DEVELOPING AN EXTERNAL BIKE RACK DESIGN FOR INNER-CITY PUBLIC BUSSES THROUGH AN ACTION RESEARCH PROCESS

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submitted by **MEHMET ERDİ ÖZGÜRLÜK** in partial fulfillment of the requirements for the degree of **Master of Science in Industrial Design Department, Middle East Technical University** by,

Prof. Dr. Gülbin Dural Ünver
Dean, Graduate School of **Natural and Applied Sciences** ____________________

Prof. Dr. Gülay Hasdoğan
Head of Department, **Industrial Design** ____________________

Prof. Dr. Gülay Hasdoğan
Supervisor, **Industrial Design Dept., METU** ____________________

Examining Committee Members

Assist. Prof. Dr. Fatma Korkut
Industrial Design Dept., METU ____________________

Prof. Dr. Gülay Hasdoğan
Industrial Design Dept., METU ____________________

Assist. Prof. Dr. Naz Ayşe Güzide Zehra Börekçi
Industrial Design Dept., METU ____________________

Assist. Prof. Dr. Aydın Öztoprak
Industrial Design Dept., TOBB Uni. of Econ. and Tech. ____________________

Assist. Prof. Dr. Aykut Coşkun
Media and Visual Arts Dept., Koç University ____________________

Date: 05.02.2016

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: M. Erdi Özgürlük

Signature :

ABSTRACT

DEVELOPING AN EXTERNAL BIKE RACK DESIGN FOR INNER-CITY PUBLIC BUSSES THROUGH AN ACTION RESEARCH PROCESS

Özgürlük, Mehmet Erdi

M.Sc., Department of Industrial Design

Supervisor: Prof. Dr. Gülay Hasdoğan

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Bicycles have a great potential of mobility and flexibility to be used for transportation besides their recreational and sports activity based purposes. However, they have certain deficiencies through which they need to be supported by other means of transportation in order to enlarge the cycling catchment area. Promoting cycling somehow returns with many benefits such as reducing negative environmental impacts of transportation vehicles with carbon emission, improving health of users together with economic and social benefits. In respect to this, integration of bicycles with public transportation would bring mutual benefits for each mode of transportation. For this reason, an action research study is conducted to develop a transit bike rack system consisting of a two-stage fieldwork held with different stakeholders associated directly with the proposed system. Basing on the findings of the fieldwork, design alternatives for a transit bike rack system are created and analyzed considering the design criteria set throughout the study. Further suggestions are made to improve the system.

Keywords: Cycling, bicycle, transit bike racks for buses, cyclist, public transportation.

ÖZ

EYLEM ARAŞTIRMASI YÖNTEMİ İLE ŞEHİR İÇİ OTOBÜSLERİN DIŞ KISMINA KONUMLANDIRILACAK BİSİKLET TAŞIMA APARATI TASARIMININ GELİŞTİRİLMESİ

Özgürlük, Mehmet Erdi

Yüksek Lisans, Endüstri Ürünleri Tasarımı Bölümü

Tez Yöneticisi: Prof. Dr. Gülay Hasdoğan

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Bisiklet sportif etkinlikler ve eğlence amaçlı kullanımının yanı sıra ulaşım için de esnek ve mobil karakteriyle büyük önem taşıyan bir ulaşım aracıdır. Öte yandan ulaşım kapsamının artırılması için diğer ulaşım türleri tarafından desteklenmesini gerektiren bazı eksikliklere sahiptir. Bisiklet kullanımını teşvik etmenin karbon emisyonlu ulaşım araçlarının çevreye olumsuz etkisini azaltma, sağlıklı yaşam, ekonomik ve sosyal faydalar gibi birçok değerli getirisi vardır. Bu nedenle bisikletlerin toplu taşıma ile entegre edilmesi her iki ulaşım türü için de karşılıklı yararlar sağlar. Bu doğrultuda, eylem araştırması yöntemi kullanılarak otobüsler için bir bisiklet taşıma aparatı geliştirilmiştir. Eylem araştırması kapsamında sistem ile doğrudan ilişkili olan tarafların dahil edildiği iki aşamalı bir alan çalışması yürütülmüştür. Alan çalışmalarının bulguları ve çalışma sırasında belirlenen tasarım ölçütleri dikkate alınarak bisiklet taşıma sistemi alternatifleri oluşturulmuş. Bu alternatifler analiz edilerek bir bisiklet taşıma aparatı önerisi ileride geliştirilmek üzere sunulmuştur.

Anahtar Kelimeler: Bisiklet kullanmak, bisiklet, otobüs bisiklet askı sistemi, bisikletli, toplu taşıma.

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CHAPTER 1

INTRODUCTION

1.1. Background and Motivation for the Study

This study was initiated by a design proposal concerning transit bike rack systems which aimed to enable integration of bicycles with public transportation. This design suggestion was created by a mechanics expert who works for *MAN Türkiye* which is a major bus manufacturer and is mentioned as the "collaborated firm" in this thesis. *MAN Türkiye* offered this initial design project to be developed by a graduate researcher pursuing a study in the M.Sc. program of *Industrial Design Department of METU*. The proposal involved certain features which differ from the current rack system alternatives in the market. The researcher accepted to study this proposal for his master's thesis as a research through design process.

Estimated benefits of improving the project about the integration of bicycles with buses with the help of a transit bike rack system proved the subject's having high potential and value after a quick market research and literature review process. The most important motivation for the study for the researcher was the distinct characteristic of working on a thesis in which a design process would be held by the support of a corporate firm which gives the opportunity of working by the guidance of a large research and development team. After completion of the study is a product outcome was expected.

The current examples of transit bike rack systems' being inefficient and having problems on certain issues, which could be considered as basic design criteria of the related product system, directed the researcher to determine the major goal of the study. Thus, the major goal was stated as developing an integration solution for bicycles with public transportation by creating completely new and compatible alternatives which would not only meet the deficiencies of the current models but encourage more people to prefer public transportation with an increased interest for cycling at the same time.

1.2. Methodology: Action Research

For the main methodological setup of the research study with creations of distinct design alternatives as outcomes, action research method is applied from the first stage of the study for progressing all followed stages throughout the thesis. Carr & Kemmis (1986) describe action research as being about;

- the improvement of practice,
- the improvement of understanding of practice,
- the improvement of the situation in which the practice takes place.

Through this action research process, the starting point was to follow a methodology supporting to improve practice regarding the design of relevant current products in the market within real life conditions and context. This made action research essential for utilizing.

This method basically consists of four main stages in progress during implementation which are planning, acting, observing and reflecting and these stages are not definite and have a fuzzy characteristics that is interlacing each other in advance. According to Waters-Adams & Maureen (2006), the action research proceeds in action-reflection cycle or spiral. This structural difference is related in regard to whether these four stages prove a success with the applied methodology or need further revision(s) in planning by more iterations. Thus, action-reflection cycle presents a continuum in a circular structure while spiral model needs a certain linear progress when there is a change in the planning stage (Figure 1.1 and 1.2).

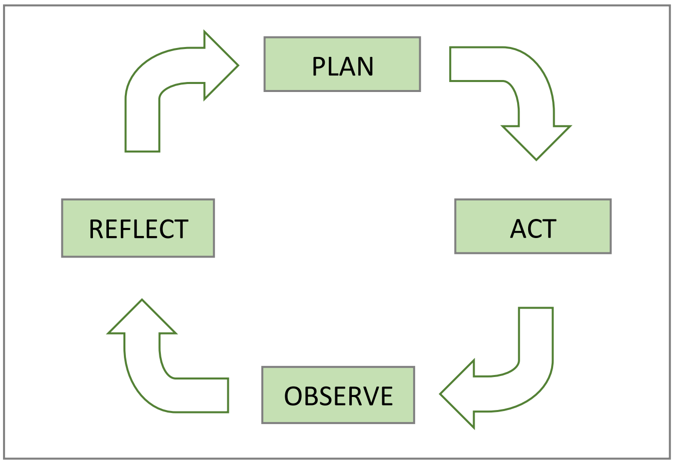


Figure 1.1 Action-Reaction Cycle (Whitehead, 1985)

