ENHANCED NAVIGATIONAL USER INTERFACE EXPERIENCE IN MOTORCYCLE HELMET DESIGN

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for a Master of Design degree.

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ABSTRACT

ENHANCED NAVIGATIONAL USER INTERFACE EXPERIENCE IN MOTORCYCLE HELMET DESIGN

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Design Studies Master's Program

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The helmet is the single most critical piece of motorcycle safety for motorcycle users, and technology advances day by day to develop smart helmets. The technology that makes smart helmets life-critical is improving day by day. This thesis analyzes the user experience in the face of technological designs when we examine advanced navigation equipment in motorcycle helmet design. In this study, various sources have been used including, literature reviews, internet forums, internet questionnaires, and first-hand experiences with the motor riders. In the mixed survey method we use, we have made face-to-face interviews as well as using the internet survey. A sufficient number of participants were reached by a random sampling method. The study was carried out in two stages. In the first stage, 150 people participated in the online survey. In the second stage, a connection was established for in-depth interviews with the participants. The survey results show that users can achieve more satisfactory results if they adjust their smart helmets themselves. Among these settings, there are many details from image brightness to selection of

settlements. In this adjustment skill, where the primary criterion should be to maintain the standards, it is offered as an advantage to examine the interface designs of the game simulations and to identify the graphics that distract the perception.

Keywords: Smart helmet, navigation, motorcycle, user experience

ÖZET

MOTOSİKLET KASK TASARIMINDA GELİŞMİŞ NAVİGASYON KULLANICI ARAYÜZ DENEYİMİ

Velidedeoğlu, Turgut Kaan

Tasarım Çalışmaları Yüksek Lisans Programı

Tez danışmanı: Dr. Öğr. Üyesi Ahmet Can ÖZCAN

Ağustos, 2020

Motosiklet kullanıcıları için yaşamsal önemi olan kaskları, akıllı hale getiren teknoloji günden güne gelişme kaydetmektedir. Bu tez; motosiklet kask tasarımında gelişmiş navigasyon donanımını incelediğimizde, teknolojik tasarımlardaki incelikler karşısında kullanıcı deneyimini ortaya koymayı amaçlamaktadır. Bu çalışmada literatür incelemeleri, internet forumları, internet anketleri ve motor sürücülerine yönelik ilk elden deneyimler dahil olmak üzere çeşitli kaynaklar kullanılmıştır. Karma anket yönteminde internet anketini kullanmanın yanı sıra, yüz yüze görüşmeler yapılmıştır. İki aşamada gerçekleştirilen ankette rastgele örnekleme yöntemi ile yeterli sayıda katılımcıya ulaşılmıştır. İlk aşamada, çevrimiçi ankete 150 kişi katılmıştır. İkinci aşamada, katılımcılarla derinlemesine görüşmelerde bulunulmuştur. Anket sonuçları göstermektedir ki; kullanıcılar, akıllı kasklarındaki ayarları kendileri yapmaları halinde daha tatmin edici sonuçlara ulaşmaktadır. Bu ayarlar arasında görüntü parlaklığından, yerleşim noktası seçimine kadar pek çok detay bulunmaktadır. Öncelikli kriterin standartları korumak olması gereken bu

ayarlama becerisinde, oyun simülasyonlarının arayüz tasarımları incelenmesi; algıyı dağıtan grafiklerin saptanmasında bir avantaj olması çözüm olarak sunulmaktadır.

Anahtar Kelimeler: Akıllı kask, navigasyon, motorsiklet, kullanıcı deneyimi

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CHAPTER I: GENERAL PRINCIPLES

1.1 Introduction

In this day and age, the innovative design and development concept that exists in the automotive industry makes itself felt in the motorcycle world. Along with the engine, aerodynamics, chassis, and technological advances, motorcycle designs, especially helmet designs, have become more and more remarkable. Helmets are designed to address the needs of all users traveling on motorcycles for short or long distances. These motorcycle helmets are a blend of quality material and excellent design, with safety, comfort, and comfortable handling and standarts. Catalog models of the helmet are presented in a wide range. Each model has product ranges suitable for all kinds of needs.

The technology offers more attractive options day by day to attract motorcycle user's attention and now taking shape overall future smart helmet designs. It points out that it is difficult to use the navigation on motorcycles, and the road information is reflected in the field of view on the helmet of the rider, making it easy to see the road.

1.2 Aim

The world's largest motorcycle companies, which set off with the slogan of "smart motorcycle helmet", promise a safer and more comfortable ride for motorcycle riders. The new generation motorcycle helmet is preparing to change the driving habits with its great technological features.

This thesis aims to highlight this change and introduce Enhanced Navigational User Interface Experience in Motorcycle Helmet Design. By evaluating the opinions of motorcycle drivers about the smart motorcycle helmet, this thesis examines the issues of "determining the points that are important in the development of the smart motorcycle helmet, compiling the errors and deficiencies determined by the users, and determining the demands and needs of the users by considering the user type and behavior."

1.3 Research Objectives

The research objectives in this thesis are shown below:

- Determining the effect of user's driving habits on the choice of motorcycle and motorcycle helmet types,
- Determination of the factors affecting the sensory organs of the driver during the use of motorcycles,
- Examination of the communication with the driving elements and passengers during motorcycle riding,
- Comparison of the field surrounding the sensory organs of the driver and the indicator equipment with different vehicles while driving,
- Determination of the advantages of Internet-of-Things (IoT) systems added to motorcycle helmet,
- Investigation of user experience in the use of IoT systems to be integrated into motorcycle helmets,
- Evaluating the consistency of the received data against the reintroduction of IoT systems positioned with reference to the user experience.

1.4 Methodology

In this study, various sources and methods have been used including, literature reviews, internet forums, internet questionnaires, and first-hand experiences with the motor riders. The method we used to detect and analyze the experience Enhanced Navigational User Interface Experience in Motorcycle Helmet Design was a mixed survey application and methods. The questionnaire is a way for a researcher to collect information about people's feelings, thoughts, and tendencies on the topic. In the mixed survey method we use, we have made face-to-face interviews as well as using the internet survey. A sufficient number of participants were reached by a random sampling method. The study was carried out in two stages. In the first stage, 150 people participated in the online survey. In the second stage, a connection was established for in-depth interviews with the participants. The researcher also took short notes during interviews to capture important points.

To understand the Turkish rider's user experience, a qualitative approach with acceptance of quantitative data research is available. Motorcycle websites and forum pages are essential resources to understand the expectations of experienced riders who have acquired the user experience in different regions.

The questionnaire is composed of 42 questions within three categories by the content relevant to the subject of the thesis. These categories are demographic questions, factual questions, and attitude questions. Descriptive information about the respondent was provided in demographic questions. Information on gender, age, and education level was obtained. Factual questions were asked about behavioral habits, lifestyle, and mastery of life. In the attitude questions, respondents were asked about their attitudes, opinions, habits, and perceptions about smart helmet experience.

1.5 Research Questions

The research questions about the topic are shown below:

- Assessment of the effect of distraction factor in causing traffic accidents,
- How to examine general visual distraction of the positioning of audible and visual stimuli and user feedback,
- How the audible and written indicators affect the driver's attention while driving from the perspective of user experience?
- Can design standards be created in the light of data collected from users' experience so that visual and audio notifications integrated into the motorcycle helmet inform the user in a way that minimizes the attention factor of the user?

1.6. Frame

According to the research method presented in the above chapter, the structure of the thesis is presented in Figure 1.1. Accordingly, the thesis is structured into two main chapter: foundations and research areas. In the foundation chapter, examination of motorcycle helmet types and relationship between motorcycle helmet and driving area of different types of vehicles are presented. In the research chapter, what is done in accordance with the method presented above is presented. The thesis is completed with the presentation of the results.

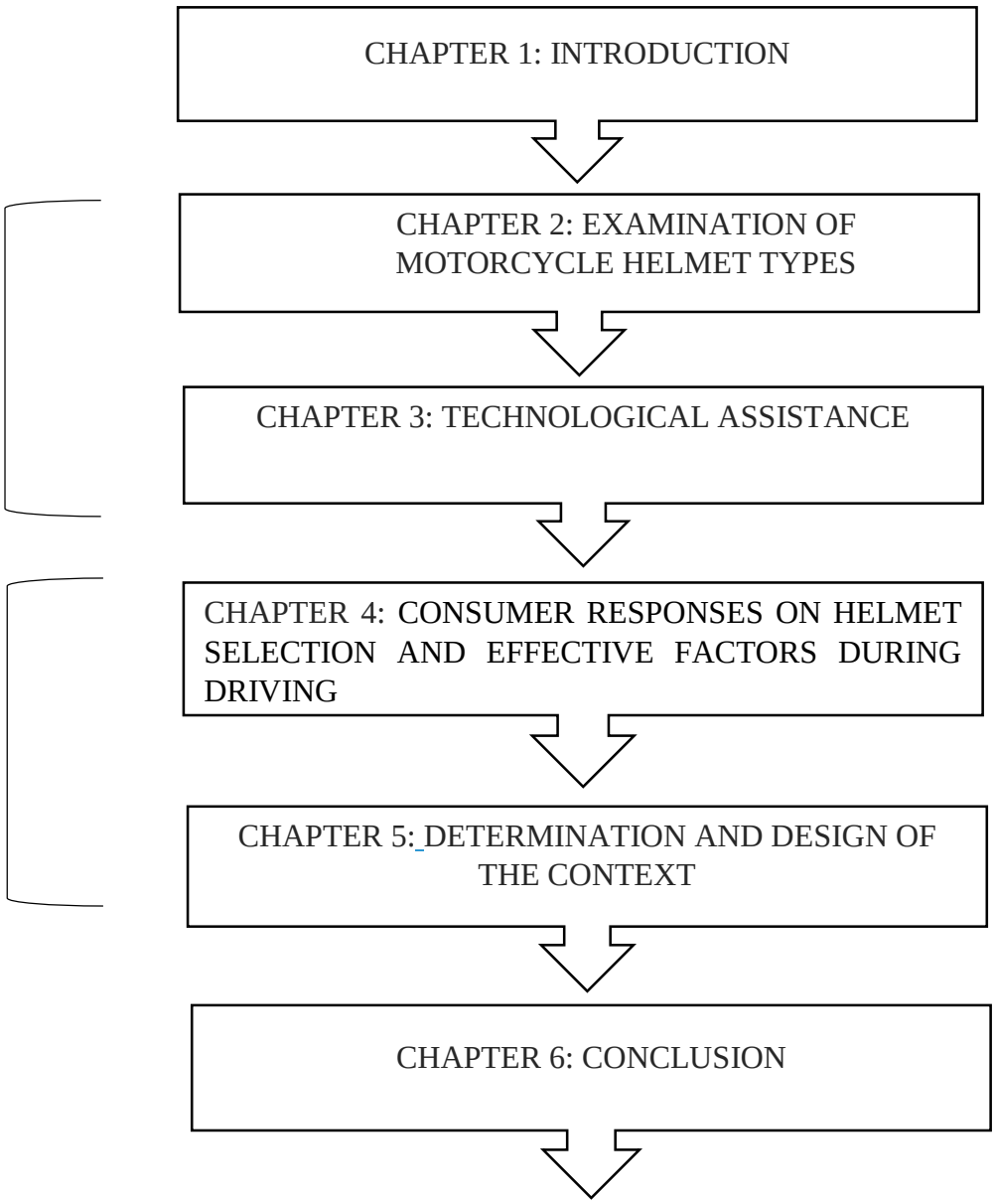

Figure 1.1 Structure of the thesis

CHAPTER 2: EXAMINATION OF MOTORCYCLE HELMET TYPES

2.1 Background

Considering the new smart helmet technologies, smart helmet with live map navigation in terms of direction and transportation information is a great help and special idea for motorcyclists to drive safer than using standard helmets. Recently, the adaptation of technological developments to the products in use also plays a major role in how to ensure the safety of the driver in these drives. The developments we see nowadays in connected devices will continue to play an important role in increasing this security, by the innovations that will be offered in the future, by the comprehensive closed systems and the improved new systems to which these closed systems will be connected. Similar to the sense organs of humans, these smart devices can be expected to collect additional data to help us through sensors that they use to collect information from around. This can be implemented by using advanced features like microdisplay, electronic mainboard, light sensor, earphone, battery, and microphone (Ahire, and Patil, 2018). For that purpose, this study focuses on the design and development of design a wearable device called Smart Motorcycle Helmet or shortly "smart helmet" (Tayag, 2019). Whose main objective is to help motorcycle rider in times of emergency. Utilizing sensors such as alcohol level detector, crash/impact sensor, internet connection thru 4.5G, accelerometer, short message service (SMS) and cloud computing infrastructure connected to a Raspberry Pi Zero-W and integrating a separate Arduino board for the anti-theft tracking module is used to develop the propose Internet-of-Things (IoT) device (Tayag, 2019).

In addition to the indicator data on motorcycles, motorcycle users incorporate new notification indicators and communication devices that use IoT systems to motorcycle use. This trend of motorcycle users also reflects this trend in wearable equipment. Nowadays, users wear apparatuses to communicate with helmets, find directions, listen to music, hear audible warnings, and record audio and video. Although there is a risk that these apparatuses may cause accidents, their use continues to be preferred due to the advantages offered to the user. The use of these retrofit IoT systems preferred by motorcycle users in helmet design, which

constitutes an example of wearable technology in the head area where the sensory organs are concentrated, should be aimed to reach the design standard in the light of user experience.

The identification of psychological and socio-economical factors affects motorcyclists. Moreover, it illustrates the patterns of behavior of the riders as well as the preference of motorcycle helmet types. The attitudes towards the use of the helmet, high-risk traffic behavior and awareness of traffic rules, and the norms were the key determining factors of helmet usage. However, perceptions of enforcement did not have any impact (Haqverdi, Seyedabrishami, and Groeger, 2015).

There are several other factors that affect the use of the helmet, such as the duration of casual motorcycle rides. It was proved that regular use of the helmet lowers the risk of head injury. For that reason, the positive attitude toward making the use of the helmet compulsory among the adolescents who had no road accidents in the last year increased (Aida et al., 2005).

Motorcycle riders, as previously demonstrated, seem to be under great risk of injuries in traffic accidents. The head is among the parts most exposed to deadly injuries. The most common injuries caused by motorcycle accidents is the head, as demonstrated in Fig 2.1. 66.7% of the COST database was head injury cases (European Commission, 2001).

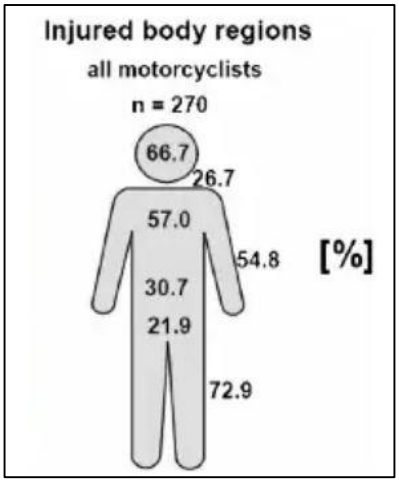

Figure 2.1 Injured body regions (Source: Fernandes, and De Sousa, 2013)

The benefits of wearing a helmet are highlighted below:

- Prevention of head injury: The most concerning problems faced by motorbike drivers are traffic accidents. Wearing helmets help them to protect their selves from traffic accidents. Helmets provide around 63%-83% of reduced rates of head and brain injury risks for the riders. For example, if the driver rides his/her bike at a speed of 55 km/h, it means that he/she is traversing 15 meters every second. And it signifies that if he/she jump from the fourth floor of a building, the speed at which smashing on the ground is 15 meters per second.
- Visibility: Helmets protect eyes from dust and strong lights coming from other approaching vehicles.
- Weather protection: The weather is unpredictable sometimes, and wearing a helmet is necessary if one does not want to get tormented by the hazards such as strong sun, heavy rain, and hail.
- Set an example: Adults can set up a good example by being law-abiding citizens and wearing helmets. Prioritizing security prevents suffer from grave injuries during an accident.
- Street auto collisions (RTAs) are a noteworthy reason for incapacity and passing everywhere throughout the world, especially the creating nations. World Health Organization (WHO) has perceived RTAs as a noteworthy issue. WHO ventures HIV/AIDS, Unipolar depressive issues, Ischemic coronary illness, and Road car crash to be the four driving reasons for the weight of infection by the year 2030 (KODAM, 2015).
- Helmets are often compared to seat belts. Of the 4,311 motorcycle drivers killed in the USA in 2014: Unhelmeted Killed = 1,561, Helmeted Killed = 2,610 Helmet use unknown or unreported Killed = 140, Therefore, in 2014, 61% of the motorcycle drivers killed were wearing a helmet. However, 71% of motorcycle drivers observed driving were wearing a helmet. In brief, helmets are correlated to a reduction in fatalities in motorcycle crashes (Motorcycle Institute, 2018).

2.2 Divergence of Generational Differences

The motorcycle helmet story takes us to one hundred years back. The year was 1914, and the primal motorcycle racing culture in the UK was starting to get popular. The

Brooklands race road was 4.43 km motor racing circuit near Weybridge where Dr. Eric Gardner performed as a medical officer. He found that there were several cases of motorcycle riders with fatal injuries in the head (Safer Turn, 2018).

Dr. Eric Gardner suggested that the idea of designing a motorcycle helmet to use in a motor ride to prevent head injuries. The risk of dying with a helmet and those without it are very different. And the history of the helmet started like this:

- **Mid-1940s:** British Army issued helmets to dispatch riders with either a cork shelled lid or a rubber one.
- **1953:** C.F. "Red" Lombard who was a professor at University of Southern Carolina developed and patented the first modern-day motorcycle helmet.
- **1954:** Roy Richter developed the Bell 500. The first fiberglass helmet to cover the back of the head and wrap around and cover the ears. These helmets cost $200, about one month's average salary. – Bell 500
- **1957:** Snell Memorial Foundation started for the purpose of providing independent helmet testing.
- **1961:** Australia introduced the world's first mandatory motorcycle helmet law.
- **1966:** American national Safety Standard for Motorcycle Helmets was introduced.
- **1967:** First helmet with face shield introduced providing improved field of view and vision protection. – Bell Star
- **1971:** Motorcycle Specific version of the Star. – Bell Star 120
- **1974:** U.S. Department of Transportation (DoT) Federal Motor Vehicle Safety Standard No. 218 requiring all motorcycle helmets to have a DoT-approved sticker (Griswold, 2013).

The underlying reason for the development of motorcycle helmets is to prevent injuries and even death. Therefore, when the development history of the motorcycle helmet is examined, the importance of studies for human life can be understood. The biggest reason for the emergence of a motorcycle helmet at the mentioned times was the high number of injuries and deaths encountered at that time. Considering that it is known that it was wrong to wear a helmet even in 1914, and riding a motorcycle without a helmet in 2020 is incomprehensible. As the designs became more widespread and on the agenda, the innovations made were accelerated and continued.

Just as there are many different kinds of motorcycles, motorcycle users in different styles and motorcycle helmets in different styles take their place in the world of motorcycles. Considering these different styles, it is quite easy to see that there is a connection between motorcycles and helmets in the same styles, and based on these connections; we examine the types of motorcycles and helmets that are shaped according to these usage styles, by collecting them into main groups.

Of course, although the choice of helmet is crucial for a motorcycle user, it should not be forgotten that the motorcycle, which is the essential part of motorcycle riding, should be considered as one of the most important criteria. While bicycle helmets of all styles can be used in almost any type of bicycle selected for bicycle users, this is a very critical situation for motorcycle users. The reason for this is that it is essential for motorcycle users to match the motorcycle style and helmet type they are using. The style and the look are important for choice, but it's not the only reason. The most common habit is to consider the type of motorcycle while selecting the helmet. If the rider is traditional, he/she may want a vintage style helmet for the vintage style motorcycle. The type of bike and the place to ride will determine what the rider needs so that one can think something more modern looking is likely to work better when a more contemporary bike is considered. In terms of design, this will give a motorcycle rider a more formal and smoother look, but it should definitely be taken into consideration that the safety and comfort features of the helmet are much more important than their appearance. Adventure helmets, retro caps, and sporty MotoGP-Esque models all have their own customized uses, and each one is designed to fulfill specific purposes. Everything from the size, shape, sun intake angles, sun visors, air ducts, and even the spoiler wing openings that make up the air passages is such that it will be useful in different environments and for different types of driving.

The technology strengthens motorcycle riding from day by day. There are four main types of helmets. Firstly, an adventure helmet is made for riding in difficult terrain or generally in an adventure, motocross-style. The second helmet is an open face helmet, also known as jet helmet, which is mainly great for scooters, choppers, maybe naked bikes, for a kind of light, short-distance touring. A very popular type of helmet is a modular, flip-up helmet. It combines benefits of the helmets, and it's mainly used for touring. More than 60% of helmets that people buy are flip-up

helmets. Then, there's a full-face helmet which is the proper choice for sport riding. It could be used for touring as well, but it's made for high-speed riding, on a sportbike, on racing circuits, by racers and so on.

Full-face and modular helmets are two alternatives for sport motorcycles. However, it should be foreseen that "Modular is not stylish neither functional". For long-distance drivers like cruiser motorcycle users, the alternatives are even more. In some cases, one can easily suggests that the use of a modular helmet or full-face helmet will be appropriate for cruiser riders, where even a pair of sunglasses to be worn together with a half helmet can be seen sufficiently. For full-face helmets, it should be said that it can be considered as a helmet type that can create a higher priority choice because it is more protective. Criteria for selection of a helmet is heavily depends on the driving type and functionality. In fact, anything else could be considered unsafe, even if it's just due to being a distraction. It can be determined in accordance with the motorcycles and the speed that the driver chooses (Wheel Scene, 2019).

- *Motorcycle use as a standard driver*: If it is considered that the purpose of the motorcycle user is not to confront the grim reaper, the use of any helmet type to be selected will be suitable for use in this type of driving for the driver. Therefore, when evaluated, it is possible to say that the use of half bullets or open face helmets is preferable for every situation.

- *Motorcycle use for high speed or performance rides*: The suitability of using only two types of helmets can be mentioned for this type of driving. Considering the fast rides, both the intensity of the wind hitting the rider's face and the fact that the insects and dust that have come along with this wind are hitting a shield a few centimeters from the face makes us far from the acceptance of a journey independent of this shield while driving.

Another approach suggests that there are six main types of motorcycle helmets which are full face, open face, modular, off-road, half, and dual-sport, shown in Figure 2.2 (Motorcycle Legal Foundation, 2018).

Figure 2.2 Types of Motorcycle Helmets (Source: Motorcycle Legal Foundation, 2018)

1. Full-face helmet: It has the most protective features among other types of helmets. It provides complete protection compared to other helmet types in terms of protection by protecting the entire area from the end of the neck area at the back to the junction of the neck area and chin by wrapping the entire head and face at the front, and the protection factor due to the integrity of this protection is due to the increase of the protection factor.

Figure 2.3 Full-face helmet (Source: Wheel Scene, 2019)

The fact that the chin bar is positioned in full-face helmets, which is not in other types of helmets and increases safety, is the most important distinguishing element of this helmet type. When official data examining motorcycle accidents and injuries in motorcycle users are examined, it can be concluded that almost half of the injuries in

motorcycle accidents are observed in the chin and jaw regions of the users. Considering such injuries where only full-face helmets can provide full protection, the preference of such helmets is of great importance (Padway, 2020).

Figure 2.4 Full-face helmet (Source: Top Gear, 2016)

The wind visor, which also serves as a visor in this type of helmets, can be kept active in use by the user depending on the effect of natural events on the driving and road conditions or can be turned on by scrolling upwards, depending on the effect of the natural events on the driving and road conditions. It can be suggested that full-face provides the best protection for both motorcycle users who drive performance and speed, as well as for tour riders who travel long distances due to its aerodynamic structure. On contrary, the limited ventilation caused by keeping the size of the ventilation areas smaller to increase the protection may be relatively more disturbing in such short and low-speed driving as it may be insufficient to provide the necessary air intake for the driver in city driving where slower driving is performed. Therefore, this helmet type may be a less preferred helmet type in city motorcycles than other helmet types. However, among all helmet types, it can be said that the full-face helmet type is the most known helmet type among them, and it is the most preferred helmet type by motorcycle users.

Figure 2.5 Full-face helmets (Source: Padway, 2020)

Full-face helmet has been constantly exposed to changes and improvements due to the needs and complaints of motorcycle users. The user's who experience this helmet for the first time may feel drowning or isolated inside it, but it is an action that the user will get used to in time. It has been observed that such problems with the evolution of this type of helmets over years have been reduced and they have been made compulsory to take other measures. In addition, this feeling is relatively dependent on the use of the helmet and, to a large extent, on the quality of the helmet (Top Gear, 2016). Covering the front, back, and top of the head, full face helmets offer the most complete protection among all helmet styles.

2. Off-road (motocross): Compared to standard full-face helmets, the major differences between off-road helmets and full-face helmets are quite larger jaw areas and visors of off-road helmets. The air entering through these jaw openings helps the driver to feel the speed more sensitively during the off-road experience, where the driver contacts with more air, thus reaching higher adrenaline levels. The air entering from the enlarged areas is necessary for the driver to breathe. It can be said that it is a result of the upgrade processes we mentioned before, which facilitates the expansion of the area.

Figure 2.6 Off-Road (Motocross) Helmet (Source: Top Gear, 2016)

In addition, many of the off-road drivers know how to wear safety glasses inside the helmet. Due to this method of use, space left for the helmet to allow the use of safety glasses is larger. When examined in general, the hard shell systems placed to meet the high protection requirement, and this type of helmets not only increase the protection against external factors but also provide the chin protection against possible accidents and collisions via improvements and the effect of the widening in

the chin area (Top Gear, 2016). In the use of glasses, the element that can be shown as the main reason will be effective in the driving areas where dirt and mud are dominant in the prevention of dirt, mud, and water that may enter through the openings of the helmet. It means their structure, which is suitable for almost entirely closing the entrances from the sides and from below, makes these glasses useful for use in such areas. When these helmets are examined, it is observed that composite materials such as fiberglass, kevlar, and carbon fiber are mostly used in these helmets designed to provide less fatigue for the head and neck areas even after long rides. (Motorcycle Legal Foundation, 2018).

Figure 2.7 Off-Road (Motocross) (Source: Motorcycle Legal Foundation, 2018)

Off-road helmets, as the name implies, are seen when the usage areas are examined, which are the types of helmets that contain the design details preferred for use on land conditions or aggravated soil trails rather than asphalt roads. Although they do not provide a comfortable driving dynamics due to the incoming air and harsh usage patterns, even if they are not suitable for the use of simple Bluetooth speakers, they generally have maximum protection in their lightweight structures, and the amount of air entering in hot weather increases the user's breathing easier (Motorcycle Legal Foundation, 2018).

3. Modular helmet: Modular helmet is generally a blended version of the two helmet types we mentioned earlier. These helmets, which provide protection close to full-face helmet protection in their closed use, leave most of the face exposed so that their chin guards can be used as half-face helmets when the chin guards are opened upwards. These helmets, mostly known as "flip-up" helmets by motorcycle users, are

emphasized with their comfort they provide to their users in touring as well as high-speed structures in performance driving. In addition, easy-to-breathe features and less overwhelming structure of modular helmet also provide a comfortable use for city driving and cruising. This is one of the best intentions regarding motorcycle helmets (Top Gear, 2016).

Figure 2.8 Modular Helmet (Source: Top Gear, 2016)

While the modular helmets are similar to both full-face helmets and open face (¾) helmets, the materials used in the production of these helmets are similar to the alloys and composites used in full-face helmets, while the presence of visors added for eye protection increases these similarities. There are separate secondary visors added for sun protection is in detail in these helmets (Motorcycle Legal Foundation, 2018). The difference between these helmets are the hinge system and the opening and closing areas, which are used to hold the openable area in the flip-up helmet area, create a weighting effect by using materials that will increase the total weight of the helmet in modular helmets.

Figure 2.9 Modular Helmet (Source: Top Gear, 2016)

Figure 2.10 Modular Helmet (Source: Motorcycle Legal Foundation, 2018)

The modular helmet is often used by tourers, cruisers, and adventure riders, as it is designed with an upright riding position in mind. The eye openings are more straightforward and the chin bar is designed to position lower on the face. Modular helmets help drivers protecting the perception during driving while making the users more comfortable, safer, and more controlled via dual visor technologies and even anti-vapor visor systems. Such helmets also allow the windproof helmet structure, which is also very convenient for the use of Bluetooth speakers (Motorcycle Legal Foundation, 2018).

4. Open-face helmet: Also known as 3/4 helmets, open-face helmets are designed for use in low-wind and speed conditions, while they stay in traffic during commuting in the daily lives of motorcycle users. However, these helmets lack of full head protection and comprehensive chin protection compared to full-face helmets. The open areas left for the use of this type of helmets provide comfort when inserting and removing the helmet. On the other hand, it may contain wind visor and visor according to the model, dust or mud. It involves lighter structure in terms of protection against physical factors such as sunlight and water. Leaving aside all these negative effects, we can say that it provides a cooler look for the user when used with almost all types of models and types of motorcycles (Top Gear, 2016).

Figure 2.11 Open-Face Helmet (Source: Top Gear, 2016)

It should be noted that the choice of this helmet type of motorcycle users may lead users to injuries due to lower protection and error compensation as a result of possible errors. For this reason, motorcycle riders should be more careful during use and consider possible sunlight problems. In general, users are recommended to purchase these helmets with visors to minimize the risk (Top Gear, 2016).

Figure 2.12 Open-Face Helmets (Source: Top Gear, 2016)

Since this type of motorcycle helmet has a serious protective deficiency for chin protection due to the lack of chin bars, they have significantly lower protection compared to helmets that protect the chin, like full-face helmets. On the other hand, due to the fact that the face area is open, the feeling of wind on the face of the rider, who feels the feeling of being on the road by the motorcycle users, is the reason of preference for comfort that the wind passes on the user (Motorcycle Legal Foundation, 2018).

