural point of view would be supportive of a developmentally oriented UX Design while it would not cause focus diffraction (Ferreira, 2017).

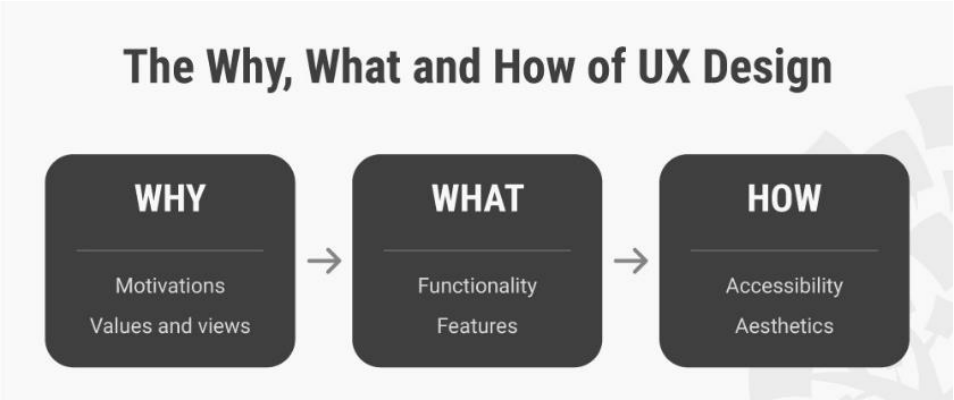


Figure 14. The Why, What and How of UX Design (Source: IDF, 2019)

The three essential factors for UX Design are shown in Figure 14 (See Figure 14). These three factors contain what would be an UX designer's approach to the project at the beginning. "Why" aims to find answers for user's motivation about the product or service. The "What" tries to meet the expectation of users from the perspective of the product and its efficiency. Finally "How" relates to researching into the user/ product relationship in terms of the physical side and is also related to its accessibility (IDF, 2019).

4.2.1. Introduction to User Experience Design

A design discipline brings various considerations with it when it comes to a product, a service, or a system, not only for professionals but also primarily for its users. When a product design is thought to make inferences, the improvement process clearly comes into view (Norman, and Nielsen, 2016).

Designing a product not only relies on creating more admirable objects or delightful services but also involves being a part of creating meaningful creations (Gajendar, 2018). In this scope, a design process should not only be constituted of creating an up to date aesthetic version, it should consist of innovation, improvement, function, and also visual and tactual quality too (Han, 2016). When User Experience Design is compared to find common points between it and the general terms of Industrial Design, UX design can be seen as a loyal subset of the Industrial Design discipline. There are many definitions of UX design; one of the most accepted ones is below:

> *"Person's perceptions and responses that result from the use or anticipated use of a product, system or service (ISO, 2010)."*

according to the International Organization for Standardization.

User Experience is such a design division that it can be mixed with its subcomponents, especially with User Interface. The main elements of UX will be explained in the upcoming chapters but it would be useful to explain the relationship between UX and its subcomponent UI with a metaphor as it was exemplified according to Jennifer DeRome (2015) who is a Senior Content Strategist:

> *"Imagine the human body: the bones are the code, the UX is everything internal that makes thebody function well, and UI is everything on the outside that makes the body look nice and appealing (DeRome, 2015)."*

The father of UX design, Don Norman, is the first person who coined the term "user experience" and used it in line with its inclusive basis when he was working at Apple in the 90s. Norman explained the fundamental scope of UX according to his past experiences at Apple. He mentioned how customers' interaction with Apple's products were important and required attention in order to become a coveted company. UX is a design discipline which questions the whole lifecycle of a product or a service (Hartson, and Pyla, 2019). It analyses and fathoms out the usage or experience efficiency and the pleasure of a product or a service for its presentation for selling or marketing. It aims to collect data and get feedback after the product has been used or consumed (Norman, and Nielsen, 2016).

Apple's products lifecycle process is a successful example within this context according to Norman, as he mentioned that the *"experience"* term is not only related to a website or an application, but also about the whole interaction of a product or a service with its user. For example, think about a computer from Apple. What is making this product so valuable? Which experiences are the company presenting to its users so that they are remaining faithful to Apple by continuing to be a customer of them? All of these questions are not answered in one day; they are all an integral part of a whole (Buley, 2013). The box the computer comes in, its positioning and appearance at the store, its transportation ease or difficulty, how the packaging feels, the method of opening the packaging, the scale of the product and its relationship to the environment, product usability and efficiency, visual quality, functional quality, competence of its duration of use, quality of the repair and after sale service are the

basic considerations for an Apple computer when it is considered within the realms of UX (Watch Nielsen Norman Group, 2016).

4.2.2. Elements of User Experience Design

There are major factors or components for user experience that makes it meaningful when the method is applicable or adaptable to each case of design, where it can create added value to them. Multi-directional thinking is the major and most effective way for developing, creating, and furthermore detailing a project throughout its progress according to Peter Morville, who is one of the pioneers of user experience and information architecture and also the creator of "The UX Honeycomb" (Morville, 2014) (See Figure 15).

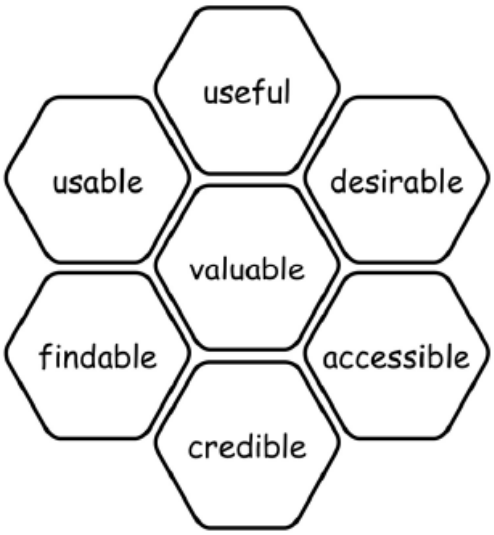


Figure 15. The UX Honeycomb (Source: Morville, 2014)

A systematic and effective design, even it is for a product, system, service, or any output, requires defining the main steps of the user experience before presenting it to the market and for meeting the needs of its customers or users (Quesenbery, and Brooks, 2010).

Because of the basic missing information between UX and usability, these two terms are confused by their users, while usability is being the answer to "ease of product usage". As Ditte Hvas Mortensen, who is an editor at the Interaction Design Foundation, explains UX is unthinkable without usability, but is it not true to

describe user experience as equal to usability, it is one of the supplementary factors for UX (Watch IDF, 2002).

When all the seven major elements are examined, it becomes sight clearer that even though these unique factors are being effective on their own; the strength of aggregation is more powerful than their singular authority.

“Useful” is the first component of the UX Honeycomb which Morville created. This component tries to explain the direct relationship between a product and its goal for the reason to exist for a focused customer group. “Usable” is a more supportive element than “useful”. If we are required to make the subject more concrete, thinking about a car would be beneficial. As a transportation vehicle, a car meets the requirement of arriving at point B from point A, which is a specific result of a “useful” factor. On the other hand, a ventilation button on the dashboard is an example of “usable” for a car because it provides more comfort, while safety is also an exclusive experience for its users that differentiates it from its competitors. “Findable” is easy to explain for a product or a service, as it is the requirement to present its function or specialties easily to its users. For example, setting the water temperature should be easy to understand and findable for a washing machine. In the opposite case the user would cease to have satisfaction with the product or service. “Credible” is more related to the reliance relationship between the product/service and the users. The product/ service should meet its promises not to lose the customer’s loyalty. “Desirable” is another effective element for a product or a system in the scope of properly handled UX design, which consists of the whole perceptual consideration, which is not only visual but also emotional. For example, think about being given the chance of having a car free of charge, and there are two options to choose from, Ferrari or Ford, which one would be the most desirable one logically and emotionally? The common answer, Ferrari, is about all the attributes of the brand: design, quality, functionality, brand identity, etc., it is not because a Ford car does not having successful features, design, comfort, etc. but the “desirability” between these two brands is the main reason of Ferrari being the chosen one. “Accessible” seems to be more related with whether the product or service meets the desire of not having disabilities but it is actually more related to designing comprehensive and fair products. Having the definition of “ease of use for everyone” is an important factor for each interpretation in the name of a creation. “Valuable” is

the final factor for UX design. This factor states that a product should not only be valuable to a customer or a user but also it should be valuable to the business. On the other hand, the value of the different elements of UX design can change from user to user or market to market. Value could be stabilizers between these different factors, which effectuate a whole from different pieces (Watch Interaction Design Foundation, 2002).

4.3. Usability

While UCD handles the product as a whole and comprehensive approach it furthermore puts the user at the core of the research where they also affect and design the total process according to their requirements and demands, which should also be suitable to the business goals. Beside UCD, UX design gives importance to the interaction between the product and the user taking into consideration various perspectives such as;

> *"emotional, social, cultural, psychological, and physiological (Kristin, 2003)."*

while evaluating the outcomes in the light of market conditions. At this stage, according to the ISO, Usability can be defined as the:

> *"Extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (ISO, 2018)."*

Along with this explanation, IDF suggests that the definition of 'usability' should take the place of the "user-friendly" term of the 1990s, which was mentioned as a past approach of design research contributive methods. The term has an accepted perception, which brings added value to the designers' community for their creation processes (Soegaard, 2020). Another definition for Usability is:

> *"Usability refers to the quality of a user's experience when interacting with products or systems, including websites, software, devices, or applications. Usability is about effectiveness, efficiency, and the overall satisfaction of the user. It is important to realize that usability is not a single, one-dimensional property of a product, system, or user interface. 'Usability' is a combination of factors…" (Usability.gov, 2020).*

Usability as being one of the important determinants for a design process will be explained in further parts of the study.

4.3.1. Introduction to Usability

The clear definition of 'Usability' can be distinctly understood in that just like UCD, HCD and UX design, 'Usability' serves with the aim of presenting qualified, effective, and efficient products or services to the users. As a *"sub-discipline" (*IDF, 2020) of the UX design, thanks to the Usability's handling modality of a product or a service, designers collect interactional feedback from the direct targets of the services. As Quesenbery mentioned in her research:

> "*…the true goal of all usability work is to provide actionable recommendations for how to improve the final product (Quesenbery, 2001)."*

It is trying to say that Usability is not like a unidirectional design method that is focused on users' inclination to the design, against the general perception. It is more related to having a contented experience from a product as a whole form.

4.3.2. Elements of Usability

There are five crucial dimensions of Usability which are called the "5 Es", according to Quesenbery. These dimensions provide confident guidance to the designers or researchers. It is expected that these dimensions will present different inferences to the designers and researchers, and also it is expected of them to be helpful for defining required usability factors as a framework, being a lead for the designing period as an instrument and defining not only the positive but also the negative features of the product or service in order to propose analytical solutions to them as an assessment.

> "*Effective: The completeness and accuracy with which users achieve their goals.*
>
> *Efficient: The speed (with accuracy) with which users can complete their tasks.*
>
> *Engaging: The degree to which the tone and style of the interface makes the product pleasant or satisfying to use.*
>
> *Error Tolerant: How well the design prevents errors or helps with recovery from those that do occur.*

Easy to Learn: How well the product supports both initial orientation and deepening understanding of its capabilities (Albers, and Mazur, 2003).”

As a brief but clear explanation, it can be said that these “5 Es” aimed to present different approach styles to the designers. These factors would be expected to bring balance for a product’s stability, but also, with the various demands requested by diverse users, bring along alterations with it.

While the purpose of a product or a service is to meet users’ needs and demands, a solution focused usability approach also has defined goals for this reason. The four fundamental factors that generate the goals of Usability are:

“User Definition: Which users does this goal apply to?

Task: What should they be able to do?

Context: Under what conditions does the goal apply?

Criteria: How will the success of this goal be measured? (Albers, and Mazur, 2003)”.

As a sub-set of UX Design, Usability also provides and supports the designers and researchers in collecting credible and improvable sources. The ongoing adventure of the user’s and the product’s relationship is like a symbolization of a truck and truck driver’s continuous interaction. As Idler (2019) mentioned in her research the repetitive planning of design enables the improvement of a product (Idler, 2019).

CHAPTER 5: WHAT IS AUTONOMOUS TECHNOLOGY?

Autonomous technology entered our lives like an inevitable step of revolution and as a necessary requirement in the improvement progress of transportation. When it considered as the first step of this "demand-solution" interaction, autonomous technology forces member of society to think about it (Frost & Sullivan, 2016). Is it an actual requirement for human beings to better their means of transport, either now or in the planned future, or is it just the result of individual's luxurious and flaunting curiosity?

Like most improvement progressions, autonomous technology is not entering our lives suddenly and aimlessly. There are several features which are integrated into today's vehicles with various titles. These integrations are firstly defined according to user observations, user demands and their suitability to environmental conditions. After these identifications, professional studies, which are based on UCD, progress to meet these requirements and tasks. Later a long designing, engineering and testing period follows and finally the international and national regulations give direction to new features in terms of their feasibility for our vehicles. Like the previous fifty years of transportation developments and inventions, today's automation subject and its evaluation is considered as a modern interpretation of mobility. The definition and aim of transportation have not got similar terms or expectations in comparison to previous times. The term mobility and its requirements include new inventions and application to the concept of transportation (See Figure 16).

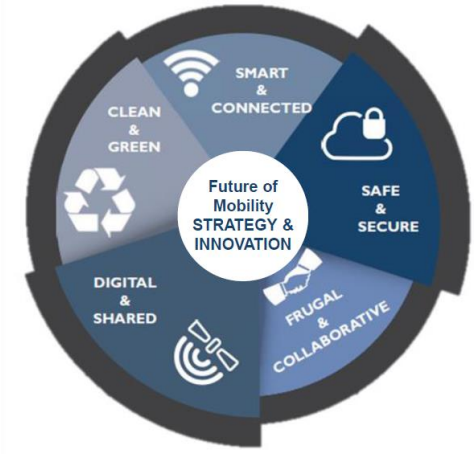


Figure 16. Vehicle Systems Road Map: Major R&D Focal Points, Global, 2015–2025 (Source: Frost & Sullivan, 2016).