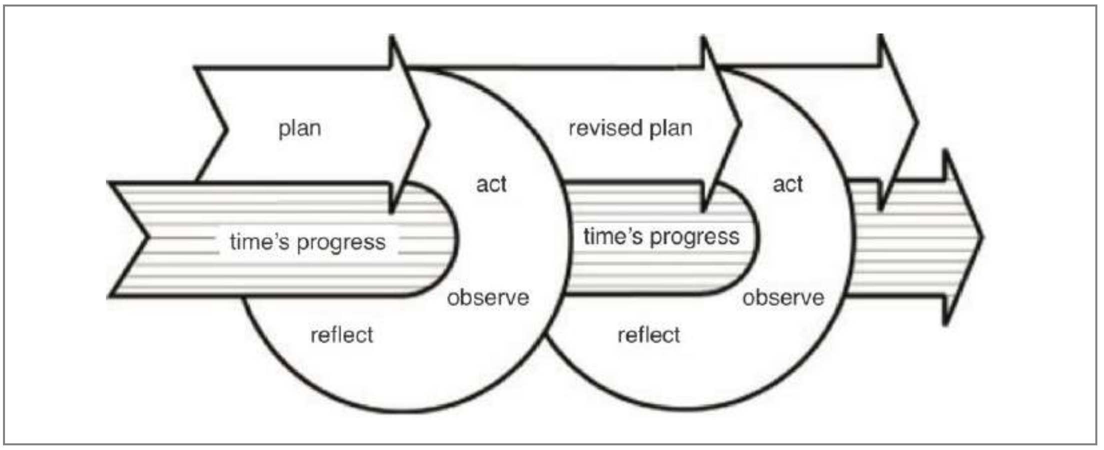


Figure 1.2 Action-Reflection Spiral (Kemmis & McTaggart, 1988)

For these methodological structures, at the planning stage, the problem is identified with the given situation, then for this problem, an initial solution is offered to the members of the system in which the problem is faced. Afterwards, this solution is experienced by them and the data from the observation is collected and analyzed for further reflection. This cycle continues until the reach of a success by more revision(s) in the plan when needed.

Gilmore, Krantz, & Ramirez (1986) mention that action research aims to contribute both to the practical concerns of people for a problematic situation and further the social science goals. Hence, through the implementation of it, a mutual collaboration of the researcher with the members of the system is essential.

This method which is described clearly by Bruce Archer is needed to be explained to some extent as it shapes the entire study. Action research is mainly aimed to tend towards acquiring information through an action as its distinct character which could be mentioned as necessary to be employed in industrial design profession, as the outcomes of this profession are evaluated mostly through qualitative and perceptional approaches in a way that of speculative measures being different to other professions, such as engineering and field of medicine. Through proceeding this specified method, certain considerations are needed to be taken into account as stated by Archer (1999), first, the main aim should be to obtain new information from the process to be implemented on the specified project. Second, through the processes which are needed to be lead systematically, the base model with the related project should be experimented and refuted and findings of these processes should be documented in an honest, clear and objective manner. This newly acquired knowledge with the studies should also be planned to be tried and evaluated appropriate to the conditions closely to the real-life constructs, including all elements associated, such as time, location and the stakeholders of the project. One of the most significant features about this method to be accepted as being successfully implemented is very much related to the researcher. The researcher is defined in a special position with the implementation of this method, in which he/she should isolate himself/herself from affecting the assessments about the project theoretically, ethically and ideologically. According to O'Brien (1998), the researcher would also adapt possibly many different roles at various stages of the project such as; planner leader, teacher, listener, facilitator, catalyzer, observer, designer, synthesizer and reporter.

Although the method is quite challenging and needed to cover many considerations, the estimated data which would be taken at the end is considered of being applicable and clear for utilizing with further studies by other colleagues and it is also considered having a direct means which is limited on making generalizations from.

1.3. Aims of the Study and Research Questions

The aim of the study is to assess the given design proposal in regards to certain appropriate design criteria and to develop it further by the findings from literature and field studies which would be held throughout the study. The study aims to answer the main research question which is:

- What are the ways in which integration of bicycles with inner-city public buses would be achieved?

This main research question is taken forward with its sub-questions, answers of which will be responded to make the proposed design suggestion being developed through the process accordingly.

- Which is the most appropriate way of integration among the alternatives?
- What are the major advantages and drawbacks of the current suggestion?
- Which criteria can determine the design features of a transit bike rack system?

- According to these criteria what is the most preferable transit bike rack system for users?
- How can such a system be developed regarding users’ and experts’ based on these criteria?

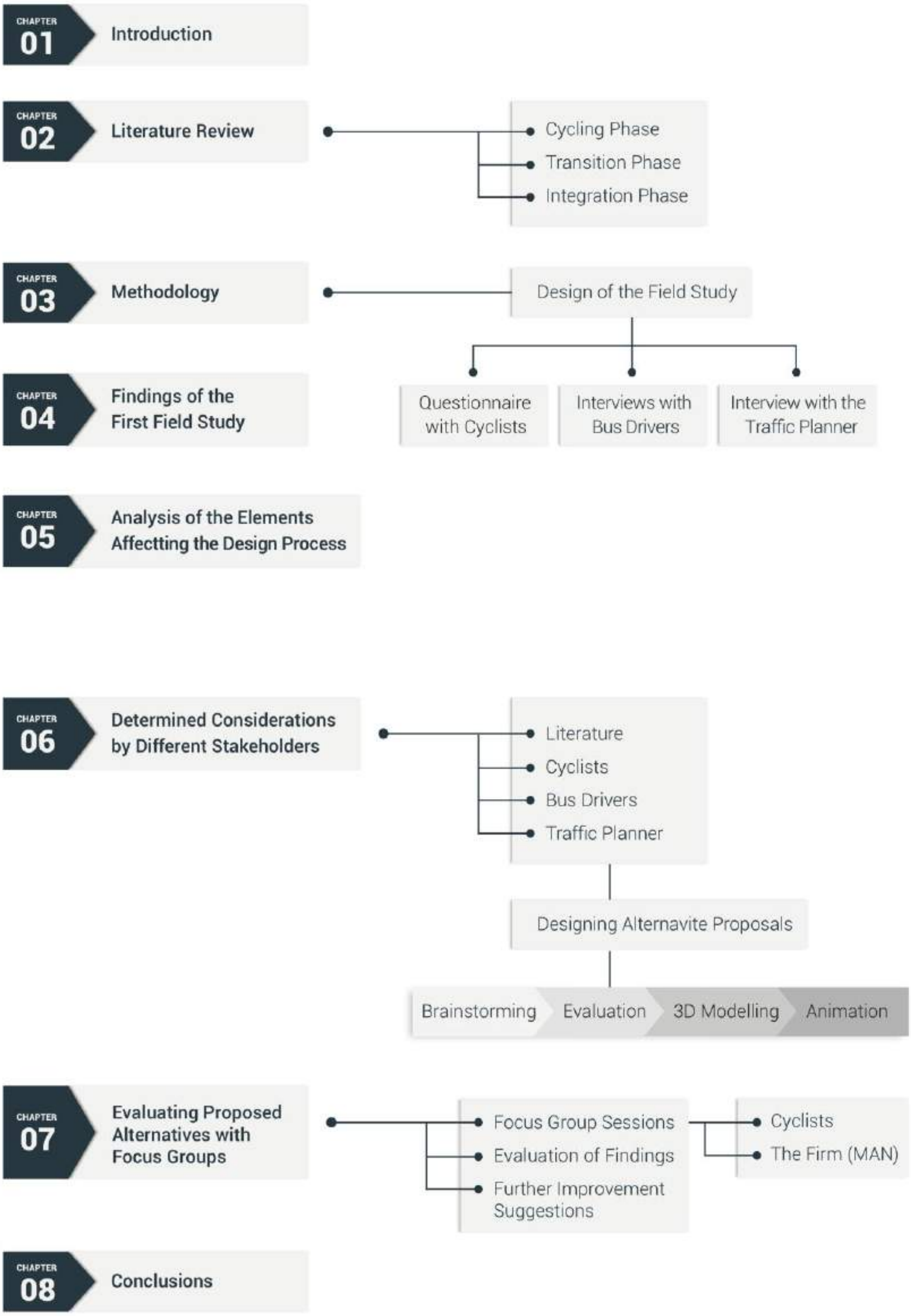


Figure 1.3 The Structure of the Thesis

1.4. The Structure of the Thesis

The overall layout of the thesis is schematized as given in the above Figure 1.3

The thesis consists of eight chapters.