5. Half helmet: Also known as “taboo” or “bao” (coconut shell) among motorcycle users, half helmets are also called as “brain bucket” due to having the least protection among all other helmet models. It is strictly not recommended for use on any high-volume motorcycle, with the shape of a helmet that only covers part of it, protecting only the upper part of the head (Top Gear, 2016).

Figure 2.13 Half helmet (Source: Top Gear, 2016)

While the almost non-protective structure of the half helmets provides partial protection to the neck over the user’s eyebrows, it can also be observed that some of these helmets are in a structure that will protect part of the neck area and just behind the ears, but consequently, in contrast to the efficiency in the amount of airflow they provide for these helmets that leave the entire face exposed. Despite all these deficiencies in protection, it is still possible to access DOT approved helmets.

Figure 2.14 Half helmets (Source: Motorcycle Legal Foundation, 2018)

Most of the half helmets are presented to the user free of visor or face spray so that it becomes compulsory to purchase eye protection in the form of glasses or glasses. Since there is not enough room for additional features to be added by the motorcycle user in this type of helmet, it would be worth mentioning that additional elements

such as Bluetooth speakers are not suitable for these helmets. It should be noted that the add-ons for motorcycle helmets of this type are minimal (Motorcycle Legal Foundation, 2018).

When the head injuries are examined, the protection provided by half-coverage helmets has found to be the lowest level of protection among other helmet types. However, as a result of the selection of the appropriate helmet type, it is seen that in the accidents to which motorcycle users are exposed, the protective elements of the helmet are not used in the right area, in the accidents where the protective factor does not match the need during the accident, the injuries take an action that reduces the protection of the helmet. In cases where full-face helmets are selected, it is observed that the motorcycle user performs higher than other types of helmets because of the nature of the motorcycle user, the head protects the user's head completely. Putting the whole head in the protection area and protecting the chin with the help of a chin bar are the biggest factors preventing injuries in these accidents. Since motorcycle helmets generally aim to absorb and change the direction of their design, they contain the first fiberglass or thermoplastic shell that provides the first shock absorption by the materials used in the structure, and an inner structure that is in contact with the user with energy-absorbing foam to dissipate the deceleration forces. In addition, these helmet systems include the chin strap, which is the holding system (Hopes, and Chinn, 1989).

6. Motocross helmet: Among the motorcycle helmets, this type of motorcycle helmets that are specially designed for use in difficult terrain conditions is called motocross helmets. The helmets of this type draw attention with their definitive and distinctive features among the helmet types, with their wide-face parts left open to allow the use of goggles, which are left to the desire of the motorcycle, for eye protections such as pointed chin guards and "sun visor" sections at the top. These motorcycle helmets, which are produced by considering the best off-road and trail rides in terms of driving dynamics, have become the preferred element even for street rides outside of motocross competitions (Top Gear, 2016).

7. Dual sports helmet: This type of helmet with integrated wind visor is the development of a motocross helmet. Apart from the models designed for general

road use, it can be said that the products that come with ready-made packages that can be used in serious off-road conditions in this helmet type are also accessible to motorcycle users. Dual sports helmet which covers a wide range of driving styles such as adventure and standard motorcycle rides from motocross, with different styles and wide functionality options compared to other motorcycle helmets, is not recommended for motorcycle types that will be faced with high-speed cruising, just like motocross helmets (Top Gear, 2016).

Figure 2.15 Dual Sports helmet (Source: Top Gear, 2016)

Dual sports helmet can be considered as a renewed and improved version which designed as a combination of the off-road helmet and full-face helmets. These helmets are similarities such as large visor structures resembling a motocross helmet, as well as the designs with lower jaw bars, having a much more internal filling and comfort with full-face helmets. Dual sports helmets are suitable for off-road use and road driving (Motorcycle Legal Foundation, 2018).

While the opening forming the face area in the design of the dual sports helmets allows the use of a larger eye protection visor, which is separated to have a full face area, however, it provides a useful vision for the user by adapting it to the upper position so as to enable the use of the glasses of the motorcycle user. Helmet's aerodynamic feature contributes to the visor structure by preventing the problem of moving with the wind experienced in off-road helmets. Unlike the motocross helmets, this type of motorcycle helmet is not similar to the off-road helmets, and the sound insulation is better than the motocross helmets, even if the air intake is less. It is quite comfortable to provide both off-road and on-road driving on the same day with this type of motorcycle helmets. The user can easily continue his off-road driving on the off-road thanks to an eyewear device that he wears to lift the visor

while keeping the wind flow under control while using the visor while he is riding the motorcycle (Safer Turn, 2018).

A case-control study was conducted to examine numerous different helmet types and improper helmet use affected protection against head injuries among motorcyclists in Taiwan. This study shows that although there are differences in the field of protection between motorcycle helmets, no significant difference was observed between the protection provided by full-face helmets and open-face helmets. In addition to this information, it should be noted that the protection provided by half-coverage helmets is significantly weak compared to the protection provided by the other two helmet types (Wen-Yu et al., 2011). It is concluded that a) Among full, open-face, and half-coverage helmets, the latter gave motorcyclists the least protection from head injuries, b) Improper helmet use may affect helmet fixation in a crash and thus reduce the helmet's effectiveness for preventing or reducing head injuries, c) It is time to promote legislation that requires motorcyclists to wear safer helmets and to fasten the helmets properly.

Another similar type of dual sports helmets is the dual sports modular helmet which have minor differences with the usual helmet types. However, these differences are negligible and non-deterministic and appear in a limited number of helmet models (Touratech Adventuro Mod, Schuberth E, etc.). It is observed that these helmets have the characteristics of dual helmets and modular helmets, which are aimed to offer more flexibility, functionality, and comfort to users during the use of motorcycle users. These helmets, which are the mentioned helmet type, can be preferred by users as modular (full-face or half-face without a hill), motocross (without windshield), and double sports helmets, and these helmets reach different users thanks to these wide spectra. It can also be said for these helmet types that it could customize motorcycle rider helmets with screws or pegs (Top Gear, 2016).

2.3 Smart Features in Motorbike Helmets

Emerging technological developments in smart devices play significant and effective role in increasing the demand for smart helmets by including the innovations on helmets. In addition to the tendency to use smart, sophisticated wearable technologies that motorcycle users would prefer to use for their safety, it reflects the

conclusion that motorcycle users will be expected to increase their demands on smart helmets in the next five to six years, given their fear of motorcycle safety (Top Gear, 2016). The demands of users from their experiences result in some improvements in terms of smart motorcycle helmet production. This section discusses different smart features attached to different types of motorcycle helmets.

It is clearly observed that the wearable technology equipment entering our ordinary lives has created awareness that there are no detectable limits. Considering the developments made for motorcycle helmets in general, lighter materials are preferred to reduce the pressure applied to the neck area of the motorcycle user, additional filling options are offered to the users in order to increase the usual comfort, smartphone or navigation devices, and even other Bluetooth devices to benefit from music and similar features. Today, they are able to accommodate developing voice command systems and searches in order to keep up with the developing technological factors where the connectable devices such as wifi are prepared for the interaction (Padway, 2020).

A smart helmet can be briefly defined as “a type of protective headgear used by the rider which makes bike driving safer than before”. The main purpose of a smart helmet is to provide safety for the rider. Safety of the rider can be achieved by using advanced features like location tracking, hands free devices, fall detection, alcohol detection, accident identification. Therefore, the motorcycle become s smart bike as well, by this features of smart helmets (Shravya et al., 2019).

While the fact that smart helmets confront users with unspecified actions, even manufacturers can not clearly draw limits on what they can do, motorcycle helmets that can share music beyond the listening of music in today’s smart helmets can now convey information to the user on the provision and transfer of navigation data by carrying functions integrated with GPS systems. In a full-face smart helmet model which consists a micro screen located in line with the chin bar of the helmet and positioned downward in connection with the viewing angle that is used to reflect virtual information to the driver is also an augmented reality helmet. In some smart helmets, a battery pack is used by placing a fulcrum pad from the skeleton of the motorcycle to meet the power requirement of the smart helmet. Wind turbines of the

helmet confront as natural energy sources that can be used to charge these batteries and direct the exhausts to cool the battery and head area of drivers. These turbines, which can be placed on smart helmets, are controlled in a way that they can also act as a kind of circulation fan in order to provide ventilation in the helmet. Another factor that can be found in smart helmets is digital gyroscopes, and the use of these gyroscopes is used to track the driver himself/herself. This monitoring feature in smart helmet systems can provide suitable control input for the user to control a steerable headlamp of the motorcycle, and authorize smart helmet systems to open the required process directory by contacting emergency response teams to reach first aid after a possible collision. The rear-view cameras of these new generation smart helmets are positioned to fit the aerodynamic structure at the back of the helmet, with wide-angle 170-degree viewing angles (Digital Trends, 2019).

The development of smart helmets with advanced technology today led to appear products such as built-in microphone systems housed in smart helmets, sound-oriented systems such as speakers, visual data collector systems such as rear camera systems. Drivers can have a safer and more enjoyable travel experience with a smart helmet model that combines what one thinks will be necessary or fun from smart systems. With the introduction of HUD (Heads-Up Display) technology which can be regarded as a game-changer in smart helmet technologies, the data transfer provided with overhead indicators has gain importance for the data tracking of the drivers. HUD is a suitable screen technology that transfers data to its user with a display system that acts as a transparent screen that provides access to information by reflecting on it (Digital Trends, 2019). The Sena INC helmet is “smart” to the extent that it uses integrated technology to solve riders’ problems.

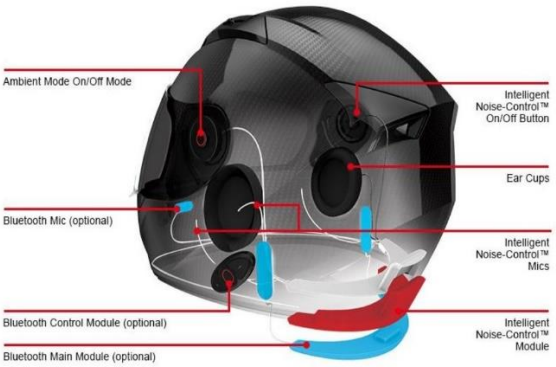

Figure 2.16 Smart Helmet Technology (Source: Digital Trends, 2019)

While examining smart helmets, perhaps the most extraordinary of the examples that may be mentioned, perhaps, it looks like an ordinary full-face helmet when viewed from the outside, but BMW helmets, which evaluate even the smallest details among the smart helmet concepts, can be at the forefront of the examination. Despite the fact that there is no clear news source about the date when these helmets will meet with users, BMW did not hesitate to inform motorcycle users about their work on smart helmets. Some of the features that BMW promises to motorcycle users with these shares are as follows (Bad Ass Helmet Store, 2019).

For motorcycle users who prefer these smart helmets, from motorcycle speeds to the information they need about road safety, an overhead display (HUD) that gathers information in almost every need, and with the help of the augmented reality lens- "DigiLens", motorcycle driving is smart. It offers a very different experience for helmet users. As a consequence of this smart helmet type, the motorcycle rider will learn about the upcoming construction sites and possible changes in road conditions while driving. Another factor to be taken into consideration in the meantime is that there is no loss in the field of view of the motorcycle user while these notifications are transmitted to the driver (BadAss Helmet Store, 2019).

Considering this smart helmet type of BMW, while the motorcycle user is operating the motorcycle whom is using, the smart helmet technology quickly checks the condition of the motorcycle and informs the motorcycle user on issues such as whether the tire pressure is at the required levels and the adequacy of the gas and or oil levels. Apart from this, if there is a change in this information while driving, the smart helmet also includes a warning system for such situations. It provides additional elements such as programming options for additional types of gears to be displayed on the screens in these smart helmets. For example, functions such as current gear, step-by-step directions, locations of other drivers, current gear can be shown as simple examples in this area. In addition, more smart features are expected to be added in the future. Another benefit of this type of smart helmet is the front view and rearview camera features and viewfinder systems, which make the use of motorcycle mirrors less necessary. In the use of these camera systems, the task of the front camera is to be more important to detect motion, while the rear camera is used as a rear-view mirror as well as an important tool that warns the motorcycle user

against possible blind spots. These smart helmets of BMW allow adjustments within the smart helmet systems by using the controls of the left handlebar of the motorcycle, which are also products of the same brand. Whether for location services, internet connection, or just by phone, these smart helmets can be connected to the smart device of the motorcycle rider (BMW Motorcycle Magazine, 2016).

When the smart helmet manufacturers are examined, it is seen that BMW is not alone in producing smart helmets by using these developments. Other helmet manufacturers are making provisions to apply these smart technologies on their novel products. Some examples of smart motorcycle helmets that are the harbingers of the beginning of a new era can be listed as “Sena Momentum Inc Pro, Sena Momentum Lite, Skully Fenix AR, Quin Design Spitfire, Crosshelmet, Reevu MSX1”. For example, Fenix AR has ability to follow driver’s eyes, view direction, and providenecessary visual information via blind spot camera. Looking forward and then back to the Heads-Up Screen followed by focusing again will activate the blind spot camera. Another feature that should not be surprised when seen in a smart helmet is in the form of smart voice commands, this time we come to Skully to reach the voice commanded and smart features of Fenix AR, to get directions, from increasing the sound of the music the user listening to while riding a motorcycle or It facilitates many functions such as answering phone calls. It also provides a navigation system that can assist them step-by-step in any situation where they need to find directions with voice navigation technology. Not only with these features, this smart helmet, which does not allow it to affect their driving without being aware of possible changes, can also share instant information about the weather. In addition, Connected Audio, which is ready-made, provides an audio system designed with the aim of keeping the sound quality at the highest level. While Fenix Ar maximizes the user's sensation with crystal clearness in voice calls, it meets the user who wants to listen to music with really superior sound quality and feeds it with a good sound processor. Of course, it should not be overlooked that the Livemap, Cross Helmet X1, and Jarvish Smart Helmet’s avant-garde designs also draw attention among smart helmets (BMW Motorcycle Magazine, 2016).

SKULLY AR-1, which is claimed to be the first of the HUD smart motorcycle helmets, is the first integrated system that motorcycle users reach this screen

"vertically". SKULLY's Synapse™ It aims to increase the awareness of motorcycle users on the road and environmental factors while driving and establishes a network that will provide the necessary information to the motorcycle rider by using camera systems and advanced optical technologies used with these systems, a large number of sensors and microprocessors to process all this data (Iot Now, 2014). When the features of this smart helmet are examined briefly, one of the most determinant features is the position of an overhead screen that never goes out of the focus of the motorcycle rider the electrochromic instant color visor contains active GPS that helps the motorcycle user with both voice command and visual information transfer. These include the navigation system, a camera system that is extended in view and located behind the smart helmet, the connection features of the smartphone that your smart helmet can connect to, and access the internet, Bluetooth, and hands-free call enhancements for phone calls (IoT Now, 2014).

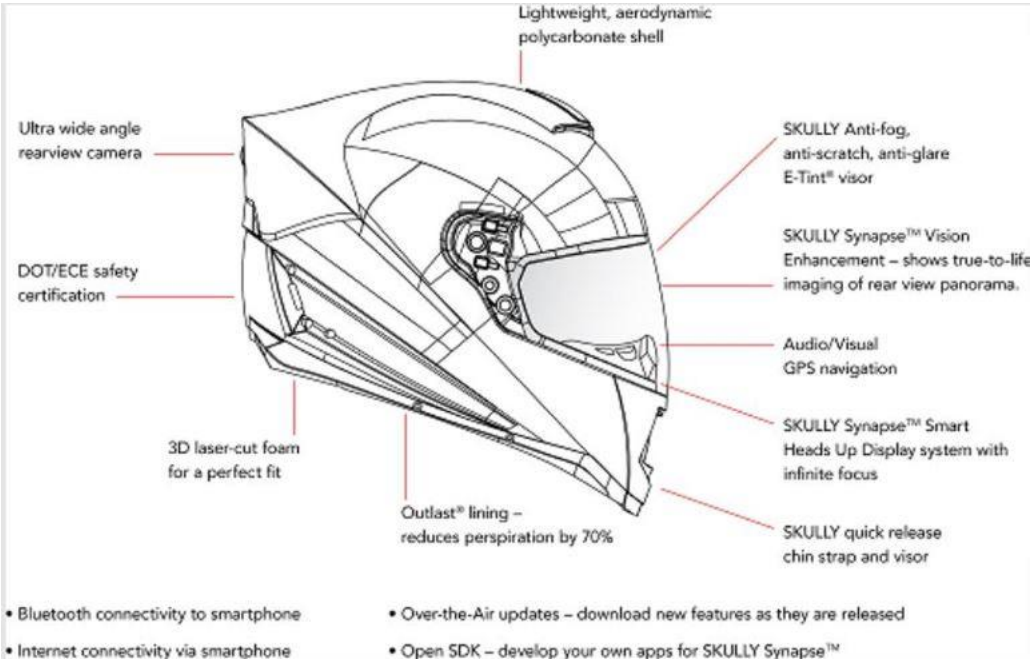

Figure 2.17 The Skully AR-1 helmet (Source: IoT Now, 2014)

Livemap is a commonplace for motorcycle users to keep up with the developing technology in their smart helmets, to develop display technologies, and to spread the use of these displays. The screens mounted on the helmet will eventually share the same fate as the flat screens. Some innovations, which we used to consider as state-of-the-art technology, are now outdated and replaced by new ones. Perhaps the use of

overhead displays (HUD) will become quite common when projection technologies become a little more common, and smart helmet technologies become easier to adapt. Although the use of augmented reality is highly developed today, it is a technology that seems to continue to progress with more radical steps on this path, and Livemap, which uses this technology in the field of navigation, is an important example of a smart motorcycle helmet even if it is in prototype form. Among the features brought to life with this smart motorcycle helmet are features such as the transmission of step-by-step directions to the motorcycle user as well as the speed information that the motorcycle user is informed immediately, transferring information such as street names directly to the world around with the help of augmented reality. This feature gives motorcycle users a chance to be more careful due to avoid distraction and stay focused on road. Motorcycle users can display a large map on the screen of their smart helmets to slow down their speed or stop for more detailed examinations. These smart helmets also include speaker systems and microphones in the structure, allowing the motorcycle user to listen to music, make phone calls, and benefit from the voice control system. Although these smart helmet systems are not yet on sale, the estimated cost is expected to be around $ 2,000 (Digital Trends, 2019).

Among the smart helmets, the features introduced for Cross Helmet X1, which shows itself as “New generation helmet”, are as follows. In addition to a phone application-specific to X1, Bluetooth connection and voice control options, as well as a rear camera that is preferred to be placed on the top instead of being placed on the back, and smart helmet monitoring technology with the 360-degree camera viewing angle, navigation and digital clock information are indicated on the viewfinder. If the X1 can be used as designed, it will have a very important feature to be one of the safest motorcycle helmets. This feature is that the motorcycle user can easily see the whole road thanks to the wide viewfinder on the X1. The application that comes with X1 also aims to block traffic noise while driving in environments with relatively few vehicles and pedestrians with less danger or slow flow of traffic. In addition, developments in this matter have been advanced so much that it even has the technology to make it possible to open the ears. For this, it works synchronously with its application in order to control noise insulation. New features expected for the X1 include communicative innovations that enable group conversations and security

lighting options. It will become more attractive with these additional features when it begins to be sent in 2019. It will cost $ 1,600 (Digital Trends, 2019).

Jarvish Smart Helmet which is targeted to be entirely made of carbon fiber and thus will have both a light and a very strong structure, will be presented with an augmented reality screen that will provide the users with data such as weather, speed, and navigation information. Alexa integration, which is expected to be in connection with this smart helmet, also provides a significant use advantage to the helmet and its user during motorcycle use. The cameras located on both the front and back of the helmet, voice command technologies, noise-canceling technologies reveal the most prominent features of the helmet. Micro-draw LED strips of Jarvish's Tron helmet can be turned on via voice command to have more attention at night for save driving (Digital Trends, 2019).

Figure 2.18 Jarvish features (Source: Digital Trends, 2019)

All of the smart features of aforementioned helmets described so far in this section focuses on high functionality, safety measures, comfort, and aesthetics for riders. Smart helmet technologies draw more attention to needs of motorcycle users day by day. In this technology, the difficulty of navigation usage on motorcycles can be fulfilled by reflecting the road information onview of the rider's helmet, allowing them to easily see the road to be driven. A smart helmet with easy of use live

navigation feature can easily replace its equivalents for safer, easier and reachable drive without taking the rider's eyes off the road. Therefore, navigation info without delay is a significant and interchangeable feature for smart helmets which also contributes to safety besides comfort and aesthetics.

2.4 Interchangeable Definition of the Navigation

The following definition can be used briefly for navigation. The term "navigation" is used to describe users getting from one place to another while "navigation map" represents the route instructions (Parush, 2015). The word navigation is originally a seafaring term. Navigation refers to "the process of estimating one's present position based on various tools." In earlier times wind, tide and currents acted as navigation instruments and today there are maps, magnetic compasses and even satellite-guided GPS systems that are used as navigation instruments (Stopper et al., 2012).

The fact that motorcycle riders use innovative GPS navigation technologies in their transportation to the location on their routes while driving allows them to travel faster and safer. The GPS system for a motorcycle rider creates a system that allows the rider to see his or her position on the map. When using a motorcycle, the user can easily see which direction they are going with their motorcycle by seeing the full-color images that appear in the center of the visor on the Navigation screen. Accessibility to the brightness settings of this image offered to motorcycle users is also important, and these systems make it possible to access these setting options. (GPS Tracker Info, 2019).

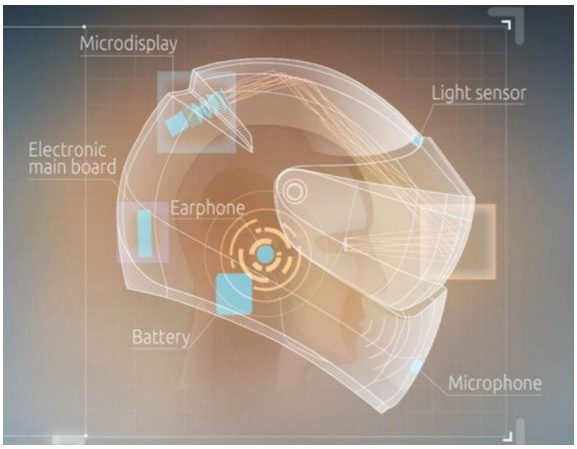

Figure 2.19 Moto helmet with navigation (Source: Livemap, 2013)

With the development of smart helmets, there is no need to use old navigation methods. Now, the convenience of finding directions with pre-loaded map options will make it unnecessary for the driver to download these maps from the internet every time via smart helmets working in connection with GPS navigation technologies.

2.5 Categorizing the "Things" and Defining IoT

"Internet of Things" (IoT) has started to take up a more important and larger place in our lives in recent years. IoT involves devices which take part in individuals' everyday life and can be connected to the internet, provide information to a database, and recognized by other devices. In the Internet V.2, the data is created by things, and it is described by the IoT (Bernard Marr & Co., 2017).

The IoT is the system that provides interrelated computing devices, mechanical and digital machines, objects, animals, or people through the UIDs (unique identifiers). Moreover, it does not require human-to-human or human-to-computer interaction while providing data transfer and the other features mentioned above (IoT Agenda, 2016).

The IoT include a human that has a heart monitor implant, a farm animal with a biochip transponder, a car with built-in sensors alerting the driver about tire pressure when it lowers, or the rest of the artificial items assignable with an Ip address and transferable data via a network (IoT Agenda, 2016). IoT combines physical objects with the virtual world. Intelligent devices and machines are connected to each other and the Internet. They capture relevant information about their direct environment, then analyze and link it (Infeneon, 2020).

The ecosystem of an IoT incorporates web-enabled smart devices that collect and send and act about the data acquired from the environment through using embedded processors, sensors, and communication hardware (IoT Agenda, 2016). It can be mentioned briefly for IoT devices as follows: IoT devices make sense of the sensor data collected by either analyzing the data they provide from the sensors locally, sending them to a gateway, or sharing them with another edge device for analysis in cloud systems. In some cases, these IoT devices can act in light of the information

they receive from each other thanks to the communication they provide with other related devices due to their functions. Although IoT devices are devices that are under human control, people ensure that the functions of these devices are maintained without human intervention, except that people adjust, instruct, or access their data (IoT Agenda, 2016).

Network and communication protocols depend on the use of device applications that require working in connection with web bases that provide large-scale distribution. (IoT Agenda, 2016).

For IoT systems, it can be said that the technologies that we encounter and are important in many areas of life in today's technology are such that, with the help of these technologies, people have the opportunity to live and work smarter, while allowing full control over their lives. It enables companies to reach clear information about their working status by accessing the systems of businesses and companies, and IoT technology, which affects a long scale from the supply chain to logistics operations to the performance of the machines, enters home lives thanks to smart home technologies (IoT Agenda, 2016).

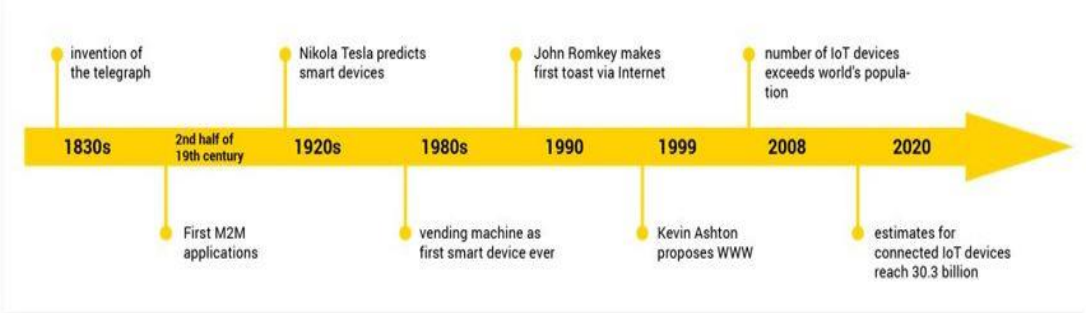

Figure 2.20 History of IoT (Source: Rouse, 2020)

The tasks performed by these devices are basically this way. For example, in order for a device to turn on the heating, an external sensor can send the data collected about the temperature to the smart device by the data provided to the device that will turn on the heating by the smart device. It should be noted that the users do not need to take any action during the implementation of all these processes. In addition, users can control these IoT devices remotely with different devices such as smart-phones when desired (Infeneon, 2020).

The four indispensable elements of the IoT are explained below:

Things: Every object you can think of will enter this layer. Today, every device with an internet connection, sensors, microprocessors, smart cars, daily auxiliary objects, and even iconic coffee machines are IoT devices (AV System, 2019).

Connectivity (or, the Internet): It is obvious that the connected devices need to communicate with the help of a channel, and through this channel devices, can share information about what they perceive or where they are, as well as those channels that contain such a "language" and "expressions" through which such "conversations" can be made by IoT connection components. The systems that can be preferred as a connection channel may include laser information technologies, Long Range Wide Area Networks (leading standards such as Sigfox or Narrowband IoT), as well as Wi-Fi or Bluetooth systems or other little-known technologies (AV System, 2019).

Software: It would be appropriate to say the brain of smart devices for software. So that it is the software that enables the analysis, management, and configuration of the data collected by objects on smart devices, and this unit determines whether or not the action will be taken about an action to be performed by the device. It includes a system that is kept away from the eyes of the end-user even though all the thinking action takes place in this unit, from the information to be transferred to the user and the information flow that will initiate the action (AV System, 2019).

Application: In case the system's own management capabilities are insufficient when human action is needed, the user is provided with visual information, analyzed data, and collected data are visualized through the application layer, as well as useful information about the whole system operation. In this section, where the end-user is engaged, the device control is left to the control of the user through the application interface (AV System, 2019).

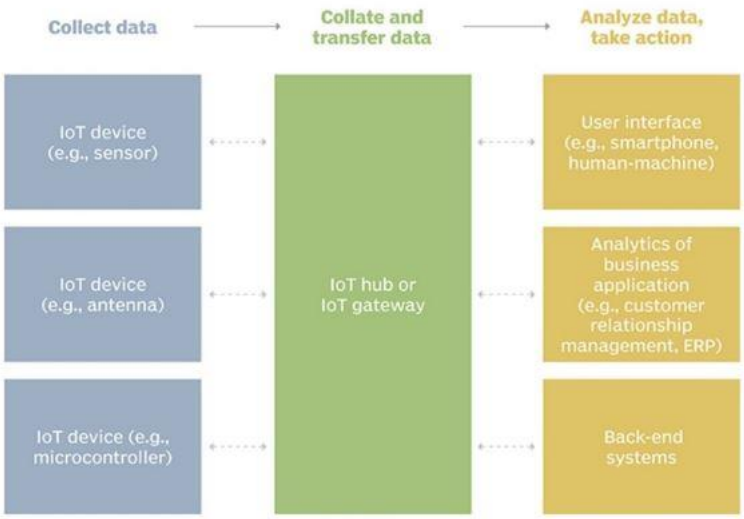

Figure 2.21 Example of an IoT system (Source: Rouse, 2020)

The usage of electronic and digital devices is increasing more than 13 billion, in equals of 2 devices per person. It reaches the lofty predictions of 50 billion connected devices by 2020. One of the devices that can be a suitable example for this situation is “Smart Home” technology. It can be mentioned that many smart devices are used during the development of these houses and that these programmable devices are devices that can be controlled by remote access. The variety of sectors in which IoT systems will develop in the future is a sign that the use of IoT systems in almost every sector will be encountered. IoT technologies, which are expected to be encountered in industrial and commercial areas, appear to be inevitable in sectors related to the economy such as health, public, and security, as well as these areas. (UL LLC, 2016). Even if they are not directly undertaking tasks such as changing our living space and the way we work, these systems that undertake daily objects and utility components and have an internet connection shape our lives with their strong data and analytical features. As a result, it is possible to say that our lives are differentiated both at work and at home. Therefore, the IoT can be defined as extending the network connectivity and computing abilities of both computers and casual objects with the purpose of generating exchange and consuming the data with fewer humans as possible.

IoT technologies have mostly discussed among smart vehicles and rapidly took place in the market today along with the motorcycles and other transportation vehicles.