According to ERTRAC's research and as Figure 16 shows what is expected and planned via the technology diffusion to transportation systems also affects the automated driving concept. According to Frost & Sullivan's (2016) research about the "Future of Mobility Strategy and Innovation", new and improved mobility would be desired to present society with five crucial elements; Clean and Green, Smart & Connected, Safe & Secure, Frugal & Collaborative, Digital & Shared. All of these five elements are studied in detailed to prepare more innovative and substantial duties (Frost & Sullivan, 2016).

To answer these requirements and also changing world conditions, there are many technical, systematical, engineering and designing developments which have been implemented thanks to the technological development of the automotive industry. Advanced Driver Assistance Systems (ADAS) is one of the most important comprehensive developments for today's automotive industry. The primary aim of these systems are to guide the driver and provide usage ease during driving time. Furthermore, providing a pleasurable and comfortable driving experience is another essential target for it. Before moving on and getting more details about ADAS, it should be known that ADAS took place thanks to Driver Assistant System (DAS) (Lewis, 2017).

> *"DAS is a system that informs and warns, provides feedback on actions, increases comfort, and reduces workload by actively stabilizing or maneuvering the vehicle. ADAS system is considered as a subset of DASs, with increased use of complex processing algorithms to detect and evaluate the vehicle environment based on data collected via a variety of sensor inputs (Zhao, 2015)."*

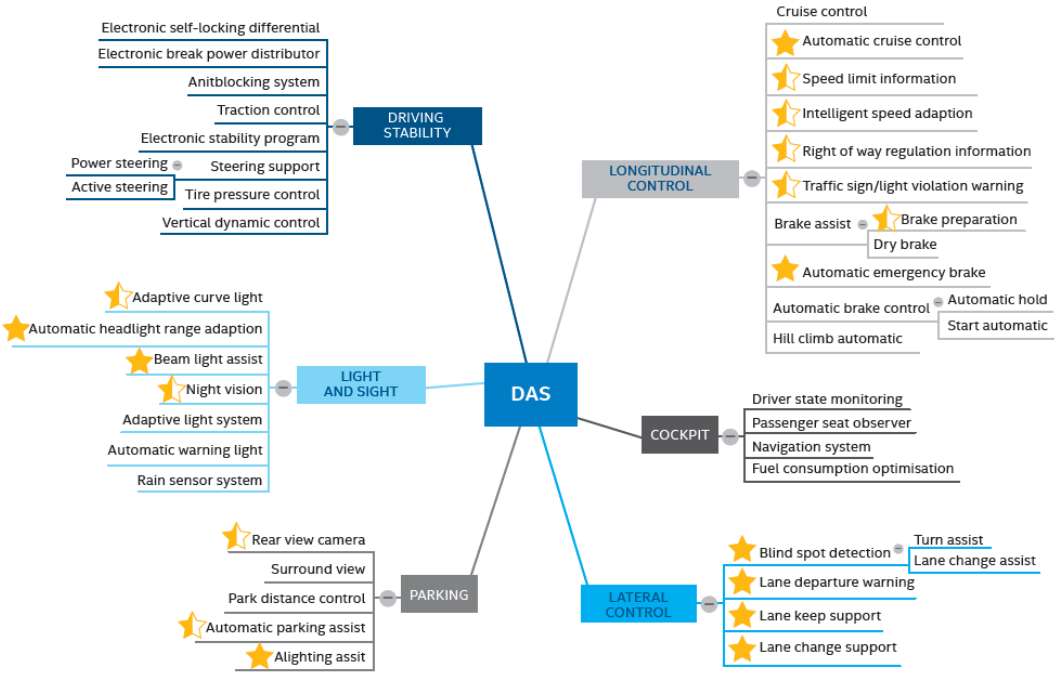


Figure 17. Spectrum of DAS and ADAS Functions (Source: Zhao, 2015)

In Figure 17, the full colored stars indicate ADAS's existing applications and technology, while half colored stars highlight ADAS functions which currently require more improvement and study (See Figure 17). All of these factors are under the umbrella of DAS. It should be remembered that these factors are not only dependent on individual or restricted to the scope of the application, but also most of them are related to their environment and ambient conditions (Winner et al, 2016).

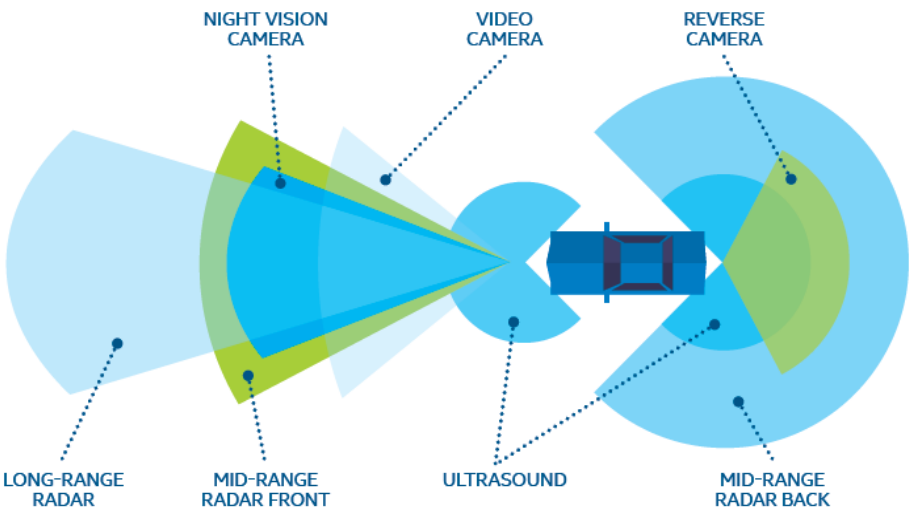


Figure 18. Example ADAS Sensors (Source: Zhao, 2015)

A vehicle, which is equipped to meet the requirements of ADAS, should have several technical and engineering installations (See Figure 18). Figure 19 shows a clear timeline for these equipment developmental areas (See Figure 19).

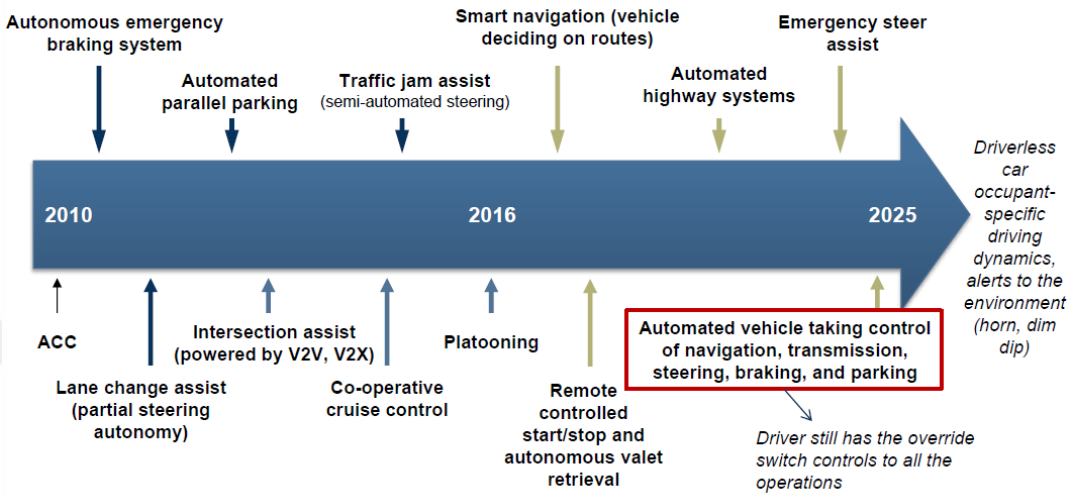


Figure 19. Vehicle Systems Road Map: Autonomous Mobility Applications Snapshot, Europe, and NA, 2010–2025 (Source: Frost & Sullivan, 2016).

According to Frost and Sullivan's (2016) research, while ADAS features are more involved in our daily lives day by day as a regulative topic, in pursuit of it autonomous mobility it has set its stage emphatically.

Depending upon the increasing transportation vehicle users, not only the experts on this issue but also governments' related departments are started to think about how the running traffic and also future transportation systems should be shaped according to the changing needs and user profiles. At this point, some clear factors became prominent in considering these issues

"- *Safety,*

- *Efficiency and environmental objectives,*

- *Comfort,*

- *Social inclusion,*

- *Accessibility (ERTRAC, 2017).*"

According to the European Technology Platform these five major elements are defined as a starting point to make improvements to and develop the autonomous concept. When these topics are examined in detail; safety is directly related to accidents, which are commonly caused by human mistakes. Efficiency and environmental objectives are mostly aimed at improving the transportation system's capabilities as well as trying to save time. In addition to these missions, thanks to the expected improvements, the ecological approach that is raised by intense traffic and fossil fuel energy usage is aimed to be enhanced. Comfort has become another topic of concern for the users, which aims to provide a more enjoyable time for the driver or passenger in the vehicle. Under favor of related developments, controlling the vehicle and other several driving tasks should not be focused on the driver or passengers in the due course of transportation. According to previous factors, social inclusion is more related to having equal rights to improved mobility for all citizens; being elderly or having some physical or mental disability should not be a reason for not having basic human rights, so this topic is being investigated to find out how the conditions could be bettered or the system should be change according to other environmental considerations. Finally, accessibility is related more to the availability of reaching anywhere depending on the improved transportation system.

When the automation of a vehicle becomes the subject, there are three major tasks for motor vehicles: steering, acceleration and braking (ACEA, 2019).

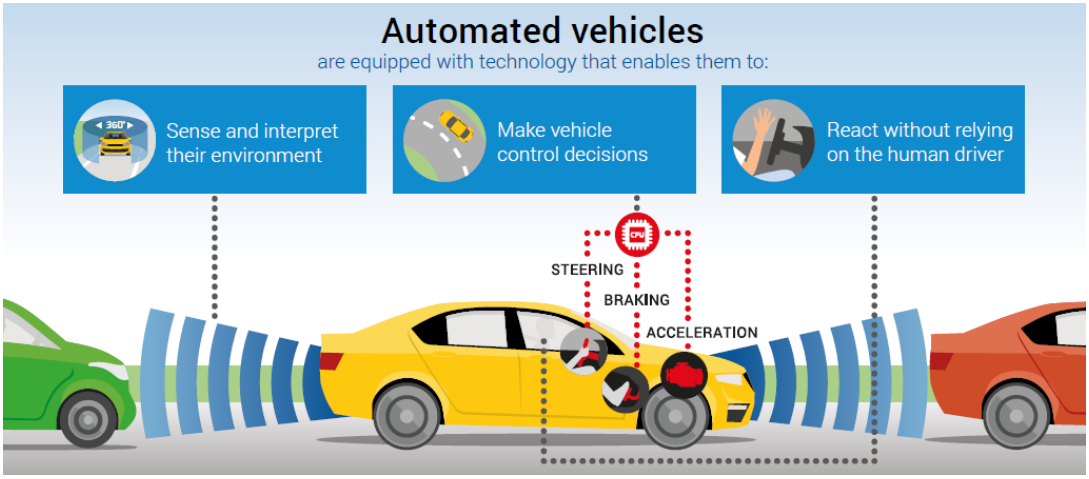


Figure 20. The Automated Vehicle Major Factors (Source: ACEA, 2019).

The automation level of a vehicle is determined according to the percentage of who is managing or being responsible from these tasks (See Figure 20) As it mentioned above there are several technical, engineering and design related innovations which have been applied and such developments still continue to be integrated into today's vehicles under the umbrella of DAS and ADAS (ACEA, 2019). But automated vehicles, which are expected to create an autonomous mobility system in the future, still require more technical, experienced, and iterative processes before having a normal place in society's daily life.

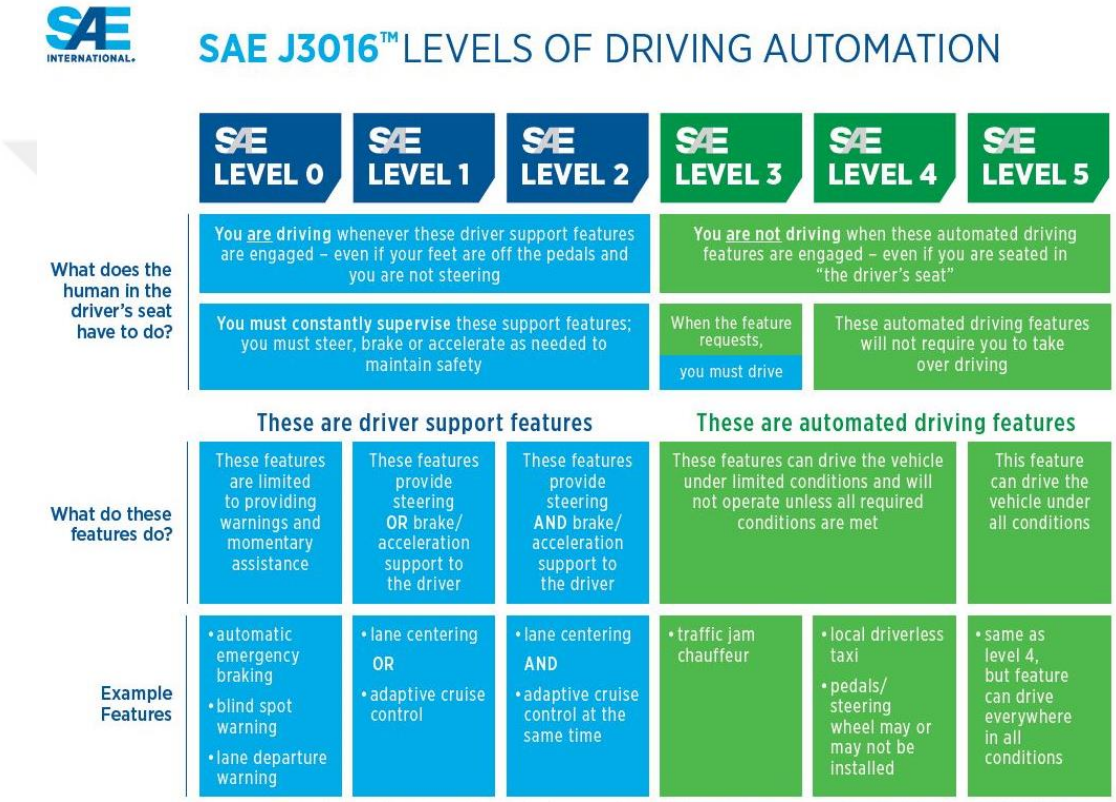


Figure 21. SAE J3016 Levels of Driving Automation (Source: SAE, 2017)

According to SAE's most recent document, which clearly explains the levels of autonomous driving, there are six main levels from Level 0 to Level 5 (See Figure 21). While Level 0 expresses "no automation", step by step driving supporting features (DAS & ADAS) and other required technological developments are added to the vehicle and finally the whole driving experience is deserved to be titled as "Full Automation".