Chapter 1 presents the background and motivation for the study together with the aims of the applied methodology about action research and research questions to perform this methodology.

Chapter 2 presents three phases of cycling, transition and integration by the review of the related literature, in order to have a broad understanding about the evolution of transit bike rack systems from the start of 1990s.

Chapter 3 explains the proposed methodology chosen for progression of the study including the first field studies which are questionnaire with cyclists, interviews with bus drivers and the interview with a traffic planner in order to draw first considerations to create different ideas accordingly by various relevant perspectives with the specified system.

Chapter 4 presents the findings from the first field studies and assessments of each study. These findings will be utilized to determine some certain design criteria to consider them through next the design process.

Chapter 5 presents analysis of the components affecting the design process which are current transit bike rack system solutions of major dominators of the market, the proposed bike rack design solution taken from the collaborated firm, Lion's City bus model as related with the suggested solution and a typical bicycle in relation to the rack system and utilized to refute current examples to create distinct alternatives.

Chapter 6 presents determined considerations from different stakeholders, which are literature review, cyclists, bus drivers and traffic planner as policy-maker. In this chapter, also the design processes of three different transit bike rack system alternatives are explained in four stages with their specifications.

Chapter 7 presents evaluation of proposed alternatives trough generated design criteria with focus groups held with the participation of cyclists as users and engineers of the firm as developers the project for manufacturing processes.

Chapter 8 presents the answers to the research questions in a broader sense and suggestions for future studies are given lastly.

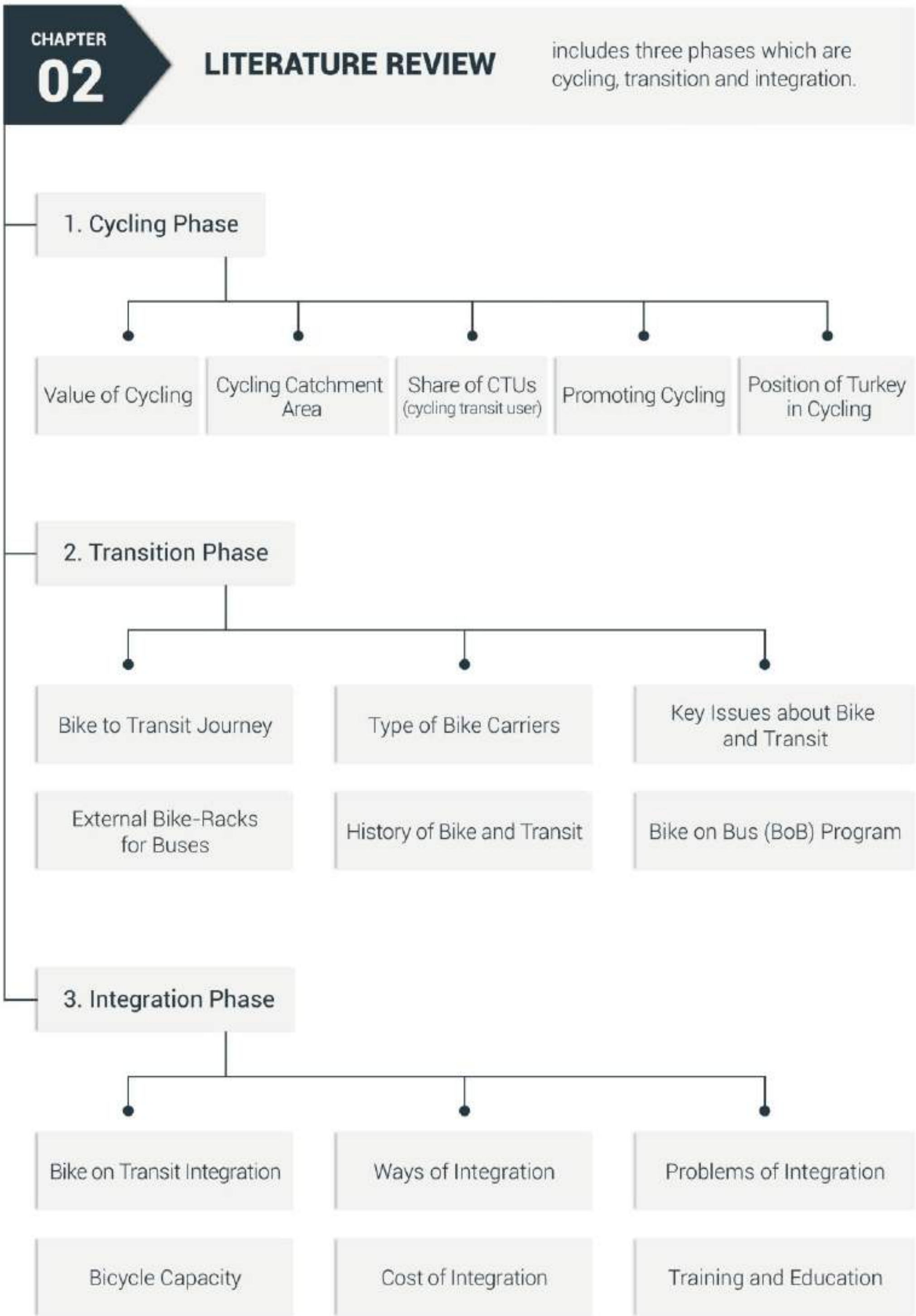


Figure 1.4 The Structure of Literature Review

CHAPTER 2

LITERATURE REVIEW

Oxford dictionary defines cycling as the use of bicycles for transport, recreation, exercise or sport (Oxford University Press, 1989). This action is also called bicycling or biking. Although bicycle itself has the meaning of transportation, in some circumstances this type of transportation remains incapable and needs to be supported by other modes of transportation. In the literature review part of this thesis, the transition from merely cycling to the mode of cycling integrated with other public transportation will be searched in three phases, which are cycling phase, transition phase and integration phase.

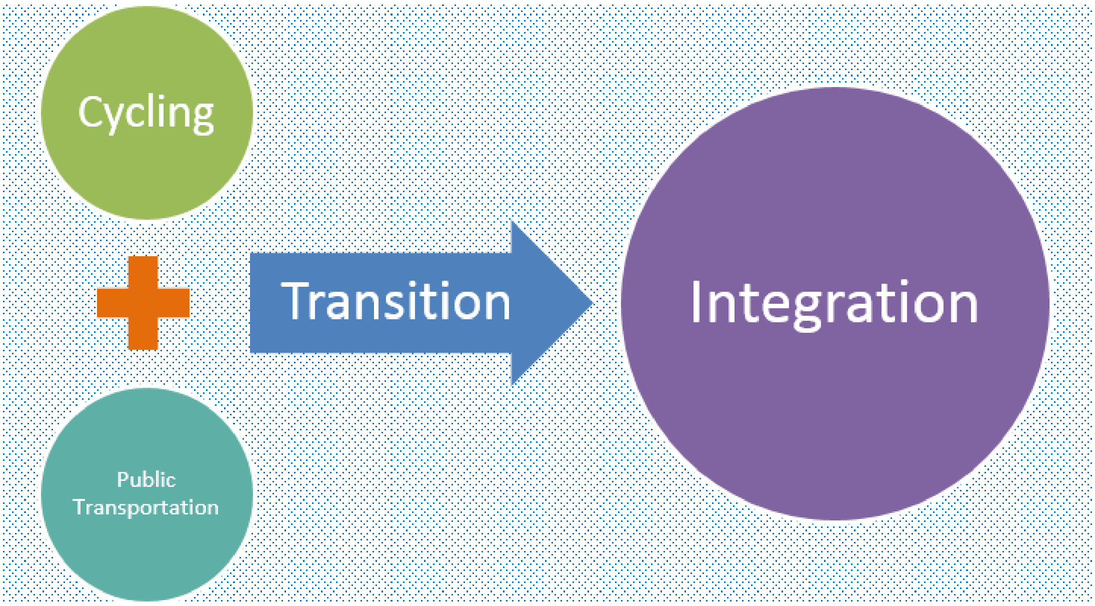


Figure 2.1 Phases from merely Cycling to Integration with Public Transportation

2.1. Cycling Phase

In the cycling phase, value of cycling, coverage area and the extent of cycling in transportation network, share of cycling transit users and promotion of cycling issues are covered under separate titles.