California-based Zero Motorcycles, which has proven itself especially on electric racing motorcycles reaching high speeds, produced the first of its prototypes in 2006 in a garage in Santa Cruz, California, while producing its first bicycle in a garage where they sold their first bicycle in 2008. In the area the company is currently turning to, to link motorcycle owners with the IoT packages used to connect services and shops to the associated motorcycle market (Fourtané, 2015). Founded in 2013, Skully established and continued the improvement in driving safety, which was determined as the focus during the development process of AR-1, one of the smart helmets they were developing, with the help of company CEO and president Marcus Weller and deputy head of business operations Mitchell Weller. When the main features of this smart helmet are examined, it is observed that the use of blind spot cameras, the integration of GPS and navigation technologies, creates a structure that aims to protect the motorcycle rider by providing a full situational awareness. The aim of this helmet is to provide the motorcycle rider with the information that is most needed and not to lose the driver's attention to the road during this ride. When this helmet is examined, it will be seen that this helmet, which also has Telenav Scout SDK navigation features, utilizes a technological system that provides step-by-step navigation information in real-time and transmits it directly with the helmet. When this helmet is examined in the field of connection methods, it can also be connected to smartphones that can reach the internet and communication network via Bluetooth, and it is sufficient to provide the necessary updates through these platforms. This also means that AR-1 can be connected to both other AR-1 helmets and motorcycles with the help of Bluetooth.

According to Marcus Weller, the co-founder of Skully, the helmet can be paired with up to 10 other AR-1s at a time. The AR-1 is completely compatible with the 2016 Aprilla RSV4 and the 2015 Aprilla Caponord, with more partnerships in the future. The rider can program the fuel gauge into their AR-1 via the smartphone application, knowing the capacity of the gas tank and MPG. The AR-1 is able to receive software updates via the smartphone application (Fourtané, 2015).

Motorcycle helmets designed using IoT (Chandran, Chandrasekar, and Elizabeth, (2016) have begun to be used to detect and report accidents. Cloud computing infrastructures and Wi-Fi enabled processors are used in the creation of IoT systems

and accident detection systems that continuously monitor the variations of the accelerometer values and transmit them to the processor. After that, cloud-based service is used when transmitting details about the accident to the contacts. Meanwhile, the global positioning system is actively used to determine the position of the vehicle.

The paper on Smart Helmet System Using Alcohol Detection for Vehicle Protection shows motorcycle users can be controlled with the help of smart helmets. In the smart helmet technology developed to control the motorcycle driving while under the influence of alcohol, it brings a new usage area for smart helmets as it provides detailed control of the user from whether he/she is wearing the smart helmet while driving and checks whether the driver is under the influence of alcohol or not. With the help of a transmitter placed on the helmet and a receiver placed on the motorcycle, it is determined whether the driver is wearing a smart motorcycle helmet (Mugila et al., 2016). However, innovations in control systems do not remain with this. If the motorcycle user takes care of the phone while driving, the motorcycle is forced to slow down. In addition to these features, the sensors placed on the front part of the smart helmet, corresponding to the rim of the rider, are used to determine whether the motorcycle rider is drinking alcohol (Vijitha et al., 2019).

2.6 The Role of Games and Simulations in Learning

Games and simulations are structures that are almost similar enough to be intertwined. There is no clear line to separate a game and a simulation (Tobias, and Fletcher, 2011). Randel et al. (1992) defined simulations as below:

> *"Simulations are interpersonal interactions, with and without computers, to achieve specified goals that are likely to depend on skill and may involve chance, competition and/or imaginary settings"* (Tobias, and Fletcher, 2011, p. 7).

> *"Simulation games have a goal of discovering causal relationships in a nonlinear fashion. These games are usually used for training, and the motivation to engage in simulation games is based on the need to learn more about a situation or is required for training and non-discretionary"* (Hoffman, and Nadelson, 2010, p. 246).

When it is examined, it is clearly seen that the use of simulations, especially in the field of social sciences, dates back to the early 1960s. When the usage areas of the simulations are examined, they can be used for many other purposes instead of being used only in the process of entertainment, performance, or prediction. For example, it should not be surprising that there are studies for educational and scientific discovery among the areas that will benefit from the use of these simulations (Axelrod, 1997). It's used as an educational learning tool from simulations.

> *"A simulation need not be rich enough to suggest a complete real or imaginary world. The main use of simulation in education is to allow the users to learn principles for themselves*" (Axelrod, 1997, p. 2).

> *"Social studies lend itself well to simulations, offering students opportunities to inhabit different worlds and assume the perspectives of others"* (Stephens, Feinberg, and Zack, 2013, p. 257).

It is quite possible to see how students interact in the classroom and simulation environment, especially in the field of social sciences. It will be quite natural to see these simulation games in different lesson areas such as history and literature during a class lecture.

Simulations and games are firmly planted in the ideas of constructionism. Seymour Papert (1991) defined the concept. Papert's idea was that students learn best when they are actually constructing something, and particularly if it is on a computer. He created this idea while at MIT in the late 1970s and early 1980s, obviously long before mainstream internet usage.

In these simulations, it helps to collect information in any field, regardless of what content is reached in the attempts of the drivers for a successful drive by using the information about the subject they have previously learned to. It was not only possible for students to develop this engine and provide information about the subject, but also to teach the users about game information. On the other hand, it is necessary to teach how to understand some simple systems in simulation for those drivers who are not familiar enough with technology. Simulations are structures that

are not open to debate in terms of ties to this type of real-life and cannot be structured with simple discussions. In addition, they are sufficient to create a copy of some events that will be expected in real life, which cannot be solved by discussion. (Feinberg et al., 2012). Today, with many factors such as the development of the game industry and technological developments, our drivers have started to close their training simulations and their distances to games. This natural familiarity created by drivers against games and simulations started to be reinforced with the introduction of our lives. In the mentioned simulations, simulations bring the level system with it, and this level system creates an effective factor in easier understanding and use of the simulation. Simulations and games allow social experiments to be carried out in areas where users are more comfortable. Drivers' familiarity with video games also helps test new things and lay new grounds for innovations.

These implications of learning are predicated upon simulation games such as motogpgame.com, ridevideogame.com. The data collected from these games show that when factors such as driving factors and application patterns of the drivers are considered and calculated, these games are useful. It has been observed that the real-life driving of the drivers who play these games are also positively affected. Technological advances will also play a major role in creating better simulation game engines in this context.

It can also be said for simulations and games that they ensure a very successful structure in implementing constructionist learning theory. Simulations are systems that are intended to provide a better understanding of the content, and they are the formations that are intended to create more favorable environments for information gathering, not only to convey more information about the subject.

CHAPTER 3: TECHNOLOGICAL ASSISTANCE

3.1 Main Characteristics

3.1.1 Indicators

A visual indicator, for example, a light source, on the device generates a visual signal to other devices around the user based on the user's state. The visual signal identifies an interference state of the user. The interference states include, for example, different levels of interferences (e.g., do not disturb, ok to talk to, talk to if important). In one example, the visual indicator generates different light colors (e.g., red, yellow, green) based on the user's state (e.g., focused, distracted, relaxed) (Kazatsky, 2019). The visual signal is indicative of the user's state and enables other users to decide whether to contact or interfere with the user of the Head-Mounted-Display (HMD) based on certain conditions or events. These examples focused only on possible variations. Unless otherwise specified data is transmitted, it is acceptable for these elements, parts, and operations to be used together, to be used separately or combined, components and functions can be combined or subdivided and fully optional, and processes can be alternately combined or subdivided or modified or to be used in separate ways. In the description and explanations to be mentioned, as many details as possible are tried to be included in order that the explanations to be made contain detailed explanations and do not allow for misunderstandings. It will be evident to one skilled in the art, however, that the present subject matter may be practiced without these specific details.

The virtual indicators may include arrows with shapes and colors that change based on real-time data. For example, the HMD could have a visual indicator LED display on a predetermined location (e. g., top or side of the helmet externally visible from other users). The interference status detection, as determined by the sensors and flowchart depicted in connection with FIG. 4, an interference prevention indication, could be displayed with a red LED. Ambani (2013) used indicators in his own way. the LEDs in the brake indicator are used in the rectangular shape, while the orange LEDs used for the indicators are arranged in the form of an arrow. As in these examples, the design details are designed according to local traffic regulations,

preferences, and traditions, from the indicator colors to the selection of the colors used in the indicators. For this reason, important choices should be made from the colors that will be preferred when LEDs are used, and what the shapes they will take in the arrays where LEDs are installed, and the edited high flux type LEDs should be used (Ambani, 2013).

3.1.2 Helmet visor

Helmet use is compulsory for motorcycle use for safety reasons. Helmet model The European continent ECE 22.05 should be adjustable according to the size of the head of the motorcycle user as well as the definition, the use of suitable helmets means that the maximum safety measures stated by the authorities of our continent are met. There are many visors on the market that can be preferred, these visors can be said to be the most noticeable module on the helmet, and it is possible to reach a large number of variants when the amount of transparency is considered, some of the samples that can be given for these varieties are darkened visors, darkening according to the amount of light they receive, can be exemplified as mirrored visors. It should not be forgotten that there are elements to be considered while choosing a helmet visor. Among the visors with their own standardization, the use of visors with the "CE" ID engraved on the visor and helmet should be preferred. Depending on the visor type and transparency, even if there are some exceptions, this certificate can be trusted to check whether the helmets are legitimate (Fundacion Mapfre, 2020).

- *Completely transparent visor:* Although the most common viewfinder type among all viewfinder types is this viewfinder type, if you prefer this viewfinder, you can wear sunglasses under the viewfinder to protect from sunlight. For the users who prefer this viewfinder, although the beauty of the design is relative, how comfortable it will be can be associated with several factors, the harmony of glasses, helmet, and head.

- *Helmet with integrated glasses:* When the motorcycle helmet models are examined, it can be seen that in the options that can be selected in recent years, the helmets containing sunglasses that are used when the visibility with the second visor, which can be activated with the help of only one button, is offered to its users.
- *Smoked visors:* As it is known, the use of smoked visors is recommended only for

users in sunny times, and it is not recommended for motorcycle users in areas where there is a decrease in the amount of light (tunnel locations on the road and its use in cloudy times) even at this time. Even the use of this type of visor in low light conditions is shown as a reason for punishment. Motorcycle users who will choose this type of viewfinder will also receive an article about these situations when they are warned by the manufacturer. Apart from all these effects, it can be said that they are quite suitable visors for use in high sunlight.

- *Dark, mirrored or iridium visors:* These visor types, which you can get a fine when used on public roads, do not pass the visibility tests of helmet standardization processes, but these visors are not only aesthetic but also provide good protection against intense light.

In the existing system helmet's visor can't move automatically and during an accident, it's helpless. The research titled "Automatic Movement of Helmet Visor Through Speech Recognition and Weather Detection" to overcome these drawbacks the helmet, suggest to provide automatic movement of visor through speech recognition, weather detection and using some module in a system the person who met to an accident can be saved by tracking its location. According to this research, "This new design, a generalized system application voice or speech-controlled helmet visor is the evidence for the efficient automation and is constructed around the microcontroller and microphone. When the motorcycle user gets involved in a possible accident, the visor on the smart helmet is closed, and the emergency information specified by the helmet user is notified via SMS along with the information about the accident and the location information. In reaching this position information, the last position information recorded by the GPS module is used" (Pal, Jadhav, and Mandade, 2017).

"Facial warming and tinted helmet visors" is another research title. The use of colored visors on motorcycle helmets allows its users to prefer these visors in different lighting conditions. With new technologies, innovations that rapidly change the color level in their visors for motorcycle users and thus reduce safety risks to lower levels will make these helmets more preferred. However, it should be noted that minimizing the heat load on the body is of great importance for these motorcycle

users. A good harmony between the measured and perceived heat loads have been achieved by measurements at medium color levels, and the disadvantages in this area have been reduced as much as possible. The results of these optical transmission properties carry important information about visor configurations. When the relevant inputs are examined, it is seen that a possible improvement in the visor structure technologies, which show negative sensitivity to infrared lights, will be met (Buyana et al., 2006).

Production and use of colored helmet visors can be preferred for many reasons such as comfort, thermal protection and good appearance. Considering how to evaluate these effects as well as for the industry, “comfort” will play an important role in the use of such products in different areas.

The panels used for these visors, the measurements of which can be measured with the help of a panel, should be similar to a standard glass window used to obtain relevant data for sound radiation and vibration, but with similar dynamic properties. Compared to a 4 mm thick aluminum panel, 4 mm glass panels were found to have no difference, and tests were provided to evaluate the frequency of overlap and panels of different materials, similar to the system in which the scatter curves of a standard car glass are being extracted. When these test panels are examined, it can be said for both test panels that after the data near the ideal zero displacement limit is reached in the areas of the panels close to the edge sections, they are attached to a frame that will protect this situation with the help of screws and fixed. Repeatability of EC polymer windows, which can change color with the help of electrochemistry and spectrophotometry methods, is envisaged. It can be said easily for the "smart window" technology in question that almost all of the applications requiring a rapid color change will find its place in the usage area and it will show enough features to complete the transition between transparent and color states very quickly (Chunye et al., 2003).

3.1.3 Shield system

When structures of motorcycle helmets draw attention with their primary material structure and cross-sections for protection, there are also end shields mounted on each of the endplates, as well as the shield plate and the cover section that protects

the opening on the front face of the head body. The structures that will act as shields in such helmet protection systems contain the endplate consisting of materials such as ABS, nylon, and polyacetal as well as polyvinyl chloride or acrylic resin as well as the preferred polycarbonate material. The system is provided with high transparency on the shield plate, and the purpose is to provide a good view, and the system's durability is ensured for the mechanisms that can be held by clicking and stopping at the desired opening degree (Kamata, 1993). Most motorcycle helmets protect the rider's eyes from debris, bugs, and wind with a face shield. The rider can typically raise the shield to a fully open position to increase helmet ventilation or to defog the interior surface of the shield. Unfortunately, the typical helmet does not aloe the rider to partially open the shield without the oncoming wind blowing the shield into a different position.

Inventor Scott S. Hong (1994) developed a motorcycle or bicycle helmets which operates with a ratchet system and has a one-piece face shield that has end nails with additional teeth extending radially along the curved edges and one end of the raised teeth with an end nail structure. In addition, it is mounted on the helmet with a pair of side plates, each of which is a central spring leaf with the ratchet system, which passes into the grooves between the radial structure of the end nails and its compatible teeth. Motorcycle and bicycle riders may have to be protected from the sun, and in this case, the face shield for a motorcycle helmet that will protect the rider's face from the sun contains an ultraviolet ray coating on one surface of the helmet and a reflective coating on the same surface of the body in addition to this coating (Hong, 1994).

With its improved shield system, Z-7, which has been renewed in all aspects, can be fixed or removed easily and securely with its variable axis double-action mechanism as well as high airtightness. In order to prevent the unexpected opening of the shield or possible shield movements, when a shield is completely closed, a hook on the back of the shield nozzle is locked in a shell, thus preventing the shield from moving with the wind and ensuring that the helmet shield will not open unexpectedly, and thus this helmet protects its high airtightness (Shoei, 2019).

Figure 3.1 A shield lock mechanism (Source: Shoei, 2019)

A shield lock mechanism is equipped in a nob in bottom of a shield and hold a shield firmly when it is fully closed. Shield base slides fore and rear in 5 steps by rotating a dial. Airtightness of a shield can be fine adjusted in both sides by maximum 1mm.

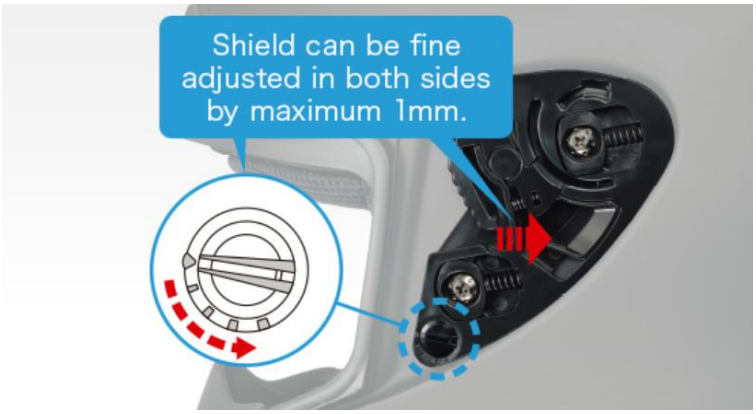

Figure 3.2 Shield base slides (Source: Shoei, 2019)

“CWR-1 Shield” with its minimum distortion rate that provides natural and clear vision, stands out with its advanced optics by applying the best and different radii and thickness in each area of a shield with its newly developed system. The ribs under a shield and the ribs on it increase the stiffness of the shield and make it more resistant during opening and closing actions while providing the necessary strength to prevent bending when the shield is exposed to wind pressure. These developments provide high quality when driving at high speeds for motorcycle users, providing easy sealing in opening and closing operations.

Figure 3.3 Shield System (Source: Shoei, 2019)

This shield, which is necessary for motorcycle users to ride comfortably, can be used to prevent mist effects occurring under low temperatures or rain. The PINLOCK® EVO lens is standardized on the Z-7. This visor attachment, which is famous for providing comfortable vision in almost all conditions while preventing misting, is also produced by choosing the size and positioning that can cover almost all vision.

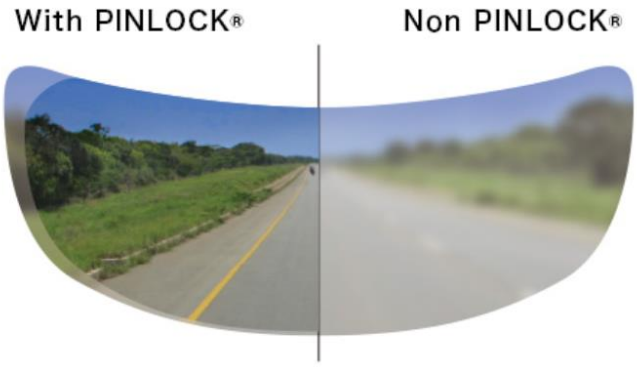

Figure 3.4 Anti-fog sheet (Source: Shoei, 2019)

Anti-fog sheet covers large area of a shield. The photo has only illustrative purpose.

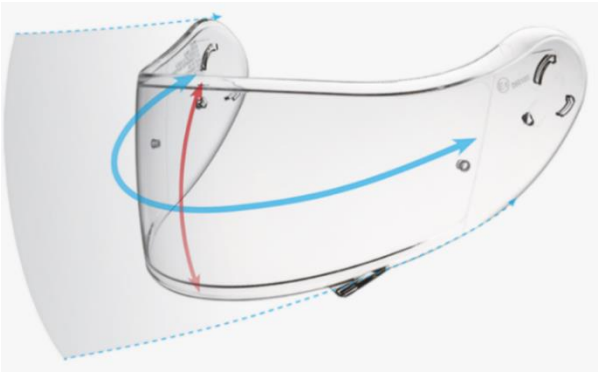

Figure 3.5 Shield System (Source: Shoei, 2019)

A standard helmet comes with a Pinlock® EVO fog-proof system which aims to protect the motorcycle user from 99% of the sun's harmful ultraviolet rays, this add-on reduces noise and is also important equipment with air and water tightness. 3D injection-molding methods are used to produce these systems that can provide images without distortion in the whole field of view. Airtight window beads, which are positioned to drain and prevent water from entering the helmet, also signal that this system will be a suitable environment for use.

3.1.4 Ventilation

For motorcycle users, the helmets they use need to sit tightly on their heads, but this may result in insufficient ventilation in the helmet, and this is the fundamental disadvantage for using motorcycle helmet. This disadvantage which motorcycle users complain about due to their discomfort, emphasized in the tropics where the users are exposed to higher amounts of humidity and temperature. Motorcycle riders may experience distractions due to heat stress, and such attention deficiencies can cause accidents. Therefore, proviing sufficient amount of air to the driver is very important in terms of attention and safety (Raju, Banthia, and Nassar, 2009). For body heat exchange through convection, evaporation, and air movement, motorcycle riders are exposed to forced airflow and heat transfer with forced convection, an easy way to provide ventilation inside the helmet, can be used to solve this ventilation problem (Yamashita et al., 2005). In addition to reducing the obstruction and humidity, this airflow, which shows its effect, especially on temperature, is generally used in the air outlet devices while the rate of 0.25m / s is due to the determination of the most appropriate air velocity when considering human comfort.

It has been observed that in cases where the amount of oxygen in the air where people are breathing is insufficient or contains more CO_2 than it should be, there is a decrease in the cognitive functions of people. A study showed that the CO_2 concentration for a rider cruising in still weather with a speed of about 0.2% without wearing a helmet is similar to the inhaled CO_2 concentration of a motorcycle user traveling at a speed of 50 km/h. CO_2 concentration is generally equal to oxygen deficiency and may negatively affect the cognitive abilities of the motorcyclist (Brühwiler et al., 2005).

A study was carried out by using simulation tools in order to make the ventilation mechanisms in the motorcycle helmet more effective. The geometric model built in CATIA V5 was used to model the behavior of the airflow around the designed motorcycle helmet. Study findings showed that the locations of potentially promising locations for the ventilation ducts in the helmet lining have been determined based on the airflow behavior around and inside the helmet. A fine adjustment to the ventilation grooves in the helmet made possible drag coefficient, and arousals are reduced by combining to provide internal ventilation (Raju, Banthia, and Nassar, 2009).

There are motorcycle helmet systems and methods used to prevent the visor from the misting in the motorcycle helmet and to reduce the condensation and formation of steam in the interior of the helmet. Among the regulations that can be valid and exemplary for motorcycle helmets are; It is interesting to use a visor system combined with a helmet shell with a ventilation tube, and a ventilation system intended to remove moist air from the inside of the helmet, as well as the use of moisture sensors, used to detect moisture in the inside of the helmet (Nolan, and Katsaros, 2014).

Inventors Claudio Canuto and Flavio Cimolin offer a thermodynamic model for the sweat's evolution in a porous medium in contact with a part of the human body, able to describe the evaporation-related heat transfer phenomena. With this method, which indirectly affects the safety of the driver, such as increased comfort, the analysis, and optimization of the motorcycle's interior ventilation, can be achieved. It is possible to make calculations for temperature, absolute humidity, and sweat in the model. Simulations, which have the feature of highlighting the regions where sweat accumulates, also show the beginning of the free border separating wet and dry regions (Canutoa, and Cimolin, 2011).

When features of a standart helmet is considered with an overview, top and bottom vents equipped with large shutters to be easy to use, which may be deemed necessary in terms of being suitable for use with motorcycle gloves, openings that allow air intake from 3 different locations with increased inlets and air intake performance, cold air intake with the help of wind tunnels that are subject to high developments

and arrangements for hot air outlet, improved air inlets, and fully renewed exhaust outlets to ensure air purification are among the systems) that serve to provide ventilation of the interior of standard helmets. A ventilation system or the cheek bar portion of a helmet, including a motorcycle helmet. Ribbed passageways used in the aforementioned ventilation systems facilitate the airflow through the inner part of the helmet and use this airflow from the ribbed passageways to the area in the helmet where it comes into contact with the user by making use of the access openings in the intermediate parts (Shoei, 2020).

3.1.5 Light Usage

Safety helmets with safety lights are used to increase visibility in motorcycle helmets, and these helmets not only contain a perimeter wall adapted to be placed on the motorcycle user but also have inner and outer wall surfaces. There is a channel in the outer shell of the helmet, and a connection to this channel is provided with a hole on the outer surface of the helmet, usually located in the front of the helmet. The light sources mounted to spread light on the helmet can be attached to these channels. The power supplies are mounted by placing them in the hole on the helmet, which is usually located in front of the peripheral walls. To perform the operation of all these light tools on and off, operating means must be operatively connected to these light tools (Vega, and Ramirez, 2002).

The first cluster includes more favorable conditions like no wind, no drugs, good lighting, whereas the second consists of less favorable conditions for road safety like windy, lighting, and unknown DUI conditions. Those hints at a meaningful separation of the examination of two-wheeler accidents when the influence of outside factors is considerable (Ziakopoulos, 2018). Among these factors, lighting can be the most effective one in terms of road safety, especially for night rides.

Motorcycle users prefer to use lighting safety measures on their helmets. The new generation helmet light technologies enable motorcycle users to travel with a futuristic and sophisticated appearance, especially for motorcycle drivers in regions that do not provide sufficient light conditions such as bad weather and insufficient street lighting. The bodies of motorcycle helmets are relatively difficult to choose by the eye, as they are often far from the reflective structure that reflects light, as in

motorcycles. The use of such helmet lighting systems, which increases visibility in such cases, will be very advantageous. Although light systems added to motorcycle helmets are legal in many states and California in the US, they may be considered illegal in some parts of Canada for purely technical reasons. High-level helmets, including light systems in their internal systems, are also available to motorcycle users today. These lamps, which are extremely resistant to water and weather conditions, are mounted on helmets under factory conditions. There are many different helmet lighting types such as EL (electroluminescent) tape, LED (light-emitting diode) Strips, Amatory Helmet Lighting System, Whistler Group Motoglo, The Street FX 1044081 and LightRider (Motorcycle Helmet Hawk, 2019).

3.1.6 Noise cancelling

It has been observed by the researches that not only traffic but also environmental factors should be examined as a whole in the study of noise sources because they are quite effective. In case of this need, not only transportation-related sounds such as highways, railways or airways, but also mechanical services should not be ignored in this study in expanded music and indoor noise sources, or industrial facilities (Berglund, and Lindvall, 1995). Noise zones for urban agglomerations are defined as given in Table 3.1 while Table 3.2 shows the noise zone categories for Turkey.

Table 3.1. Noise zones in relation outdoor noise levels (Source: McCombe, and Binnington, 1994)

Zone	Noise level
Black zone (Very noisy areas: Hot spots)	$L_{eq} > 65$ dBA
Gray zone (Moderately noisy areas)	$L_{eq} = 55$-65 dBA
White zone (Quiet area)	$L_{eq} < 55$ dBA

Table 3.2. Noise zones according to Turkish regulation (Source: McCombe, and Binnington, 1994)

Zone	Noise level
Category A	$L_{eq\ (day)} < 55$ dBA
Category B	$55 \leq L_{eq\ (day)} < 64$
Category C	$64 \leq L_{eq\ (day)} < 74$
Category D	$L_{eq\ (day)} \geq 74$

Operating environments where the noise level permitted by European standards is limited to 87 dB (A) (Official Journal of the European Community, 2003) or less can also lead to the presence of people at the same time, with very high levels of sound, such as the environment in which motorcycle riders are driving. Motorcyclists who use helmets without noise reduction technology must wear headphones just like those in loud working environments. This action is encouraged to avoid possible damages (Mccombe, 2003). With these incentives, awareness has been widely provided (Castañé-Selga, and Peña, 2010). It is obvious that the negative effects of ambient noise with the helmet cannot be ignored, and it is acceptable for all that these negative effects coincide with the risk of hearing impairment. An 80-hour drive can result to a temporary threshold shift of 11 dB at 1 kHz, and the studies show that 45% of Grand Prix motorcycles, 36% of motorcycle medics and motorcycle riding Of the 6, instructors are exposed to noise-induced hearing loss (Mccombe, and Binnington, 1994). Noisy helmets can be quite dangerous as they block attention, slow down reaction times as well as slow down reaction times by reducing perceptual and reactive effectiveness in traffic and clearly pose a great risk for hearing damage (Gilden, Thornton, and Mallon, 1995).

Although it may differ in various types of vehicles, it can be said that the factor that determines the large amount of noise produced by a motor vehicle will primarily depends on the output of the engine and the speed. Total noise is created by combining various component sources, and the process of identifying the required individual sources is essential for the noise reduction action. As a source of components, noise reduction is difficult in motorcycles, where sound cancelling is made quite difficult due to their design with gears, air cooling, fuel gas, rattle, valves, and low weight and small dimensions that the cylinder can be considered. We can talk about the existence of several ways to research individual resources separately. As a first step to reduce noise, it is decided by following this way which gearbox, cylinder and valve drive, which is generally neglected over time, will be intervened. The development and publication of the new type standardized measurement procedure developed in Germany ended with the application of all new vehicles to be released, and purpose of this action is due to the uniform evaluation of all vehicles. The maximum sound levels that are tested with the control measurements on traffic should be below the limit prescribed by the law (Bobbert, 1956).

Among the factors that can reduce concentration for motorcycle users, excessive noise in the motorcycle helmet has an indispensable place. Studies on the effect of sound on attention show that different sound levels can affect environmental perception in a very negative way. However, it is a negative factor that should be taken into account that the sounds that the driver is constantly exposed to, such as engine sounds, can overwhelm the external sounds. Nevertheless, the real noise factor in the helmet comes across due to more than one factor. While making improvements on different elements such as ventilation systems, visors, comfort fillings, aerodynamic structures, the need to reduce the amount of noise in the helmet should not be neglected. There are a number of behaviors that can be carried out by the users for preventive purposes such as using earplugs or buying wind-reduction motorcycle helmets.

One of the measures that can be used in noisy environments is the use of noise-cancelling microphones. In addition to aiming to hit the microphone cartridge diaphragm, the noise entering the front part of the microphone enclosure is stated to be provided to be located close to the rear of the microphone enclosure, especially through the entrance openings when looking at their strategic location. In this system, the cancellation of the diaphragm vibrations is tried to be affected in order to provide noise to the rear surface of the microphone diaphragm. The entrance openings, which are placed in the direction of the line of the front entrance openings, which are the biggest source of noise, and out of the road, have been selected to transfer air behind the part where the microphone is located. In the use of helmets, the effects of many air inlets positioned perpendicular to the microphone during motorcycle use are tried to be minimized when the strategic positions are taken into consideration. If the horizontal wind is not taken into account since the biggest noise source is above, it will be directed vertically to this microphone, or it will remain below the operator (Lazzeroni, and Carevich, 1994).