5.1. Autonomous Trucks Design Specifications

From the SAE graphic below it is easy to understand that the human factor is directly on the top of the driving task or is ready to intervene in the vehicle's handling between Level 0 to Level 3. After Level 3, High Automation (Level 4) minimizes the driver's level of intervention and Full Automation (Level 5) frees the driver throughout the whole transporting process (FIA, 2017).

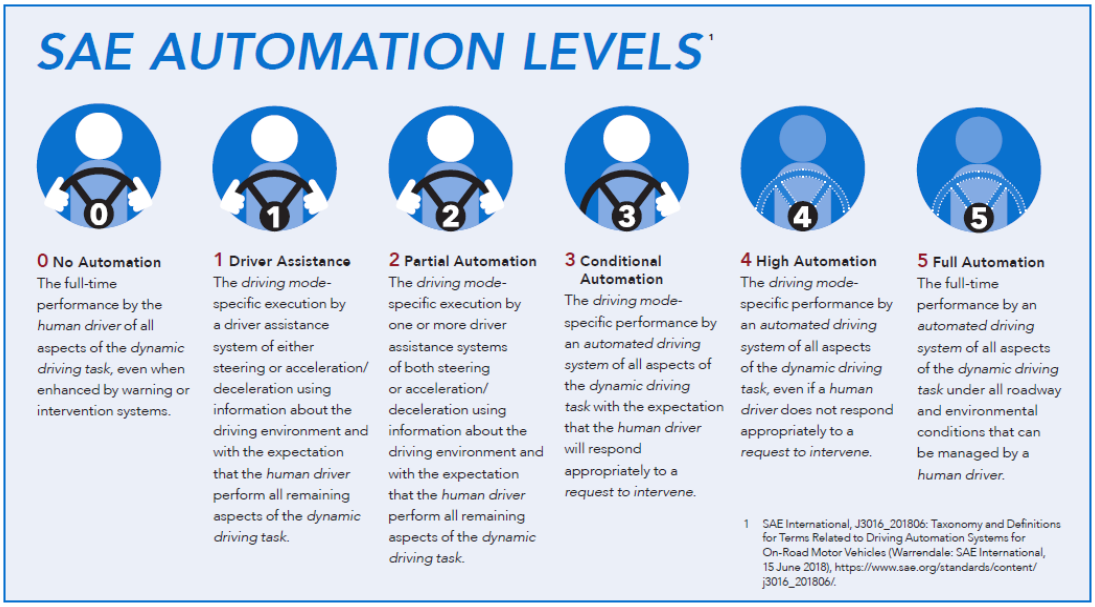


Figure 22. SAE Automation Levels (Source: U.S. Department of Transportation, 2018)

The Autonomous Driving feature brings about new identifications to existing driving terminology (See Figure 22). Some principals of these are:

Conventional Vehicle: a vehicle that is designed and engineered to be directly used by an existing driver thought the whole driving period.

Conventional Driver: a driver who is directly having the control of the vehicle and giving the physical direction to it while giving decisions about braking, accelerating, steering and gear transmission choice.

Automation Levels: the levels which determine who has the control of the vehicle or which features provides operational support to the driver and to which degree.

A driver is someone who manually utilizes in-vehicle braking, accelerating, steering, and transmission gear selection input devices in order to operate a vehicle (SAE International, 2018).

Up until this part of study the passenger cars' autonomous driving system has been explained mostly. It was important to include detailed and accurate information about the topic. When the subject turns to the automation of trucks, the system and requirements show differences depending on the vehicle volume, mechanical equipment variety and usage target of the vehicle (U.S. Department of Transportation, 2018).

According to the European Automobile Manufacturers Association Manifesto (2019-2024), trucks perform a vital role in Europe's commerce. It is mentioned that thanks to freight transportation in EU, nearly 76.7 % of loads, which corresponds to 15 billion tons per year, is delivered to determined locations by trucks. These conveyances result in 6.3 million trucks travelling on roads (ACEA, 2019). When you stop to think for a moment, it becomes easy to realize that nearly all society's daily necessities are transported and delivered thanks to trucks. Not only principal requirements but also nearly all the public services like garbage collection, firefighting and construction services are provided via trucks. It is clear from information about trucks' freight transportation that, while €5.2 billion is gained as a global trade profit per year for the EU, heavy-duty trucks account for more than €334 billion of this business and provide 3.2 million job opportunities to Europeans (ACEA, 2019).

Kouchak and Gaffar (2018) defend and discuss designing autonomous trucks rather than cars in their study, which essentially focuses on usage area, driver's behaviors predictability, having specific routes and duty factors like controllable features as per a private vehicle (Kouchak, and Gaffar, 2018).

When examined in detail what are the advantages of truck automation adaptation in terms of bettering trucks?

> *"...Different placement of sensors, longer braking distances, and more space to turn, as well as more physically robust components (Viscelli, 2018)".*

While the engineering solutions could be transformable from vehicles to vehicle, it is important to invent appropriate solutions according to the related requirements.

In compliance with Viscelli (2018), truck transportation is the most suitable type of vehicle for autonomous transportation because of the long-distanced highways they travel on. The study predicts that there would be truck ports at suitable areas, far from the city center and easy to reach from highway locations, to provide freight loading and unloading (See Figure 23).

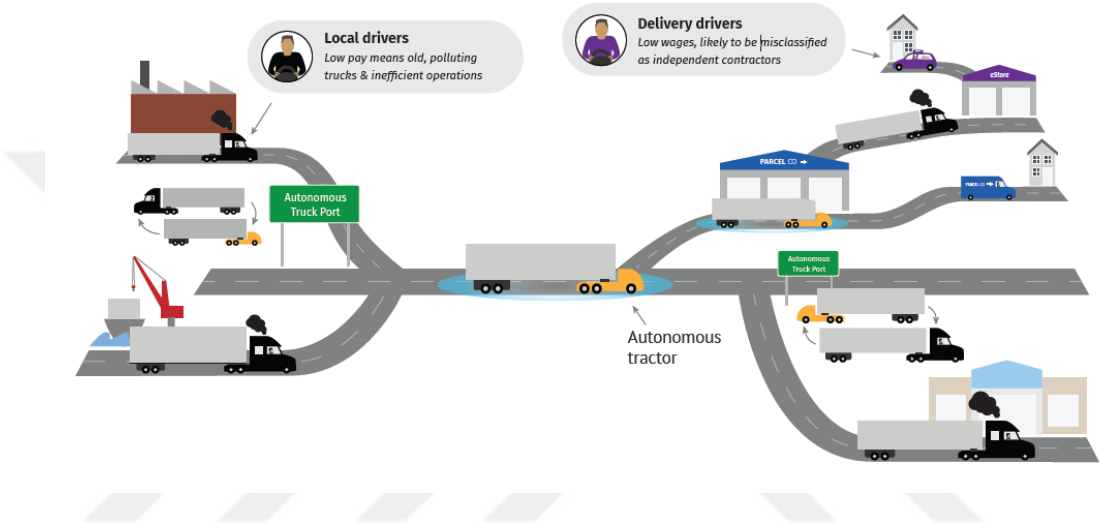


Figure 23. Automation Scenario due to Absent Policy Intervention (Source: Viscelli, 2018)

There are six possible scenarios for Automated Driving integration to US's truck transportation:

"- *Human–human platooning,*

- *Human–drone platooning,*

- *Highway automation + drone operation,*

- *Autopilot,*

- *Highway exit-to-exit automation,*

- *Facility- to- facility automation (Viscelli, 2018).*"

While each expected scenario has its own technical specialties and environmental arrangements, it could be said that the essential aim of this technological integration to truck transportation operations is the same. These similarities can be described as:

"- Decreasing truck accidents,

- Providing safe driving environments for the drivers,

- Saving time,

- Increasing driving operation efficiency,

- Gaining more profit at the end of the trade (Kouchak, and Gaffar, 2018)."

Figure 24 explains the expected development direction of freight vehicles according to the European Technology Platform (See Figure 24).

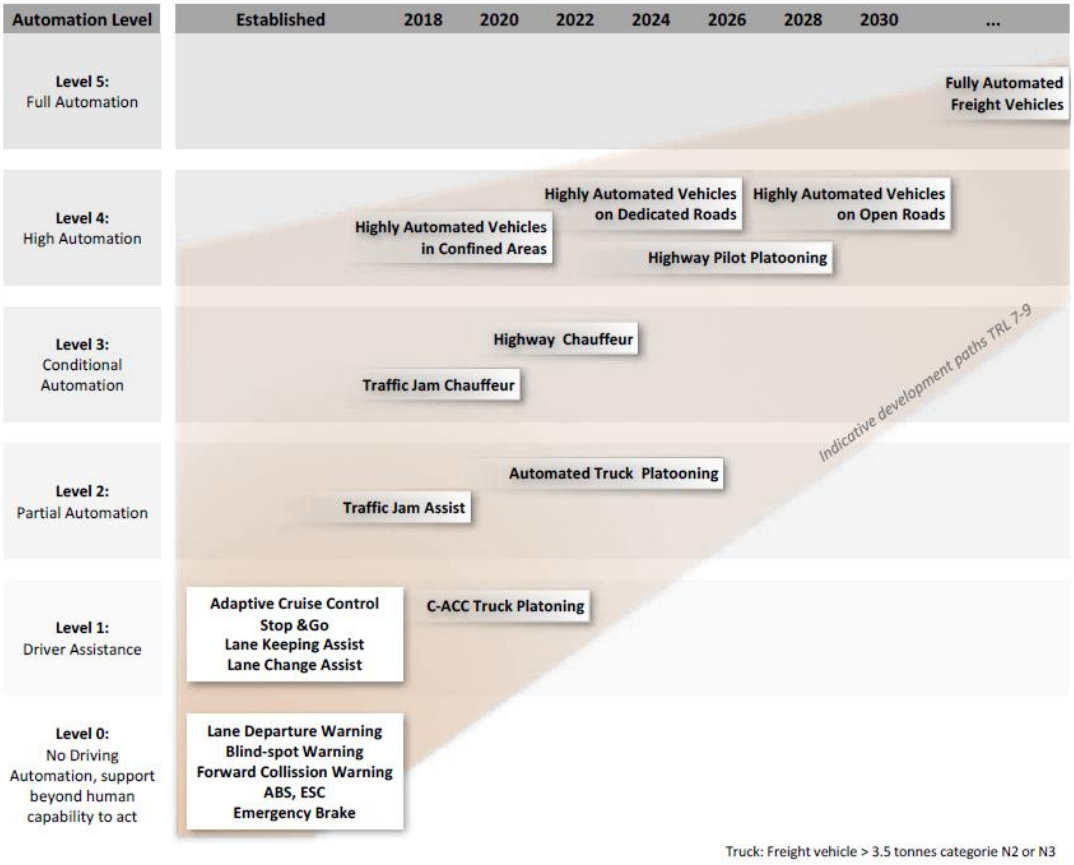


Figure 24. The Automated Driving development path for freight vehicles (Source: ERTRAC, 2017)

Together with automation validity, which has now got a place in the daily terminology of transportation, several sub-topics would appear to raise some issues for discussion, such as environmental arrangements and what would be the expected job losses or decreasing work quality due to this. Furthermore, what would be the economic repercussions of gaining more profit thanks to uninterrupted transportation against the disappearance of a branch of a business? These subjects are considered as discussion topics for this study.

5.2. Homologation and Standardization about Autonomous Trucks

The most important objective of all automotive producers and inventors, who are spending countless working hours on this target, is providing a safer driving experience and operation. While these developments are being integrated into today's existing vehicles more emphatically, there are several advanced systems solutions (ADAS) like; blind spot detection, lane departure warnings and automatic emergency braking (TUV-SÜD, 2019) which are being used on existing automotive systems to prevent the drivers from potential accidents. According to TÜV-SÜD (2019) research, it is expected that almost 370 million vehicles are going to be equipped with machine-controlled features by 2030 (TUV-SÜD, 2019). While the planned innovations would follow each other, it will be inevitable that we will face a new transport concept in place of the traditional one.

The terms automated and driverless present new technological innovations to the new normal identification of transportation. In this context the "Cyber Physical Systems" should become known by related authorities.

> *"Cyber physical systems are systems or devices which are comprised of interacting digital, analog, physical and human components engineered for function through integrated physics and logic." In real-world applications, cyber-physical systems utilize a sophisticated array of wireless sensors that actively monitor physical and environmental conditions and then send data back to a central processing unit. This unit then assesses these conditions against the system's library of preprogrammed operating scenarios and executes changes in the relevant mechanical or electromechanical systems as appropriate (TUV-SÜD, 2019)."*

There are various reliable international and national institutions which promote road safety and order. While these regulatory bodies are proceeding to regulate the traditional transportation operations, the new innovation required systems are waiting to be tested according to common and recent factors. These two similar environments could be controlled using the same regulations, but it clear to understand that different technological instruments, equipment and interaction between driver-road-vehicle would not give similar answers from the point of view of homologation. So new regulations and homologation requirements systems are become a necessary factor that should be given due consideration.

The United Nations Economic Commission for Europe (UNECE), which was constituted in 1947 by the United Nations Economic and Social Council, is at the top of regulations and homologation concerns about the new mobility vision and autonomous vehicles. The commission started to work on the subject of autonomous vehicles in 2014. After the commission related studies in 2016 the international regulative community took two effective decisions, which will be applied to autonomous vehicles too. These decisions were:

"- ...the 1968 Vienna Convention on Road traffic was amended to open the door to automated vehicles in traffic,

-The 10 km/h limitation for autonomous systems was removed from UN Regulation No. 79 (UNECE, 2017)."