2.1.1. Value of Cycling

Cycling has been gaining importance in today's world as a mode of transportation with its other aspects such as recreation and sport. It can provide a number of social, environmental and individual benefits, which are interrelated and hard to distinguish from each other.

To begin with, cycling has various impacts on environmental and social circumstances. According to Scharrenborg, cycling is coming into very fast in terms of policy discussions about sustainable transportation. It leads to reduction of greenhouse gas (GHG) emissions and slows down the motorization of transport worldwide. Slowing down the motorized mode of transportation decreases automobile dependency and as a result, it reduces car traffic and congestion in big crowded cities (Scharrenborg, 2012). Martens (2004) states that, when compared to the private cars, cycling brings many environmental and social benefits including "reduction in energy use, air and noise pollution, as well as lower congestion levels on specific corridors and access routes to public transport stops" (p.282). It is very obvious that switching from private car to a bicycle affects carbon dioxide emissions significantly. The National Bicycling and Walking Study (Replogle & Parcells, 1992) reported that "switching to bicycling has important air quality benefits because, emissions from short one or two mile trips are nearly as great as typical five to ten mile trips, and that approximately 90 percent of emissions occur in the first mile after a cold start" (p.84). That is, if such short distances were traveled by bicycle instead of private car, emission reduction would be at reasonable levels.

The other benefits of cycling are effective for individuals as mentioned in the literature. Along with being flexible, it is also time and cost efficient way of transportation. Scharrenborg (2012) mentions that, there are many benefits of cycling as being active and efficient for short-to-medium distances. It also provides door-to-door transportation in relatively cheaper way, which comes with a potential to support mobility of the poorer and rural segments of society. Although it is an efficient way of transportation in rural areas with a weak public transportation infrastructure, cycling is also efficient and a faster mode of transportation in large and crowded cities. Pucher & Buehler have proved this example with a social experiment held in NY, the United States as:

“In the seventh annual New York Commuter Challenge held by Transportation Alternatives in 2008, a cyclist raced against a bus rider and subway driver. The bicycle became a clear winner, taking just over 16 minutes; the car took 22 minutes and the MTA (Metropolitan Transportation Authority, NY) rider took 29 minutes. Transportation Alternatives also measured the carbon footprint of all the commuters: the bike had zero, the transit rider one pound, and the 5-mile (8km) drive produced six pounds of carbon dioxide (2012, p.57)”.

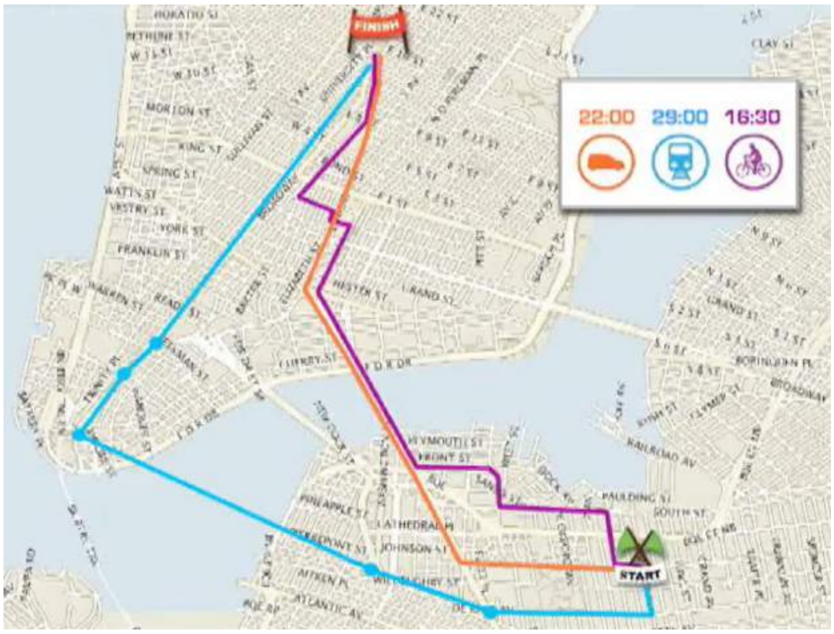


Figure 2.2 The Routes of Transportation Alternatives between Brooklyn's Fort Greene and Manhattan's Union Square, NY (Press, 2008, streetfilms.org)

That is why, it can be concluded that many cyclists are able to reach their destinations faster than public transportation commuters and individual drivers particularly in peak traffic hours, in a carbon-free way.

Moreover, there are also health benefits of cycling, which affects individuals directly or indirectly. As stated before, the decrease of car uses returns as in the form of declining “air and noise pollution, road traffic injuries, congestion, and greenhouse gas emissions” (Pucher & Buehler, 2012, p.43). Apart from that, personal well-being could be the most direct and related health benefit of cycling. According to Pucher and Dijkstra (2000), walking and bicycling are the best ways for the minimum daily exercise needed to maintain health. Hagelin & Datz (2005) state that, obesity epidemic is one of the biggest problems in US. Since the late 1970s, the amount of obese adults has reached to nearly 60 percent. However, the crucial point is that the rate of childhood obesity has almost tripled. According to the American Medical Association, the opportunities for burning calories are declined in everyday life, since car trips have been replaced with the ones used to be made on foot or by bicycle (Surface Transportation Policy Project, 2004).

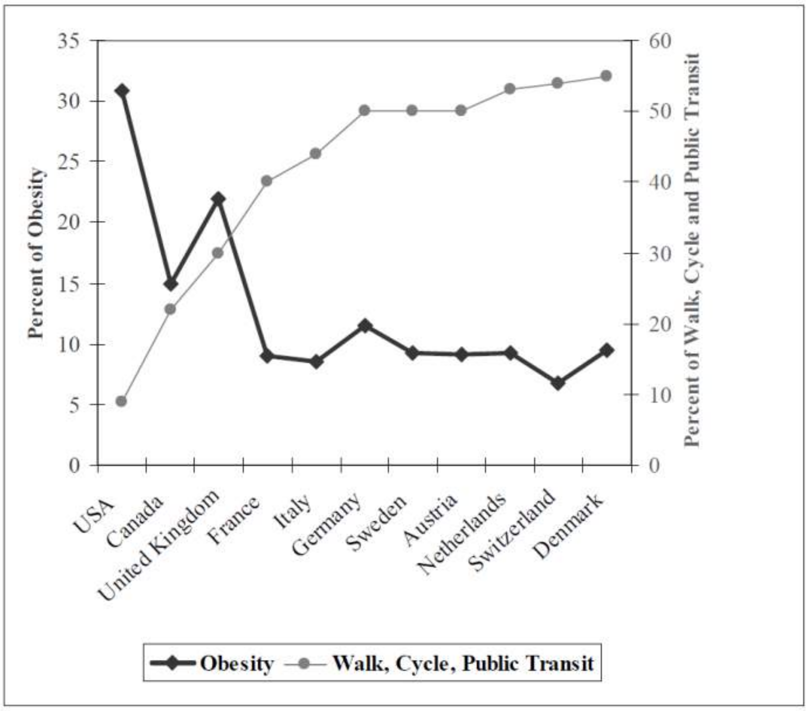


Figure 2.3 Comparison of Obesity and Bicycling/Walking/Transit Trips by Country (Pucher & Dijkstra, 2000, p.4)

The Figure 2.3 illustrates the percentage of obesity in comparison with the percentage of walk, cycle and public transit. It can be inferred that the relation confirms a reverse association, so unequivocally, walking or using public transit is much healthier way of transportation than dependency on private car on an individual basis.

2.1.2. Cycling Catchment Area

When compared with other modes of transportation, especially public transportation channels, cycling has a great potential of both mobility and flexibility. While using bicycle with the aim of transportation rather than recreation or a sport activity, the cyclist has a route and a destination point in order to complete his/her total travel. For this travel, flexibility, time, distance and convenience are the most important factors that affect the cyclist’s decision.

During the travel, using one or more public transport vehicles can be required but it would not always be sufficient for a person to get to the final destination. Kuruba & Sinha (2014) state that, Bus Rapid Transit System (BRTS) serves the people's need of mobility, however it has some weaknesses when the subject is door-to-door connectivity, as the system is not able to overcome access and egress distances for the traveler.