Charles Brown, and Michael S Gordon, in their research titled 'Motorcycle Helmet Noise and Active Noise Reduction,' revealed factors affecting the high noise levels associated with a motorcycle. The study in this area consists of two experiments, and in the first experiment, noise level measurements were made by using "Neumann KU-100 dummy head with embedded binaural microphones" to measure the effect

created by the speed. Two different helmets have been used to measure noise levels, one of the helmets used has active noise-canceling technology, and the other is not. When the measurements made with these two helmets are compared, it is reached to the data that the noise levels exceeded even high values such as 100 dB (A) at highway speeds, while the measurements made with the helmet where no noise-canceling technology is used, the amount of noise measured in the helmet using active noise canceling technology shows that with the help of the earplug. The noise level has been reduced to 26 dB. It can be said that active control technology is a promising innovation for the helmet industry, where developing silent helmets is important for both highway safety and hearing protection. In the second experiment phase, where this study was carried out, it aimed to investigate the subjective perceptions of helmet noise by motorcyclists. The results obtained in this study show that 63.5% of motorcycle riders wear earplugs while driving, 92.1% of motorcycle riders complain of the loud noise of motorcycle, 46.8% of them have noise-related tinnitus complaints and contributors 95.2% of motorcycle users state that they want motorcycle helmets to be quieter (Brown, 2011).

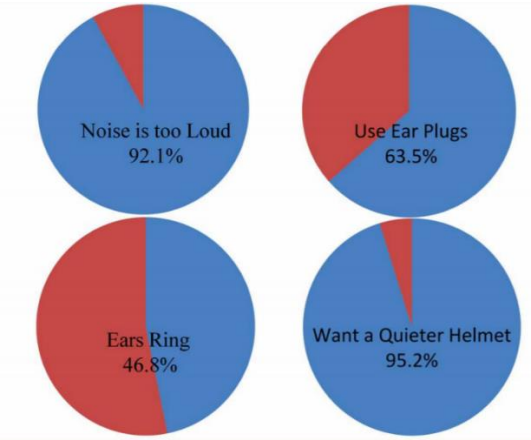

Figure 3.6 Survey Results for Charles Brown and Michael S Gordon's 'Motorcycle Helmet Noise and Active Noise Reduction's research (Source: Brown, and Gordon, 2011)

The online survey results show that most of the motorcycle helmet and earbud users stated that they were disturbed by the high noise in helmet use, while more than half of them mentioned that they needed to use earplugs and 9 out of 10 wanted quieter

motorcycle helmets. In addition, a significant portion of the participants faced complaints of tinnitus. Considering the number of helmets sold only in the middle and upper segments, it is seen that more than 4 million helmets reach its users every year. 90% of these users state that they want to reach helmets with better sound insulation (Daal, 2019).

3.2 Examination of Auxiliary Element IoT Systems Integrated into a Motorcycle Helmet

3.2.1 Navigation systems

A navigation system determines the position, speed, and direction of an object during travel and these systems are mainly categorized as physical model based and external data based methods. Navigation systems determine the existing positions of an object by measuring its velocity and acceleration. In modern era, exact positions and speeds of objects can be found by artificial satellites, global navigation satellite system (GNSS) and inertial navigation system (INS). Today, navigation has become a mechanical device in ground vehicles including motorcycles, ships, and aircraft to find their positions (Lee, 2018).

Figure 3.7 JARVISH X-AR - Live on Kickstarter (Source: Youtube, 2018)

Helmets, developed by Edison Cycle Co., are one of the most prominent examples for smart helmets which provide significant innovations in the motorcycle world with their smart device features. Unlike most of the current smart systems, this system transmits the information about motorcycle users' motorcycles directly to their helmet users through the Edison system by taking them directly from their motorcycles. Moyerman's announcement will tell you that you want to go home to the smart system in the motorcycle helmet, and your smart helmet will direct you to the route that will take you home. However, by calculating the gasoline consumption and the amount of gasoline left in the tank with the information it provides from the motorcycle, it adds the road to the nearest gasoline in the route if there is not enough gasoline available. Since this system also has intelligent navigation technology, it will warn you of oncoming sharp turns taking into account your speed (Wallbank, 2015).

- *AI (Artificial intelligence):* The broad branch of computer science, whose task is to build smart machines to perform tasks that require human intelligence, is called Artificial intelligence (AI) (Builtin, 2019). In today's technologies, the development of artificial intelligence (AI) and Virtual reality (VR) technologies enables new dimensions to be opened on the road that is driven by the development of smart devices. If we briefly review VR technology, we can say that it is a simulation of a 3D image or a computer-generated environment simulation that looks like virtual reality and can be physically interacted with the help of special tools with its gloves equipped with sensors and screens placed inside the helmets (Stevenson, and Lindberg, 2010).

- *ASI (Artificial Super Intelligence):* The investments of state institutions and big technology companies on the development of technologies for artificial intelligence, it will have a great impact on improvements for Artificial Super Intelligence (AIS). As a result of the creation of conscious machines that will eventually be produced in the field of AI, the concept will change, and discussions on this issue will be radically reshaped. Starting from the current definitions of AI (see Oxford and Cambridge dictionary) and the perspective of Bostrom (Bostrom, 2003) regarding the concept of Superintelligence, it is likely that in the near future, the term of Artificial Intelligence will be replaced by AIS. When the features of Artificial Super

Intelligence applications, where more than one developing technology plays a role, are examined, it is understood that it is similar to some of the features of the human mind such as perception, learning, speech recognition and decision making. It should not be forgotten in the evaluations about these machines, which carry some of the features of the human mind, that these devices will not have full awareness about their own assets and environment, and they will lack in feelings and emotions. As technological achievements and milestones continue to accumulate, ASI will be developed and introduced. Experts are working on the effects of creating smart life in this area in the ethical field (Vezina, 2016), taking into account the moral aspect of this situation AI (Clark, 2016) and ASI (Baciua, Oprea, and Riley 2016).

- *HMI (Human-Machine Interface):* Yamaha won an iF Design Award 2019 for its concept motorcycle called the MOTOROiD. MOTOROiD, which is a tool that recognizes the user and reacts accordingly to the user, also has a self-acting feature. With these features, HMI (Human-Machine Interface) sheds light on a future far beyond "Transfer Vehicles."

Figure 3.8 The MOTOROiD (Source: Yamaha, 2017)

This AI-developed motorcycle is not only a motorcycle that can auto ride and recognize its driver; it is not only a smart device that keeps track of the rider's inputs on home and personal devices but also keeps track of day-to-day plans, movements, and emergency needs. Apart from being able to react to the gestures of the driver,

this smart motorcycle, which has a tactile system, reacts by sensing the touch of the driver via its features (i.e., touch feeling).

- *AR (Augmented Reality):* Augmented reality (AR) technology, which is accepted in many fields, is also highly accepted in the automobile industry. Highly useful and developing AR technology is the technology that blends the virtual visuals created by the computer with what the users see in real life. It can completely change how the real environment is displayed by the user, with the virtual scene and software it implements and the improvements it makes. The technology that offers a three-dimensional visual world to the user by combining the live images feeds from the camera and the virtual images transmitted to the smart glasses is called AR technology.

Some of the screen provider technologies that can create blended and augmented facts for us; It can be exemplified as “retina screen, spatial optical transparent screen, hand type screen, head-mounted screen, the screen projected to object” (Ahire, and Patil, 2018).

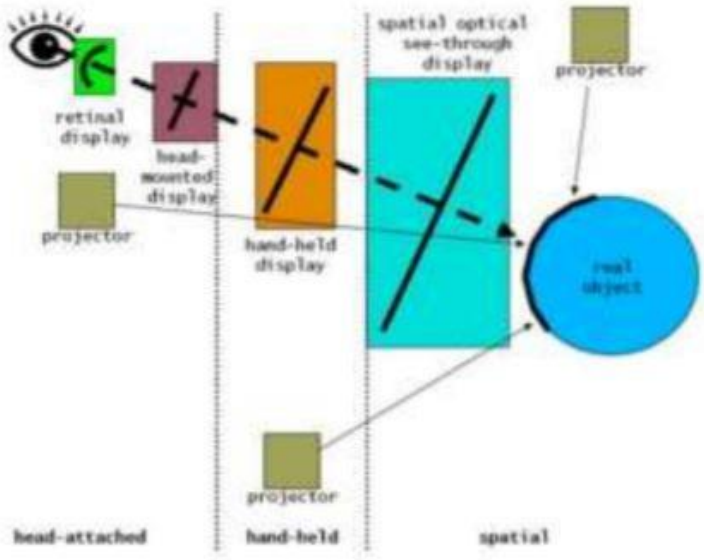

Figure 3.9 Image-generation for augmented reality display (Source: Ahire, and Patil, 2018)

Proximity dimension:

- Proximal: retina and head set up displays, which may be grouped together as augmented visual field device (AVFDs),
- Distal: free standing presentations (e.g. monitors or projected shows),
- Hand-held: hand-held devices inclusive of tablets or phones (Ahire, and Patil, 2018).

The Augmented Reality (AR), which enables us to experience an interactive version of the real-world environment with the help of technology, is a blending of computer-generated perceptual information and objects in the real world with multiple sensory methods: “smell, auditory, visual, tactile somatosensory” (Williams, 2017). In this real-time interaction where virtual and real objects are under 3D recording, this technology, which contains the features of creating a combination of real and virtual worlds, can be defined as AR technology with these three features (Wu et al., 2013).

The overlaid sensory information can be destructive (i.e., masking of the natural environment) or constructive (i.e., additive to the natural environment). In this experience, which is perceived as an immersive aspect of the real environment, it is perfectly intertwined with the virtual environment (Rosenberg, 1992). Thanks to augmented reality, virtual reality completely replaces the user's real-world environment with a simulated one, and it alters the ongoing perception of a real-world environment (Steuer, 1993). The terms computer-mediated reality and mixed reality are synonyms and are used to express augmented reality.

For the augmented reality that encompasses many industries, it can be said to cover the communication, education, health, and entertainment industries among the commercial industries. It is possible to realize the use of AR in the field of education, to scan and monitor the contents with a mobile device, and to access them using an AR technique (Brown, and Gordon, 2011). The development of helmets used in construction areas, which will provide information about construction sites with AR use, can make a significant difference in the construction industry.

LiveMap Helmet, one of the leading helmet brands with its system that allows viewing a projected image instead of using bulky and inappropriate screens, prefers to use the augmented reality interface in its innovative movement, and the augmented reality technology that ensures uninterrupted flow of information about the route and important parameters prevents the loss of focus on the road while driving.

Figure 3.10 The Motorcycle helmet Livemap (Source: Livemap, 2019)

With the HUD technology used in automobiles, the images reflected by this smart motorcycle helmet are projected onto the visor using a safe focal distance, thereby avoiding factors that may cause safety issues.

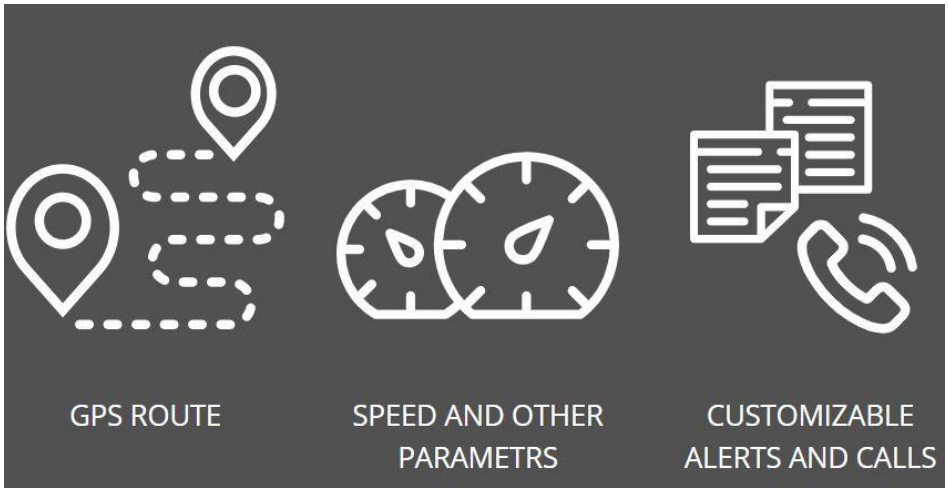

Figure 3.11 Augmented Reality Interface (Source: Livemap, 2019)

AR technology where the colored and transparent screens are used, prevents using bulky and inappropriate screens. Besides, these screens, where only important security information is prioritized, will have more focus and less risk for the motorcycle user.

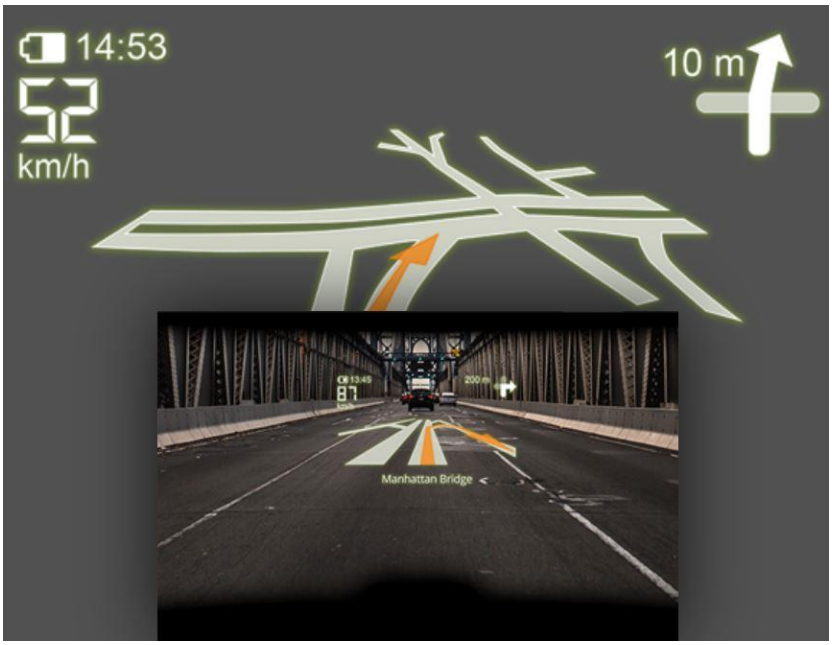

Figure 3.12 Augmented Reality Interface (Source: Livemap, 2019)

The information and indicators appeared on visor are spread on the entire area but it is not a problem for safety of users' driving because there is appropriately enough room for the road to be seen. Certain areas are attributed to speed, time, location info, and route on the surface of the visor, shown as in Figure 3.12.

• *Augmented Vision System (Augmented Reality HUD):* Augmented reality HUDs (head-up displays) are up to assist the transformation of driving. By providing data for the driver, it is going to become indeed more comfortable and secure as the driver will be able to see the traffic's external outlook state before the vehicle.

In this system, the driver can use the navigation details provided by the virtual view attached to the original image he uses while driving to track the route. Considering such features, it can easily be said that the extended reality overhead display is different from an ordinary windshield-HUD, considering that it is part of driving activities and reflected data. The augmented reality head-up displays allow the driver

to see the identified car ahead with a marking once the distance controls; in other words, the adaptive cruise control (ACC).

Furthermore, eases the driving course by providing a visual straight-forwardly linked to illustrative information, in these times, when everything is getting highly complicated. Given all these new features that make the augmented reality HUDs faster - fundamental for more secure driving and assurance- the driver can register the driving situation (Continental-Automative, 2019).

- *VR (Virtual Reality):* This simulated experience has various purposes, such as instructive or entertainment. The informative purposes may include military or medical training, while entertainment can be exemplified as gaming. Moreover, it can be the resemblant to or totally distinctive from the actual world.

AR and mixed reality are two of the classifications of virtual reality innovations. The artificial world can be discovered via VR headsets by looking and moving inside the VR world. The users can even have an interaction with the VR features. The VR systems achieve this by using the headsets and multi-projected environments, creating sensations, such as realistic sounds and images in the virtual environment, that mimic the existence of the user. Those mimicking effects can be both created in the rooms that have big screens inside or by head-mounted displays. The head-mounted displays place small screens before the user's eyes.

Figure 3.13 A VR parachute simulator demonstrated by US Navy medic at the Naval Survival Training Institute (Source: Wikiwand, 2019)

Figure 3.14 A Missouri National Guardsman using a VR training head-mounted display at Fort Leonard Wood (Source: Wikiwand, 2019)

Figure 3.15 Researchers with the European Space Office in Darmstadt, Germany, equipped with a VR headset and movement controllers, illustrates how astronauts might utilize virtual reality within the future to prepare to extinguish a fire (Source: Wikiwand, 2019)

Unlike traditional user interfaces, VR creates a simulation using computer technology and delivers the user within the experience. Furthermore, it can be said that cyberspace is an organized VR.

The user becomes fully immersed in a virtual world via HMD (head-mounted display) that commonly offers different images for both eyes. They contain LCD monitors as well as small high-resolution OLED. The stereoscopic graphics offers

three-dimensional images in the virtual world. Moreover, six-degrees of movement can be tracked with the rotational and positional real-time head. This is achieved with a binaural audio system, as well.

3.2.2 Communication systems

There has been a strong demand for the smart motorcycle helmet (MK1) of Forcite, which contains a microphone, a handlebar controller, speakers, and a camera. Through these features, the riders can interconnect to highways, communities, and cities. It was initially created for the police. Moreover, the Australian start-up (Forcite), is putting their helmet on the US market.

In July 2019, Forcite launched the helmet into the Australian market. Furthermore, they said

> *"You'll know where the police are. Know the road surface ahead. Know where to go and when to turn to avoid traffic. You'll know where to park, where your mates are, and even which pub has Happy Hour. In short, you'll know everything you need to know to be safe, stay safe, and arrive home safely"* (Corner, 2019).

Forcite uses its patented helmet system called RAYDAR, which works via server-based software. The system collects data from various locations worldwide. Mobile applications, cameras, and GPS are where it collects the data that is obtained with the help of Al. The data is transmitted to riders via a particular LED display. Those LED displays provide colored visual signals. The high-tech Formula 1 steering wheels work similarly. It provides directions, possible risks, and warnings for the driver. Moreover, with this technology, the riders do not need to lose focus off the road, and they are not distracted by the dangerous head-up.

With the colorful visual indicators, the driver makes choices at pace — without losing focus off the road, much like Formula 1. The right and left are indicated by the green. For caution, orange is used, whereas the weather is indicated with blue. Lastly, flashing red and blue are used in case of the police's presence. Also, both the verbal messages and this patented system (RAYDAR), take the user into the future itself. Moreover, it is possible to repeat the last instruction on the navigation, pause

and listen to music plus take calls, turn the camera on and off, or even if one needs to, immediately delete the footage. All the features are absolutely easy to reach, thanks to Forcite's handlebar controller. Therefore without any distractions, the rider is able to operate the technology inside the helmet fully. The GPS-personalized - to a motorcyclist, a vehicle, and driving- vital insight is converted from billions of bytes of crucial data by the back end of Forcite via pushing it firstly inside the application than the helmet, and finally to the rider. Having phonecalls is facilitated by unchallenged sound isolation and navigational warnings. Moreover, listening to music and communication with other Forcite users is very easy.

Figure 3.16 Forcite Helmet Systems App (Source: Forcite Helmets, 2019)

3.2.3 Head-Up-Display (HUD)

The HUD is defined as a head-up or heads-up display (Oxford Dictionary of English, 2010). It offers a see-through preview of the information according to the direction of the user's standard eye view. HUD was evolved from the reflector sight for military fighter aircraft. Fundamental role of HUD is to "provide primary flight information, guidance and navigation information to the pilot in a forward transparent screen." "Head-up" enables users to view the information with "head up" and looking forward, instead of looking away from the usual view of field and reading the traditional head-down displays (Xi, 2011). Nowadays, HUDs are in civil aviation, automobiles, and other professional use, however, they were primarily created for military air platforms. Some aspects, that interplay in designing a HUD are the following (Yeh et al., 2016):

- *Field of View:* There three types of field of view, narrow, broad, and binocular. A narrow field of view indicates a few complementary information, for an example view of a runway, through the symbology with regards to the external view shown by the combiner while a broad field of view provides more “extensive” view and the binocular field of view displays the identical image for both eyes thereby meets the contemporary expectations. However, the HUD image can be viewed by either one eye or both. It depends upon the financial and technical situations in the course of the designing process. All these three types signify the angles subtended vertically and horizontally, to the pilot’s eye.

- *Collimation:* The collimation of the projected image transforms the rays as parallels. When they are sent in order to see clearly, the human lens focuses on the infinity. The collimated images are recognized to be existing at/near optical infinity on the HUD combiner. As a result, so as to see either the outside view or the HUD display, the pilot's eye does not have to re-focus. The image overlaps the external world and seems to be out in the field.

One of the core advantages of collimated HUDs is not having the necessity to re-focus amidst the information overlaid onto the external world and the HUD-displayed symbolic data, which the essential feature for efficient HUDs. As for instance, last moments of landing are crucial for a pilot who requires a few seconds in an effort to re-focus on the outside; then again in the cockpit, the HUD addresses safety-critical and time-critical manoeuvers. Consequently, collimation is a fundamental character trait of high-efficient HUDs. On the other hand, it discriminates against them among consumer-quality systems. As an exemplification, consumer-quality systems solely reflect uncollimated data off a car's windshield, which breaks the driver's concentration off the road and makes them re-focus.

- *Eyebox:* In favor of viewing, the display may only be available whilst the individual's eyes are someplace within the cylinder, which is a three-dimensional area named the eyebox or the head motion box, the optical collimator creates a cylinder of parallel light. The latest HUD eyeboxes are generally around five laterals by three verticals by six longitudinal centimeters, which, to some extent, provides the user freedom of head movement. However, in case of excessive up/down movement

or left/right, the display will disappear from the collimator, and also it will crop off around its edges (vignette) with the movement back too far. Additionally, given that the pilots have one of their eyes inside the eyebox, they can see the whole display (Spitzer, 2007).

- *Luminance/contrast:* Ambient lighting, which has various types such as the glare of bright clouds, jet-black nights, or dim places, is considered, displays are adjustable in terms of luminance and contrast.

- *Boresight:* HUD features for aviation are aligned at high accuracy with the plane's three axes which is called as boresighting. Thereby the information displayed may differ in the HUDs FOV as well as complies with reality in general with the authenticity of ±7.0 milliradians.

"Comply" indicates the alignment when an object is both in view and projected on the combiner so that the display demonstrates the location of the artificial horizon along with the highly accurate projected path of the aircraft. For example, once the real runway lights are visible, the display of it aligns with the actual ones via the use of enhanced vision (Spitzer, 2007).

- *Scaling:* A picture is overlaying the external world is presented in 1:1 relationship sharp, to the pilot. These pictures include scaled flight paths, yaw scaling, and pitch. The HUD display must show 3-degrees below the horizon objects, which includes a runway threshold as viewed from the cockpit.

- *Compatibility:* Especially, the HUD components are designed with the purpose of being harmonious with other avionics, displays (Spitzer, 2007). Premium quality real-time footage is provided by a camera of 180-degrees placed on the backside of the helmet. Notwithstanding the fact that without turning the head, one only glances at the screen on the visor to see whether a car is approaching or not.

Figure 3.17 HUD experiment of immersive simulator use (Source: Ogi, 2013)

Smart technology integrated into BMW HUD helmets. Thus provides access to GPS, mobile phone, and various other functions for the user's eyes that are accessible, controllable, and observable. Although it sounds appealing, having the media in the face while driving sounds disturbing. However, it is convenient to keep the focus on the road instead of checking the mirrors.

Figure 3.18 That is the HUD view propose of BMW's smart helmet design (Source: Canada Moto Guide, 2019)

Skully has not added yet this incredible technology into a HUD system for bikers. It is going to include answering calls with the user’s voice and various other helpful functions. By far, the most innovative tool is the wide-angle-rear-view camera, which is mounted on the back of the helmet (Sternberg, 2015).

Figure 3.19 HUD-System (Source: Canada Moto Guide, 2019)

BikeHUD, which offers the users simple data without losing their focus on the road, is another HUD system, and it is attachable to the existing helmet system. The effect of the peripheral view enables the user to drive without transparent layers on the central view (Sternberg, 2015).

3.2.4 Bluetooth

One might encounter some different terms like "Integrated" and "Bluetooth ready" while shopping for Bluetooth motorcycle helmets. The integrated Bluetooth system means the helmet has a Bluetooth communication system. Nevertheless, it should not be confused with Bluetooth Ready helmets as they are standard helmets that have a recess and space in them that fits the user's seperate Bluetooth system. Taking into account all these, the client needs the latter if they have an existing Bluetooth headset to install into another helmet (Auto Wise, 2019).

To track the heart rate, Babaali, mainly recognized with the smart helmet developments, integrated Bluetooth optical heart rate collector into the helmet. It shows the heart rate statistics through an application, to which it is connected. Smart Construction Helmet is another product of the company which measures the user's speed, heart rate, oxygen level, pressure, the temperature of the body, and lastly, the VOC. Visit their website if the user needs more information about their other selections of helmets (Kosir, 2016).

3.2.5 Biometric wearable

Biometrics in wearable form has become increasingly popular day by day. Smart biometric wearables have been used for identification and they have also been replacing traditional password and chip and pin authentication methods (Hill, 2015). For the security perspective, a study in Philippines addressed a biometrics which can be used as an anti-theft and safety device. This device is located under the handle of the motor and the sensor is placed on top of the helmet. An Arduino compatible fingerprint scanner is suggested as a security system for biometrics used in motorcycle anti-theft device (Maranan et al., 2019). There are some example uses of smart helmet involves biometrics.

As a model, LifeBEAM, a smart helmet, not only monitors the heart rate but also gives calorie count. In addition to all that, it gives a proper performance analysis and protects the head of the user. Usually, the heart rate level is detected by smartwatches that integrated optical heart rate using IoT. Those devices do not require chest straps. Starting to develop products for the military, then moving little by little to the consumer world is the distinctive feature of LifeBEAM. That granted them the opportunity to have accurate data, thus better for the user's to know about what their bodies are going through (Kosir, 2016).

Mohawk, attachable to whichever helmet type, is an action camera. Mohawk's functions include taking a photo, recording a video, tracking the user's activities, and being their emergency system. Moreover, through an application it is connected to, the user is able to share their experience with friends. With the help of this camera, the riders also know their speed, the routes they take, and many more. The product has a fascinating feature that provides all the information 2 minutes before the accident, is called the Black Box. Besides, it locks down the footage for the rider to review what happened, exactly.

3.2.6 Mounted Display (Micro-Display)

A head-mounted display or HMD is a display device that has two types, which are monocular or binocular head-mounted displays. It is worn as part of a helmet or on the head and has a small optic displaying before the eyes. The first type shows the display for just one eye, whereas the latter shows it to both eyes. HMDs are used in

multiple areas, such as gaming, aviation, engineering, and medicine (Shibata, 2002), and they are the main elements of virtual reality headsets.

In addition, there is an optical head-mounted display (OHMD). It is also a wearable display and is able to reflect see-through projected images (Sutherland, 2018). There is an optical view of GPS that is installed in a helmet. Much like iPhones "Siri," the based path records use a natural language type voice commands device. The display projector is located within the helmet and the carbon filter. In addition to that, it is positioned on the backside of the user's head.

3.2.7 Light Sensor

The projected image must be clear, in the unfavorable clarity conditions. Thus, the light sensor is designed accordingly. It is automatically adapted to the environmental lighting, very much like the iPhone or android cellphones. According to the World Health Organization, each day, 350 people around the world are killed in the accidents caused by negative visibility on the road (Ha, 2014) when the mild sensor is automated, the brightness changes in accordance with the surroundings (Ahire, and Patil, 2018). The comparison of display on a sunny day, at a dark night and a bad weather have shown in Figure 3.20, Figure 3.21 and Figure 3.22.

Figure 3.20 Display on a sunny day (Source: Ahire, and Patil, 2018)

Figure 3.21 Display at a dark night (Source: Ahire, and Patil, 2018)

Figure 3.22 Display in bad weather (Source: Ahire, and Patil, 2018)

There s also an “adaptive light notification system” developed bu inventor Reem Jafar Alataas (2016) which actives turn signals using sensors. The helmet is equipped with sidelights which is activated by a head movement therefore it increases the safety of riders and other users from all directions. This system not only increases the visibility of turning direction of rider but also has minimum interaction by the users.

3.2.8 User Interface (UI)

Within the user interface (UI) design, which this the procedure of creation of the interfaces, whether in software or computerized machines, the intention of the designer is to make user-friendly and enjoyable designs focusing on the looks or style. UI designs generally indicate graphical user interfaces. However, voice-controlled interfaces are referred, as well (Interaction Design, 2019). They are, in

other words, access points for the users to interact with the design.

Within the course of the design, target users must be taken into account; for instance, supposing that the UI is confusing or not modified to the target, the user might not manage to discover the information or have the service they seek for. Thus the layout must be explicitly rendered in order to be found in a logical position by the user (Pidoco, 2019). UI designs should be done in the best possible way for the users so that they can operate an app as fast and effortlessly as possible.

User interface elements are generally classified as one of the categories below (Career Foundry, 2019):

1. *Input controls* enable the users to enter input to the system. For example, if the user requires the country of the user, you should use an input control.
2. *Navigational components* enable users to move around a website or product. Tab bars on iOS and the hamburger menu on an Android demonstrate popular navigational components.
3. *Informational components* share information with users.
4. *Containers* keep linked content together.

In web and app design, UI design and UX design are commonly confused and conflated terms. Generally, they are written as a single term, UI/UX, and seem to interpret the same thing (UX Planet, 2019).