The World Forum for Harmonization of Vehicle Regulations', under the umbrella of UNECE, primary working subjects are becoming automation related topics thanks to the recent inventions and sector demands. To gather speed and hear various point of views from several disciplines, the World Forum constituted a Working Party on Autonomous and Connected Vehicles (GRVA) in 2018. The committee consisted of members from several different disciplines such as the automotive, IT, telecoms, and insurance sectors which are the building blocks of automated systems, together with civil society groups to represent the different sides of public opinion (UNECE, 2017)." This working group's main areas of consideration are:

"*Safety measures,*

Connectivity,

Cyber security and software updates,

Testing methods,

Safe integration of autonomous vehicles in road traffic (UNECE, 2017)."

Level 3 and higher automated/ autonomous vehicles are under the scope of the Working Party. Not only the new technology adaptation is under the WP's responsibilities but also providing harmonization of them within existing regulations is one of the key matters for them. In this context;

> *"...an automated/autonomous vehicle shall not cause any non-tolerable risk", meaning that automated/autonomous vehicle systems, under their automated mode (Operational Design Domain (ODD) or Operational Domain (OD)), shall not cause any traffic accidents resulting in injury or death that are reasonably foreseeable and preventable. Based on this principle, this framework sets out a series of vehicle safety topics to be taken into account to ensure safety (Inland Transport Committee, 2020)."*

This explanation provides a clear statement of what is the defined target of the group. The Working Party published a guide list for further studies, the key subjects of which are:

"a) System Safety,

b) Failsafe Response,

c) Human Machine Interface (HMI) /Operator information,

d) Object Event Detection and Response (OEDR),

e) Operational Design Domain (ODD/OD)] (automated mode),

f) Validation for System Safety,

g) Cybersecurity,

h) Software Updates,

i) Event data recorder (EDR) and Data Storage System for Automated Driving Vehicles (DSSAD) (Inland Transport Committee, 2020).”

Each of these critical themes are being examined by these experts on the subject in order to provide the most reliable and safe service to the whole of humanity (Eugensson, 2017).

CHAPTER 6: METHOD

Throughout this chapter several research methods are used to find the most comprehensive sources according to the related topic of the study.

When, the total approach's point of view is altered from the main set to subsets for the study, the scope width of each chapter would be realized easily. Each chapter's topic, which are all one of the building blocks of a precious whole, have their own worth of detailing too. It is aimed to transfer refined but comprehensible information to the reader in each part of the study. It is targeted to present clear introductions about general information to the readers with the continuing historical past, especially in the second and the third chapter. Literature review was the most powerful method for supporting this issue; it is used not only for these chapters but also in the total scope of the thesis too.

While the main subject of the study is related to the "Truck", as a commercial vehicle family member, auxiliary subjects, which are "Autonomous Vehicle Technology", as an incontrovertible development for the transportation community and "User-Centered Design", as a mediator between today's existing technology and the future, are explained thanks to the related chapters. The combination of automotive history, truck division, and the existing circumstances of it, as well as future expectations and plans about it are explained as a clear whole, under the user-centered design umbrella, while fundamental information is integrated with detailed information by means of several data collecting methods. This manner of transference is the source of incorporating the readers into the cumulative subject of the study.

Reaching refined and verifiable facts about today's truck structure, the vehicle's relationship with its user, autonomous technology and its adaptation as of today, the feasibility of the technologic developments and its acceptance in real life, drivers existing usage habits and the transformation progress that is related to the user - centered design approach and its assimilation were the questions, the answers to which are expected to be found in this chapter.

Interviews were considered to be the most suitable instrument for consistency of this thesis. Not only collecting qualitative data was aimed at by doing these interviews

for the study but also collecting quantitative findings was believed to be the best method for giving clear expression.

"a face-to-face verbal exchange, in which one person, the interviewer, attempts to elicit information or expressions of opinion or belief from another person or persons (Maccoby, and Maccoby, 1954*)."*

As it is briefly explained above by Maccoby & Maccoby, it is an important issue for an interviewer, as a data collection instrument, to create a genuine interactive relationship with its participants to get clear and relevant answers. Using the interview is the appropriate decision for this research in order to collect primary users' direct experiences and opinions on future trends.

According to the research question of the study, having experience and knowing how to compare different vehicle features are critical issues, so that interviews became an efficient selection compared to other methodological instruments. It supported the main and sub questions of this research, thanks to giving an opportunity to the primary users to contribute.

Truck drivers are defined as the main "Focus Group" of the interview. Drivers that had used or have been using BMC production trucks were specifically selected in order to take comparable answers from participants. Also a few truck drivers who are not using BMC trucks but are using Mercedes and other brands' vehicles were included in the interviews to get a different point of view and to evaluate past and recently designed competitive brands' vehicles.

The qualitative data, which mostly relied on face-to-face interviewing with the drivers, produced unexpected contributions to the research's course of events. The Likert Scale questions were designed to promote flow-based conservations; even it had a plan, with their clear findings.

In addition to the experienced participants, other educated profiles such as industrial designers, engineers, design specialists were also included in other participant groups to collect various perspectives for the research. The main aim was to reveal their expectations about the sector and their harmonizing approach in line with their personal professional backgrounds and their ideas on future trends.

6.1. The BMC Automotive

BMC was established in 1964 in Izmir, Turkey. The company has a remarkable history in the nation's automotive industry. As Küçükerman (2008) mentioned in his book the company produced its' first licensed vehicle the "TM 135" in 1966. Light commercial vehicles constituted most of the product range of the company for a defined period. Later, during the "Leland 30's" vehicle family production period, the "TM 100 and TM 140" vehicles were produced. The company developed itself after the initial development period by arranging productive investments and co-operations. After the Land-Rover production agreement, the "Volvo-Yavuz" production gained speed at the Company. Thanks to the joint work with Cummins, the legendary trucks called "Fatih" started to be produced. After a period of time and changing dynamics, some administrative alterations happened in company. Sometime later, Çukurova Holdings became shareholders in the company, and as a result new vehicle models were included in the production plans. After a long time, today the company has a new managerial structure and product range (Küçükerman, 2008).

BMC serves both the commercial vehicles sector and defense industry nowadays. Commercial vehicles consist of city buses and heavy trucks. A design study was conducted together with lots of designers and engineers to create the company's new family of trucks which is called "Tuğra".

6.2. New BMC Truck "Tuğra" Examination

BMC's previous trucks, the "Professional Series", were designed by the Italian design team Pininfarina. The new truck family which is called "Tuğra" is a product of a co-operative study with BMC's in-house industrial design and engineering teams with outsource design and engineering teams such as Design-um and Infotron.

The exterior design of the truck preserves some characteristic features from the previous truck models of the company (See Figure 25 and Figure 26).

A variety of user feedback was collected to present better equipped vehicles to the market throughout the designing process of Tuğra (See Figure 25 and Figure 26).

Figure 25. The BMC new Truck Tuğra Exterior (Source: BMC, 2020)

Figure 26. The BMC new Truck Tuğra Exterior (Source: BMC, 2020)

The interior of the truck is aimed to present safer, more comfortable, and easier to use features for its users (See Figure 27, Figure 28 and Figure 29).

Figure 27. The BMC new Truck Tuğra Interior (Source: BMC, 2020)

Figure 28. The BMC new Truck Tuğra Interior (Source: BMC, 2020)

Figure 29. The BMC new Truck Tuğra Interior (Source: BMC, 2020)

User demands, requirements and innovation harmonization between market necessities and business profit became some of the key elements of the Tuğra's project process.

6.3. Case Study: Interview with BMC Truck Users & Designers

Interviews with BMC Truck users, who used both the old and more recent "Tuğra" models, along with company experts, who are working as Industrial Designers, Engineers, Design Specialists, Department Managers, and the General Manager, were applied to collect data for the study's method chapter.

Because of the existing Corona Pandemic, while all the interviews with truck drivers were conducted face to face, the other experts' interviews were conducted using e-mail sharing and face to face group explanations to prevent any health risk. After taking the required permission from the company's related departments and authorities, the interviews with drivers were conducted in January 2021 on three separate occasions. Each session with a participant took between forty minutes to one hour.

According to the final calculation, the interviews were carried out on a total of twenty truck drivers; In addition to this number, forty-six experts completed the interviews.

The numbers of BMC truck users, especially both of the old and new model vehicle was restricted, because while participation of a higher number of interviewees was what this research was originally based on, the BMC Company's production schedule had changed to a more intensive one. The new mass production timeline, along with the Pandemic, caused a decrease in driver participation. But this decrease in participation by drivers provided a new perspective to the study, thanks to the inclusion of experts as participants.

Direct user experience, positive & negative interpretations, desire and expectations about the past, recent and future truck models were expected to be the topics of the data collected from the truck drives thanks to the interviews.

On the other hand, gathering information by percentage of what they expected as an industrial designer, an engineer, or a design specialist and what they actually have by comparing technical and technological application feasibility and interpretations about future transportation were the main questions that required answers from the experts.

The interview consisted of thirteen questions, and the questions for the drivers and experts were kept the same as much as possible although there were minor changes made due to the differentiations in the participants' job descriptions.

The participants' age, education status and truck driving experience (for drivers) or automotive sector experience (for experts) were asked to determine if there would be enough information to make a generalization, between age, education, or vocational experience.

The first five questions were directly related to UCD in the interview. While it started with the essential questions, it further aimed to reveal the participants' awareness of UCD.

By using the Likert Scale assessment system, it aimed to measure how different profile types would individualize a defined question. By using this question type it

was expected to provide varied results by the reason of having different occupational group participants. The sixth, seventh and eighth questions were more interpretation oriented. Collecting designer's, engineer's, and user's different approaches to the vehicle and also various comments according to experience level were expected from these questions.

The ninth, tenth and eleventh questions were focused on autonomous technology. It was expected to take different information according to the appropriate education levels. In addition, another aim was to determine the participants' particular focus on their own jobs in relation to developments about the near and far future. Finally, in the eleventh and twelfth questions the target point became BMC brand efficiency and future expectations.

All of the answers were evaluated according to literature review sources, academic research, and questioned based quantitative data.

It should be mentioned that, while the aim of these interviews was to collect data from the study's participants, it was not desirable to incorporate any concept of bias, and so for this reason before the first related question, a definition of UCD and its aims, as well as a full description of its features were given to the drivers. Also before answering the first related question about Autonomous Driving the drivers were furnished with a clear explanation of the term, and its level differentiations and the environmental issues were also shared with the drivers. This informative part of the interview was shared via email with the expert participants as well.

6.4. Findings and Discussion

It was proposed to take direct and indirect findings in order to contribute to collecting logical answers to the question of "What can be learned from a user-centered design assessment of autonomous truck interior design in comparison to conventional truck design?"

Truck drivers were chosen as prior-direct users of the trucks, which is the production under examination, to indicate user-product relationships as a basis of collecting information about the UCD approach.

Analyzing the interview questions was identified as an efficient method to understand what the results were from conducting such an interactive method.

In the first question the level of awareness of UCD was measured for both participant groups. From the results it can be understood that drivers do not have a similar level of knowledge about the terminology of UCD, although it could be said that they are like living representatives for UCD in the area of transportation. While the experts are more familiar with the term, they still could not manage to adapt to the approach's requirements mainly because of the needs of the business and limited project completion.

The second question was like a continuation of the first one and again aimed to determine quantitative data. According to the answers, the experts commented that they often use UCD in their projects. According to the experts, drivers are not aware that their daily usage habits are actually being served by the use of UCD and are like an interrogator for it.

The third question was focused on discovering how the evaluation differs between the users and designers of the trucks.

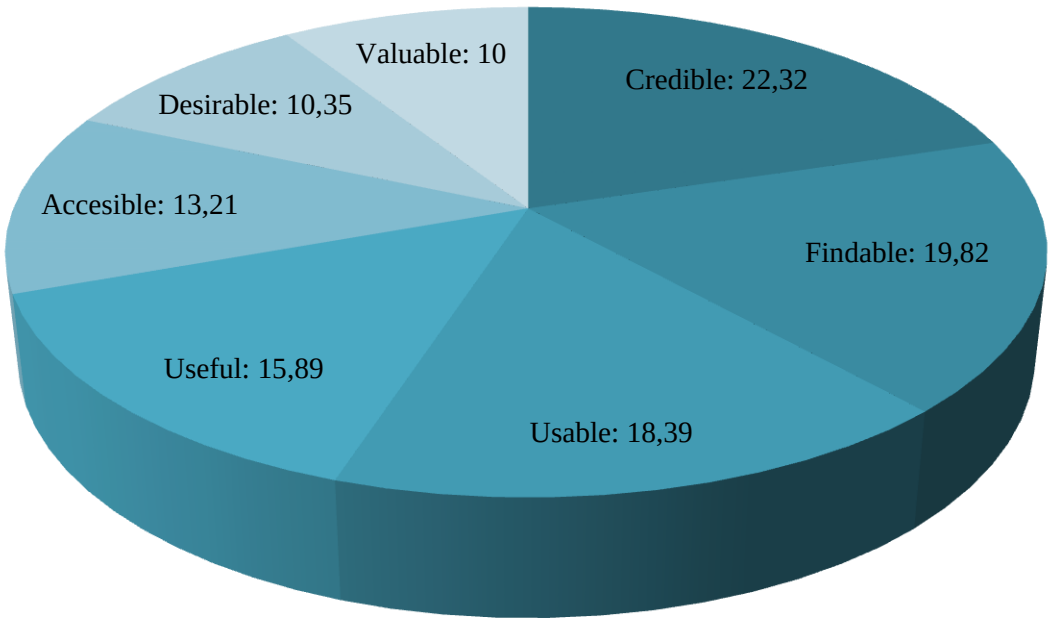


Figure 30. Truck Drivers' UCD Approach Features Ranking according to interview results

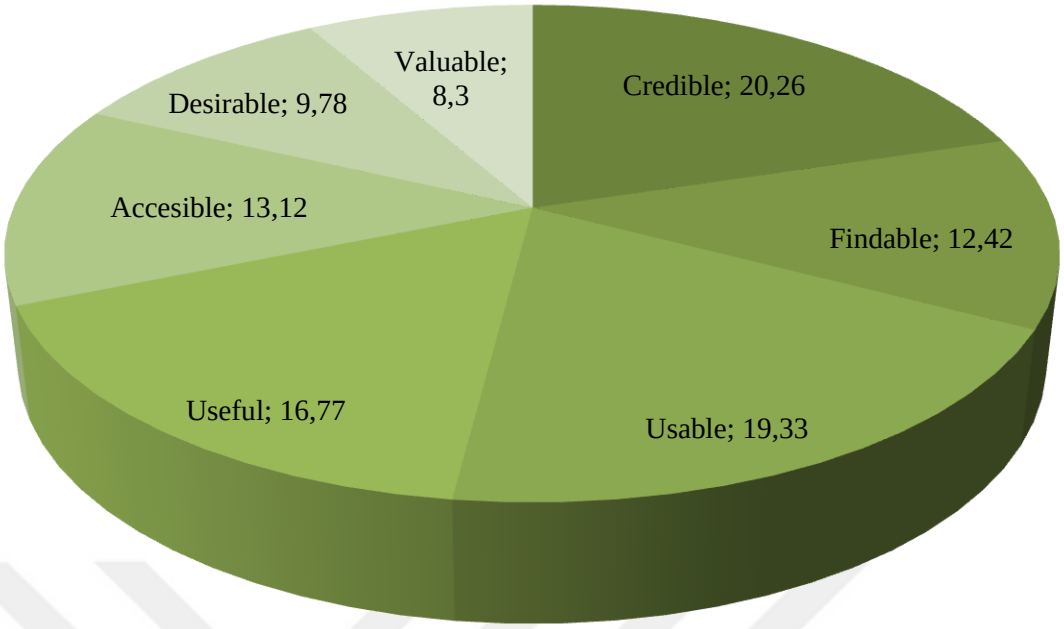


Figure 31. Experts' Drivers' UCD Approach Features Ranking according to interview results

The results show similarities between each groups, but it is clearly discernible from the more detailed information gathered at the interviews that truck drivers give more attention and higher importance to the usage related elements and easy access to their desired requirements (See Figure 30 and 31).