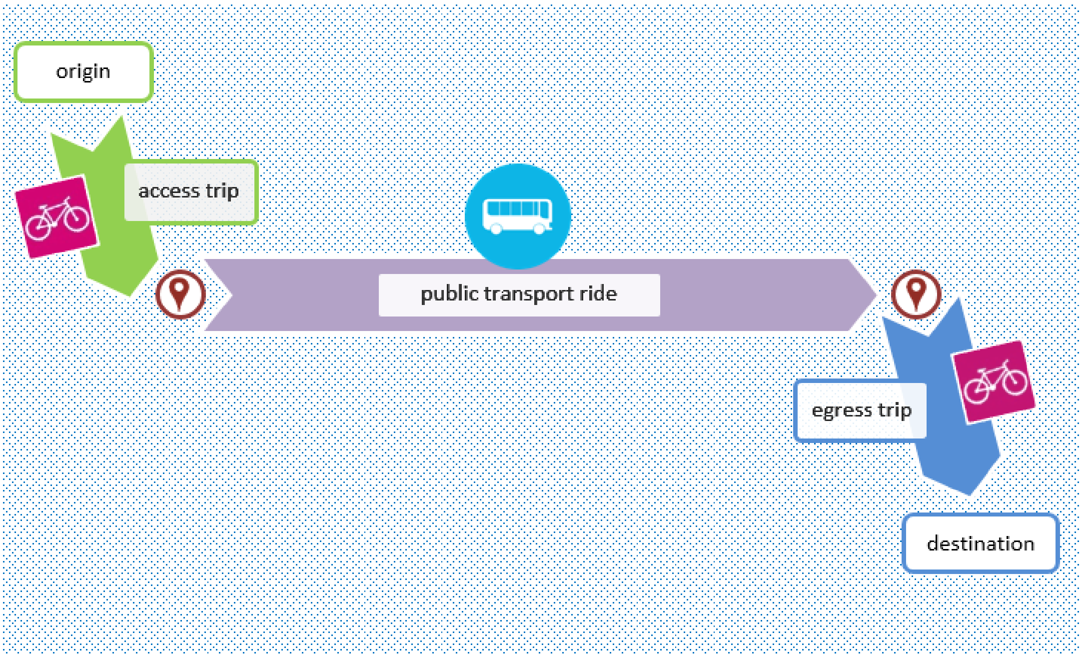


Figure 2.4 Structure of a Total Travel Cycle

As Godefrooij (2012) explains in Figure 2.4, the main problem associated with the system design of public transportation is that it schedules services that are not focused on the available time for passengers and it requires passengers to take these services from stops where they are not usually standing still, to stops which are not their targeted final destinations. That means there is a travel time gap because the public transportation stops are in a constant line and they continue making a loop apart from access and egress distances specialized for every kind of users to go. Keijer & Rietveld (2000) explain the situation by defining travel time effectiveness of a bicycle when it is used with public transportation. They claim that the use of a bicycle both in access trips (from the home to the station) and egress trips (from the station to the end of a trip) causes a significant reduction of door-to-door travel time of the trips made combined with public transport, thanks to the flexible nature of bicycle and its being much faster than merely walking.

For travelers, travel distance is another important factor that they depend on. At short to medium distances, the bicycle could be a better idea than walking or using public transport; nonetheless, when there is more distance to go, the bicycles are less attractive. Faster types of public transportation attract people on long distances as being time-saving and they have wider catchment areas. This, in turn makes the bicycle an alternative to walking or public transport for shorter distances (Keijer & Rietveld, 2000). However, faster types of transportation have their routes and stations at the points very far from each other which brings much longer access and egress distances for travelers. In such situations, the traveler either selects the shortest distance from access and egress trips and uses his/her bicycle as a feedering mode of transportation by walking or uses two different bicycles at each sides of the main public transport stops. Already, Pucher & Buehler (2009) have clarified with the surveys made in North America which suggest that the cyclists want to take their bicycles in order to ride them at the both sides of their trips when they need to use the public transportation and they also mention that they feel being relieved of the concerns about theft and vandalism which bicycles face with generally at parking hubs, bus or rail stations. After all, it can be inferred that using bicycle by its own as a mode of transportation would be preferred at moderate distances, but for long-distance travels, it is appropriate to use the bicycle as a feedering mode supported by public transport. Integration of public transportation allows cyclists to make extended trips. Moreover, transit facilities could help cyclists under the conditions of "bad weather, difficult topography, gaps in the bike-way network, and mechanical failures" (Pucher & Buehler, 2009).

2.1.3. Share of Cycling Transit Users

Cycling transit users (CTUs) ride bicycles to utilize them as a feedering mode with public transportation in order to complete their total trips. The share of CTUs is affected by many factors but the most significant elements are transportation mode, egress catchment area, trip purpose, population density and public transportation infrastructure where they live or where they travel. Martens (2007) states that,

> "Transit services that quickly transport users relatively long distances (i.e., 48 km) with few stops (e.g., commuter rail or express buses) tend to draw a larger share of CTUs than slower and shorter-distance routes. The reason why CTUs prefer high-speed transits during long distances can be explained by the preference of reducing the overall travelling time (p.327)".

However, according to Taylor & Mahmassani (1996), the relatively shorter distances like up to 8 km are better and faster to travel by bicycle than public transport. Another factor that affects the share of CTUs is the urban fabric and the public transportation network of the city. Martens (2004) states that suburbs generate higher levels of CTUs than cities according to the results of European studies. Krizek & Stonebraker (2010) have explained that the higher densities with cities also provide higher quality public transport services which have stops closer to each other and in a shorter range, which gives access throughout the city while suburbs have less frequent public transport services with greater access and egress distances, which is not spread frequently compared to the big and compact cities. Moreover, egress catchment area is also one of the leading factors related with the share of CTUs. Although cyclists could not always travel with their bicycles integrated with public transportation, a study shows that still there is not much need of using the bicycles for the end trips to reach the destination point. According to Keijer and Rietveld (2000), the study held in three European countries including Netherlands, Germany and the U.K determined that 80% of egress distances were less than 1.6 km and almost 50% of survey respondents replied that their egress distance was less than 0.4 km. This is not surprising when the dominant profiles of CTUs are the ones travelling for work and education related trips. As these commuter types go to a school or a college for educational purposes, or to a factory or plaza like workspaces, the city's public transportation routes could be mentioned as being arranged for these highly populated areas accordingly.

2.1.4. Promoting Cycling

> "The number of policy initiatives to promote the use of bike-and-ride, the combined use of the bicycle and public transport for one trip, has seen a substantial increase over the past decade in many industrialized countries as part of the search for more sustainable transport solutions (Doolittle & Porter, 1994; Hagelin, 2005, p.326)".

Nelson/Nygaard Consulting Associates starts presenting their reports which is the Seattle Transit Master Plan Briefing Book by mentioning that, creating a safe and comfortable bicycle environment for all ages requires a range of bicycle programs, policies, and facilities (2011). These policies and facilities will find meaning when bicycle itself starts to be considered as a part of city's transportation network like other vehicles and pedestrians on the streets. Creating a bicycle culture can only be initiated by amenities for cyclists and by the application of some policies to define cyclists' privileges and liabilities to be able to sustain a new transportation infrastructure together. In Seattle Master Plan (2011) it is stated that, when the system provides cycling amenities and services directly to cyclists, they are more willing to use transit services. In the report of "acknowledging sustainability in Rio de Janerio", the major subjects to maintain the use of bicycle(s) are explained as; "a culture of cycling, high quality cycling infrastructure-often integrated with public transport, compact cities, high levels of bicycle ownership and high traffic safety" (2012, p1). However, there also mentioned that although these factors are presented in most Dutch cities, different levels of success are identified. Recent researches suggest that two key explanations can be given for these differences: The first one is, cycling flourishes in cities with continued and consistent attention for cycling in transport policy development; and the second is the integration of cycling planning within transport and urban spatial planning as a whole, particularly at the municipal level (Fietsberaad, 2009).