Figure 3.23 User View (Source: Ahire, and Patil, 2018)

Figure 3.24 Display of the Map View (Source: Ahire, and Patil, 2018)

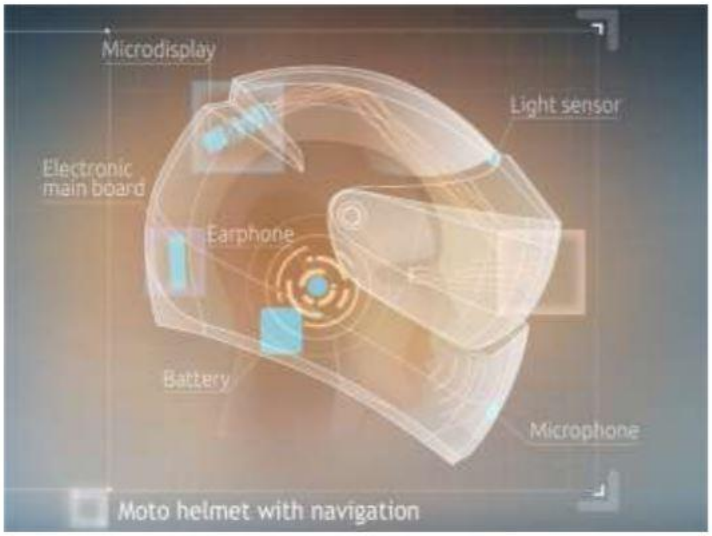

Figure 3.25 Smart helmet Design (Source: Ahire, and Patil, 2018)

In this section, the meaning of UI design will be analyzed. As it was mentioned above, the abbreviation represents the user interface. It is also considered to be the graphical layout of an application, which consists of the user's interaction with the content such as the texts they are looking or reading, the images they look, sliders, boxes they fill by clicking on them. These also cover screen design, transitions, interface animations, and all the other micro-interaction. Everything must be designed, like a visual element, interaction, or animation (UX Planet, 2019). It is the UI designer's work, who creates the appearance and feel of an application, such as the width of lines and the fonts used for text. Furthermore, the UI designers are graphic designers who are concerned about aesthetics. They need to ensure that the

App's interface is appealing, visually-stimulating, and the theme selection is matching the purpose or personality of the App. And also, they need to make sure each one of the visual elements seems to unite within the framework of aesthetics and aim.

3.2.9 User experience (UX)

Even though the terms “User Interface Design” and “Usability” are also used instead of "User Experience Design," it is essential to underline the fact that they are sub-group. As a matter of fact, it is safe to assume the UX design area is much more comprehensive.

So what does the UX mean? Firstly, it refers to the user experience. It covers how is the interaction realized by the user. That indicates the user’s experience. Is the experience smooth? Is it intuitive or unfavorable? Is it puzzling? Is the navigation within the application feel reasonable, or is it random? Does the interaction between the user and the App make them think they are effectively carrying out the tasks they mean to achieve, or does it give the impression that they are struggling? The user's experience depends upon the hardness of the interaction with the user interface features created by UI designers.

The reason why people can not differentiate UX designers is that they deal with an application's user interface. Here is the main difference, a UI designer decides the appearance of the user interface while UX designers are responsible for the operation of the UI (UX Planet, 2019). In other words, they are in charge of the functionality and the structure of the interface. For example, the organization of the relation between all the parts. Briefly, they determine how the interface operates. The user is going to have a great experience only if the application works right and feels flawless. However, if the navigation is complex and unintuitive, the user is going to have a terrible experience. UX designer is in charge of the prevention of the latter situation. User experience design is what the designers use in creating products by providing purposeful and appropriate experiences for the content for the user. It includes the design of the whole product’s acquirement and integration of the procedure, which involves design, aspects, usability, and function (Interaction Design Foundation, 2019). Both of the designs’ skill requirement is distinct from

each other. For example, an appealing design can not recover a complicated interface with unuseful navigation, and corrupt visual interface design can ruin magnificent and entirely appropriate user experience. All the two of them have to match in terms of alignment and execution, which should be flawlessly realized, taking into consideration former expectations of the users in order to develop outstanding feedback of the UI (user interface), and UX (user experience). Once all the abovementioned features are combined, the results will be wonderful (UX Planet, 2019).

Let us take a website of movie reviews into account as a means of exemplification. In the event that fundamental database incapsulates movies from major studios, the UX will be insufficient for a user looking for a small independent release regardless of the fact that the UI is perfect for finding a movie (Nielsen Norman Group, 2019).

So as to clarify this issue, Taylor Cygan, in his case study, subjected two corresponding navigational applications, one on one and determined which one of them has the better UX. Within the framework of this study, Cygan compared two almost five-star rating applications based on Appstore, Google Maps, and Waze. With the ranking number one and two, respectively (Cygan, 2018). This case study demonstrates which of the applications a rider thinks they can arrive at their destination without any problem like getting lost.

- *Home Screen-Winner is Waze:* A user firstly sees the homescreen when each of the apps is launched. Both of them have a simple and functional UI. Both of the home screens allow the user to see the location of themselves trough a contrasting symbol to their surroundings. Each of them was highly. Responsive: to take a bird’s eyes they can both pinch and swipe.

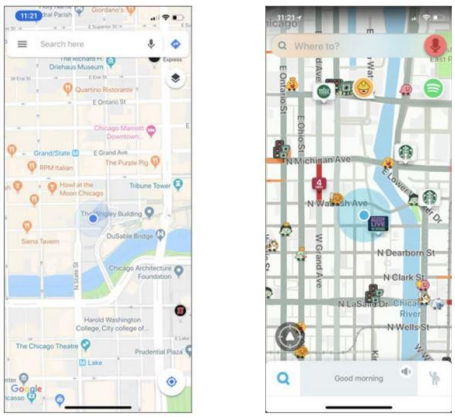

Figure 3.26 The home screens of Google Maps (left) and Waze (right) (Source: Cygan, 2018)

When Waze's main screen is concerned, it is observed that there is a significant contrast in terms of design choices. Its interface is overcrowded than the Google Map's interface. The latter is simpler than the first application. Waze can easily be described as more entertaining, whereas Google is more practical. Besides that, the design of Waze provides simpler customization of the navigation and is more functional. Even though the design is a little confusing, it has pop-ups on the map that alerts the driver about construction, traffic state, restaurants in the user's area, police officers, and photo enforced traffic lights. On the contrary, Google Maps, to some extent wasting their experience feature list with a cleaner interface. The users are not offered about the surroundings whilst driving. As a result, Waze is better in terms of the UX as they provide an updated and detailed information about their locality.

• *Search Options-Winner is Google Maps:* For a user, a navigation app is one of the most important features is the ability to search for and enter their destination. This case study indicates that both of the applications the search option (Cygan, 2018). Each application has a search bar on top of the screen. This is a simple function that any user can comprehend, regardless of their knowledge or their background. Waze points out the search bar by asking, "Where to? Google Maps does the same by directing the user, saying, "Search here." Nevertheless, the applications offer a different level of modification to the user. Flashy and remarkable graphics are used by Google Maps to offer suggestions to its user with the purpose of showing the area. Waze, though, provides prevalent search adjustments via a unique way of graphic

use, for example, the fork points out food. Furthermore, Google Maps provide a sorting list of 'foodies.' In conclusion, Google Maps seems to be more productive, owing to there chic and captivating design choices.

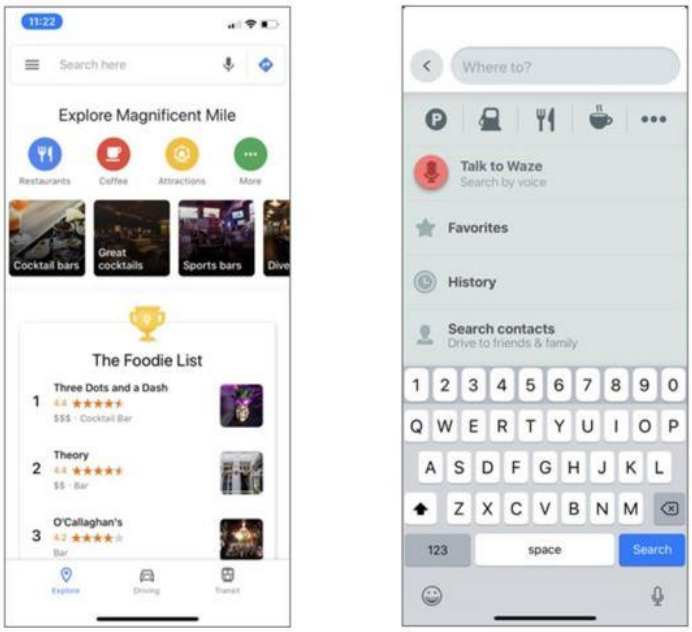

Figure 3.27 Search options on Google Maps (left) and Waze (right) (Source: Cygan, 2018)

• *Navigation Itself-Winner is Waze:* Both of the applications are evaluated within the framework of the navigating experience. The chosen location is a local Starbucks for this UX case study.

The observation shows that their interfaces are almost opposite in their design. Google Maps show the directions well organized on the button of the screen, and Waze is rich in terms of buttons as well as navigation options. Moreover, the ETA is the principal figure on the screen. According to Google Maps, simplicity is more preferable than complexity. However, Waze uses the full-screen space for the driver to customize and make their experience better. As a result, Waze seems to be better as it provides abundant options for the user to enhance their driving experience, diverse route alternatives, a way to stop, sending options for the ETA. Furthermore, the arrival time or distance is easy-to-view (Cygan, 2018). The consumption or usage is not the only aspect being considered during the designing process of a product that provides perfect UX. The whole procedure of problem-solving, acquirement, and

owning it is also being deemed. Equally, the user experience designers also prioritize creating operable products and other aspects of UX, like pleasure, effectiveness, and entertainment. Hence, there are multiple definitions of good user experience. A great user experience is able to accomplish the user's needs within the particular context of using the product (Interaction Design Foundation, 2019).

UX design covers the process of enhancing the user contentment while interacting with the application by improving the usability, accessibility, and pleasure. The application should be easy to navigate and cognizable. In addition to that, it should smoothly lead the user where to click to get to where they need to go. This is all essential for good user experience. Furthermore, the UX designer should be able to make all those possible (Career Foundry, 2020).

CHAPTER 4: CONSUMER RESPONSES ON HELMET SELECTION AND EFFECTIVE FACTORS DURING DRIVING

4.1 Consumer Response on Motorcycle Helmet Type Selection

As mentioned in the introduction, the first three questions of four research questions were evaluated in this chapter. The first question is about the assessment of distraction factors which may cause traffic accident while driving according to the user experiences. The prevention of head injury in the crashes is the primary and critical feature of motorcycle helmets—an exclusive system within the framework of the regulation of the supply and the usage of the helmet. One of the core elements of those systems is the motorcycle helmet standard. Standards are based upon the sales and on-road use of the product (McIntosh, 2015). Therefore, helmet standards should consider both technical and experiential values to prevent distractions while driving.

In this chapter, texts compiled from the website and forum content, where motorcycle users share their riding experiences with other motorcycle users. These texts are useful for observing a reflection of the user experience and shed light on the positive and negative events and elements during use.

- For example, on June 18, 2014, a motorcyclist on www.motorcycleforum.com/, alias r6 asked for a consultation and said that s/he had been riding and realized s/he did not want to put on his/her iPod anymore, s/he wanted to connect the music from the mobile phone to the motorcycle helmet via Bluetooth. Moreover, for that, s/he needed a tool with a Bluetooth system. Firstly listed the needs that are the music, a radio, receive a call, wireless Bluetooth. Secondly, s/he mentioned the approximate cost, which is 300$ of maximum. And lastly, the exceptional speaker quality. Thus, s/he concluded that s/he needed advice over a tool that fulfills the needs or a modular flip-up helmet with integrated Bluetooth that provided the abovementioned need list.

- On Jun 18, 2014, the user got an answer from alias NordicMan. He said that they used the uClear HBC 200 system, and they were highly satisfied with it (Uclear Digital, 2019). Mentioned that it offered him listening to music and using the phone for GPS navigation, receiving phone calls, and communicating with other riders

(intercom). Highlighted, the most important aspect of it was the uClear system, and he had no boom microphone in front of the face. He admitted the quality of the audio was average and did not have much bass when listening to music.

- Another user, alias deadrift, shared his/her ideas on Jun 18, 2014, saying that s/he had begun with the Uclear then shifted to Sena SMH10. Furthermore, he added that s/he was more content with the sound of the Sena. S/he thought the abovementioned requirement for "exceptional" speakers were optimistic at best. Furthermore, that s/he wore earplugs within a full-face helmet and thought the sound level and quality was fine, but whenever s/he did not put the earplugs in, it caused a more severe sound from the speakers. S/he said it was as if they made wearable earplugs so as to reduce some of the high-end static out. Besides, none of the systems would produce acceptable sound without the earplugs. However, s/he was pretty glad to have music in the course of riding, even if the audio quality did not correspond to the Bose or Klipsch earbuds.

- On Jun 18, 2014, alias Unkle Crusty shared that if whoever is on the road and encounters a rider at a lower speed, they should pass him/her as rapidly as they can and should not follow them. He said that the reason why was clear. When the rider is fast, high concentration is needed. However, when the slows down, s/he loses the rhythm and concentration. On the public highways, when an error in navigation happens, either caused by his fault or instigated by someone else, which would still be counted as his fault, he would note how to prevent it in the future. So he thought, adding distraction to the ride, the rider might not be able to process the information needed. He found sounds and smells, the scenery, and the traffic, sufficient to keep himself happy. He thought, back in the say, some younger minds were looking for distractions.

- On Jun 18, 2014, alias wadenelson also shared his experiences and said that one could buy a helmet with built-in Bluetooth, or add it on with units from Sena or Cardo Scala and at that time, they seemed to be the leading ones in the market of Bluetooth helmet communications, according to the articles in the motorcycle magazines. An add-on unit usually would lean outside of the helmet with double-sided tape. S/he added that the Sena SMH 10R was the most current and best model,

which offered Bluetooth interface to the phone, mp3 player, plus intercom ability. Moreover, they had an excellent user interface (buttons). The Cardo Scala QZ was offering both phone and mp3 integration, but no intercom capability. Back then, he picked up a 2-pack of the SENA SMH10 (not 10R) by only intended to use one of them. The other was for $125.

The kit he ordered was oriented toward the Bell Mag-9 helmet but by no means limited to that particular helmet. 10 and 10R had the same electronics, battery life. Just different packaging. None of the mfr's seemed to have a smooth or cheap integration path for radar detector tones back in the day. The Skully was a $2000 prototype helmet with Bluetooth and augmented reality; similar to Google glass, he continued. He said that it was the future of helmets with rearview cameras, screen navigation.

Nevertheless, they were not available for purchasing yet. The mirrors on the Kawasaki Concours were nearly useless. He was excited to have a helmet with a built-in rearview camera and head's up display of the rearview. Navigations were wrong time to time. He was not looking to take phone calls while riding, until pulling over, there were plenty of times he needed to make or take a call, and remove the helmet, sunglasses were painful. One would need quite a bit of volume while riding to overcome wind noise as for the tunes. Some systems were speed-adaptive, which was a useful feature. He is not into intercoms. The Bluetooth based intercoms generally were limited to 2-4 riders versus like a Motorola or CB radio type setup where everybody could hear each other. Recharging the Bluetooth systems were either by power connector or USB, many had software updates one would need to download via USB for the foreseeable future.

- Alias SgtSlag, on Jun 19, 2014, said that actually, most of the add-on systems used a clamp to attach to the side of the helmet, not double-sided tape, which was very weak in holding/supporting anything substantial. The boom mics were attached to the clamp-on unit, which in turn had the removable intercom locked to it. Anything using double-sided tape should have been a non-starter. With regards to the list of requirements, mentioned by alias r6, virtually any Bluetooth model would work, s/he answered. However, if stereo sound is wanted, one should ensure it had A2DP

usefulness, all the others would be mono. The phones would support MP3's and various music formats to listen to music; thus, they could provide music, communication, and possibly a GPS, depending upon the phone type. Moreover, s/he added that nearly all cell phones by that time were Bluetooth equipped. In order to be sure, s/he suggested checking the intercom device for the helmet had voice command function, and the smartphone would probably require a voice command feature, either. S/he also mentioned that the easiest way to use a minimum amount of devices, avoid incompatibilities, and avoid switching among devices by using buttons during the ride. A cell phone must be capable of handling switching among modes/services, without requiring to press buttons on the side of the helmet (e.x. Siri, on the iPhone) to meet the demands. One would also need to get a charger connected to the motorcycle, and the mobile phone, as running it for GPS, and other functions, would likely use its battery quickly. S/he concluded by saying that there were various chargers available and accessory outlets that could be hard-wired to the bike's battery/electrical system.

- On Jun 19, 2014, from what he had seen, alias casilver said that many like the Sena or the Cardo ScalaRider. He had the Scala Rider G4 and not the current G9 of that time. The user reports that it had worked great for them via Bluetooth. He says that his wife also rode and had a G4, and they could communicate easily at any speed. When they would stop speaking, the music (hers=iPhone, his=Android) would start playing again. If the phone rang, they could answer it and talk to the caller.

- Alias Zebraranger, on Apr 8, 2016, said that s/he agreed with Gary. S/he had been using the Sena SMH-10 for five years, and it would still hold up to 8 to 10-hour of charge and never had a device that got that kind of battery life. Besides s/he said, the clarity was great, and it held up through a few rainstorms. When that one would finally die, s/he thought of substituting it with the new lower profile Sena 20S.

- On May 2, 2016, alias laszlobauer said that s/he used use 2x BT Motorcycle Helmet Bluetooth Interphone Motorbike Intercom Headset 800M FM. Moreover, it was better than s/he thought. The battery was long-lasting. S/he would listen to music and talk to the passenger for a whole day of 16 hours, and it still would not die. It only had just a few big buttons and had a simple to use with gloves on. The sound

was sufficient with even with 1600cc. Noise filtering was amazing. Also, it was pretty comfortable once the position of the speakers was right, s/he concluded.

- Alias Offcenter's had an interesting question about this interpretation on May 2, 2016. The user asked if s/he could talk with friends who have Sena units on their bikes, with laszlobauer's unit. S/he said that the Senas were a bit too expensive for him/her. Laszlobauer answered the user that s/he would not. However, s/he also was not sure how the range was as s/he used it just for rider-passenger intercom. He added that it was said to be "approximately 80 meters", which is not much.

- On Aug 28, 2016, Alias Charlie Tango Xray said they were halfway through a month-long motorcycle trip. Those who had Sena units (s/he had the SMH10) did not experience any issues. Both of them had different brands of units, and they finally gave up and picked up Sena units mid-trip. Between the six of them, they had three or four different Sena models, and they all worked well and were easy to use.

There is another obtained data of user experiences from https://forum.arduino.cc/

- Alias Johnklastow, on Feb 19, 2019, said that s/he was trying to put a speaker and a microphone into the motorcycle helmet and either connect them to a Bluetooth module to his/her phone so as to call other people and talk to them while riding, or somehow connect the mic and speaker directly to the cellphone phone. The plan was to put the speaker behind the padding near the ears and the mic attached to the bottom of the helmet near the chin. S/he had not coded or used Arduino in a while and did not know what mics or speakers to use or how to code this at all. S/he knew that there were devices that could do this for the user like a Sena, but a Sena was way too expensive, and so s/he thought this would be the better way.

- Alias groundFungus said on Feb 19, 2019, that as an old racer, s/he would caution him/her about modifying the helmet. The helmet made with communication built-in might be expensive, but they were carefully engineered to be safe. Johnklastow expressed his concern and said that s/he was worried s/he would break them because they were on the outside of the helmet. Moreover, s/he asked if s/he knew any on

only on the inside in case a fall? GroundFungus suggest he wearing earbuds instead of using speakers. And that no helmet mods that way. The answer is that they tended to fall out and were a pain to get back in with the helmet on. S/he had been looking at alternatives to a Sena and would probably get one of those.

- Alias Geotec said on Jun 3, 2018, that s/he had a Sena S10 and used it mainly for navigation. It also worked great as an intercom when riding with a group (Triumph Rat, 2019).

4.1.1 The effect of consumer's driving habits on product selection

In 2018, the global smart helmet market size was worth USD 372.4 million. From 2015 to 2019, it is presumed to develop at a Compound Annual Growth Rate (CAGR) of 18.6%.

Smart helmets involve various electronic devices and sensors, helping users to collect real-time information. Furthermore, to assist them in lower the operational risks and improve safety in the long term. For their enhanced safety, security, and comfort, these helmets are getting more and more common between motorcyclists. They are not only broadly used in military and firefighting areas but also in multiple sports events. By the government's strict road safety regulations, the adoption of advanced wearable technology, and awareness for personal safety is growing. Thus, it is expected to affect the demand positively directly (Grand View Research, 2019).

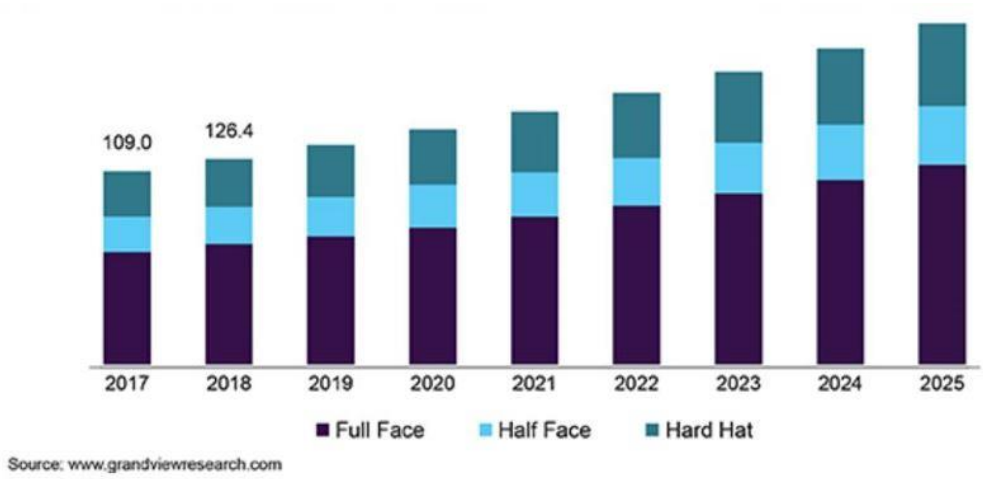

Figure 4.1 US market size of smart helmets 2017-2025 (USD Million) (Source: Grand View Research, 2019)

The improvement and marketing of the creative multi-featured and advanced helmets

had a great chance with the enhanced aim of minimizing smartphone use during the drive.

Due to the fact that increasing product adoption by motorcycle riders is connected with rising the sales of motorbikes, significant market growth is presumed. Product innovation and development strategies are on the focus of key market players, as well, and the companies, for example, are using carbon fiber filtered sensors in order to detect impacts. Reducing the weight, enhance connectivity, and transferring of data in real-time are some of the reasons the re-enforced fiberglass is used.

Users are enabled to monitor their vital statics and environment, efficiently thanks to the advanced sensors like optical heart-rate sensors, accelerometers, and video recording cameras. Nevertheless, some significant factors like expensive smart helmets, considerable investments in the product research and improvement, vision distraction issues, inadequate awareness about the advantages and security aspects can disturb the smart helmet market growth, through the estimated term. By using multiple digital media forms, the manufacturers are concentrating upon boosting awareness over the smart helmet functionalities so as to address these problems (Grand View Research, 2019).

The exact location of the individual is pinpointed by the navigation tool GPS (Global Positioning System) with the help of satellites, and one of the technologies that have a significant life-saving function. One of the essential helmet performance data sources is the investigations after the accidents.

It indicates that presently GPS has a significant influence on transportation (Glasscoe, 2018). Arrival time on the spot has vital importance for the accident victim. In his article, Brodsk underlined that each second is crucial for the emergency response team (Brodsk, 1990). Thus, as can be predicted, providing the exact location is highly critical for the responders. Sending an emergency message to the emergency rescue team is inevitable. That is the point the GPS location and alert notification, which are also called the Internet of things (IoT), can be codified as live-saving technology.

The IoT is highly prevalent in the current technology-focused infrastructure. The

functions of it are enlarging each day. They are continuously being implemented in several automated and sensor-focused systems (Tayag, 2019). In 2003, Kevin Ashton found the term IoT. The IoT will cover multiple industries, including agriculture, manufacturing, transportation, and security, with the connected machines intercommunicating via the network, Wi-Fi, and Bluetooth, as well as collect information with sensors (Porter, 2018). Another area where IoT tech can cover is road security (Vishal et al., 2017). It will contribute to reducing the road collision.

As Dickenson's article explicitly explains the critical function of IoT over road security, the roads can be smarter, with the help of sensors able to detect temperature and humidity and other environmental variables, especially in the transportation areas (Dickenson, 2018). Nowadays, various Smart Helmet implementation was made. GPS and GSM are used by Faizan Manzoor (Manzoor, 2017) smart helmet for sensor monitoring and notification that operates with the implementation of a vibration sensor, just like the crash sensor. Whereas Wi-Fi is used by (Hobby, Gowing, and Matt, 2016) with the purpose of having connectivity on the cell phone to ensure communicating via Bluetooth.

The final market research report of Technavio suggests that, between 2018 and 2022, the global motorcycle smart helmet market is presumed to have a CAGR of approximately 24%. The research, as mentioned earlier, also delivers an opportunity to analyze the major trends presumed to influence the market forecast over the estimated years. The improvement of smart helmets, integrating connectivity functions such as health and wellness, is among the core rising tendencies in the global motorcycle smart helmet market, is also underlined by Technavio.

During the estimated years, the rising sales of luxurious motorcycles will significantly influence the growth of the markets. Expensive accessories (advanced motorcycle helmets), the target user of which are ultra-luxury motorcycle owners, are hard to adapt to commuter motorcycle users who are price-sensitive. Technovio's report emphasizes the development of helmets that integrate connectivity features like the essential trend.

In order to boost the riding experience, motorcycle helmets can have an essential part

by providing storage of rider's security, comfort, and health data, as stated by automotive experts and engineers. Take LifeBEAM, for instance, that created an optical heart rate sensor for the smart helmet to measure the heart rate level. The security and comfort quality of the riders is enhanced by the transformation of a helmet from an absolute safety item into a great, connected system. Within the framework of auto accessories research, an analyst at Technavio stated that the urge to blend human and machine interaction had led to the appearance of systems, allowing riders to track every mechanical factor of their two-wheeler. Suchlike innovations are influencing the outlook of the motorcycle industry.

The globally advanced motorcycle helmet market is segmented technology such as conventional advanced helmets and smart helmets, and main regions such as The Americas, EMEA, APAC), by Technavio's report. In 2017, with 76% of market share, the market was dominated by conventional helmets. Nevertheless, between the years 2018-2022, an increase of 4% of the market share in the small helmet segment is presumed. The Americas, in 2017, held approximately 44% of the global premium two-wheeler helmet market, which was the biggest share. EMEA (Europe, the Middle East, and Africa) and APAC (Asia Pacific) were next in line. Nevertheless, the Americas and EMEA's market share is presumed to fall within the 2018 and 2022, whereas APAC is likely to rise (Business Wire, 2018).

Figure 4.2 Technavio published a new market research report upon the global premium motorcycle helmets market from 2018-2022 (Source: Business Wire, 2019)

Between the years 2018 and 2022, the market size of the premium motorcycle helmets will experience a growth of $389.83 million. Within the framework of technology and region, Technavio's report provides an analysis of the market. Furthermore, it provides an analysis of the market's competitive outlook and data about many companies such as Bell Helmets, Dainese, HJC helmets, SHOEI, and SCHUBERTH.

One of the main aspects that lead to the market's growth within the next few years is the government regulations upon the use of motorcycle helmets. Strict laws were framed by economically advanced countries such as the US and the UK connected with the appropriate authority intervention. The EU, for example, has legislated the helmet requirement for all motorcycle riders, which increased the adoption of connected helmets, consequently. With the purpose of raising the motorcycle helmet usage, effective policies are being introduced in the rising markets, that are within the APAC region. Moreover, to rationalize the use of helmets throughout India, state governments are implanting helmet laws in Tier-II and Tier-III. Thanks to the increasing demand for harmonizing humans and machines, systems offering the motorcyclists to follow each mechanical component of the vehicle have emerged significantly. For that reason, smart helmets with integrated optical heart-rate sensors increasing the safety and comfort of the rider are being developed by the companies in the market (Business Wire, 2018). Considerable annual growth rate is expected in the global smart helmet market with rising awareness about safety. The most extensive consumer base of smart helmets is presumed to be in North America. It is thereby making the US dominate the smart helmet market. Europe will follow it due to its stringent government regulations.

4.1.2 The effect of subculture on consumer product selection

The main characteristics of smart helmets are that they are user-friendly and autonomous. Through an internet connection, the helmets are able to carry out traffic monitoring, GPS guidelines, in-built headphones, and much more. The product is designed to maximize the security of the rider by sending an emergency alert to friends and family, and it has a flexible layer on the inside. Smart helmets are also adopted in the sports field, including the bike riders around the world. Their functions include an emergency alert system, engine control system, built-in cooling

fan, and Bluetooth system, and phone charging via solar power. These functions draw the interest of the consumer to adopt smart helmet technology. Smart helmets for cycling are simple monitors, counting the heart rate and calories during the exercise. It can be connected to smartwatches and applications via Bluetooth, to show the statistics (Research Nester, 2019).

Within the smart helmet market, the presumed fastest-growing region in the Asia Pacific. Besides, the helmets will be much more affordable, owing to the increasing consumer's disposable income.

Product-based Market Segments:

- Full helmet
- Half helmet
- Smart Hard Hat, mainly for construction workers.
- Accessory-based Market Segments:
- Motorcycle Bluetooth communication system
- Motorcycle Bluetooth HD cameras
- End User-based Market Segments:
- Cycling
- Motorcycling
- Construction Sector
- Industrial Sector

4.2 Factors That Affect Sensory Organs During Motorcycle Riding

The second question of this study is about general visual and audible distractions and stimuli of drivers and their feedback on this issues. Examining the factors affecting user's sensory organs during a ride will reveal the requirements of certain improvement to prevent potential accidents. Since physiological and psychological factors are main contributors to attention and focus on the road while driving, it is believed that drivers' vision and hearing abilities play significant role on fostering safe drive.

Riding experience itself reveals relief and adrenaline along with the social advantage of group rides. It is one way of getting rid of the stress, which might affect one's day. As the study of UCLA, which is funded by Harley Davidson, indicates that scooting makes the rider experience similar benefits. It is like a workout, and it lowers the cortisol level, which is the hormone signifies the stress. Fifty expert riders were subjected to the report of The Mental and Physical Effects of Riding a Motorcycle. The riders were observed in terms of biological and physiological reactions, through the of EEG technology.