The fourth question was like a confirmation of the previous one, so that nearly all participants from the different groups answered in a similar way in that they all believed the constructive effects of the UCD's approach will lead to creating more efficient trucks.

The fifth question is one of the most important ones in that it would be a reference point for the autonomous related questions and autonomous design targets. The resulting percentages are shown below (See Figure 32 and Figure 33):

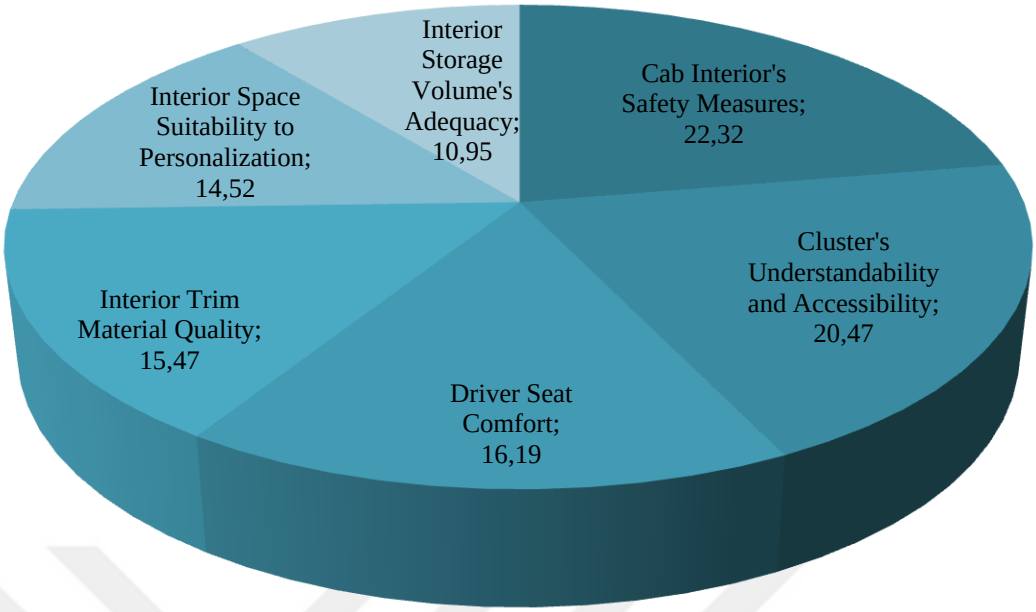


Figure 32. Cab Interior Area Importance Ranking according to UCD approach by Truck Drivers according to interview results

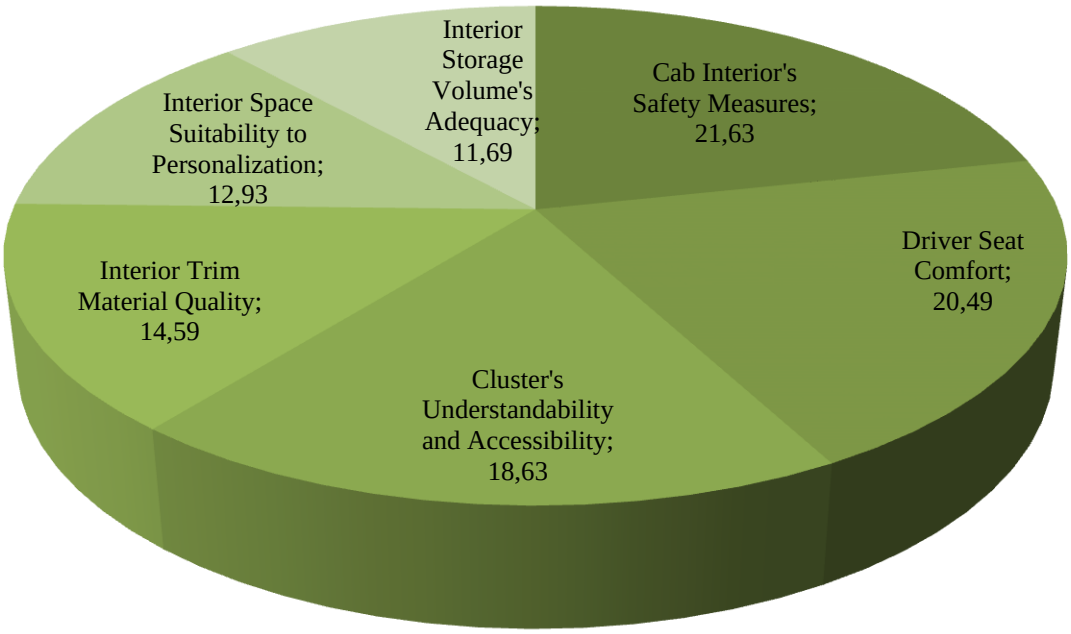


Figure 33. Cab Interior Area Importance Ranking according to UCD approach by Experts Drivers according to interview results

While the first preference was the same for both groups, the second most popular choice for the drivers was Cluster's Understandability and Accessibility while the experts chose the Driver Seat Comfort. Each of the elements should be considered as key factors for designing or innovating a new version of a truck and also an autonomous truck.

The sixth and seventh questions were mostly based on individuals' interpretations. The aim was to collect different information from various participant profiles to understand the truck brands' evaluations and differences. In addition, the question's responses could be constituted as a design brief for industrial designers and engineers thanks to the information shared by the truck users in their face-to-face interviews.

Regarding the eighth question, the aim was to ascertain the participants' expectations about the existing and potential future transportation systems along with new mobility approaches and future vehicles. Automated driving system expectations, electrified vehicles integration as the new norm, an increase in platooning transportation style usage especially for freight transportation were common answers to this question.

The ninth and tenth questions were mostly enquiring about autonomous vehicles and their related driving systems. Trucks drivers surprisingly were familiar with the terminology of the autonomous system and vehicles, while the experts' familiarity percentages were not at a very satisfying level.

The following question forced both groups to think about how society, truck drivers and related designers and engineers will be affected after autonomy becomes a norm as part of life and work. While the positive expectations were identified as having secular and clean traffic systems, decreasing the number of truck accidents, saving money and time and getting more efficiency from transportation based jobs, the negative or thought-provoking ones were loss of some job branches, increasing unemployment levels, the concept of increasing social loneliness and a different view of secularity; who will be responsible if an autonomous truck or a vehicle has an accident? These questions created long discussions, and furthermore the secularity and regulation processes were highlighted as a possible follow on study topics that could take some reference points from the outputs of this study.

Mercedes-Benz's and Volvo's autonomous trucks and driverless vehicle concept visuals and videos were shared to collect the participants' opinions. At the end of these questions, the experts found the vehicle to be possible and triable while drivers did not feel comfortable with them. This question highlighted that this could be a signal for how breaking the traditional usage and customary approach might require a lot of time and effort. This topic could also be examined in further studies.

The last questions were more related specifically to the BMC company itself and the participants' expectations from it. The answers showed that while the potential of the company and excitement towards development were both recognized by the users and designers, defective planning systems and large scaled target deficiencies have caused the company to not develop at the desired speed for the transportation sector in line with other global brands.

In the statements given by the truck drivers and experts during the interviews, there were some main elements which became common considerations after conducting the interviews:

- The importance of UCD's integration into the organization of the truck's interior is a directly effective factor for both participant groups according to their answers to the questions.
- While the drivers are mostly concerned with the vehicle's usage quality, especially performance and security elements, the experts are also concerned about similar elements. Furthermore, they try to meet these requirements and their future expectations.
- Truck drivers commonly mentioned in their comments the importance of drivers being listened to much more by the experts. These should be design brief inputs for the creators.
- While drivers require to be listened to much more by the experts, the experts themselves mostly complain about the strict project timetables, business requirements and market expectations.
- Both participant groups suggested that a more cooperative working style would result in more innovative and more effective vehicles and services.

- Not only the experts' group but also the drivers are also aware of the transformation of mobility and future approach for the work distribution. But the geographical impact was the most effective and suggestive parameter for both groups.
- While experts argue that autonomous technology should be improved by companies which want to exist in the future transportation industry, truck drivers are mostly focused on technological improvement to the existing conventional trucks.

The majority of the interviewees were forty-six or over for the driver group, while the twenty six-thirty five age range was the most populated for the experts (See Figure 34 and Figure 35). This finding causes us to think how the results would be for the future focused questions in relation to the different generational factors.

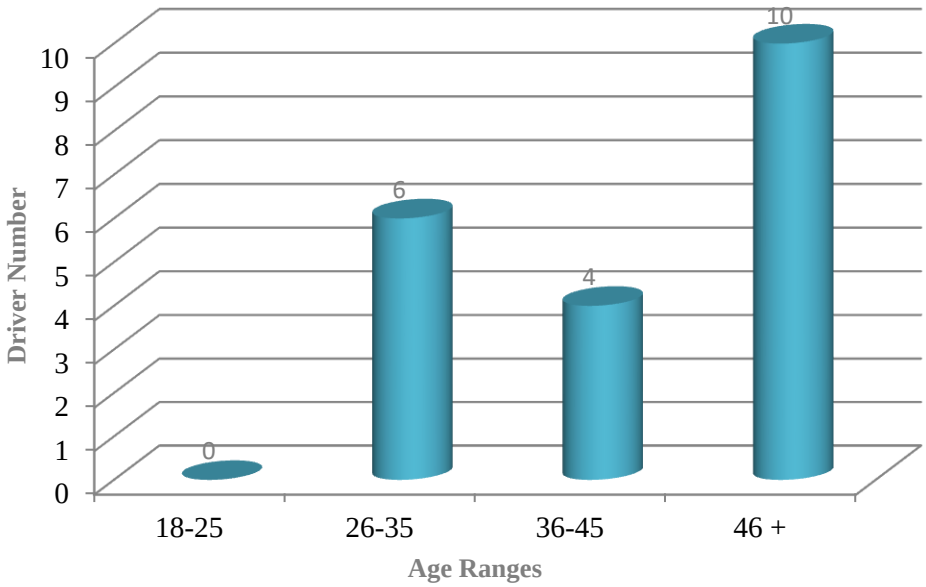


Figure 34. Truck Drivers' Age Range Graph according to interview results

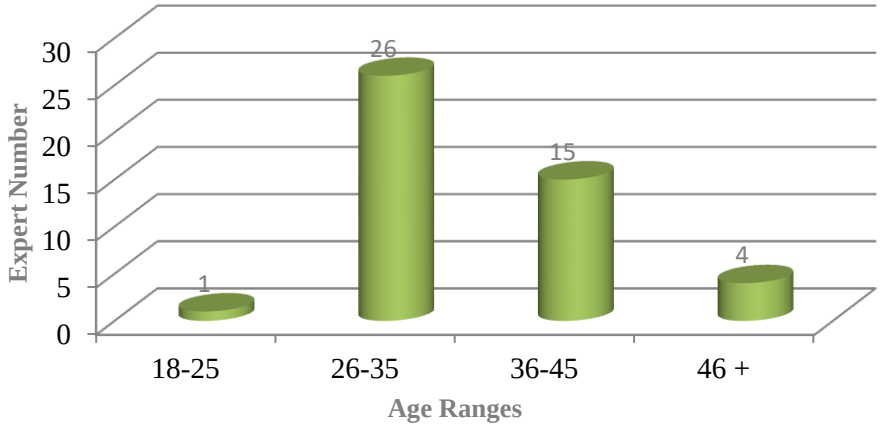


Figure 35. Experts' Age Range Graph according to interview results

Also, the differentiations in the age levels of the participants show that the excitement and enthusiasm levels could also be changeable, both for experts and designers, according to the given answers. The predictions about the work may change because of the incompatibility between expected working opportunities and real production systems or working conditions, even the user-product interaction is at the core of this topic.

It is observed thanks to the differences in the education levels of the participants for truck users, that education is not considered a key factor for personal and professional development. While for experts, it is mentioned and observed that because of the intense working hours and compressed project deadlines, further education provides some opportunities to the participants to gain developer experience and examination requirements (See Figure 36 and Figure 37).