Improving cycling infrastructure and most importantly constructing this structure in parallel to the available public transportation system in cities would attract more cyclists as new riders and would make bicycle an intermediate mode of transportation means supported with public transportation by increasing urban mobility and fostering multimodal type of travel with a low levels of capital investment. According to *A Synthesis of Transit Practice* report (2005), as many bicycle trips are made during off-peak times like weekend days and early or late times of the day, this collocation of bicycle and public transport would lead more people towards using transit services. In this report (Lee et al., 2005), the benefits of this collaboration are clarified by mentioning that "agencies felt that their bicycle services could increase transit ridership" through:

- Enlarging the scope that clients might use the service to arrive transit points and stations,
- Providing more flexible schedules for the passengers to reach destinations at the end of a transit trip,
- Providing consistent solutions about transportation regarding both bicycle and transit modes together,

• Making transit more attractive for customers by amenities (p.12).

Transit agencies provided more opportunities to support the usage of bicycle-related services as follows:

• Extending the use of multimodal trips,

• Creating extra space by eliminating motor vehicles from streets or parking areas,

• Improving the quality of life as a result of the decrease in air pollution and traffic congestion,

• Promoting cycling with an image as being a feasible way of transportation,

• Enhancing the perception of transit to establish a bicycling community which supports additional transit funding,

• Taking part in regional commuter assistance programs,

• Creating alternatives for cyclists to skip the areas considered as barriers for bicycling, such as bridges tunnels, steep hills, roads with traffic and to refrain from night-time travels or bad weather conditions (Figure 2.5).

Figure 2.5 Bridge as Barrier for Cycling (bikewalk.org, 2004)

• Creating a better public framework that would encourage people of active-living and would keep them from having passive life-styles as a result of lacking physical activities.

2.1.5. Position of Turkey in Cycling

According to Elbeyli (2012), there are mainly four factors influencing the cycling level which are climate & weather conditions, topography, travel distance and social factors. In this case, most of the cities in Turkey could be defined as convenient with their climate and topography in which there are a high-level of cycling would be expected, however, the cycling level in cities are very far behind European cities and the world. Elbeyli (2012) defines this conflict as that there is a common belief about bicycle as it is perceived like having a meaning of a professional tool for only sports experts or of a toy for children. Cycling is also labeled as a transportation means which addresses the lower class regarding social status of a cyclist with a poor image. Although, cycling is not widespread in Turkey, certain cities have high level of cycling activity which are Konya, Eskişehir, İzmir, Antalya, Denizli, Bursa, Samsun, Gaziantep, İstanbul and Ankara. Konya can be given as the capital of Turkey in cycling having 275 km of cycling road and an appropriate cycling infrastructure with a 5% cycling usage ratio in transportation (Hürriyet AA, 2014). The overall cycling ratio of Turkey compared with other European countries is given in Figure 2.6 as well with a 2% ratio.

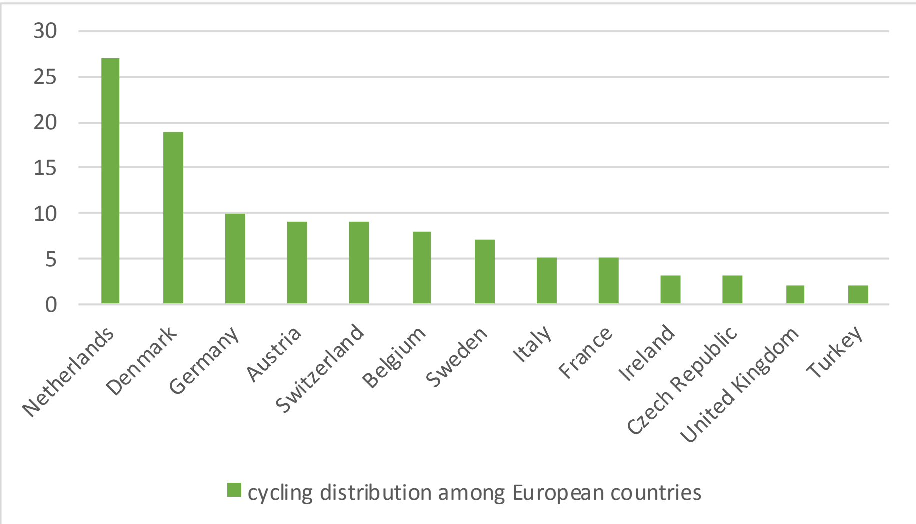


Figure 2.6 Cycling Level through Transportation in European Countries

2.2. Transition Phase

After cycling phase, transition from merely cycling to the integration with public transportation is searched with the starting journey and continues under some titles such as; key issues about bike-to-transit, types of bike carriers, external bike racks for buses, the bike and transit history and bikes-on-bus (BOB) program.

2.2.1. Bike-to-Transit Journey

Cycling could be named as an efficient way of transportation only when it is supported by other means of transportation modes. Hence, it is important to define cycling together with compared to other types of transportation channels. Regarding the public transportation and car use, cycling and similarly walking are efficient at short distances made in inner urban trips, but handicapped as being limited for carrying extra load like luggage. Public transportation is more effective during longer trips as a means of mass transportation; however, it requires feeder trips to access to the stations arranged for public transportation network. On the other side, individual car use is convenient for longer trips like public transportation especially in low-populated areas, yet it is not that much preferable for highly populated urban areas with the issues about congestion.

In the transition from merely cycling to the integration with public transportation, bike-and-ride concept serves for cyclists in many different cases. Martens (2004) states that the meaning of bike-and-ride could be explained as the shared use of bike and public transportation together for one trip. According to Martens, this combined use may be in various shapes. For example, the traveler can use his/her bicycle for either access trips or egress trips, or for both as a feedering mode. S/he also adds that the search for the alternative multimodal trips for private car(s) has caused the significance of bike-and-ride facilities to be increased. However, there are some factors, which affect ensuring of bike-and-ride concept properly and make it considered as being whether convenient or not. According to the report presented by *Nelson and Nygaard Consulting Associates* (2011), there are two alternatives for cyclists after reaching a transit stop or station, which are either storing their bikes at the specified parking areas there or bringing their bicycles with them. The most critical system criteria of a parking facility is the availability of offered safe and protected storages for bicycles to be parked for an extended time. Some cyclists also want to bring their bicycles on board with them in order to use the bicycle at both sides of their total travel. For these reasons, the attractiveness of bike-and-ride is mostly related with the convenience of parking facilities and the possibility of accommodating the bicycles inside of transits during travels.

The weather condition is another factor, which affects bike-and-ride. Martens (2004) explains that climate in terms of long term seasonal changes and weather with short term daily changes have an important impact on cycling which may be considered as a factor affecting the level of bike-and-ride. Lastly, location of public transport stops could be given as an influencing factor for bike-and-ride.

According to Martens (2004), data from the localities of suburb has shown higher levels of bike-and-ride than cities. Marten explains this difference, which is also related with the urban public transportation texture in three main reasons. The first reason is about relative distances within the public transportation stops and the range differed for access/egress distances that the system is given having much shorter spans with a large connection network in cities than suburbs. Another reason is similar to the first one, numerous public transportation stops make transits extended relatively close to all passengers regardless of place they are. In this example, transit vehicles could be mentioned the ones collecting passengers, yet not followed by them with an extended routes characteristics of many stops. Lastly, there are much more alternatives of feedering modes of transportation in compact cities than neighborhoods and relatively smaller towns.

It can be concluded that the characteristics of bike-and-ride trips and users are affected by the travel motives, the distance to be traveled, climate and weather, public transportation infrastructure of location and individual car availability.

2.2.2. Key Issues about Bike and Transit

The integration of bike and transit takes place in two modes, which are storing the bicycle in a transit stop or bringing it through the journey. Both actions have several key issues about combining bicycle with public transportation. If it is discussed from specific to general terms bringing bicycles with cyclists during the travel can be achieved by some solutions. In the Cycling Note of Queensland Transport (2006), it is reported that, rather than storing their bicycles prior to boarding, cyclists generally prefer taking their bicycles with them on public transport, which is also useful for bicycle tourists. The defined opportunities to carry bicycles on public transport(s) include:

- Front or rear mounted bicycle racks
- Trailers to accommodate bicycles pulled by buses
- Folding or removable seats to place bicycles on the board and
- Bicycle storage spaces like luggage storage areas on both sides of buses.