Under normal circumstances, a group of healthy and expert motorcycle riders was required to pilot their bikes for 22 miles, on the predefined road, by the researchers from UCLA's Semel Institute for Neuroscience and Human Behavior for the neurobiological study.

The research focused on the brain activity and hormone levels of the riders before, during, and post motorcycling, driving, and resting. With the help of EEG technology, the electrical brain activity, heart rate, adrenaline, noradrenaline levels, and cortisol of the subjects were monitored by the researchers. The result has shown that the participants increased the sensory focus and resisted to distraction whilst driving. Rising adrenaline levels and heart rate, and decreasing cortisol levels were produced while riding, similar to the results one would get after a small exercise, which reduces the stress level, as well.

Using that technology was a breakthrough, according to the neuroscientist on the head of the research team, Dr. Don Vaugn. He said that there was not any technology that allowed an elaborate measurement of the influence of activities on the brain, riding a motorcycle, for instance. And that the brain is an amazingly complex organ, and it's fascinating to investigate the physical and mental effects riders report (Cherney, 2019). The research also highlighted the following main issues:

- The hormonal biomarkers of stress lowered (28%) by riding a motorcycle.
- Similar to a light workout, riding for 20 minutes raised the subjects' heart rates (11%) and adrenaline levels (27%).
- Riding a motorcycle enhanced the sensory focus while the same effect was

observed while driving a car.

- Similar to drink a cup of coffee, the increase of alertness while riding indicated the differences in subjects' brains.

4.2.1 Factors that effect on driver's vision while driving

In the past, many studies examined the efficiency of numerous conspicuous measures in day and night conditions for motorcycles. A large number of these researches were made in the 70s and 80s. All the indicators show that vision the primarily important sense. In 1974, the report vision of Henderson and Burg, made up over 95% of driving from a sensory perspective (Henderson, and Burg, 1973).

Gordon and Prince assessed the helmets in terms of their influence on the FOV (field of view), in their study (1975). Some riders were required to wear three-quarter helmets that are on average. Another group was asked to wear full helmets, whereas the other group wore nothing. Along the road, the subjects were asked to identify the moment they recognize the items moving into their central view. The items would come from ten distinct angles. It was observed that a three-quarter coverage helmet is wearing a subject lose the horizontal plane around 3% (6.5E), whereas full-coverage helmet-wearing group loses from 7.3% (16.9E) to 21.9% (51.7E). Observing motorcycle accidents, Hurt, in 1979, concluded that the rider encounters the risks primarily from the front. When Hurt’s report about the main causes was observed by McKnight, McPherson, and Knipper, in 1980, they concluded that the accidents were dependent on the field view of the rider by 11%.

On the other hand, the data showed if any of those accidents were caused by helmets (Mcknight, Mcpherson, and Knipper, 1980). Nowadays, riders to be are not elaborately informed enough about the dangers of motorcycles to decide whether or not to drive consciously. Students are not aware of the fact that motorcycle drivers with helmets are killed more than car drivers. They also do not know that while driving a vehicle, particularly the motorcycle, the Blindness While Paying Attention, in other words, Intentional Blindness can occur (Motorcycle Institute, 2019).

Inattentional blindness refers to the failure of the ability to notice obvious unexpected things within the field of view when the attention is shifted to another

thing in that same visual field. Inattentional Blindness expert Professor Daniel Simons explains that inattentional blindness is a result of individual's ability needed the most to focus. So as to focus attention selectively on just what we want to, we need to filter out other distractions. Most of the time, that filtering is essential. On occasion, though, we miss something we would want to notice (i.e., an unexpected object such as a motorcycle turning when we are paying attention to cars). Even when we are not distracted, we cannot take in ALL the information. The reality is that we always are aware of only a limited subset of our world — we have limits on how many things we can pay attention to at once, and only those we do pay attention to entering awareness. If someone is continually looking for motorcycles, it is possible you will not notice other aspects of the environment. Due to limits on attention, we have to prioritize some information over other information (whatever we focus attention on), and as a consequence, we often fail to notice unexpected (and, hence, unattended) things. Inattentional blindness often is not a problem for us. It becomes a situation where we lack time to adjust (i.e., driving). The problem is amplified because most people do not realize that they can easily miss fully visible things. We may not realize how inattentional blindness is increased by distraction or divided attention. One of the solution of reducing the risk of becoming a victim of inattentional blindness is control of motorcycle that corresponds to the speed and accelerations of the traffic. This will reduce the risk of being unexpected in another driver's field of view. Remember that there is a chance you might experience Inattentional Blindness, as well and not being able to process a turning car or other risks forthcoming in your path (Motorcycle Institute, 2019). Being aware of the possibility of experiencing Inattentional Blindness can reduce the risk of motorcycling.

Moreover, with the purpose of assessing the visual deterioration of the elderly, new mechanisms emerged to reduce the driving risks of visually impaired drivers (Shinar, and Schieber, 1991). The primary sensory channel, the vision, is responsible for up to 95% of inputs related to driving. Moreover, it is generally considered by the models of driver data processing. This essential function of vision is assisted by driving task analysis (Mcknight, and Adams, 1970). If a good vision is required for safe driving, does it also mean that poor vision causes unsafe driving? When researchers concentrated upon the relationship between vision and driving, they have

encountered mixed results. Certain mass-scaled research provided poor and yet consistent support for the connection of criterion visual performance levels to safe driving (Burg, 1977). All of these studies were correlated, and the only support for a causal link between vision and accident involvement is derived from theoretical considerations rather than empirical data (Shinar, and Schieber, 1991).

Vision is also affected by other factors. The Swedish Transport Administration in-depth studies of fatal accidents involving motorcycles indicate that one out of three riders were killed riding a vehicle they did not own. 14% of the cases, the owner was unidentified. Not even half of the riders who were killed without a valid A license, between the years 2011 and 2012, owned the motorcycle, the majority of which were not registered, commissioned or insured (Trafik Verket, 2011). These statistics clearly suggest that untrained and inexperienced motorcycle riders are under considerable risk when riding a vehicle, they are not capable of handling. However, motorcycle owners are aware of the risks. A study focusing on attitudes to road safety suggested that almost all the riders claim that the motorcycles should not be lent unless it is someone trustworthy (Sveriges MotorCyklister, 2014).

Not to mention the fact that riding under the influence of drugs and alcohol can be fatal. SMC members conducted a study that put forward the fact that motorcycle riders tend to use drugs and alcohol more than car drivers (Nordqvist, and Gregersen, 2010).

An IoT product Smart helmet, having motor and helmet units, is being developed based on the paper "Implementation of Smart Helmet." The helmet unit covers the alcohol sensor, which won't allow the user to ride under the influence of alcohol and the eye blink sensor alerts the rider in case of sleeping whereas the motor unit enables the user to communicate with the caretaker through messages while the GPS support the system to track the location in case of emergency. This system, in other words, is accident prevention and detection system (Deekshitha, and Pushpalatha, 2017).

Proof-of-concept study demonstrated that electrodes mounted to the inside of a motorcycle helmet can reliably record doziness, alcohol detection, and pulse rate.

Pulse rate signals were recorded. The helmet can help to prevent the damage in the vehicles caused by accidents, as well. Thereby, this helps to curb road accidents by implementing mandatory Helmet detection of alcohol use before starting the bike. In order to run the motorcycle, the rider must have the helmet and also must be sober. Moreover, in such cases, the family members will also be informed. Using the UV sensor, the helmet can detect the safe distance between the two vehicles. On the other hand, for sensor activities, the LED is used. As for more, there are buzzers inserted into the helmet for the alarm which alerts the rider and slows down the vehicle once the signal is received. Moreover, in the case of an accident, the family members receive the location of the motorcyclist via an SMS which ensures proper and prompt medical attention for the victim.

4.2.2 Factors that effect on driver's hearing ability while driving

Determinating the hearing impairment can be done by questioning a person on a survey. Generally, an average person with a hearing ability can hear the sounds below 20db HL (decibels hearing level) across a range of frequencies of 250,500, 1,000, 2,000, 4,000, 8,000 hertz (Hz). A person with a hearing impairment can detect the sounds between 25 dB HL to 110 dB HL (Figure 4.3). This hearing sensitivity loss may appear at the entire range, multiple frequencies, or just one frequency. The degree of intensity of hearing impairment was outlined based on the average of pure-tone thresholds at 500, 1,000, and 2,000 Hz, by Hayes A. Newby, (Newby, 1979). The level of impairment in the hearing will vary by the issue in which it is applied (Office of Technology Assessment 1986). The test requirement for visual acuity is very popular among licensing agencies whereas it is not for auditory or olfactory abilities. In addition to that, it is acknowledged driving is possible with only the visual sense in functional order (Platt, 1962).

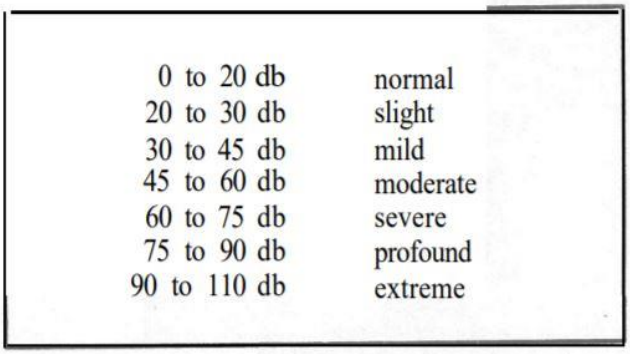

Figure 4.3 Audiogram (Source: Platt, 1962)

The interest in this review is centered around the following questions:

1- In what ways the hearing ability is related to safe drive experience?
2- How is the driving will be affected by eliminating the hearing ability?

All of the four senses -vision, hearing, touch, smell- have their role in driving (Platt, 1962). Several reports suggest that hearing is also helpful for safe driving even if it is not as important as the vision. Henderson, and Burg (1973) reobserved the task of driving within the framework of hearing ability, in the first chapter of their evaluation. They defined for classifications of auditory stimuli that may be essential for the safety of the driver, truck drivers in particular. The attention-getting stimuli included sirens, horns. Feedback stimuli are the reaction of the engine during acceleration. There are also others that can be easily identified, such as air brakes or there are sounds hardly identifiable like metal sounds coming from the tire. The above-mention stimuli were assessed on the basis of the driving environment. There are three types of environments within this study high-noise, low-noise, and quiet. Moreover, taking into account those environments, the driver's behavior was ordered on the basis of their significance for the driving activity. They concluded that hearing is mainly vital in off-the-road tasks in quiet environments (e.g. during a vehicle inspection) (Henderson, and Burg, 1973).

A noisy environment may affect the driver and possibly his/her performance through three mechanisms that are masking, temporary threshold shift ('ITS), and noise-induced hearing loss. The relationship between these three mechanisms can result in a more significant reduction in the communication capacity than any single effect. Not to mention that a single noise itself can suppress the audibility of other sounds (Office of Motor Carriers, 1992). Another way of evaluating the importance of hearing in motor vehicle accidents, the relationship between noise and industrial accidents can be observed, as well. Many claims that a possible cause of accidents is the noise, as it hampers the communication and masks warning signals (Wilkins, 1982).

In addition to protecting the biker's brains, the motorcycle helmets have a contribution to the hearing loss. Although Harley's engine is highly louder than

others, the surveys indicated that motorcyclists are disturbed by the buzzing sound of air over the helmets. Researchers from Bath and Spa University placed motorcycles helmets on top of mannequin heads, mounted them in a wind tunnel, and turned on the fans. The researchers noticed that an area under the helmet and near the chin bar is a key source of the noise which reaches the sensitive eardrums, with the help of microphones placed at multiple locations around the helmet (Kennedy et al., 2011).

Having 50 riders operate over a test route, changing lanes in response to a sound signal under three helmet conditions that are none, partial coverage, and full coverage, the effects of motorcycle helmets upon both seeing and hearing was measured by another research. Half of the riders were evaluated in terms of their head rotation degree when changing the lane. Whereas the other half were assessed for the decibel level at which they first responded to a sound signal. As a result of the vision study, it was observed that the degree of head rotation of the riders increased in proportion to the helmets' vision restriction (Mcknight, and Mcknight, 1994). While the degree of rotation totally corresponded to the full extent of the restriction, individual differences in head rotation far exceeded the effect of helmet variations. The hearing study showed that sound level at which the sound was detected across the three helmet was the same. The influence of helmets upon the ability of vision and hearing are extremely small to compromise the safety benefits offered by head protection.

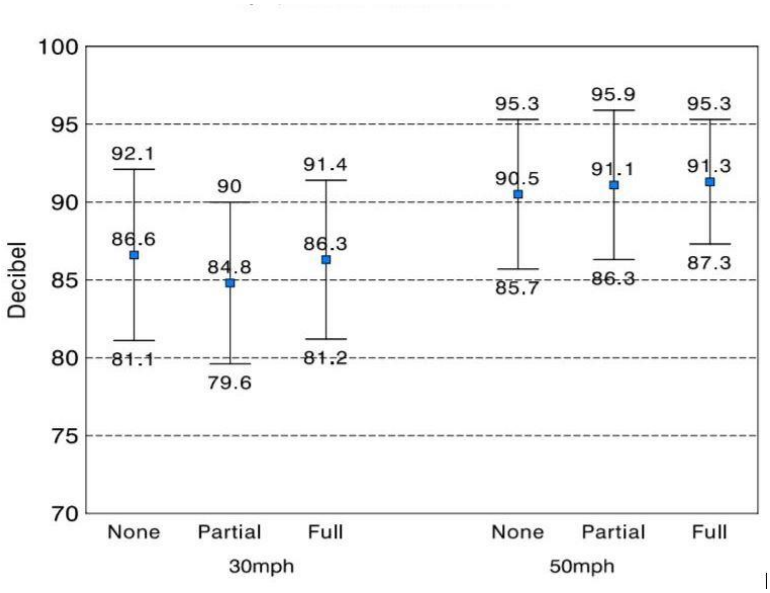

Figure 4.4 Sound Threshold in Decibels by Speed and Helmet Condition (Source: Mcknight, and Mcknight, 1994)

The results show that the ability to hear horn signals or the possibility of detecting a vehicle in an adjacent lane before changing the lane is not affected by wearing a helmet. Neither the type nor the use of the helmet affects the minimum detectable sound level. However, as the helmets do not have a negative influence on the hearing ability, they also do not have a positive effect (Mcknight, and Mcknight, 1994).

Nowadays, bluetooth helmets provide users to listen to their music while riding. The question is either they are safe or cause more distraction. A number of riders claim that it is contributing to their concentration as it suppresses the roar of the wind, the thrum of the cylinders, and the growl of the exhaust, on the other hand, some of them say that it distracts them. Sharon Ledger, a psychologist, and rider, responded to the question of whether it is safe or not and said that there is not a definitive answer. It is yes and no at the same time as it depended on the individual as well as the type of music. Moreover, that wordy songs or intricate beats in the songs activated more of the conscious brain, therefore detracting from the motor skills (Hinchliffe, 2017).

There were also studies that showed slow songs decrease the reaction times, which was not good. Fast beats might increase the reaction times, but they might also cause the rider to be more aggressive and reduce the logical judgment, she concluded. Many studies have indicated that when the rider listens to highly loud music, above 95 decibels, the reaction time becomes slower. Aggressive music like punk or heavy metal can cause tenseness and prevent the rider from relaxing. The rider is on twisty and technical roads; the tension on the motorcycle can become a huge problem. The riders possibly can miss a turn, make mistakes forget the signal while listening to music they love, and might even ride aggressively. They might concentrate on the music to the point where they might miss the outside world's hazards (Gayle, 2019). Unless the music is too loud to distract the surrounding vehicles, it is not dangerous. However, trying to change the music while riding is another problem that is a risky distraction. Taking hands off the bike and eyes off the road is a severe distraction and can lead to a fatal accident. It is also a massive distraction to use a mobile phone, which often leads to dramatic accidents. Even if the user has a hands-free device, there is again a possibility to have an accident, as the rider will be distracted from the road and concentrate on the conversation. The riders must be aware of their limitations.

4.3 Communication

The third question of the research is about the effect of audible and written indicators on driver's attention while driving. Therefore, user experiences about the relationship between driver and attention factors are addressed in terms of communication which can be occured between the driver and control units or between passengers and driver or between a group of drivers.

The roar of the engines, the wind, car, and truck noises make the riding experience highly noisy, which makes it harder to communicate for the groups that travel together. At those decibel levels, not everyone is capable of mustering those voices. For that reason, riders have developed certain hand signals in order to communicate with each other (Rhoda, 2019). The first significant factor is the communication between driver and motorcycle control units.

4.3.1 Communication between driver and motorcycle control units while driving

On the road, being able to communicate with fellow riders can be highly useful. In the past, riders adopted multiple complicated hand signals so as to stay in touch. However, nowadays, advanced technologies allow the rider to communicate safely and clearly by employing one of the brilliant motorcycle intercom systems.

Smart helmets are also capable of offering a wide variety of other communications, functionality, and safety features, including built-in speakers, microphones, rear-facing cameras, fans, solar chargers, and sensors for health monitoring. Manufacturers use materials that are strong and light, such as fiberglass reinforced plastic and carbon fiber, for weight reduction and improved safety. Growing adoption of next-generation technology such as Augmented Reality (AR), Virtual Reality (VR), and Artificial Intelligence (AI) is anticipated to accelerate the development and implementation of smart helmets. Variables including emerging road safety regulations, wireless communications infrastructure development, large-scale motorcycle production, and increased disposable incomes are anticipated to propel the smart helmet industry in developing markets such as India, Brazil, and China (Sunilrathodgvr, 2019).

Grand View Research has recently conducted a new study that predicted the global smart helmet market size is to expand with 18.6% CAGR within the years 2019-2025 and to hit USD 1.20 billion by 2025. The increasing usage of the product in different fields such as s riding, adventure sports, manufacturing, and construction is expected to support the growth further. Additionally, the communication devices segment is highly essential—the best way to communicate while riding is the Bluetooth motorcycle helmet communication devices. If the rider needs to make calls, listen to music, or interact with other people with whom he/she is traveling, a Bluetooth motorcycle helmet communication system is just enough. There are several alternatives, although not all of them are equivalent. There are plenty of options when it comes to communication equipment. Here are the top ten motorcycling communication tools (Bad Ass Helmet Store, 2019).

1. Sena 10C Pro Bluetooth Headset & Camera: This Bluetooth headset is a single package containing a communication tool and an action camera. The integrated camera technology provides video capabilities of 1080p and 60fps, as well as video time-lapse functionality. The device features are Bluetooth 4.1, Wi-Fi, four-way intercom with a range of up to one mile, advanced noise reduction, mobile connectivity, Android and Apple application, smart audio to blend music with video, and water-resilience to use in poor weather conditions (Bad Ass Helmet Store, 2019).

Figure 4.5 Sena 10C Pro (Source: Youtube, 2020)

2. Cardo Q-Solo: Giving the fact that this Bluetooth headed that have one Bluetooth connection, is designed for only one rider makes it unique. This, in other words, indicates that the rider is likely to connect directly with the cellphone in the course of the ride. Although, it can also be connected to a designated GPS either. It contains an embedded microphone that raises the volume automatically to balance the sound against the background noise. Moreover, it is waterproof and dustproof (Bad Ass Helmet Store, 2019).

Figure 4.6 Cardo Q-Solo (Source: FC Moto, 2019)

3. Sena 20S EVO Bluetooth Headset: The Sena 20S EVO provides thirteen hours of talking time. During the standby time, the capacity to the intercom is at a distance of up to 1.2 miles with up to eight different users, and it offers the FM radio. Furthermore, for additional functions like music and GPS, it integrates with the user's mobile phone, and it allows the user to adjust the intercom entirely and different settings via the application for the phone. Speakers of this headset are waterproof and high sound quality (Bad Ass Helmet Store, 2019).

Figure 4.7 Sena 20S EVO Bluetooth Headset (Source: FC Moto, 2019)

4. Sena SMH5 Bluetooth Headset Dual Pack – Universal Mic: It is a smart choice for the users who are unfamiliar with the Bluetooth headsets or only needs some device that provides much functionality at affordable price. The product allows Bluetooth intercom for four riders with a distance of 400m. Both for communication and music, it has a small boom microphone and two small speakers that deliver the sound, successfully. The device offers eight hours of talking time. It can last up to seven days of standby time, as well. The jog dial allows the user to move easily through functions (Bad Ass Helmet Store, 2019).

Figure 4.8 Sena SMH5 Bluetooth Headset Dual Pack-Universal Mic (Source: Amazon, 2019)

5. Sena SMH10 Bluetooth Headset: The most recent update from the SMH5 unit is the Sena SMH10 Bluetooth 3.0 Headset. This unit has multiple similar functions with the SMH5. However, it has better quality in terms of the range between the users, battery life, communication capabilities among the riders, and quality of delivery of the sound by the speakers and headset. The SMH10 has a global setup that offers the user to intercom with other various types of Bluetooth headsets, features an audio booster, individual volume control, the jog dial to control the unit quickly, and advanced noise control. The user is able to have a talking time for up to twelve hours on this device, and out of a single charge, one gets a good ten days standby. It takes fast 2.5 hours to charge and the product is quite economic for its features (Bad Ass Helmet Store, 2019).

Figure 4.9 Sena SMH10 Bluetooth Headset (Source: Amazon, 2019)

6. Sena 30K Bluetooth Headset: It helps to make it easier than ever before to communicate with a high number of riders. The Sena 30 K can allow sixteen riders to connect at the same time within a 1.2-mile distance. Falling to 4 riders can increase connectivity to roughly 5 miles. Also, even when a rider disconnects because of any of the reasons mentioned above, user will immediately reconnect as soon as s/he comes back in within the range. The most upgraded Bluetooth is also included allowing to connect to three other riders from a distance up to a mile. Furthermore, the system meets all the expectations from a premium waterproof and Bluetooth headset, which are music, phone connection for GPS. It has 13 hours of use for Bluetooth connection and 8 hours of use to mesh connectivity. The charging lasts 1.5 hours (Bad Ass Helmet Store, 2019).

Figure 4.10 Sena 30K Bluetooth Headset (Source: Amazon, 2019)

7. Cardo PackTalk BOLD Headset: Cardo's PackTalk Bold Headset is an exceptional unit that also uses mesh technology for up to 15 riders within a distance of up to five miles. The natural voice command, similar to Siri, Amazon Alexa, and Google Assistant, is its highlighted feature. The user is also able to use their phone to

perform voice commands. The Cardo headset is waterproof and dustproof; in addition to these revolutionary features, Bluetooth 4.1 communications are supported by this device. Thus nine riders at a range of a mile can connect to it. They can take phone calls, as well. This system further offers a smooth transition from intercom to phone calls, provides noise-reducing technology, self-adjusting volume based on pace and noise levels, and includes a customizable hot-dial number (BadAss Helmet Store, 2019).

Figure 4.11 Cardo PackTalk BOLD Headset (Source: Amazon, 2019)

8. Sena 10S Bluetooth Headset: It presents so many high-quality features in a Bluetooth headset, but its price should not be ignored. Moreover, it is more affordable than 20S. However, it is far more developed than the SMH models. The features of 10S' Bluetooth intercom connectivity with ten other users at the same time. Furthermore, it allows us to connect up to two separate Bluetooth devices, so if needed, one can also connect to a GPS and an iPhone. It further provides sound microphones, a boom microphone. Moreover, it enables the user to intercom up to a full mile with other users. Besides that, this device offers advanced noise control, extensive volume control, and an integrated FM radio. It takes three hours to charge the 10S, and it delivers twelve hours of talking time, and it can last up to ten days on stand by mode (BadAss Helmet Store, 2019).

Figure 4.12 Cardo PackTalk BOLD Headset (Source: Amazon, 2019)

9. Cardo FreeComm 4+ Motorcycle Bluetooth Headset: It has a lower price and thereby has fewer functions, for example, the mesh technology is missing. Nevertheless, it is still truly a great system at a low price. Cardo collaborated with JBL to provide a premium quality of audio experience. It provides an easy connection with a mobile phone to stream music or use the integrated FM radio. The Freecom 4 +, thanks to Bluetooth 4.0 technology, enables users to connect with four other riders within a range of 75 miles, as for the intercom connectivity (BadAss Helmet Store, 2019).

Figure 4.13 Cardo FreeComm 4+ Motorcycle Bluetooth Headset (Source: Amazon, 2019)

10. Sena 10R Motorcycle Bluetooth Headset: Among the externally mounted Bluetooth headsets, this one has the lowest profile. It comes equipped with Bluetooth 4.1. With that feature, it represents a major advance, and it outshines the former Sena units. The 10R substituted the Bluetooth 3.0-lit SMH10R, which indicates the latest 10R increased connectivity. Moreover, its battery lasts longer than the others. The 10R will support intercom capabilities of up to four users. It can also be connected to the mobiles for different services, and FM radio will be a new option for this type of unit. It is capable of connecting to two Bluetooth devices, so the user can connect it to the phone and a specified GPS unit if necessary. It even has capabilities that one can find in a Sena unit, namely advanced noise control, reduced wind noise, and considerable volume control. It offers ten hours of talking time with three hours of charge time (BadAss Helmet Store, 2019).

Figure 4.14 Sena 10R Motorcycle Bluetooth Headset (Source: Amazon, 2019)

Various user experiences were listed regarding communication devices (Motorcycle Forum, 2017).

- Alias hogcowboy American Legion Rider wrote on Jun 7, 2017, that s/he did not use a Scala or Sena but did use Bluetooth. S/he did not know if it was a hard requirement, but s/he could only connect one Bluetooth device at a time. Although, s/he could daisy-chain all of the Bluetooth devices. So, s/he suggested if one could get the proper order, it was possible to have all the devices connected and, in his/her case, s/he had a headset at the top. So, s/he could have the Garmin Bluetooth'ed to the headset that was connected to the radio. It was also possible to have another device Bluetooth connected to the Garmin. S/he underlined that even though it was confusing, it worked well (Motorcycle Forum, 2017).

- Alias 66sith, on Jun 5, 2017, said that s/he had a 2017 Yamaha FZ-10 and rode it non-stop. Furthermore, that music was a crucial part of the ride. At that time, s/he had been using a pair of Beats Wireless X, to listen to music from the phone. The audio quality was excellent. However, it was a significant pain to get the earbuds to fit right inside the helmet every time s/he would take the helmet off or put it on. Because of that, s/he decided to go with a comm unit. The ease of already having the speakers inside his/her helmet without having to make constant adjustments and being able to use the phone to take calls improved his/her experience quality. However, the main thing s/he was looking for was excellent audio quality. Moreover, that is where it appeared to get hard. S/he wondered that if the cost was not an issue, what would be the best setup for what s/he was after. S/he concluded the technology

of the Sena was very appealing. Nevertheless, everything s/he would read indicated that their speakers were 'less than' capable of the audio quality s/he was after (Motorcycle Forum, 2017).

- Alias Jim Duval, on Jun 5, 2017, said that s/he gave up on communication units and went back to earbuds. There were simply not enough volume with in-helmet speakers to satisfactorily overcome wind noise (Motorcycle Forum, 2017).

- Alias Badlands-4-2, on Jun 6, 2017, said that s/he used the Sena 20-s system and really liked it. S/he pointed Revzilla for their video reviews. S/he added that there were several others available besides that one (Motorcycle Forum, 2017).

- Alias soupy1957, on Jun 6, 2017, wrote that Ear Buds for him/her were easy, cheap and they worked perfectly. Same user said that the headset on the far left was the one that s/he put on the helmets they wear. S/he thought that if it was not that one exactly, it was really close to it. S/he added that they used it for communication between the two of them, but the video seemed to imply that s/he could also use it for Bluetooth, and s/he was not exactly sure how to set that up. S/he asked if the Bluetooth would have to be an option on the Faring-installed radio system. An that they had to “pair” the phone to the system (Motorcycle Forum, 2017).

- Alias Zebraranger, on Jun 6, 2017, wrote that many bikes did not have Bluetooth capabilities, although more and more, we are starting to have it. S/he the Sena SMH10. Furthermore, his/her Triumph Trophy had Bluetooth capabilities, and s/he could synchronize to it to listen to the bikes stereo system and the GPS turn by turn instructions if necessary. Most of the time, s/he did not bother to synchronize up to the bike. S/he would usually Bluetooth to his/her smartphone and stream music from one of the many music apps available.

If s/he did connect Bluetooth to the bike, which had a USB port, s/he would usually listen to music that s/he had on a thumb drive or another device like an iPod and just plug it into the bikes USB port. Since s/he wore a full-face modular helmet, s/he could also receive or make phone calls while cruising down the highway. S/he did the same thing on the Goldwing because both bikes gave him/her a nice large pocket

of undisturbed air. With the helmet closed up, people on the other end would not even know that s/he was on the bike cruising down the interstate at 128,74 km/h. Since the Guzzi s/he was riding had no windscreen to speak of or a fairing, and it was much louder, s/he quit to do that (Motorcycle Forum, 2017).

4.3.2 Communication between driver and passenger while driving

Behavioral studies have reported the connection between passengers and drivers as an important aspect of the influence of passengers on driver behavior and, consequently, the safety of both the driver and the passenger. It has been stated that friends or peers as passengers generally have a detrimental effect on the young driver's behavior, especially the young male driver, thus undermining safety. Today, passengers play many different roles: navigate, change the radio and other dials, keep the driver company by communicating, warn the driver to dangers and alert the driver to the speed at which they are driving (Regan, and Mitsopoulos, 2001). https://electricbikereview.com/ demonstrates the user experience by providing the thoughts of the riders upon communication with the passenger and those devices:

- Alias graham, on Aug 9, 2016, said that he and his wife used to cycle together 10 years before. With the discovery of e-bikes, they were excited by the idea of getting back into it after a long lapse. Back in the day, they used to carry a couple of walkie-talkies with earpieces so they could communicate with each other while touring. Added that times and technology had changed - what was the best solution in those days? He said that a web search brought up Terrano-X (Cardo), but parts of it seemed a little clunky. They were also considering just a Bluetooth headset paired with their iPhones and a walkie-talkie app (or just a phone call) but could not find many reviews on that approach. He wondered about the other choices. He requested real-world advice instead of trial-and-error on these relatively expensive systems (Electric Bike Reviews, 2019).