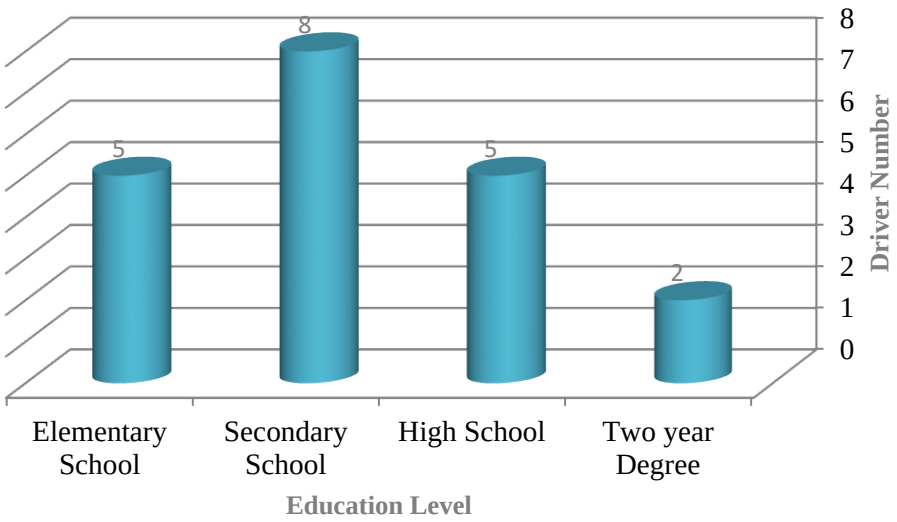


Figure 36. Truck Drivers Education Status Graph according to interview results

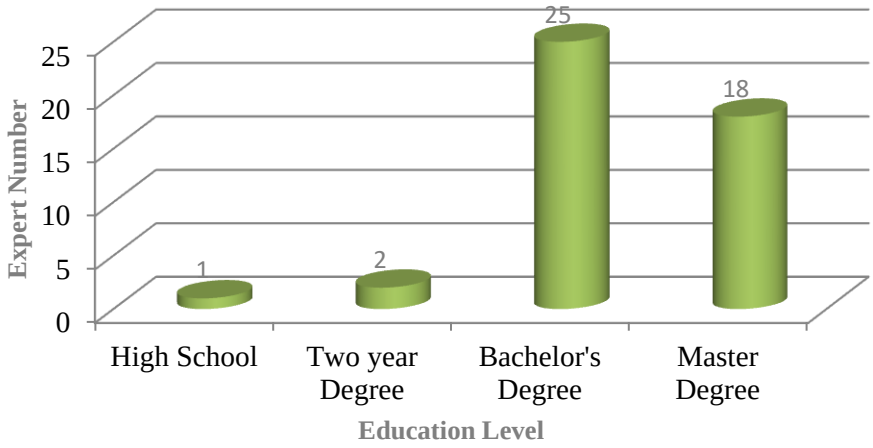


Figure 37. Experts' Education Status Graph according to interview results

Having the chance to experience any topic actively provides priceless teaching to anyone. For the automotive sector it is crucially important to observe and examine in detail physical, technical and design issues. In this context, the interview results show that, the experienced truck driver's way of handling a design related issue provides priceless and more equipped answers for the innovators. On the other hand, experts' increased experience levels provide multidirectional evaluation capabilities and sufficient blending of different subjects to create a common benefit. This feature is in parallel with each other as it is understood (See Figure 38 and Figure 39).

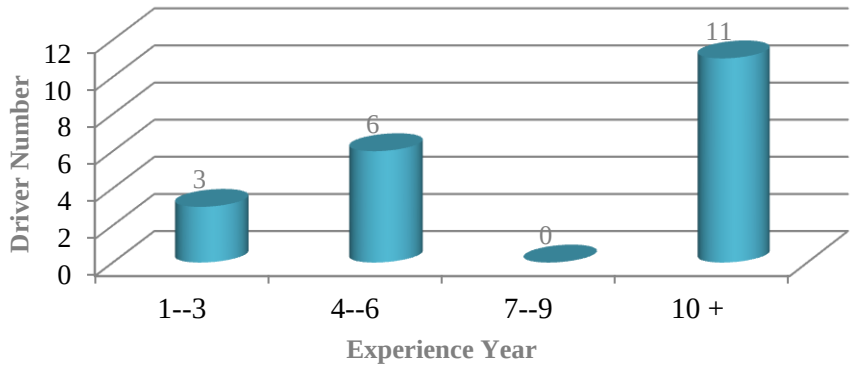


Figure 38. Truck Driving Experience according to interview results

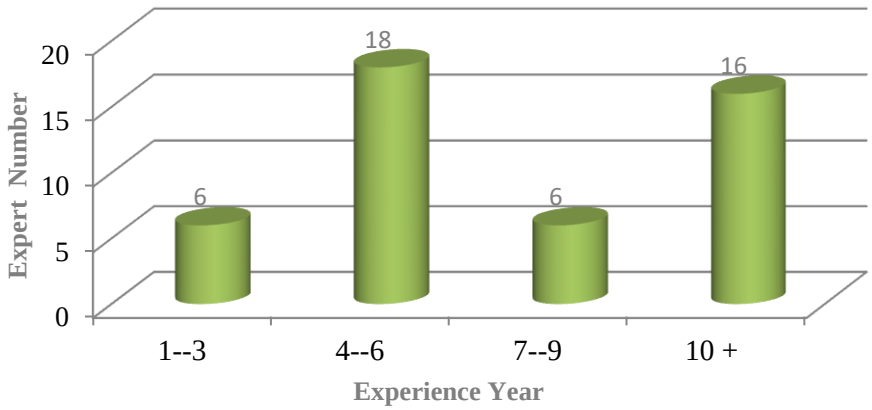


Figure 39. Automotive Sector Experience according to interview results

It is clearly understood after deatiled examination of the interview responses that both participant groups have an insight into the relationship between UCD and design even if they are not particulary aware of the terminology of the approach (See Figure 36 and Figure 37)

While approaching the topic, because of usage habit variations, each driver has an individual interpretation method even if the results are the same. This can be noted as a beneficial contribution for further studies.

The truck's interior is the living space for a truck driver while at the same time it acts as an office for them. The office needs to be safe as well as being comfortable. Moreover, the volume should allow for ease of access to any function while also making the driver feel special in it. As a user and an owner, a driver contends that he or she has the right to desire these factors. At this level of the evaluation industrial

designers, together with engineers should be responsible for answering these user-centered requirements.

Even though a few factors' percentages show some variations, according to the interview results, safety and comfort related items are becoming a topic of more concern for experts and drivers.

The foreign branded trucks' strengths are accepted by both of the participant groups, according to the interviews. Drivers and experts determine that the common brand "Volvo" is the most successful in terms of its trucks.

Safety of both the exterior and interior of the truck, driver usage ease, interior volume efficiency, clean and understandable style design, advanced technological features are the most important factors according to all participants.

Thanks to the autonomous driving and technology related questions in the interview, it can be said that existing truck users could not establish a bond with today's driving environment and habits, while experts have not yet accepted that these systems are inevitable for our future mobility.

From the perspective of truck drivers, a truck's interior should answer the users' wishes with great harmony and pleasure. Long distanced roads, environmental problems, negative external factors already have sufficient power to make their job harder so a truck should be like a home, both if it is conventional or autonomous.

CHAPTER 7: CONCLUSION

It is necessary to mention that according to the detailed literature review and their long-term automotive sector experience, truck drivers are not unconscious users as regards to other vehicles. According to the literature review, case study and professional interpretation for this research it could be said that the user-centered design approach and its integration into the trucks, not only in a physical sense but also into the 'brain' of the vehicle, is the most effective factor for achieving innovative, beneficial, and promising trucks. These essentials primarily take into consideration the user, who is being the truck driver in this study. User desires, necessities and usage habits should be crucial factors as reference points for the designers whether the vehicle is conventional or autonomous. It can be easily seen that the user's - the truck driver's - experiences and comments should be investigated to reveal the contributing design essentials for autonomous trucks.

Understandability, perceptibility, acceptability are some of the effective essentials for truck design, especially throughout the transformation period from conventional to autonomous trucks. It is well known by the designers and engineers that autonomous technology will enter our daily lives soon. But the current conditions' suitability, geographical preparations, roads, and other technical arrangements make it impossible to reach this technology in our country in the near future. Although it has some negative or uncertain areas, the advantageous and contributive factors transform it into a modern way for the new century's mobility approach.

When the past innovations and current vehicles are examined, today's existing conventional truck's guidance to new autonomous trucks would become more logical.

This study has provided an insight into the comparison between a vehicle user and designer. It is hard to find connective studies between industry and theory. This study will hopefully be an academic source for the future researchers who are carrying out examinations into the automotive industry, theoretical knowledge, conventional and autonomous trucks and the UCD approach. Thanks to the various researching methods used, its aim is to present a comprehensive study about conventional and autonomous trucks based on the UCD approach.

When the related literature was examined, it was hard to find interactive information and its interpretations according to different profile evaluations so that the approaching style of this research considered it as a contributory factor for further studies.

Thanks to the outputs and final evaluation of the method chapter, the study reveals that the past analysis processes and their transformation to present time could act as a guide to new autonomous adventure. The similarities, and also the differences, should be used as design and engineering inputs at various levels of the creation periods.

While the main subjects being investigated were focused on “UCD”, “UX” and “Usability” and the relationship between each of them, it was hard to find similar connective research which was based on the interaction of these supportive tools and their contributory impact on vehicle design. For example, while “UCD”, “UX” or “Usability” are mostly associated with computer sciences and development of digitalization (Vermeeren, Roto, and Väänänen, 2015), this study approaches these more as an assembler to the discipline.

As an answer to the main research question of this study “What can be learned from a user-centered design assessment of autonomous truck interior design in reference to conventional truck design?” it could be said that for truck drivers, the interior design of a truck is equally significant to the design of a house and must be as efficient. Also, UCD essentials directly serve to contribute to how this area would be designed in an effective way for drivers and while conventional trucks are today’s vehicles, autonomous trucks are likely to be our future mobility. The important point is to realize the common design essentials that are derived from UCD. Furthermore, usable, useful, desirable, accessible, credible, findable and valuable are elements of UCD that could be direct and beneficial sources for reaching consistent design and technology transformation between conventional and autonomous trucks. Finally, putting the user at the core of the design research requirement, as the primary doctrine for the future autonomous truck interior design approach just as it should be for conventional trucks too would be another essential answer to the question.

After the main question responses, the study found answers for the first sub-question: “What are the main differences and similarities between conventional and autonomous truck design in terms of user-centered design.”

Digitalization would be the most crucial factor in terms of the differences between conventional and autonomous trucks. While in conventional trucks, nearly all the instruments and commands like steering, braking, mirror control or menu navigation are controlled by drivers thanks to the physical equipment. However, in autonomous trucks these features are starting to be managed by the vehicle’s digitalized brain, depending on the level of autonomy. On the other hand, for the driver’s usage area, effectiveness is the most important factor to be considered both for conventional and autonomous trucks. What the user’s requirements, desires and evaluations are for better vehicles should be the common consideration for both truck types.

“What are the roles and effects of design for the transformation of conventional trucks to an autonomous structure in the context of user-centered design?” was the second sub-questions of the study and had satisfying answers after the research. Questioning ‘what is better?’ and ‘how would it be more effective?’ are the major considerations of design to provide and present innovative vehicles to its users. These inquiries are prior supporters for the transformation of conventional trucks to autonomous trucks. Also, design is given as the mediator between these two different types of equipment. Finding a path for presenting the new technology to its user in a sympathetic way, while at the same time creating potential commercial benefits of the vehicle are thought to be the primary roles for design.

Finally, in response to the last sub-question, “What is the feasibility of a relationship between existing sectoral factors and planned truck transportation development in the future?” according to the literature review, evaluation of the actual sector and the interview results, it would be true to said that autonomous integration into today’s existing transportation organization requires more time. Also, it is certain that this integration directly depends on the geographical location in which it is taking place. Technical features and the abilities of autonomy, environmental factors, regulations, and sector adaptation research are developing day by day. It does not make sense to deny that this technology will be the world’s new approach to mobility, but at the

same time it should be accepted that time is required to fully realize the true potential of autonomous vehicles.

The aim of this beneficial research is to provide more concrete evidence for industrial designers, engineers or any other discipline researchers who want to collect and evaluate truck industry facts and information on autonomous trucks and their interaction with traditional ones, thanks to the UCD approach.

This research can improve with further studies on “Autonomous technology integration according to geographical location”, “Users’ perception and approach to transformation from conventional to autonomous mobility” or “Differences and similarities between autonomous truck designers’ working methods in comparison to conventional truck designers’ methods”.

There is still much to learn regarding user-centered approaches in truck design. Not only are these technical issues, but also social and ethical ones that will need to be studied using multidisciplinary methodologies due to their complexity.

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APPENDICES

Appendix A – Drivers' Interview Questions

Appendix A includes the interviews questions and explanations which are conducted with "Truck Drivers" to collect data for this thesis. Totally twenty truck drivers are answered these questions as participants of this thesis.

Açıklama: İEÜ, Tasarım Çalışmaları Yüksek Lisans Programı kapsamında, Prof. Dr. Deniz Hasırcı danışmanlığında yürütülen Nimet Dilaver tarafından hazırlanan "Geleneksel Ve Otonom Kamyonda Kullanıcı Odaklı Tasarım Esasları" başlıklı tez kapsamında Kullanıcı Deneyimi konusunda on üç sorudan oluşan röportaj gerçekleştirilmektedir. Yanıtlar, akademik amaçlı ve isimler gizli tutularak değerlendirilecektir. Değerli katkılarınız için çok teşekkürler.

Katılımcı onayı (imza): -----

İsim:

İletişim Bilgileri:

Yaş:

18-25	**26-35**	**36-45**	**46+**

Kaç yıllık kamyon kullanım tecrübesine sahipsiniz:

1-3	**4-6**	**7-9**	**10+**

Mevcut Eğitim durumunuz:

İlkokul	
Orta Okul	
Lise	
Ön Lisans	
Lisans	
Yüksek Lisans (Mezun / Öğrenci)	
Doktora (Mezun / Öğrenci)	

Röportaj Soruları

Genel bilgiler:

1)Kullanıcı Odaklı Tasarım (Sürücüye Önem Veren Tasarım) kavramı hakkında bilginiz var mıdır? Var ise paylaşır mısınız? Bu kavramı araç kullanım süreçleriniz ile nasıl ilişkilendirirsiniz?