Mentioning broadly, either parking bicycle or using transit or bringing the bicycle to public transportation in order to have a complete trip also have some key issues. Hagelin & Datz (2005, p.4) describe these issues under the criteria of:

- "Extent of expansion of service area,
- Quantification of the ability to attract new riders,
- Impact on route delay,
- Policies governing allowing bikes in the bus,
- Permitting/training requirements,
- Provision of bicycle parking and concerns with bike theft, and
- Maintenance of rack systems".

2.2.3. Types of Bike Carriers

There are three types of bike carriers differentiated in their placement:

- On the roof of the vehicle
- On the tailgate or boot
- On the tow ball, or hitch plate

Although other types of attachments exist, these three types are the widespread ones. They are designed according to the bearing capacity of vehicles at the roof and the rear sides.

2.2.3.1. Roof-mounted Bike Carriers

These types of carriers are known as the first versions of the market and the cheapest. The advantages of roof-mounted bike carriers are being easily adaptable to all types of vehicles, having roof bars at the top and not blocking the visibility and the accessibility for the rear part of the vehicle. However, with an elevation over the vehicle, they cause higher levels of energy consumption and noise pollution. Moreover, they can cause a trouble while entering to low-level parking area or passing the bridge like obstacles. The height of the system also makes loading and unloading the bicycle harder, when the weight of the bike is taken into consideration (Weiss & Cedex, 2012).

Figure 2.7 A Roof Mounted Bike Carrier (subaruxvforum.com, 2014)

2.2.3.2. Tailgate and Boot Bike Carriers

These types of carriers are less common compared to the roof-mounted type of bike carriers. There are flexible straps that connect the system to the vehicle with two upper hinges and a lower lock. These connection straps are affected by the environmental conditions and it is needed to check them anytime and replace them when they wear off. The system can accommodate up to three bicycles as the rear side payload allows up to 45 kg (average weight of a single bicycle is 15 kg). When these types of carriers are hung on the back of the vehicles, the rear vision is partially blocked and the taillights are less visible. Moreover, the user should add extra warning lights to the electronic system of the vehicle and should check the straps whether bicycles are fixed properly in order not to cause any injuries related with the bicycles’ falling out of the system (Weiss & Cedex, 2012).

Figure 2.8 A Tailgate and Boot Bike Carrier (roofrackworld.com, 2015)

2.2.3.3. Trailer Hitch Bike Carriers

This is the most expensive type of the carriers, which also requires the vehicle being convenient to the trailer hitch. It can hold up to four bicycles and can handle dynamic forces created during a travel. Rear light repeaters are also integrated to the system as trailer hitch makes the vehicle longer and blocks visibility of taillights. Although the system needs to be assembled by professionals, as they are different from other types of carriers, some companies provide extra equipment added with their vehicles in the factory fitted manufacturing (Weiss & Cedex, 2012).

Figure 2.9 A Trailer Hitch Bike Carrier (towsure.com, 2015)

2.2.4. External Bike Racks for Buses

Many transit agencies in Europe and some regions of the United States provide external bike racks mounted generally in the front part of a bus. These carrying systems can accommodate two or three bicycles at the same time. The rack system flips up against the bus when it is not carrying any bikes. Current bike rack systems can be called as being practical which allows cyclists to place their bicycles easily and quickly, as they are designed considering the criteria of easy and fast-use in order not to delay route times of transit vehicles. According to Hagelin & Datz (2005), it takes only one or two times experience for a user to learn how to load and unload his/her bicycle thanks to the instruction illustrations located on the front part of the bus.

Since bicycles were prohibited inside of the buses as a result of some safety concerns, external bike racks have started to be used by some transit agencies. However, the external racks also have some standards and limitations, which do not allow some bicycles to be placed in the system. Lee et al. (2005) state that the basic rule for the rack systems is the bicycle’s fitting to it. Some regulations have been made to prohibit some types of bicycles like “recumbent, tandems, tricycles, unicycles, electric bicycles, or any type of bicycle with a wheel less than 20 inches in diameter”. Some extra features added by cyclists like “crates or baskets” are also prohibited as they may block the visibility of a bus driver (p.23).

Figure 2.10 A Front Mounted External Bike Rack System (miwayblog.ca, 2015)

Placement of external bike racks, bicycle capacity and some safety issues are other subjects that are worth to mention about the wide spreading system. With the placement of this system, there are two alternatives of being either at the front or the back of buses. According to Lee et al. (2005), most transit agencies prefer the front-mounted type. San Diego transit applied the back-mounted type in 1976, and they faced some problems with its configuration. The main problem was about checking safety and security of cyclists, as drivers couldn't see the racks while loading and unloading the bicycle. Another problem was that the rack system placed at the back of the bus was blocking access to the engine for instant interventions during emergency situations. Also, exhaust gas released from the back of the bus caused bicycles to get dirty. Nevertheless, front-mounted bike racks also have some problems. Lee et al. (2005) also states that front mounted rack systems make the bus longer about 1m at the front, which limits maneuver around tight corners and crowded city centers. Moreover, when the system is installed at relatively smaller buses, it could block the headlight, that's why it is useless during night time.

In order to increase the bicycle capacity of rack systems, three-bike bus racks are becoming popular, however, they are longer than two-bike racks, which are added to the rotation area of the bus and are difficult to be controlled by drivers. They are also wider as the system accommodates three bicycles at the same time in an acentric array, which cause not only blocking headlights but also even close the visibility of signal lights of buses. Lastly, Lee et al. (2005) explains the safety problems faced through using the external rack systems in "the Synthesis of Transit Practice Report", some accidents happened in the early stages of bike rack integrated transit program like falling of bicycles from the rack system or being stolen during a bus trip. Some minor accidents are also mentioned such as cyclists' were injured during loading or unloading their bikes as a result of wandering moods of drivers. After such circumstances, drivers were trained about monitoring cyclists carefully while loading or unloading the bicycle and whether they load their bicycles properly to the rack systems to make sure of preventing any undesirable incidents.

2.2.5. History of Bike and Transit

According to Krizek & Stonebraker (2010), available knowledge data for cycling and transit is relatively new, yet it seems to be gaining more importance day by day. When it is searched about the roots of bike and transit, United States can be named as the initiator of integration system all over the world. Wang & Liu (2013) state that there has been an important expansion in bike-and-transit integration in U.S. since 1990s. Firstly, the integration only meant of having bicycle-parking areas at the stations and main bus stops. Transportation Research Board (2005) explains that in many parts of the U.S. transit agencies provided additional bicycle facilities like bike racks mounted buses, permitting bicycles on boards of trains, offering bike racks and lockers at transit hubs and at major transit stations by the mid-2000s. It is also reported that from 1994 to 1998, most of the transit agencies in the U.S. started to implement bike-and-transit integration program and donate their 100 percent of buses with bike rack equipment (TRB, 2005).

2.2.6. Bikes-on-Bus (BOB) Program

Bikes-on-bus (BOB) program means the carrying bicycles on buses equipped with external bike racks rather than allowing bicycles to be taken on board. Hagelin & Datz (2005) states that bikes-on-bus (BOB) programs have turned into a valuable facility for transit agencies since they started to grow in the mid-1980s. The program brings with the benefits of frequent use of transit services and makes their service catchment area to be enlarged with relatively small capital investment by applying bike rack systems on buses. The only thing that limits the sustainability of development of the BOB program is the capability of the bike rack systems of carrying only two or three bicycles at a time. Hagelin & Datz (2005) also clarifies the growth of BOB programs in the United States with some statistics. BOB program has been an innovative example of combining bicycle with buses across the U.S. since its development in the 1990s. According to the data created by BikeMap in 2002, in the United States more than 40.000 buses, belonging over 300 transit agencies, have bike racks and correspondingly it is estimated that beginning from 2002, each month around 670.000 bike and bus integrated trips have been provided. The Figure 2.11 also shows the percentage of buses with bike racks from 2000 to 2009 by an increase of almost three times in eight years in the United States.