- Alias James Kohls, on Aug 9, 2016, said that for walkie-talkie-like apps, he used Voxer for years: iPhone / Android. Furthermore, the basic functionality was free. He also said he liked the feature that provides easy re-play of the messages in case you needed to hear them again. It also supported push-to-talk and push-to-activate/push-to-end talking styles, plus texting and photo sharing. The problem was going to be

wind noise if one wanted to use it while riding a bike. He said most microphones were terrible at canceling wind noise. Depending on the phone and the microphone's location, it could drown out any voice. Especially at e-bike speeds. He had used it while riding and, on his iPhone 5S, most people told him it was acceptable in terms of wind noise. Nevertheless, there were loud bursts of noise that could be annoying. Something one could do to mitigate the problem was cutting the elastic top of an old sock off and place it over the part of the phone with the microphone. He also noted that any app like that would likely use up data. So if one had a limited data plan, this probably was not the best route. A person could certainly use a regular phone call as well. He advised for Bluetooth headsets with functional noise-canceling abilities. He claimed that most Bluetooth headsets' noise reduction was for talking and walking or standing still. Add in 32+km/h, and a headwind and most would fail. With a phone call, one would still probably have the background noise in the ear between speaking, which could be annoying. Especially if there were a lot of wind noise, he concluded.

- Alias Philip, on Mar 6, 2017, said that communications were useful. S/he discovered the joy (just like we all need our smartphones all the time) when s/he could share and warn without having to shout or cycle alongside, which could be dangerous in some road situations. For cycling, there were the Terrano and also Vertix. S/he suggested using Amazon for velo intercom. S/he liked the Vertix as it was newer at the time, more stylish, fitted nicely behind the helmet instead of at the top (for GoPro), and included remote control. They could also hear each other crystal clear and hear everything outside with the floating speakers.

- On Sep 10, 2016, alias drcollie said that he bought a state-of-the-art system, and it worked great, however, he complained about the passengers he had as they caused him a great distraction by constant talking.

- Alias Alphbetadog on Jul 23, 2017, said that an emtb riding buddy and s/he had tried many communication devices, including trying to adapt their motorcycle Sena Bluetooth headsets to their bike helmets. The solution that worked well for them was a pair of customizable amateur radios with the FRS & GMRS frequencies and using a speaker microphone (like what the cops used) clipped high up on their Camelbak straps. They did not have to take their hands off the handlebars to operate the PTT

(VOX does not work because of heavy breathing), but it had not been a problem. It was beneficial for the lead rider to be able to communicate warnings such as other trail users approaching, and when making turns onto different trails.

- Alias LugNet, on Jul 23, 2017, said that he also wanted bicycle-to-bicycle communications for his wife with as few wires as possible and not push-to-talk. He said she much preferred keeping her hands on the handlebars. He looked at the smart bicycle helmets and helmet add-ons like Vertix Velo and Terrano-X. Furthermore, he ended up finding: smartphones, Intercom app, Aftershokz Trekz Titanium headsets, and Cat-Ears AirStreamz (wind blockers) on helmets. The Intercom app supported Bluetooth headsets, VOX, and interconnected over Bluetooth or wifi. They found the range and response better-using wifi to link the smartphones. They could just call each other when there was cell service, but the VOX feature helped block some of the background noise the other rider was hearing. The Aftershokz Trekz Titanium headsets were bone-conducting: Nothing blocking their ears, so it was easy to hear the environment while still clearly hearing each other (or music/podcasts). Moreover, it said that it had no wires. The Cat-Ears AirStreamz blocked the wind. Without them, the Trekz microphones picked up wind noise instead of voice. The smartphone-to-smartphone wifi ranges varied dramatically. When his Galaxy S4 was the wifi hotspot, the range was ~12 meters. When his wife's Galaxy S5 Active was the hotspot, line of sight range was over 45 meters (they had tested further) Nothing was perfect and including that solution. Trekz's battery life was 6 hours. When the phone batteries would die, they would plug them into the bikes. He would want the range was much better. Using VOX with Intercom added a significant delay, and the person talking would hear what was said. The cost of the two pairs of Trekz and AirStreamz was less than $250. As they like comfort and enjoy the audio of the Trekz, they used it for other things all the time.

4.3.3 Communication between driver and attention factors while driving

Riders who drive more miles are more likely to encounter the risks of traffic and will, therefore, suffer more accidents. So the accident statistics should be corrected for miles traveled while examining certain variables that may lead to accidents. It is possible to base such a survey on government data. However, reliable and accurate mileage data is scarce. Case-control and questionnaires are different ways to study

rider factors within the framework of the accidents (European Commission, 2018).

Throughout all the studies, the rider's age was considered to be quite significant. Younger drivers, even though adjusted for lack of experience, have significantly higher accident rates. This must be described as a consequence of psychological factors linked to aging. For the last 20 years, risk levels by age differed in accordance with the modes. The experience of the driver has much to do with motorcycle riders' accident rates. There are numerous varieties of experiences, which are the length of the riding period, the latest ride or riding regularly, acquaintance, with a particular vehicle, and experience with riding under particular conditions. These levels of experience lead to a reduced rate of incidents. Riding experience can not be enough during winter to handle particular problems, such as weather conditions.

Numerous reports emphasize that sports motorcycles undergo higher accident risks. Psychological influences affect the rider's motivation. Furthermore, it has an impact on the riding style of the motorcyclist. The growing numbers of elderly motorcyclists are other factors that influence driver safety. There are many PTWs (powered two-wheeler riders) violating the laws - speed, intoxication, riding without a valid license, engine tampering- which results in accidents. Rider safety is often affected by other drivers' expectations. Many road users also often affected the awareness of PTW operators.

The case-control study has a moderately different research design that will study the impact of contributing elements. Facts of an incident are documented in detail in this context as soon as possible post-accident. These experiments were carried out in Australia and in New Zealand. In New Zealand research, 463 cases of injuries and 1233 control cases assessed in comparison with each other in 1993-1995. The findings demonstrate a significant association among comparative accident rate and age. Moreover, it had an important relationship with experience with a particular motorcycle.

In a study focusing on the impact upon the accident rate and the engine size, the same data were used (Langley et al., 2000). The Australian study involved 205 cases of accidents and 1225 controls (Haworth, and Smith, 1998). Moreover, the relative

accident rate was once again proved to be extremely age-related. Nevertheless, this time a weak association with riding experience was observed. Besides, the findings showed a significantly higher relative accident rate for limited riding (less than three days per week) and non-work-related riding. Both accident and exposure data were collected from 790 questionnaires answered by motorcycle riders, in another Australian study (Harrison, and Christie, 2005). The benefit of that kind of survey is that various questions about riding habits and psychological factors that seem essential in causing accidents can be asked. The research indicated that there is a relation between the accident rate and mileage. The riders were observed to have a high accident rate. The riders were divided into three groups, including recreational ridings such as off-road riding, long-distance riding on a sports motorcycle, and weekend riding the milage of which is low. In 2002, a large-scale survey was conducted, relying on 11265 questionnaires answered by licensed motorcycle riders, in Great Britain (Sexton et al., 2004).

These riders confirmed 1495 accidents, half of which happened while commuting or work-related riding. The estimated amount of accidents based on miles per year and other variables for each rider was measured by using a mathematical model. This model indicated that the rider's age is by far the most significant indicator, followed closely by miles per annum. After that came the rider's experience, followed by riding conditions. Furthermore, it showed that riders that drive more miles had fewer accidents. The researches found that, among the coeval riders, the frequency of riding is not correlated with the accident rates. In the Sexton analysis, the questionnaire included questions related to the behavior and motivation of the rider. The second part was based upon certain studies by Schulz. The psychological factors were discussed within the scope of this report. Schulz (Schulz, Gresch, and Kerwien, 1991) identified twelve different aspects of motorcycle rider motivation that were found to be strongly related to the rider's age and motorcycle type. Schulz (1998) used a questionnaire focusing on the riding style in his later research. The questionnaire of the Great Britain analysis showed:

- There are three aspects in describing the motivation: pleasure from riding, passion for speed, economic aspects.
- There are three aspects in describing the riding style: slow vs. fast, tolerant vs.

intolerant, and careful vs. uncareful.

- There are five aspects in describing the behavior: traffic errors, speeding, stunting, use of safety equipment, control errors.

Rider motivation and riding style have been found to be linked with driver mistakes and accidents causing violations. A number of self-reported accidents were caused by rider behaviors such as speed, traffic errors, and control errors that are resulted from the riding style and rider motivation. These researchers concluded that a significant aspect of the rider's safety issues arises from the motivations of deciding to ride a motorcycle.

Due to several psychological factors, PTW riders are predicted to differ from car drivers. New research with an unusual design compared and contrasted the British motorcycle riders and car drivers (Horswill, and Helman, 2003). Three clusters of participants were evaluated in a simulation with traffic conditions and answered a behavioral questionnaire that also included some psychological variables like social motivations and the desire for sensations. In terms of age, gender, and experience, the three groups were selected carefully. The first group of 47 motorcyclists was asked to respond as motorcycle riders, while the other 47 riders were asked to respond as if they were car drivers.

The group of motorcyclists reacting as riders traveled faster, pulled out into smaller gaps, overtook more often, but did not follow closer to a vehicle in front. However, these findings do not have to be applied to all motorcycle riders. However, at least one group of motorcyclists is similarly (and even more) skilled and cautious as the group of car drivers with similar demographics. Except for the fact that the riders chose to ride a motorcycle to take advantage of the motorcycle's qualities of being small and efficient. With the rising proportion of elderly motorcycle riders (aged over 30) in several countries, information on the safety measures of this community is required.

A thorough analysis of the questionnaire was carried out in Australia (Haworth, Mulvihill, and Symmons, 2002). Constant riders (384) returning riders (240) and inexperienced riders (275, with a license of seven years or less) were divided among

riders over 30. The three groups defined traveling as the most popular reason to use their motorcycle. However, they differed on other points. Constant riders were much more likely to ride throughout the year, and encounter conditions that are somewhat less likely to lead to severe injuries. Returned riders rode less, and inexperienced riders on smaller bikes mostly performed riding in urban areas. The researchers suggest that the accident rate in relation to miles for new and returned riders might be higher than the continuing riders. However, the report does not include exact figures. Furthermore, based on the study, there various examples of PTW rider behavior violating the laws, such as speeding. In 2005, Broughton put forward that 12% rider deaths, within the years 1994 and 2001, were resulted from riding under the influence of alcohol. Moreover, on the same basis, 22% of the car drivers were killed (Broughton, 2005).

The situations in Great Britain and France show differences. 23% of motorcycle riders and 32% of moped riders 19% of the passengers in a car were killed in an accident resulted from alcohol consumption pre-driving, stated Filou, in his report (Filou, Lagache, and Chapelon, 2003). French researchers also claim that 18% of the light motorcycle riders and 8% of heavy motorcycle riders did not own a registered license.

In Germany, tampering around with a 125cc motorcycle engine or a moped appears to create an issue. Prepared for 137 young PTW riders, Raithel evaluated the questionnaires (Raithel, 1998). Half of the young PTW riders admitted tampering, which causes increased accident rates. The relative rate for accidents resulted in severe injury was revealed to be approximately 50% higher for mopeds tampered in Norwegian research, as referred by The Handbook of road safety measures (Elvik, and Vaa, 2004).

Violating the law by not wearing a helmet when it was mandatory, with the rate of 85% among injured motorcyclists, Greece demonstrated an extreme example, in 1994 (Petridou et al., 1998). In contrast, the helmet wearing rates by moped and motorcycle riders is usually stated as 90% or even 100%, in compulsory helmet wearing countries. Accident reports indicate that the attitude of several road users is troublesome and a variable that leads to accidents with vehicles. Wulf gives an

overview of reports on all these concerns and addresses some theories for them.
The first explanation is about the physical features of the PTW. The compact design of the PTW, as opposed to cars, allows it to become less noticeable; however, making the assessment of distance and speed from a small frontal area or with just a single headlight is challenging (Wulf, Hancock, and Rahimi, 1989). There are other theories about the psychological nature. Due to the fact that PTW's are limited in traffic, car drivers are not prepared to encounter a PTW and are thus less likely to identify or acknowledge the existence of a PTW. Thereby, PTW's appear to lose confidence in most car drivers. Wulf further implies that a car driver is likely to disregard the existence of a PTW because the effect of a collision with a PTW is less dangerous than with a vehicle. To a certain degree, these issues are driven to become harder by the behavior of PTW riders. For example, they can overtake in conditions where car drivers can not, and they ride at high speed. Many drivers or pedestrians may not look for PTW's in situations when they do not even expect other cars, either. Because of the unexpected great speed as well as shorter approach times even than cars, they become hard to notice. Furthermore, numerous research evidence on the interpretation of vehicles has also put forward that attention can indeed be derived by physical properties and or via the significance of such objects. The lack of significance of PTW's for road users has still not been examined explicitly. Nevertheless, it is demonstrated in a report by Magazzu, Comelli, and Marinoni (2006).

MAIDS case-control studies results were reviewed to obtain 740 cases of an accident between an automobile and a PTW, together with an expert opinion on whether the passenger or automobile driver was guilty. Following the adjustment for certain demographic variables such as the age and c experience of the driver, it was reported that in this situation, car drivers who already had a motorcycle license were significantly less likely to be guilty than car drivers without that license. Possession of a motorcycle license is an indicator of interest and competence in riding a motorcycle that could have contributed to the detection and forecasting of an approaching PTW (European Commission, 2018).

CHAPTER 5: DETERMINATION AND DESIGN OF THE CONTEXT

The survey on enhanced navigational user interface experience in motorcycle helmet design leads to a comparative analysis to reveal IoT based smart helmet. Relying on information about smart helmet technology given on the last two chapters, today's riders response to the method of Enhanced Navigation, will be discussed in this chapter mainly based on the questionnaire conducted with the experienced motorcycle riders.

5.1 Questionnaire Analysis

This part of the study gives information about data collection process and data colletion methods which are observations and interviews, respectively.

5.1.1 Data Collection Process

Data collection process was performed by using different data colleticon methods such as observations, interviews, and survey in the study. The first data collection process performed by observations. Afterward, interviews held with motorcycle drivers. In these interviews, an interview form was prepared. Thesis forms are guided by resources presented in Chapter 2 and Chapter 3. As a result of this process, observations and interviews were expanded and repeated. Data were collected from motor riders by applying the current questionnaire form (Figure 5.1).

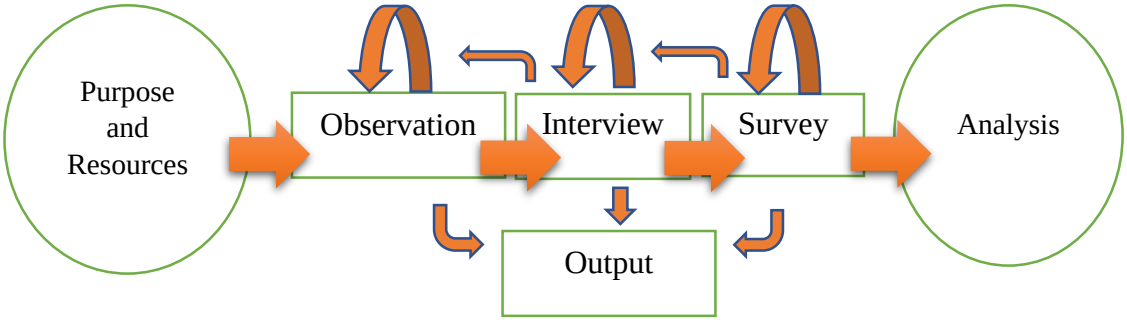

Figure 5.1 Data Collecting Process

5.1.2 Observations

In this study, we found the opportunity to encounter motorcyclists and the possibility of observing them on the highways of the Aegean and Marmara regions. Due to our 15 years of motorcycle use experience, it has been possible to be in this environment and meet with motor drivers frequently to talk about many issues, especially motorcycle technologies, chat with them, and observation.

Urla, Çeşme, Karaburun region (Karşıyaka, Alsancak, Bostanlı, Göztepe, Narlıdere, Balçova) in İzmir and the main centers in Istanbul (Beşiktaş Mecidiyeköy, Nişantaşı, Taksim, Tarabya, Sarıyer, Kadıköy, Ataşehir) are the most common points. In Istanbul, there are also Şile and Anadolu Feneri, which cannot be called as a stop. At these points, roadside gas stations and any bar -café- restaurants are random meeting places. Quick conversations are made. There is no fixed meeting place in the mentality of motorcycle riders, and the remaining routes are constantly changed. There is no common area because every route is special.

In addition to these destinations, it was possible to make frequent connections with the Izmir Motorcycle Club and the Kadıköy Motorcycle Club, which have become associations and in various non-association clubs through common friends.

5.1.3 Interviews

All interviews were started by explaining the purpose of the study. In this interview, the interview form (question set) presented in Annex. In some cases, it was tried to reveal a different dimension of the subject by going beyond the question set.

A warning to inform the user and the citizens around can be put into the helmet in order to inform the necessary first aid and take security measures. It was determined that the majority of the survey volunteers (about 75%) were between the ages of 25-55, and the individuals participating in the survey in this age range showed almost equal distribution at different ages. (Q1) It has been determined that approximately 85% of the monthly income of the respondents have an income level higher than the minimum wage. In addition, 43.5% of the participants were found to have a monthly income of more than 7500 TL. (Q2) Regions where participants live about 40% in İzmir, about 25% in Istanbul, about 15% in Ankara, about 15% in Çorum, about 5%

in other cities. Clearly, most of them are in Izmir. (Q3) About 40% in İzmir, about 18% in Istanbul, about 2% in Ankara, about 10% in Çorum, about 8% of their business addresses are in other cities. (Q4) When Q3, Q4 were examined, it is found that approximately 17% of the participants had their home and work addresses in different regions, and the majority of them included long-distance driving. It is noteworthy that most of the participants are university graduates. (Q5) It has been determined that approximately half of the participants are married and have children, and about 35% are never married and have no children. (Q6, Q7) It is noteworthy that most of the users preferred helmets in the 2nd and third place, and the helmets that protect the chin were chosen. The order of protection and weight rankings are similar in the order of selection of the top three classes (Q8). The most striking factors in users' helmet selection are safety and comfort. These results are compatible with helmet types that are frequently preferred in Q8 content (Q9). The fact that the majority of the participants marked the first option shows that the comfort is important for the users. It shows that users take the safety factor into the second place in the majority of the election. The rank of these options shows that the comfort of use before and after riding (facilitating the first step that encourages the use of the product) has been prioritized by the participants in order of comfort. The selection rate of the first and second options is approximately 50%, and comfort is more prominent in the use of fabric heads. The 3rd option, which is added to support the 2nd and the 4th options and is placed to control the 2nd and fourth options. In addition, 2nd, third and fourth options, which are linked to each other, have been selected to show us the deficiencies in the products used. The effect of the use of fabric heads on communication is the least important by the participants. Q29 supports users' comfort and safety-related data (Q10). Q12 and Q13 data also support that the Q14 data clearly shows that the physical factors exposed from outside the helmet, such as the headlights of natural vehicles and car horns, are the main factors causing distraction in driving. On the other hand, approximately 13 percent of the participants were disturbed by the in-helmet sounds and signs, while approximately 5 percent advocated the effect of psychological causes on the attention factor. While those who are disturbed by in-helmet sounds talk about the distraction of incoming calls, those who are disturbed by in-helmet lights attribute this to the light channeling of interest to different areas (Q12, Q13, Q14). Participant's data mostly show that blocking intense light with momentary dimming/filtering, offering frequency limit

resolution for loud sounds, and presenting alerts in the form of audible rather than visual, will be the solutions preferred by the riders (Q15). The priority order that provides use in smart helmets is in the form of communication, warning, navigation, and this supports Q14 and Q15 data (Q16). Participant data show that hand signals come first in communication with other motorcycles, while inter-helmet communication is preferred in second place instead of the phone, which is common in other vehicles (Q17). Considering the data of the participants, it is found that the communication between the helmets was carried out with only 35% of the passengers on the helmet (Q18). It was determined that some of the participants made a mistake in answering the question, and the data of the participants who marked both negative and positive answers were reviewed again, and these questions were re-submitted and /or their answers were overridden. The data show that the vast majority of the participants listen to music while riding and perform this action mostly in the helmet through the sound system of the helmet, or listening through the headphones alternatively (Q19). It was determined that some of the participants made a mistake in answering the question, and the data of the participants who marked both negative and positive answers were reviewed again, and these questions were re-submitted and/or their answers were overridden. The majority of the participants present the data that smart helmets are satisfied with the solutions provided by automatic arrangements without the need for adjustment by the user (Q20). It was determined that some of the participants made a mistake in answering the question, and the data of the participants who marked both negative and positive answers were reviewed again, and these questions were re-submitted and or their answers were overridden. The majority of participants do not prefer to record images. Among the participants who preferred to record images, the most preferred feature was the help of error detection, and the second factor was the design factor in which the response to physical conditions was reduced by strengthening the warning features (Q21). It was determined that some of the participants made a mistake in answering the question, and the data of the participants who marked both negative and positive answers were reviewed again, and these questions were re-submitted and or their answers were overridden. While the most important positive features for the participants were an effective use of alerts, error detection, and alternative to mirror use, while negative features were the most important reason for not using the effect of the viewpoint on the vision, and the second-order was identified as the

problems that may cause image transfer time. Overall, this data shows that the development of smart alerts is a primary factor for the use of rear cameras (Q22). The importance order for the participants shows that, while talking with the mobile phone firstly, the advantages of the smart helmet in the first place is the automatic start of the phone call in possible emergencies, the second place is to ensure the continuity of the alerts during the call and the convenience of the call control is in the third place. The data of Q28, Q31, Q32 confirm this data. This ranking shows that the most important features of the smart helmet when talking with the mobile phone is that it provides advantages such as danger reporting and reduction of focus shift (Q23). The vast majority of respondents noted that motorcycle users follow the technological advances made about smart helmets, drawing attention to financial and supply problems. Q1, Q2, Q5 shows that participants are expected to have easy access to information about smart helmets and smart helmets. On the other hand, although access to information is provided, the option that the participants have pointed out on the subject indicates that physical accessibility is low (Q24). Q25 also supports participants' access to information. The vast majority of participants use navigation, and it is observed that the number of participants using navigation during car driving is more than the number of participants using navigation during motorcycle riding (Q26). Participants stated that the primary advantage in using navigation is to provide transportation in the shortest time possible, shortening the driving distance is in the second place and reporting about the road works, and possible accidents are in the third place (Q27). Participants stated that the most important feature is to report the possible accident to the relevant unit, and during the secondary priority, they chose to make the accident person visible. Q23, Q31, Q32 confirm these answers. The participant's data about informing shows that they think that the information given to the environment has a more effective role than the information given to the person who had an accident (Q28). Protection and comfort come first in the ranking. These answers overlap with Q10 data (Q29). While most of the participants focus on two options, emergency services are in the first place, and a transparent viewfinder screen is in the second place. these data overlap with Q28, Q23. (Q31, Q32) It was determined that all of the participants had their own helmets, and most of them had two or more helmets (Q33) It was found that the participants' helmet replacement periods were mostly performed as often as they should be (Q34). It was found that more than half of the participants presented their second owners for

use after using their helmets (Q35). Participant data show that only 3.5% of the users are not satisfied with the helmet they are wearing (Q36). More than half of the participants have over three years of motorcycle riding experience, and 32.46% have over 11 years of experience (Q37). The question with the same features as Q1 and it is placed to check the reliability of the survey and is expected to contain the same data. The data of these questions overlap (Q38). The responses of the participants show that 17.54% of the participants use motorcycles for transportation purposes, and the rest shows recreational use. Among the participants, there are no motorcyclists for commercial reasons (Q39). 41.23% of the participants stated that they use motorcycles throughout the year, and 23.68% only in the summer months (Q40). It was determined that some of the participants made a mistake in answering the question, and the data of the participants who marked both negative and positive answers were reviewed again, and these questions were re-submitted and/or their answers were overridden. The data provided by the participants indicate that 55.26% of the participants have A-class and 35% have an A2 class license (Q41).

5.2 An Interpretation of the Questionnaire

Distraction plays a major role in the occurrence of traffic accidents. Distraction - loss of focus can be triggered by external factors that the rider exposed to while driving. It is possible to examine the factors that trigger distraction in two different areas as sensory-physical and psychological factors. While examining the effect of feedback on the senses caused by physical stress factors on the driver's focus on the basis of physical factors, the feedbacks of stress related to psychological factors will be ignored in this study except for instant stress factors. As an example of instantaneous stress-related situations, the violation of the safe zone, which occurs when other vehicles in motion do not maintain distance, can be evaluated. However, the effect of the general psychological state of the driver on general driving will not be discussed in this study.

The examination in sensory stress-related attention disorders is examined in two main groups, which are selected as the groups in which visual and audible stimuli are evaluated. In addition, physical stress examinations will be briefly examined as external physical stress factors and temperature change.

Distractions experienced while driving play an important role in the occurrence of traffic accidents. The feedback from the drivers shows that the following elements have the greatest role on the effect of visual stimuli on driving: "situations that cause visual impairment due to reverse light while driving, the effect of light reflections on vision, the effect of temporary blindness caused by strong light sources on driving, the application of warning lights the effects of the color coincidence that occurs as a result of the coincidence of the color used in the external warnings of the selected color, the effect of the explosion of the sudden lights on the loss of focus, the effect of the light power not being coordinated in the order of importance." The data obtained in the review of the feedbacks on audio stimuli focused on the following: "Instant voice alarms such as horn sounds of the vehicles, the distraction of the drivers who make phone calls with the helmet system, the focus of the navigation users due to the low noise, the use of the excess to detect the sound, the negative effect of sudden level changes while listening to music, the distraction caused by the discrepancy in the levels of sounds from different sources, the negative effects of repeated notifications of the alerts in the perception of important notifications."Other factors affecting driving are the main factors: "Safe area violation caused by other drivers and its repetition, the effect of pushing/friction due to sudden winds, and the effect of balance and focus loss and physical contact from the passenger."

The effect of visual stimuli on ride and conditions that cause visual impairment due to reverse light during the ride: It has been determined that the luminescence that the lights coming from outside sources make behind / around the objects while driving plays a negative role in detecting the recognition and distance of the objects. The light sources in question show their effect naturally with the effect of sun rays during the hours when the light is relatively parallel to the earth's surface, such as sunset and sunrise. Vehicle differences and high-power projector/illumination are the main factors of artificial factors because illusions caused by reverse light. Today there are helmet visors with polarized filters to minimize the radiation around objects, but the use of these visors is preferred by a limited number of users because they negatively affect visibility in dark environments. The surveys conducted with the users showed that although the participants have information about the visors with a polarized filter feature, this filtering is requested to be turned into a smart system that will be activated in case of necessity rather than continuity. Even though technological visor

dimming applications are possible, this technology supply-demand relationship, which is an unexpected feature to be presented in the near future in smart helmet models that have been introduced to the market and/or introduced in the future, has been determined in the surveys conducted with our participants.

The effect of light reflections on vision: When reflection lights, such as negative labels of the opposite light beams, for the recognition of objects, are examined as external effects lights, the illusions caused by both the reflections of the color reflections with the warning lights and the reflection of the reflected light from the vehicle being driven are to allow the external lights to coincide with the reflection lights. For this reason, the problem of mixing vehicles and objects without light sources with objects with a light source is encountered. Apart from this, the temporary blindness caused by the legibility of the road signs and the intensity of the light reflected by the vehicles with high lumen headlights are examples of negative effects caused by external reflections. Misleading images created by natural sources such as the sun at different times of the day is distracting. The negative effects of the reflections on the raw layer formed in the first hours of the day affecting the legibility of the road, the reflections of the evaporating air on the asphalt and the reflections of the parallel lights during the sunrise/sunset events and the distraction of the focus of attention are the factors that negatively affect the driver's vision. The effects of reflection lights can cause negative reflections from internal sources as well as from external sources, and/or the effects of external sources may give negative results in internal indicators. Among the negative effects of light reflections are also the following. The loss of vision due to the coincidence of the lights placed on the helmet overlaps with other light source indicators, the legibility of the reflected colors of the external sources of light sources overlapping with the internal reflective colors, the reflection of the light on the instrument panels on the misting / frosting due to the internal misting problems. The filtering method will also be effective in eliminating this problem.

The effect of temporary blindness created by strong light sources on driving: Temporary partial blindness caused by exposure to powerful light sources such as the headlights of vehicles coming from the opposite direction causes the drivers to fail to perform the function of the most basic region, they use for focusing while driving,

thus causing a loss of focus. These powerful light sources, which can directly interfere with vision, also affect camera sensors and cause camera images to become imperceptible. This problem is among the problems that can be solved by the filtering method as in the first two problems.

The effect of the color coincidence that occurs due to the coincidence of the color used in the external alerts in the application of the warning lights to the driver: In the vast majority of the important warning lights exposed while driving, the color selection is set to red. Since the color markers are different from each other in the warning markers in which the color selection is manifested as a light indicator, there may be confusion in the perception of the warning as well as the intense presence of the lights with similar color code from external sources negatively affects the visual selection of these important alerts. For example, the intense red light in the brake lights of a braking vehicle may cause the red warning that appears on the inner display that blocks awareness and/or causes the color of the warning to be faced with a color intensity so that the driver cannot see well. In order to overcome these problems, the size of the icons can be adjusted to be as clear as possible. The contour lines of different colors can reduce the negative effect that may occur for the driver.