EVET	KARARSIZIM	HAYIR

Açıklama:

---

2) Kullanıcı Odaklı Tasarım (Sürücüye Önem Veren Tasarım) kavramı ve gerekliliklerini kamyon kullanım süreçlerinizde hangi sıklıkla uyguluyorsunuz/ entegre ediyorsunuz?

*Araç içi kullanım alanlarınızdan bahseder misiniz?

A. Hiç kullanmıyorum
B. Az sıklıkla kullanıyorum.
C. Kararsızım
D. Belirli sıklıklarla kullanıyorum.
E. Araç kullanım sürecimde birçok aşamada uyguluyorum.

Açıklama:

---

3) Bir kamyonu, tasarımı ve kullanımı açısından değerlendirdiğinizde, aşağıda yer alan Kullanıcı Odaklı Tasarım (Sürücüye Önem Veren Tasarım) yaklaşımı özellikleri, sizce 1'den 7'ye kadar artan önem sırasına göre, nasıl bir sıralamaya sahip olur? (1: en az öneme sahip özellik, 7:en çok öneme sahip özellik)

Yararlı	
Kullanışlı	
Bulunabilir	
Güvenilir	
Ulaşılabilir	
Çekici	
Değerli	

Açıklama:

---

4) Kullanıcı Odaklı Tasarım (Sürücüye Önem Veren Tasarım) kavram ve içeriğinin kamyon tasarımı üzerinde etkisi sizce var mıdır? Lütfen cevabınız doğrultusunda açıklama yapınız.

EVET	KARARSIZIM	HAYIR

Açıklama:

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5) Kullanıcı Odaklı Tasarımın (Sürücüye Önem Veren Tasarım) kavramı ve özelliklerini, aşağıda sıralanan Kamyon iç tasarım alanları özelinde, size uygun gelecek şekilde 1'den 6'ya kadar değerlendirebilir misiniz?

A	Sürücü koltuğu konforu	
B	Saklama alan yeterliliği	
C	Gösterge panosunun ulaşılır ve anlaşılabilir olması	
D	İç mekânın kişiselleştirmeye uygun oluşu	
E	Araç iç tasarımındaki malzeme kalitesi	
F	İç güvenlik önlemleri	

6) Hangi marka kamyonları, hangi yönlerini beğendiğiniz için tercih edersiniz?

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7) Yerli markalar ile yabancı marka kamyonları kıyaslarsak yorumlarınız nasıl olur? (Hangi markalar, hangi özellikleri nedeniyle sizin için önde gelmektedir? Lütfen açıklayınız.)

---

8) Sizce on sene içerisinde kamyon taşımacılığı sektöründe hangi gelişmeler ön planda olacak?

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9) Otonom araçlar hakkında bilginiz var mı?

Hiç bilgim yok	Az bilgiye sahibim	Kararsızım	Bilgim var	Gelişmeleri takip ediyorum

*Yok, ise; genel bir bilgilendirme dosyası ve kısa videolar ile anlatım yapılır, takiben soruya devam edilir:

---

10) Bugünkü profesyonel iş hayatınızdan, otonom araç sistemine geçildiğinde sizce neler en çok değişime uğrayacaktır? (Tasarım süreci, Eğitim, Toplumsal, Etik kıstaslar vb)

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11) Mercedes ve Volvo markalarından iki adet otonom araç konsept görselleri paylaşılır, ardından genel yorumlarınız nedir?

---

12) BMC araçlarının tasarımları hakkındaki yorumlarınız nelerdir? Kullanıcı Odaklı Tasarımın (Sürücüye Önem Veren Tasarım) araçlar üzerinde etkisi sizce nedir?

---

13 BMC markasının otonom araç tasarlaması konusunda yorumlarınız ne olur?

Değerli katkılarınız için çok teşekkürler.

Açıklamalar

- Kullanıcı Odaklı Tasarım (Sürücüyü Öncelik Veren) Nedir?

"Kullanıcı Odaklı Tasarım" tasarımcının tüm tasarım süreci aşamalarında, kullanıcılara ve onların ihtiyaçlarına odaklandığı, tekrara dayalı bir tasarım sürecidir.

"Kullanıcı Odaklı Tasarım'da" tasarımcılar oldukça kullanışlı ve ulaşılabilir ürünler meydana getirmek için, kullanıcıları çeşitli araştırma ve tasarım teknikleri ile tasarım sürecine dâhil eder.

Kullanıcı Odaklı Tasarım süresinde tasarımcı, en talep edilen ve ihtiyacı karşılayan tasarıma ulaşabilmek için, kullanıcıların direk katılımcı olarak yer aldığı, birçok araştırma ve deneme-yanılma yöntemi sayesinde, doğru ve yönlendirici bilgilere ulaşmaya çalışır, bu süreç "Tekrarlayan Tasarım Sürecidir."

"Kullanıcı Odaklı Tasarım" tasarım düşüncesine uygun olarak tasarlanmış bir ürün, şu özelliklere sahip olmalıdır.

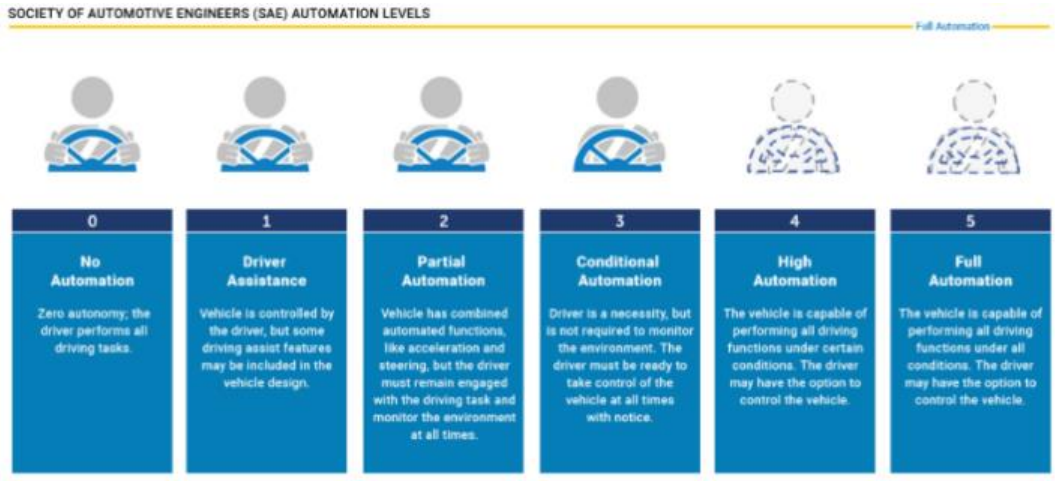
- "Kullanıcı Odaklı Tasarım" kavramını daha anlaşılır kılmak adına sektörümüzden bir örneklendirme yaparsak:

Bir tasarımcıya proje tanımı için “araç tasarımı” talebi ile gidildiğinde, tasarımcı, geniş kapsamlı beklenti kitlesine sahip olan bu talebe, en doğru şekilde cevap verebilmek adına, aracın kullanıcı profillerini; birbirinden farklı özelliklere sahip, birçok “hedef kitle” grubu kurarak oluşturur. Birbirinden farklı bu sürücü gruplarının; araçtan beklentileri, istek ve ihtiyaçları, ortaklaştırılabilinen en uygun seviyede bir araya getirilecek ve sonuç olarak, geniş bir kitleye hizmet verecek araç talebi için, tasarım girdileri oluşturacaktır.

Tasarımcıya gelen bu araç talebi, “kamyon tasarımı” şeklinde özelleştiğinde, tasarımcı birçok kullanıcı profili arasından, “kamyon kullanıcısı” üzerine odaklanacaktır. İlgili “hedef kitle” çalışmaları, araştırmalar ve dene-yanıl yöntemi ile tekrarlayan süreç, bu doğrultuda yapılacak ve kamyon kullanıcısının; istek, ihtiyaç, beklenti ve ilgili tüm talepleri detaylı şekilde araştırılacaktır. Bu doğrultuda yapılan araştırma ve çalışmaların çoğunluğu “Kullanıcı Odaklı Tasarım” kavramı çatısı altında toplanmaktadır.

-Otonom Araç Nedir?

Sınıflandırma sistemi ilk olarak 2014 yılında SAE International tarafından oluşturulmuştur. Yayınlanan J3016: ‘ Taxonomy and Definition for Term Related to On-Road Motor Vehicle Automated Driving Systems’ standardı altı seviye otonom sürüş seviyesi tanımı içermektedir ve mevcut endüstri uygulamalarıyla tutarlı olan bir sınıflandırma sistemidir. Bu sınıflandırmanın merkezinde, sürücünün ve otonom sürüş sistemlerinin birbirleri ile ilişkili roller ve sorumlulukları bulunmaktadır.



Şekil 1. SAE Otonom Taşıt Seviyelendirmesi

Sınflandırma sistemi, sürücünün taşıt üzerindeki görevlerinin(DDT) otonom sürüş sistemleri tarafından değiştirmesi temeline dayanmaktadır. Sürücü-Destek sistemleri de, sürücünün taşıt üzerindeki görevlerinden(DDT) birini ve/veya birkaçını, devamlı ya da gerekli durumlarda gerçekleştiren, 1'den 5'e kadar olan seviyelerden birine denk gelmektedir.

0. Seviye – Otonomi Yok

Günlük bir otomobili ifade eder. Sürücü, direksiyon, hızlanma ve frenleme de dahil olmak üzere tüm işlemleri gerçekleştirir ve araçta hiçbir otonomi veya otomatik sürüş kontrolü yoktur. Pratik olarak her yol aracı seviye sıfır otonomi sunar.

1. Seviye – Sürücü Asistanı

Sürücü bu seviyede taşıt hakimiyetinden sorumludur. Sürücünün dinamik görevlerinden (DDT) yanal veya boylamsal taşıt hareketlerin kontrolünün bir sürüş otomasyon sistemi tarafından yürütülmesidir.

2. Seviye – Kısmi Otomasyon

Kısmi otomasyonda, sürücülerin bazı sürüş fonksiyonlarından ayrılmasını sağlar. İkinci seviye taşıtlarda fonksiyonlar direksiyon, hızlanma, frenleme ve hız koruma gibi işlevlere yardımcı olabilir, ancak sürücülerin hala iki elinin de direksiyonda olması ve gerekirse kontrolü almaya hazır olmaları gerekir. Sürücünün alt görevlerinden olan Nesne ve Olayı Algılayıp Cevap Verme (OEDR) sorumluluğunu da mevcut otonomi sistemi ile yerine getirmedir.

3. Seviye: Şartlı Otomasyon

Koşullu otomasyon, sürücülerin arkasına yaslanmasına ve otomobilin tüm sürüşü yapmasına izin verir. Seviye 3 araçların çoğu, 60 km / s'den daha düşük bir hızda sürüldüğünde hiçbir insan müdahalesine gerek duymaz. Sistemin sürücünün hala direksiyon başında olduğundan emin olmak için direksiyona belirli aralıklarla temas etmesi istenmektedir.

4. Seviye: Yüksek Otomasyon

Dördüncü seviye taşıtlar, kendi başlarına yönlendirme, hızlanma ve frenleme kapasitesine sahiptir. Ayrıca yol koşullarını izleyebilir ve şeritlere ne zaman dönüleceğini ve ne zaman değiştirileceğini belirleyerek yoldaki engellere cevap verebilirler. Dördüncü seviye otonom sürüş ancak yol koşulları ideal olduğunda etkinleştirilebilir. Sürücüden herhangi bir müdahale isteğine yanıt verme beklentisi olmadan tüm dinamik sürücü görevlerini otonomi sistemine özgü yerine getirebilir.

5. Seviye: Tam Otomasyon

Beşinci seviye otonom sürüş için insan etkileşimi gerekmez. Taşıtlar, trafik sıkışıklığı gibi yol koşullarına göre yönlendirebilir, hızlandırabilir, frenleyebilir ve izleyebilir. Temel olarak beşinci seviye otomasyonda, sürücünün otomobilin işlevlerine herhangi bir dikkat göstermeden arkasına yaslanıp rahatlamasını sağlar. Yani, sürücünün herhangi bir müdahale isteğine yanıt verme beklentisinde olmadan, sürekli ve koşulsuz bir şekilde seyire devamı sağlayan otonomi seviyesidir

Kaynaklar:

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Appendix B – Experts' Interview Questions

Appendix B includes the interviews questions and explanations which are conducted with "Automotive Experts" to collect data for this thesis. Totally forty six participants: industrial designers, engineers and design specialists are answered these questions as participants of this thesis.

Açıklama: İEÜ, Tasarım Çalışmaları Yüksek Lisans Programı kapsamında, Prof. Dr. Deniz Hasırcı danışmanlığında yürütülen Nimet Dilaver tarafından hazırlanan "Geleneksel Ve Otonom Kamyonda Kullanıcı Odaklı Tasarım Esasları" başlıklı tez kapsamında Kullanıcı/Tasarımcı Deneyimi konusunda on üç sorudan oluşan röportaj gerçekleştirilmektedir. Yanıtlar, akademik amaçlı ve isimler gizli tutularak değerlendirilecektir. Değerli katkılarınız için çok teşekkürler.

Katılımcı onayı (imza): -----

İsim:

İletişim Bilgileri:

Çalıştığınız Bölüm/ Göreviniz:

Yaş:

18-25	**26-35**	**36-45**	**46+**

Kaç yıllık otomotiv sektör tecrübesine sahipsiniz:

1-3	4-6	7-9	10+

Mevcut Eğitim durumunuz:

İlkokul	
Orta Okul	
Lise	
Ön Lisans	
Lisans	
Yüksek Lisans (Mezun / Öğrenci)	
Doktora (Mezun / Öğrenci)	

Röportaj Soruları

Genel bilgiler:

1) "Kullanıcı Odaklı Tasarım" kavramı hakkında bilginiz var mıdır? Var ise paylaşır mısınız? Bu kavramı proje tasarımlarınızda/ aşamalarınızda ki hangi süreçler ile ilişkilendirirsiniz?

EVET	KARARSIZIM	HAYIR

Açıklama:

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*Sonraki sorulara devam etmeden, "Kullanıcı Odaklı Tasarım" kavramı ile ilgili temel bilgilendirme metnine, dosya sonunda ki "Açıklamalar" bölümünden ulaşıp, inceleyebilirsiniz.