Effect of bursts of flashes on lack of focus: Sudden bursts of light while driving can cause the driver's attention to shift in the same direction or opposite direction of light burst, while the driver's attention to the road will be distracted. Another danger is that the camera sensors may be damaged during light explosions. Although an effective solution that can be applied for the loss of attention that may occur as a result of such light explosion was not found in our research, the applicable solutions for re-focusing the focus after the event and correcting the point of view include: On-camera - (minus) exposure - aperture and contrast settings make the image readable, and the wide range of angle / panoramic shooting features of the driving cameras continue to be provided by vizors to increase the efficiency of the viewing angle, despite the loss to the path caused by the change of viewpoint. These are among the technological solutions that can be applied for post-event improvement.

The effect of light power and not having coordinated results in order of importance to driving: Transmitting each of the warnings we encounter in the vizor while driving

with the same power light beams can cause fatigue and loss of focus in the driver's perceptions. For this reason, considering the importance order of the selected signs, choosing the signs that require the most important and immediate response with the higher lumen and/or larger and legible will give an effective result in eliminating the perception blindness caused by the driver's constant stress while driving.

Voice stimulants: Instant loud stimuli such as horn sounds of vehicles while driving: It is known that the sudden loud sounds such as the horn sound coming from other vehicles while driving, which is one of the subjects frequently complained by the participants, are noteworthy. In addition, other external noises with high decibel values, such as the exhaust explosion, will bring the same problematic. Although the soundproofing of smart helmets is effective in partially preventing these and similar sounds, technological advances show that reverse frequency interferences are effective in reducing the sensation that may occur from sudden sounds to normal levels. By applying external noise listening, which has the same working principle as the working principle of the virtual noise cancelers that we see in most of the new generation headphones, the application of limiter/ trim/high pass filter operation on loud and sudden sounds with the frequency overlap method will allow the smart helmets to completely get rid of such factors that distract the driver.

Positioning of external stimuli and determining the level of effect are visual stimulants and sound stimulants: Visual stimuli should be positioned so that they are visible at every planar angle of the helmet. Lightened warnings should be selected in a flashing structure with a focus on location, not environmental lighting. Visual stimulants should be selected as global warning colors. Audio stimulators should consist of high and medium vocal polyphonic sounds at the mid-frequency and should be located on both sides of the helmet. For example, one participant says: "The leading factor among the negative factors for motorcycle is listening to music, that is, when I listen to music, I think my senses are affected negatively. Loss of attention can happen at any moment. That's why I use intercom only to use navigation for communication. In this way, if I am making a successive trip, if the posterior behind me is constantly talking, if he is in a constant intervention about my driving or if he is trying to explain something about it, whether it is about the place we are going to be, about himself, about his current thought, these factors negatively

affect the senses in the current driving." It shows and explains well that sound stimulant is a crucial distraction.

The distraction of drivers who make phone calls with the helmet system with sudden phone calls: The responses of people who participated in the survey for helmet use also show that, while driving, making phone calls is among the factors preferred by the majority of users in terms of use, distractions that occur during the first call should be avoided. Presenting such sudden calls to the user as predefined silent alerts, the transfer of visual alerts to the driver just before the audible alerts will significantly reduce the panic response to the audible alert. For the solution of this problem, the appearance of incoming calls on the vizor with size and placement that the user can decide, and the voice alert in advance between 1 and 3 seconds that the user can decide, will eliminate the sudden reaction caused by the audible warning.

The answers to the questions posed to the participants show that smart helmet users are expected to have as many pre-ride configuration options as possible, while smart helmets are expected to make decisions instead of a driver and minimize the necessity for control as possible. One of the participants says: “What is the advantage of lot usage? I choose the route that I will interfere with my helmet through the intercom on the phone, that is, using the lot system. I put the phone in my pocket. That’s how I use navigation. Integration of my mobile phone and intercom seamlessly, that is, an important emergency call came, there was a health problem, there was an accident, there could be any kind of emergency, or there was a phone that I expected for work. It is important that the integration of my mobile phone and intercom work seamlessly. For example, there may be an important emergency call, a health problem, an accident, any kind of emergency, or a call from the work. At that moment, I may be on the motorcycle, and there may be a phone call that I have to answer.” So, the intercom is important, at least to answer the phones. Another one is that in the interaction with the phone, this device can help the rider in navigation, direct by voice, save time and save from stress. This is a big plus in this context. It’s important for the helmet to be able to interact with each other with a lot; that’s, technological tools. For example, one participant says: “It is enough to have the action camera hardware on the helmet, have the intercom and the communication I use with the intercom by providing communication from the mobile phone. I do not

prefer this because we cannot read any messages or do research on the internet while driving. If my destination is a route that I do not know, if I need directions and I can integrate with my phone in a healthy way to get a clear sense from the speakers of intercom, this technology is the best helmet technology for me. Other than that, sometimes, I prefer to use an action camera to record a band performance, scenery, beauty of the road, or my driving performance. Technology is actually very important to me in this context. Of course, these are complicated; if it comes on a helmet as a whole, it would be more likely to be easier, as far as I know, there are such helmet brands."

Focus of navigation users to detect the sound more than they should have due to low noise: In the case that the voice from navigation is not heard during the use of voice navigation, it may be possible to navigate the wrong route, while it can be a distraction for the drivers spending most of their attention to listen to those directions. To eliminate such negative factors, sound levels should be determined as specific standard levels and should be increased or decreased collectively. Technological advances are at a level that can provide sufficient volume, so adjustment options related to the volume should be available before driving. In addition, these sound options should be automatically increased and decreased with the help of ambient noise listening feature while driving.

The negative effect of sudden volume changes while listening to music on the driver: While listening to the music, depending on the file from the music source, volume increases and decreases may occur. Such sudden rises can distract the driver, so the sound level should be kept automatically by the smart helmets in the same dB range, and the maximum decibels should be provided to the user as a warning sound before the music starts. Compared to the warning sound, the user can mute the sound if he wishes, or adjust the sound level automatically based on the maximum dB range in the sound file.

Distraction caused by discrepancy in the levels of sounds from different sources: Smart helmets can offer different unit-sourced sounds to the user simultaneously, but the importance and priority of these sounds should be ordered. In this way, the users will be able to follow the important sound warnings and ensure that the voices that

are present in the background are terminated in the required situation according to the order of importance. In this way, the users will be able to follow the important sound warnings and ensure to block the voices in the background in any required situation according to the order of importance.

Negative effects of repeated notifications of alerts on the detection of important notifications: Repeated notifications of alerts can create blindness in user perception after a certain level of stress and negatively affect the interest in the presence of new alerts. For this reason, it has been determined that instead of repeated warnings, warnings that constantly repeat in standard intervals are easier to follow and less distracting for users.

Safe area breach from other drivers and its repetition: While large vehicles violate the safe distance on the road, the driver does not have physical contact but causes the driver to shift the focus of the attention to a different area because he wants to be cautious. For such distance tracking and easy control of the field, violations can be realized using warning and tracking visors due to cameras of smart helmets. In addition, drivers who are just doing rule violations can be warned by the smart warning lights and sounds that can be placed on smart helmets. When technological developments are examined, proximity sensors and / or image processing methods have been observed to play an effective role in this tracking and field measurement.

Impulse/friction force due to sudden winds, loss of balance and focus: Factors that have the ability to apply physical force such as wind and hail as natural events can affect the attention and balance of the driver. Guide features can be integrated into smart helmets to restore balance or minimize loss of balance when sudden weather changes are encountered. Create a virtual horizon line, which is among the recommendations of the participants, provide pilotage standards with indicators, place units such as gyroscope with the help of technology. Moreover, it can be a guide for the rapid recovery of the user's lost focus due to sudden effects.

The effect of passenger physical contact on the driver: The effect of passenger-driven push and pull movements on drivers are among the effects that distract the focus while driving. Although no direct solution can be found in this regard, it is

possible for the driver to inform the passenger about the issue with a warning light and audible stimuli through the smart helmet.

Positioning the images: Warning lights and markers, it is more preferred by the users to select the spaces where the symbols in continuous use are not used for positioning of warning lights and markers.

Navigation markers: Provide navigation marker as simple as possible and make use of the navigation map feature in the transparent form are the main factors for users. The color codes of the navigation symbols should not be confused with other warning lights, and distance alerts should be expressed with more vivid colors that increase with the closeness of distance.

Media and communication marker: The media and communication marker must be located in the area where the warning lights are located. However, it is also necessary to choose a different color than the warning lights and to decrease its visibility both as the light source and contour thickness.

Motorcycle information images: Motorcycle information indicators should be positioned in a flexible structure so that the user can make adjustments without including the color codes of the warning lights at standards that will not prevent road tracking.

Determining the order of importance and principles of voice alerts: When determining the order of importance of audible warnings, the sounds that should be dominant should be in the form of warning sounds, navigation sounds, call sounds, music sounds, respectively.

CHAPTER 6: CONCLUSION

Turkey is a developing country where total number of land vehicles have increased rapidly for the last ten years. Therefore, the road accidents have also taken place more frequently. Especially in big cities such as Istanbul, Ankara and Izmir where traffic density is higher than other cities, traffic accident news is heard almost every day. There are many reasons for these accidents, some of which result in mild injuries, some serious injuries and even some death. In order to prevent or minimize the number of deaths and/or injuries, the use of new smart products with new technologies are needed. Temporary solutions such as widening the roads to avoid traffic and public regulations are based on a single action, therefore, long-term improvements should be made by modifying and developing new products.

Wearing helmet is a protective head gear and provides safer rides and it is a priority for motorcycle users to prevent injuries. Therefore, helmets are one of the best and versatile elements of motorcycles to use advanced features such as navigation, hands free devices, etc. This study examined navigational user experiences in motorycle helmets and recommendations were made about helmet design in line with user experiences. The study findings have primarily shown that according to the consumer responses, many factors are effective for helmet design and during driving.

Findings of user experiences data obtained from websites or forums such as www.motorcycleforum.com, www.electricbikereview.com and forum.arduino.cc have shown that pros and cons of helmet design were different to users. According to users, the most significant requirements of motorcycle helmets are bluetooth system to listen to music generally, high quality speaker for phone calls, GPS navigation, intercom to communicate with other riders, cost, long-lasting battery, built-in rearview camera and HUD, respectively.

Many user suggested that smart helmets have several advantages. In order to get full performance from smart helmets, it is necessary to establish a connection between the helmet and the phone (e.g., Bluetooth). The most important feature of these helmets is transmitting the stimuli such as speed limit, motor condition warnings,

wind speed, traffic density, road works via sound or visual signs. For example, it is quite possible that a driver who wants to listen to music cannot hear outside voices during the journey. Informing the danger possibility to the rider via visual warning is a life-saving factor. It is among the important benefits of these helmets to increase awareness by defining the road warning sounds, which can coincide with the sound of the music. The choice of the rider and the priority ranking must be according to the adjustability of the smart helmet. Raising awareness is among the important benefits of these helmets. It is also vital to access the emergency numbers recorded (through the phone to which they are connected) and even send locations during accidents.

Communication by intercom were considered as useful to share or warn other drivers. Vertix, for instance, were found newer, stylish, nicely fit behind the helmet instead of at the top, and included remote control. Users added that they could also hear each other clearly and hear everything outside with the floating speakers.

It is also an effect that the motorcycle rider’s equipment can be used in one piece. A motor rider who uses a smart helmet can control the phone call or music volume through the helmet. Smart helmets provide ease of learning information about ground direction, such as wind speed, road speed limit. Smart helmets provide ease of learning information about ground direction, such as wind speed, road speed limit. Warning lights in smart helmets increase visibility for awareness in traffic. The helmet's built-in camera minimizes the possibility of damage to the camera because of the factors such as wind and impact. As mentioned, these benefits are; It eliminates factors such as thoughtfulness and significantly reduces the risk of accidents, reminds the necessary measures to be taken, saves the driver from excess goods, saves time and effort, provides the driver’s attention to the maximum level and provides great convenience for other drivers.

There are also some disadvantages or negative experiences with motorcycle helmets for users. During non-stop long rides, users want uninterrupted music and high quality sound but it is impossible without earplugs-in which is considered a significant pain to get the earbuds to fit right inside the helmet every time taking off the helmet off or put it on. Another negative experience was wind noise-cancelling

problems of helmets. When riding a motocycle, lack of noise-cancelling will make trouble for communication. It is emphasized that higher speeds could drown out any voice, depending on the phone and the microphone's location.

In overcoming the difficulties that arise when the helmet design processes are examined, when a designer is approached with an angle of view, it can be seen that every user can reveal his own style and as a way of doing this, "tailor-made helmet designs" will have quite interesting results. Tailor-made design means a racer, and this applies to a car or motorcycle design. All in all, if clothing, motorcycle, helmet, and car designs are in harmony, it is certain that they will stand out from the crowd as a unique piece for all new generation helmets created.

Second stage of the study consists of a survey in which participants were asked about their choices of motorcycle and helmet use as well as personal information like demographics. The general findings of the survey have shown that sample of the study mostly involved participant with higher income, married, aged between 25-55, university graduates, living in Izmir. According to the findings of helmet use, it was found that users mostly preferred open-face and modular helmets and the most emphsized advantages were safety and comfort where comfort was considered more important than safety. Users who use fabric heads expressed the comfort by reducing friction in helmet use while noise-cancelling has almost similar importance. Also it was determined that all users had their own helmets, and most of them had two or more helmets. Finally, most motorcycle drivers were experienced users from 3 to over 11 years and they prefer driving for recreation rather than transportation.

According to the findings about distraction while riding, physical factors exposed from outside the helmet such as the headlights of natural vehicles and car horns, were found as the main factors causing distraction while some of them were distracted by in-helmet sounds and signs. In-helmet distractions were attributed to incoming calls and lights. Therefore, riders preferred solutions such as blocking intense light with momentary dimming/filtering, offering frequency limit resolution for loud sounds, and presenting alerts in the form of audible rather than visual.

According to the findings about smart helmet use, participants highlighted communication, warning, and navigation forms. Hand signals were mostly preferred rather than inter-helmet communication. Participants also preferred listen to music while riding and perform this action mostly in the helmet through the sound system of the helmet as in the user experience findings of first stage. Similar with the user experience findings again, most riders were satisfied with their smart helmet solutions provided by automatic arrangements without the need for adjustment by the user. Smart alert use also found to be the most important feature in rear camera use. Automatic phone calls were considered one of the best advantages of smart helmet. On the other hand, participants drew attention to financial and supply problems in line with user experiences about products with higher costs. Although the access to information about smart helmets and developments about them, physical accessibility to smart helmets was found limited.

According to the findings about navigation use, it was determined that motorcycle riders use navigation lesser than car drivers. The main advantage of using navigation was to provide transportation in the shortest time possible, followed by shortening the driving distance and reporting about the road works, and possible accidents. In case of an accident, the advantage of a smart helmet was reporting the accident to relevant unit. The most important smart helmet features suggested as emergency services and a transparent viewfinder screen in line with navigation use findings. When all the data and findings obtained from user experiences, interviews, and survey were assessed, some explanations and recommendations, which are mostly negative experiences or features, were made below.

Helmet interface design is a factor that should be paid attention to as much as the helmet's protection. The interface should have a simple and effective design as well as it should not confuse the driver or obstruct road vision. Factors to be considered while adjusting the audio alerts are the stimuli indicating the physical condition of the motorcycle. The road should take precedence over the sound of the music and phone call and should be selected at a higher frequency. It is important to draw attention to mid and treble sound, high frequencies considering that the sounds of motorcycle sounds in helmets are at lower frequencies. A wide frequency spectrum should be included for the warning sounds. At the same time, while listening to

music, it should be a standard sound that will not disturb the driver who wears the helmet by preventing the sound imbalance during the song transitions.

The main appearance elements that need to be examined during the design stages that are valid for helmet design are divided into three and are determined as a side, rear, top views. The side view is a very dominant look as it affects quite a lot of the helmet, and the side areas of the side view also include the back, top, and front of the design. For this reason, regardless of which option is preferred during the approval process, the appearance sent primarily is the side view when submitting the helmet design. After selecting the side view, if the 3-view option is requested, then the remaining views are created and matched in accordance with the side view. When the design element is examined in smart helmets, it is seen that the main focus of the design is on the user experience not to lose focus on the road and to keep the concentration at the highest level. However, it is aimed that the user will still be connected with technological factors. One of the most remarkable features of smart helmets is to provide Bluetooth audio, and it does not create an aerodynamic effect as a contribution of the system working integrated with the helmet invisibly from the outside. These elements will meet the requirements of the user when they need it most, keeping him safe.

However, it is necessary to say with regret that, even though their smart helmets are user-friendly in their design, the motorcycle helmet market is taking steps to unsuccessful initiatives. Companies like Skully have failed Indiegogo supporters. As the Nuviz company was closed, its customers remained unsupported, even though their products were quite nice. In addition, smart helmet users have justified concerns about choosing smart helmets because of their higher prices than traditional helmets. In terms of user experience, it is also seen that smart helmets are compared with communication devices in terms of price. Options not only between “integrated” and "Bluetooth ready." Like alias Laszlobauer has told above with 2x BT Motorcycle Helmet Bluetooth Interphone Motorbike Intercom Headset 800M FM unit, it was not possible to communicate to friends who are running Sena units on their bikes and distance is also important.

It is likely that the intercom battery will flow and explode due to factors such as heat. In this regard, problems such as disconnecting the communication connections of the drivers and even injuring the driver with chemical burns were observed. Another problem caused by the intercom is that it causes the driver to be startled and distracted by the sudden sound coming from the phone ringing while driving. Drivers use navigation for situations such as navigating from one point to another by saving fuel and time, seeing the speed limit on the road they are on, finding the places they will need in a location. However, as it is known, following the map while driving is both very risky in terms of safety and causes time and effort loss as it will create long stops on the road. It is also important to resolve any dispute in case of a possible accident, to use it as evidence in judicial situations, and to use the camera of the driver in order to detect errors. Drivers mostly install these cameras on the helmet. This situation is caused by wind, or other impacts may cause the camera to change its angle or break due to factors.

The leading warning indicators of the stimulus figures, respectively, navigation visuals, telephone calls, visuals, and music images, should be classified according to an order of importance. In choosing the color of the figures, attention should be paid to the contrast that will be noticeable while driving. For example, it should be sensitive to the use of colors such as red, yellow, blue, and white. As it is known, these colors are the most used colors in traffic, and it can be difficult to notice. The transparent part of the transparent images should not be too large. Otherwise, there may be deviations in filtering the light reflections coming from outside. In high light conditions, the use of automatic filtering features can produce good results, but performing these filtering can also reduce the driver's view. Therefore, it is beneficial to have more than one sensor in the helmet.

The positioning of the front and rear camera on the helmet also has great importance. In terms of the angular advantage, it is useful to position the rearview camera on the side like mirrors or in the upper center of the helmet. In this way, it enables the rider to see vehicles that change lanes to realize the possibility of crashing from behind. As is known, the side rearview mirrors provide a narrower angle view and remain inadequate. Since the misconception can be revealed in the use of fisheye cameras in the rear cameras, it should not be preferred. Panoramic cameras for the front camera

will be useful for recognizing potential hazards or for post-accident support. Attention should also be paid to the readability of the images coming from the camera, such as night vision, high-low light factor shading, and plus-minus exposure. The screen where the camera image will be reflected is as important as the location of the camera. It should be positioned well and not obstruct the vision while driving.

In addition to the smart helmet features produced; Visual and audible stimuli can be increased by adding options such as synchronizing with smartwatches, alerting the rider based on measurements such as pulse and body fever, and encouraging the rider to rest on long journeys, and ensuring a healthy ride. Health applications can be transmitted through the visual and audio panel of the smart helmet. With the help of IoT technologies, synchronous use of these healthcare applications can be integrated with smart helmets. In this way, the health status of the riders/passengers can be examined after the ride and accident. A warning to inform the rider and the citizens around can be put into the helmet in order to inform the necessary first aid and take security measures.

If rear cameras in their vehicles can be applied properly, survey participants are on the same page that will provide the user with serious comfort. Using a rear camera, which is not considered a reliable method by most potential users, can have negative factors that affect. Apart from that, it is an important choice for users whether the placement of the rear camera is on the helmet or on the motor. Users are looking more warmly at the idea of the fixed camera as they use in their cars. This is because if the camera is behind the helmet, a user who wants to control the right-back must turn her head to the left, that is, an angle opposite to the direction of view will be caught by the rear camera. This is because if the camera is behind the helmet, a rider who wants to control the right-back must turn her head to the left, that is, an angle opposite to the direction of view will be caught by the rear camera. In a possible remarkable moment when we turn with the reflex to the direction where the sound is coming, we will start to see the image opposite the direction of our rotation, which means that we cannot see the direction where the sound is coming with the rear camera. Since the rear-view mirrors, we use today to show us the backside of the right side when we look at the right and show us the backside of the left side, when we look at the left side, so the movement and the view direction are matching. It is an

important step to widen the rear camera's viewing angle and stop the necessity to turn the user's head to solve this problem. If the area where the rear camera image is projected onto the vizor is larger or smaller than it should be, it may be a problem both in terms of attention factor and narrowing the angle of view and legibility of the rear image. Today, a calibration feature such as the calibration feature offered to the user in the games should, therefore, be positioned in detail for the part where the rear camera image is projected.

Navigation is another feature that some users do not prefer to use for the reason that it disrupts the driving focus, some of them use it only with the voice description method, and some are used both visually and audibly. Users who provide driving with voice use only agree that navigation voices should have a volume and clarity over additional voices and ambient sounds such as music phone calls, but for long-term trips that do not require a return, the presence of this sound is forgotten, and the driver's reaction is heard during the first sensation. In addition, the warnings made in high volume can be a problem in understanding the priority warnings.

Although the warning lights play an important role when viewed by users, the transfer of a lot of information to the users in a limited time interval will affect the legibility of this information, which will affect the focus and negatively affect the user. For this reason, it should be able to reflect the necessary information to the user in a simple and timely manner as a condition that smart helmets can be truly “smart” by filtering these alerts in order of importance. Users are also waiting for some predictions from smart helmets, for example, the user may be warned to slow down before cornering by combining navigation with the information that it will turn 50 meters after traveling, instant speed information, and icing warning. In warning lights, the color selection should be made in such a way that it does not mix with the lights coming from outside. For example, red lights can be mixed with the stoplights of the vehicle at a standstill, in such a case, the use of symbols and the credits of the symbols can have a healing effect on the problem of perception. If we look at the weaker samples, the elements such as the stoplight signal, artificial light, ambient lights coming from the outside will have a negative effect, for example, the red light from the bottom of the screen/vizor of the slow down alert, the green light that spreads over the vizor of the forward indicator, the yellow light from the sides of the

right or left turn. The size of the warning lights should also be user-customizable. This is because of the possibility to decide how much of the road he wants to see offers comfort to the user.

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APPENDICES

Appendix A. Table of Questions

1. Please indicate in which age range you are?

- 18 - 24
- 25 - 34
- 35 - 44
- 45 - 54
- 55 - 64
- 65 - 74
- 75 and above

2. Please select the monthly income range of your household

- 2,000₺ or less
- 2,000₺ - 3,499₺
- 3,500₺ - 4,999₺
- 5,000₺ - 7,499₺
- 7,500₺ - 9,999₺
- 10,000₺ - 14,999₺
- 15,000₺ or more

3. Please indicate your address where you live.

4. Specify your business address.

5. Please select your education.

- I didn’t go to school
- Primary School
- Secondory School
- University student or college graduate
- University graduate

6. Indicate your marital status.

- Married
- Widow
- Divorced
- Separeted
- Never married

7. Do you have children?

- Yes, over 18 years old
- Yes, under 18
- No

8. What type of motorcycle helmet do you use?

- Full Face
- Open-face
- Modular
- Off-road
- Half
- Dual-sport

9. What is the primary advantage of the helmet type you choose in the eighth question?

- Security
- Ease of communication
- Stylish appearance
- Price
- Comfort

10. Do you use a fabric hood under the helmet? Why is that?

- As it provides comfort by reducing friction in helmet use
- Because it reduces the sound
- Because it reduces the incoming wind
- Warming purpose
- To protect against flying creatures such as insects and dust

11. Do audio and visual stimulus are distracter for you while using the engine?

- Yes
- No

12. Which audio stimulus are distracting while using the motor?
1- warning notices
2-sounds from outside
3- sounds from motor
4- nature sounds like wind rain thunder
5- call sounds, such as telephone inter-helmet communication
6- music sound

13. Which visual stimulus distract you while using the motor?
1- lighting on the engine
2- headlights of other vehicles

3- warning lights of vehicles such as police vehicles, ambulances
4- natural events such as lightning, rain, thunderstone
5- general warning lights and reflectors
6- reflections on motorcycle glass or helmet

14. What is the most distracting element for you in motor use? Why?

15. How do you think this problem can be overcome with the use of a smart helmet?

16. What are the most important advantages of smart helmets in order?
1- offering ease of communication
2- drawing attention to danger with warnings
3- offering music
4- navigation feature
5- being stylish
6- being cheap

17. How do you communicate with your other rider friends?
- Telephone
- Hand signs
- Communication between helmets

18. How do you communicate with the backseat?
- Telephone
- Hand signs
- Physical contact
- Voice call

19. Do you listen to music? How do you listen to music?
- With the motorcycle's sound system
- With the external sound system on the motorcycle
- Telephone with external speaker
- With headphones from the phone and / or music player
- With audio system attached to the helmet
- I don't listen to music

20. Does listening to music with smart helmets give you an advantage? What advantages does it provide?

- It helps me keep my attention on adjustments while listening to music and radio
- Automatic adjustments such as sound settings eliminate additional movement requirements while driving
- It makes settings such as music change, sound level more easily accessible, and reduces these settings time.
- Helps me adjust the volume during calls, such as a phone call
- Prevents warning sounds from being lost in music sound

- I don't listen to music with a smart helmet

21. Do you record images during motorcycle use? What are the advantages of using smart helmets to record these images?

- I do not use a recording camera
- The use of smart helmets provides comfort as the placement of the cameras is designed to minimize friction factors such as wind.
- Use of smart helmets reduce distraction during control.
- Smart helmets record the images of the camera in possible dangers and assist in fault detection.
- Smart helmets provide more efficient alerts by improving the warning features with the help of image processing by these cameras.
- Smart helmets provide support in first-aid with remote access via cameras.

22. Should the rear camera image be used? What are the advantages and disadvantages?

I do not use a recording camera

- Should not be used – No confidence with factors such as delays, image quality, reflections.
- Should not be used - as it provides information from the opposite side of cameras fixed on the helmet
- Must be used - creates an alternative when factors such as trespass, wind, rain, dust, mud affect use of mirror

- Must be used - Stop the necessity for mirrors, reduces friction, increases performance
- Must be used - Since it stops the necessity of mirror, it provides a stylish appearance.
- Must be used - As it is used to indicate the danger approaching from behind as a warning
- Must be used - As it plays an auxiliary role to defect detection with the recording feature

23. What is the advantage of smart helmet when talking on mobile phone?

- Continuity to receive warnings during the interview
- Automatic termination of the call when necessary
- Rapid response to the call
- Convenience in making and answering calls
- Possibility to automatically adjust the volume during the call
- Possibility to share the conversation with other drivers and passengers
- Possibility of starting the phone call audibly or automatically in case of emergency

24. Do you think the motor drivers in Turkey are following technological developments in this field and implements? Why is that?

- Not follows
- Follows but does not apply
- Follows but can't apply due to financial and supply problems
- Follows and apply but restrictedly
- Follows and applies daily

25. So, do you follow these technological developments?
- Yes
- No

26. Do you use navigation? Which vehicle are you using?
- Motorcycle
- Car
- Bike
- Other
- I don’t use

27. What are the advantages of navigation are the most important to you?
- Calculates the shortest distance
- Allows to determine the fuel demand
- Shows the necessary route for transportation in shortest time
- Shows temporary obstructions such as road work and accident on the road
- Enables to learn new ways
- Allows to stay at safe speed by showing my speed
- Remind temperature warning
- Provide icing and slippery ground warnings on the road

28. What should be the advantages of a smart helmet in case of a possible accident?
- Informs the relevant institutions about the possible accident
- Informs the owner of the helmet about first aid and actions after the accident
- Informs people about what to do and not to do after the accident
- Informs with warning lights to make the accident visible

29. List your expectations from the motorcycle helmet.
- Confortable
- Stylish appearance
- Protective
- Listening to music
- The ability to use communication devices such as telephones
- Windproof
- Cheap
- Sound proof
- Polarized vizor

- Product of a well-known brand

30. Do you wear a helmet while using the motor?
- Yes
- No
- Rarely

31. Which smart helmet feature is more important to you?
- Transparent Vizor Screen - information such as speed, navigation
- Emergency service - Informing the relevant instution about the status of the driver after the accident
- Camera recording - front and back
- Real-time parameters
- Other (please specify)

32. Secondly, which smart helmet feature is important to you?
- Transparent Vizor Screen - information such as speed, navigation
- Emergency service - Informing the relevant instution about the status of the driver after the accident
- Camera recording - front and back
- Real-time parameters

33. How many helmets do you have?
- 0 (Sharing)
- 1
- 2
- 3
- 4

34. How often do you renew your helmet?
- Less than 1 year
- Every 1-2 years
- Every 3-4 years
- Every 3-4 years
- I have not renewed for 7 years or more

35. How do you evaluate your old helmets?
- I throw it in the recycle bin
- I keep it as a souvenir
- I make it available to the person who will ride me
- I give it to someone who needs it

36. Are you satisfied with your current helmet?
- Yes
- No

- Impartial

37. For how many years do you ride motor?
- Less than 1 year
- 1-2
- 3-5
- 6-10
- 11 years and over

38. How old are you?
- 18-25
- 26-35
- 36-45
- 46-60
- 61-100

39. How type of ride do you usually drive?
- While going to work / school
- For the race
- For the trip
- For hobby and entertainment
- For off-road
- For commercial reasons

40. How often do you use your motor?
- During whole year
- In summer
- According to the opportunities
- Other (please specify)

41. What type of motor license do you use?
- M
- A1
- A2
- A

42. Could you share your views on smart helmets and navigation with a few sentences?
- Classic helmets and smart helmets
- Motorcycles and navigation
- Communication with people while riding
- Warning lights while riding
- Attention factor while riding