2) “Kullanıcı Odaklı Tasarım” kavramı ve gerekliliklerini, kamyon tasarım/ değerlendirme süreçlerinizde hangi sıklıkla kullanıyorsunuz?

F. Hiç kullanmıyorum
G. Sadece Projeye başlarken kullanıyorum
H. Kararsızım
İ. Belirli sıklıklarla, farklı proje aşamalarında kullanıyorum.
J. Tüm proje tasarım sürecinde kullanıyorum

*Kamyon tasarım projelerinde, “Kullanıcı Odaklı Tasarımın” dahil olduğu proje aşamalarından ve süreçlerinden bahseder misiniz? (Cevap A ise, dahil olabileceğinizi düşündüğünüz aşamalardan bahsediniz.)

Açıklama:

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3) Bir Kamyon Tasarım Projesi üzerinde çalışırken, aşağıda yer alan "Kullanıcı Odaklı Tasarım" yaklaşımı özellikleri, sizce 1'den 7'ye kadar, artan önem sırasına göre, nasıl bir sıralama ile proje tanımında yer almalıdır? (1: en az öneme sahip özellik, 7:en çok öneme sahip özellik)

Yararlı	
Kullanışlı	
Bulunabilir	
Güvenilir	
Ulaşılabilir	
Çekici	
Değerli	

Açıklama:

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4) ”Kullanıcı Odaklı Tasarım” kavram ve içeriğinin, kamyon tasarımı üzerinde etkisi sizce var mıdır? Lütfen cevabınız doğrultusunda açıklama yapınız.

EVET	KARARSIZIM	HAYIR

Açıklama:

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5) Kullanıcı Odaklı Tasarım kavramı ve özelliklerini, aşağıda sıralanan Kamyon İç Tasarım alanları özelinde, kavramın en yoğun ve önem teşkil eden şekilde kullanılacağı düşündüğünüz haliyle, 1’den 6’ya kadar değerlendirebilir misiniz? (1: en az öneme sahip alan, 7:en çok öneme sahip alan)

A	Sürücü koltuğu konforu	
B	Saklama alan yeterliliği	
C	Gösterge panosunun ulaşılır ve anlaşılabilir olması	
D	İç mekânın kişiselleştirmeye uygun oluşu	
E	Araç iç tasarımındaki malzeme kalitesi	
F	İç güvenlik önlemleri	

6) Hangi marka kamyonları, hangi yönlerini beğendiğiniz için tercih edersiniz?

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7) Yerli markalar ile yabancı marka kamyonları kıyaslarsak yorumlarınız nasıl olur? (Hangi markalar, hangi özellikleri nedeniyle sizin için önde gelmektedir? Lütfen açıklayınız.)

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8) Sizce on sene içerisinde kamyon taşımacılığı sektöründe hangi gelişmeler ön planda olacak?

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9) Otonom araçlar hakkında bilginiz var mı?

Hiç bilgim yok	Az bilgiye sahibim	Kararsızım	Bilgim var	Gelişmeleri takip ediyorum

*Yok, ise; “Otonom” araç sistemi ile ilgili genel bilgilendirme metnine, dosya sonunda ki “Açıklamalar” bölümünden ulaşıp, inceleyebilirsiniz.

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10) Bugünkü profesyonel iş hayatınızdan, otonom araç sistemine geçildiğinde sizce neler en çok değişime uğrayacaktır? (Tasarım süreci, Eğitim, Toplumsal, Etik kıstaslar vb)

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11) Mercedes ve Volvo markalarına ait, otonom araç konsept görsel ve videoları paylaşılır, ardından genel yorumlarınız nedir?

Video linkleri:

https://www.youtube.com/watch?v=XZxZC0lgOlc

https://www.youtube.com/watch?v=eQ5tUI1xW8E

https://www.youtube.com/watch?v=m4wLPfOz-c4

https://www.youtube.com/watch?v=2Gc1zz5bl8I

Video linkleri:

https://www.youtube.com/watch?v=VTm8zM0qwGE&list=PLKFJ3tQvdojTctKz6YV4FbAMywleLc1b7&index=10

https://www.youtube.com/watch?v=uOpjtz0Hluo&list=PLKFJ3tQvdojTctKz6YV4FbAMywleLc1b7&index=24

https://www.youtube.com/watch?v=CMREUiQZSIs

11) BMC araçlarının tasarımları hakkındaki yorumlarınız nelerdir? “Kullanıcı Odaklı Tasarımın” araçlar üzerinde etkisi sizce nedir?

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12) BMC markasının otonom araç tasarlaması konusunda yorumlarınız ne olur?

Değerli katkılarınız için çok teşekkürler.

Açıklamalar

- Kullanıcı Odaklı Tasarım Nedir?

"Kullanıcı Odaklı Tasarım" tasarımcının tüm tasarım süreci aşamalarında, kullanıcılara ve onların ihtiyaçlarına odaklandığı, tekrara dayalı bir tasarım sürecidir.

"Kullanıcı Odaklı Tasarım 'da" tasarımcılar oldukça kullanışlı ve ulaşılabilir ürünler meydana getirmek için, kullanıcıları çeşitli araştırma ve tasarım teknikleri ile tasarım sürecine dâhil eder.

Kullanıcı Odaklı Tasarım süresinde tasarımcı, en talep edilen ve ihtiyacı karşılayan tasarıma ulaşabilmek için, kullanıcıların direk katılımcı olarak katıldığı, birçok araştırma ve deneme yanılma yöntemi sayesinde doğru ve yönlendirici bilgilere ulaşmaya çalışır, bu süreç "Tekrarlayan Tasarım Sürecidir."

"Kullanıcı Odaklı Tasarım" tasarım düşüncesine uygun olarak tasarlanmış bir ürün, şu özelliklere sahip olmalıdır.

- "Kullanıcı Odaklı Tasarım" kavramını daha anlaşılır kılmak adına sektörümüzden bir örneklendirme yaparsak:

Bir tasarımcıya proje tanımı için "araç tasarımı" talebi ile gidildiğinde, tasarımcı, geniş kapsamlı beklenti kitlesine sahip olan bu talebe, en doğru şekilde cevap verebilmek adına, aracın kullanıcı profillerini; birbirinden farklı özelliklere sahip, birçok "hedef kitle" grubu kurarak oluşturur. Birbirinden farklı bu sürücü gruplarının; araçtan beklentileri, istek ve ihtiyaçları, ortaklaştırılabilinen en uygun seviyede bir araya getirilecek ve sonuç olarak, geniş bir kitleye hizmet verecek araç talebi için, tasarım girdileri oluşturacaktır.

Tasarımcıya gelen bu araç talebi, "kamyon tasarımı" şeklinde özelleştiğinde, tasarımcı birçok kullanıcı profili arasından, "kamyon kullanıcısı" üzerine odaklanacaktır. İlgili "hedef kitle" çalışmaları, araştırmalar ve dene-yanıl yöntemi ile tekrarlayan süreç, bu doğrultuda yapılacak ve kamyon kullanıcısının; istek, ihtiyaç, beklenti ve ilgili tüm talepleri detaylı şekilde araştırılacaktır. Bu doğrultuda yapılan araştırma ve çalışmaların çoğunluğu "Kullanıcı Odaklı Tasarım" kavramı çatısı altında toplanmaktadır.

İlgili kaynaklar:

https://www.userspots.com/rehber/kullanici-odakli-tasarim-surecleri

https://www.interaction-design.org/literature/topics/user-centered-design

-Otonom Araç Nedir?

Sınıflandırma sistemi ilk olarak 2014 yılında SAE International tarafından oluşturulmuştur. Yayınlanan J3016: ' Taxonomy and Definition for Term Related to On-Road Motor Vehicle Automated Driving Systems' standartı altı seviye otonom sürüş seviyesi tanımı içermektedir ve mevcut endüstri uygulamalarıyla tutarlı olan bir sınıflandırma sistemidir [5]. Bu sınıflandırmanın merkezinde, sürücünün ve otonom sürüş sistemlerinin birbirleri ile ilişkili roller ve sorumlulukları bulunmaktadır.

Video linkleri:

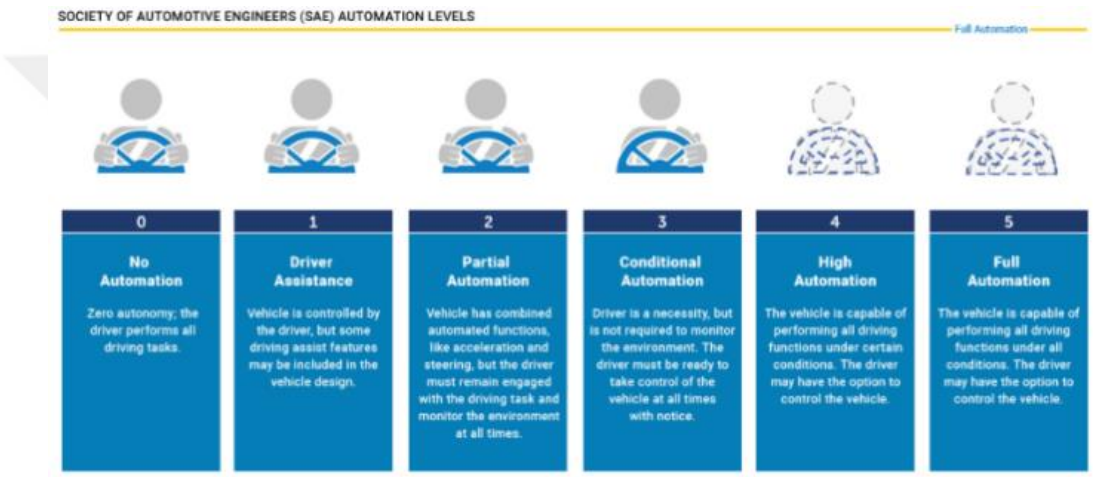
https://www.endustri40.com/surucusuz-otonom-araclar/

https://blog.toyota.com.tr/otonom-arac-nedir-nasil-calisir/

https://www.youtube.com/watch?v=HgF7E5q9sU4

https://www.youtube.com/watch?v=bicNe6onq5Q&feature=emb_logo

https://www.fia.com/autonomous-vehicles



SAE Otonom Taşıt Seviyelendirmesi

Sınıflandırma sistemi, sürücünün taşıt üzerindeki görevlerinin(DDT) otonom sürüş sistemleri tarafından değiştirmesi temeline dayanmaktadır. Sürücü-Destek sistemleri de, sürücünün taşıt üzerindeki görevlerinden(DDT) birini ve/veya birkaçını, devamlı ya da gerekli durumlarda gerçekleştiren, 1'den 5'e kadar olan seviyelerden birine denk gelmektedir.

0. Seviye – Otonomi Yok

Günlük bir otomobili ifade eder. Sürücü, direksiyon, hızlanma ve frenleme de dahil olmak üzere tüm işlemleri gerçekleştirir ve araçta hiçbir otonomi veya otomatik sürüş kontrolü yoktur. Pratik olarak her yol aracı seviye sıfır otonomi sunar.

1. Seviye – Sürücü Asistanı

Sürücü bu seviyede taşıt hakimiyetinden sorumludur. Sürücünün dinamik görevlerinden (DDT) yanal veya boylamsal taşıt hareketlerin kontrolünün bir sürüş otomasyon sistemi tarafından yürütülmesidir.

2. Seviye – Kısmi Otomasyon

Kısmi otomasyonda, sürücülerin bazı sürüş fonksiyonlarından ayrılmasını sağlar. İkinci seviye taşıtlarda fonksiyonlar direksiyon, hızlanma, frenleme ve hız koruma gibi işlevlere yardımcı olabilir, ancak sürücülerin hala iki elinin de direksiyonda olması ve gerekirse kontrolü almaya hazır olmaları gerekir. Sürücünün alt görevlerinden olan Nesne ve Olayı Algılayıp Cevap Verme (OEDR) sorumluluğunu da mevcut otonomi sistemi ile yerine getirmedir .

3. Seviye: Şartlı Otomasyon

Koşullu otomasyon, sürücülerin arkasına yaslanmasına ve otomobilin tüm sürüşü yapmasına izin verir. Seviye 3 araçların çoğu, 60 km / s'den daha düşük bir hızda sürüldüğünde hiçbir insan müdahalesine gerek duymaz. Sistemin sürücünün hala direksiyon başında olduğundan emin olmak için direksiyona belirli aralıklarla temas etmesi istenmektedir.

4. Seviye: Yüksek Otomasyon

Dördüncü seviye taşıtlar, kendi başlarına yönelendirme, hızlanma ve frenleme kapasitesine sahiptir. Ayrıca yol koşullarını izleyebilir ve şeritlere ne zaman dönüleceğini ve ne zaman değiştirileceğini belirleyerek yoldaki engellere cevap verebilirler. Dördüncü seviye otonom sürüş ancak yol koşulları ideal olduğunda etkinleştirilebilir. Sürücüden herhangi bir müdahale isteğine yanıt verme beklentisi olmadan tüm dinamik sürücü görevlerini otonomi sistemine özgü yerine getirebilir.

5. Seviye: Tam Otomasyon

Beşinci seviye otonom sürüş için insan etkileşimi gerekmez. Taşıtlar, trafik sıkışıklığı gibi yol koşullarına göre yönlendirebilir, hızlandırabilir, frenleyebilir ve izleyebilir. Temel olarak beşinci seviye otomasyonda, sürücünün otomobilin işlevlerine herhangi bir dikkat göstermeden arkasına yaslanıp rahatlamasını sağlar.

Yani, sürücünün herhangi bir müdahale isteğine yanıt verme beklentisinde olmadan, sürekli ve koşulsuz bir şekilde seyire devamı sağlayan otonomi seviyesidir.

Kaynaklar:

- SAE J3016, (2018). Taxonomy and Definition for Terms Related to Driving Automation System for On-Road Motor Vehicle. Society of Automotive Engineers (SAE).
- NHTSA, (2020) *Automated Vehicles for Safety*. (https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety).

Appendix C – Photos with Truck Driver Interview Participants

Photos with “Truck Drivers” participant in BMC Otomotiv Sanayi ve Ticaret A.S..