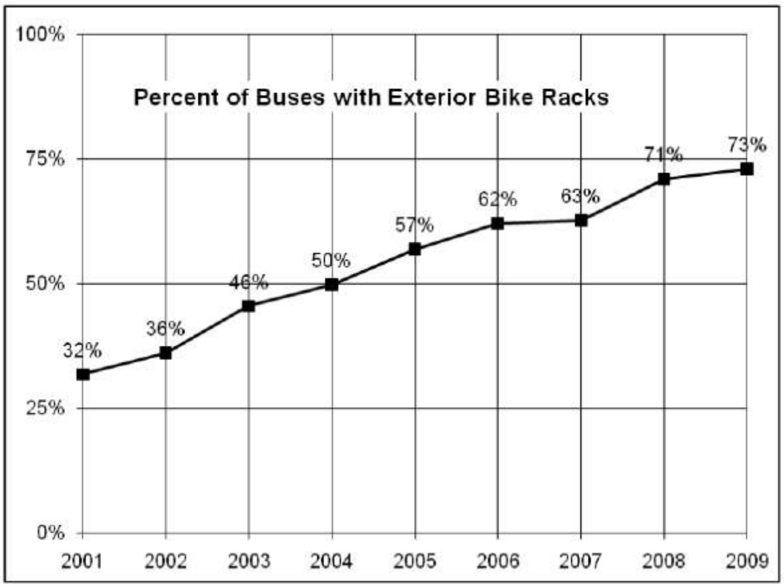


Figure 2.11 Expansion of Bike-Load in the U.S. during the 2000s
(Neff & Dickens, 2010, p.17)

Due to the expansion of service area, bikes-on-bus (BOB) program has a potential to attract new riders to the system. As a result of it, this causes a significant reduction on private car dependency and the system is preferable by the ones who have low incomes to access automobiles. There are also other benefits of BOB program for both cyclists and transit agencies that are given with their costs in Table 2.1.

Table 2.1 Possible BOB Costs and Benefits (adapted from two tables, Hagelin & Datz, 2005)

Benefits	Definition	How measured?	Costs
BOB Ridership	Total number of BOB boarding	Percent of total unlinked passenger trips that are BOB users	Capital cost of purchasing racks
Expansion of Service Area	Bicycle access to transit expands the service area buffer zone	Distance bicycled to and from transit stops to destinations	Maintenance cost of repairing/replacing racks
New Riders	BOB users that were not using transit prior to program	Percent of BOB users new to transit and report switching to transit because of bicycle access	Administrative cost of day-to-day operations
Frequency of Use	Increased frequency of transit use due to use of Bikes on Bus program	Percent of BOB users that have increased the number of transit trips since using program	Marketing costs of program

Table 2.1 continued

Bicycle locker rental fees	Fees from lockers rented at transit stations	Money collected from the renting of bicycle lockers per year	Insurance claims and incidents
Improved bicycle safety	BOB gives bicyclists the option of boarding the bus and avoiding dangerous corridors	Decrease in bicycle-car crashes on roads served by BOB transit, comparative crash rates	Permitting process and training
Reduced traffic congestion and improved air quality	Impact of switching to transit and bicycling from another mode	Number of vehicle trips reduced/eliminated by those BOB users that are new to transit	Funding of bicycle facilities to access transit and provision of bicycle parking
Health	Bicycling provides the necessary daily exercise	Individual health improvements translated in societal level benefits	Bicycles abandoned on racks
Transit agency image	Public perception of a transit agency's multi-modal and environmental efforts	Changes in public perception of transit agency	Route delay and increased dwell time
Benefits	Definition	How measured?	Costs

2.3. Integration Phase

For the literature review, integration phase is searched lastly under the titles, including bike and transit integration, ways of this integration, problems with it, bicycle capacity through the integration models, its cost and required training and education for the integration to be implemented.

2.3.1. Bike and Transit Integration

Pucher & Buehler (2009) states that integrated mode of cycling and public transportation has mutual benefits which extends advantages of both modes and it promotes a higher level of both cycling and public transportation use. There are lots of advantages of integration like effective transportation, development of urban transportation network or increase of demand for cycling when an appropriate integration is sustained. These benefits can be classified as individual for cyclist, economical for transit agencies and others benefits for rest of society.

Hagelin & Datz (2005) indicate that, there has been an important expansion in bicycle and transit integration by facilities which transit agencies applied like providing bike rack equipped buses, allowing bikes on boards of trains, placing bike racks and lockers at stations and main hubs and other bicycle related services. This integration can happen in different variations to manage the potential of cycling and public transportation in an efficient way. In the "Cycling Note" presented by Queensland Transit (2006), it is exemplified that at the integration of cycling with transit, public transport may:

- be a main mode of transportation during longer trips supported by cycling as a feedering mode,
- offer a travel for one direction which will be completed by cycling in the other direction,
- be an alternative for the areas where safe and convenient biking routes are missing or where bicycling is prohibited.

That is, integration of cycling with transit may occur in two options including either storing bicycle at the transit station to continue with a public transport or taking the bicycle on buses for a complete journey. Krizek & Stonebraker (2010) also give more detailed explanations about integration in which travel patterns and needs of individuals play a determinant role with integration in the borders of urban texture and public infrastructure standards level. They illustrate the alternatives available in five distinct options which are:

> "1. Transporting the owner's bicycle aboard (inside or outside) the transit vehicle;
>
> 2. Using and parking the owner's bicycle at a transit access location;
>
> 3. Sharing a bicycle, which would be based primarily at the transit access point;
>
> 4. Using an owner's bicycle at the egress location; and
>
> 5. Sharing a bicycle, which would be based primarily at the transit egress point" (p.161).

After an efficient way of integration is constituted, there comes lots of advantages with it. In the Cycling and Public Transport (2006), these benefits are given as:

- enlarging potential destinations significantly in number for cyclists;

- changing public transportation use into a more flexible way;

- providing a sustainable solution to individual car use and decrease the dependency on automobiles;

- expanding public transportation service and catchment area;

- preventing bicyclists from undesirable traffic injuries and circumstances;

- adding more options for cyclists with recreational and touring possibilities; and

- offering a better and healthier lifestyle by encouraging much cycling and daily needed exercise.

Considering all of the benefits cycling and transit integration offers, it can be inferred that these benefits are not only for commuters who use transportation channels but also for rest of the society and related directly with urban texture as a means of an indicator of development level in the area where the system is applied. That's why, the effective integration creates opportunities to sustain a better class of the urban environment.

2.3.2. Ways of Integration

As mentioned before, there are two different alternatives that make bicycle and transit integration feasible. Cyclists can have an option of either storing their bicycles at the stations or bringing them onboard or via external bike racks when the system is available with the type of transit. Lee et al. (2005) state that bicycle services and facilities have the potential of attracting more riders to use transit systems as these services support greater mobility and expand the service area of transit systems. Allowing bicycles with transit use also makes it convenient for cyclists to complete their travel in some circumstances where cycling is not convenient, safe or legal. However, Lee et al. (2005) also mention that not all of the transit users are in need of carrying their bicycles with them on transit, some of them prefer to leave their bicycles at stations to go on with public transportation.

Pucher & Buehler (2009) explain the ways of bicycle-transit integration under five main categories including;

1. Secure shelters placed at the stations;

2. Multi-functional bicycle storing points which offers more services rather than parking such as “bike rentals, repairs, parts and accessories, bike washing, showers and lockers, and touring advice”;
3. Bike racks on buses, generally exterior but sometimes inner storage;
4. Bikes on board of transit vehicles, generally rail transit vehicles, with a bike rack on board or even “bike cars on trains”; and
5. “Bike paths, lanes, and on-street routes” which lead cyclists to the public transportation stops and stations (p.81).

To begin with, secure and protected shelters for bicycles have an influence on bikers’ decisions about storing their bicycles at the stations for an extended time. Pucher & Buehler (2009) state that the problem of bike theft has increased the necessity of secure bicycle parking at public transportation stations. In the Netherlands, many cities started to offer secured parking lots with a personal attendant in case of theft and vandalism. This type of shelters has also the advantage of protection against bad weather conditions.

Figure 2.12 A Secure and Protected Shelter in Valparaiso,

Indiana, the U.S. (duo-gard.com, 2012)

Another similar application to those secured bicycle shelters is staffed bicycle parking where there are offered some extra facilities to cyclists such as bicycle parking, repairs, rentals, restroom and changing facilities, and car sharing services (Lee et al., 2005). The main features of staffed bicycle parking are its potential to accommodate lots of bicycles at the same time and being placed at the major intersection stations for cyclists to change their modes of travel. If these types of bike parking areas are surrounded by fences, they can be called as bicycle cage as well.

Figure 2.13 Staffed Bicycle Parking (humofthecity.files.wordpress.com, 2012)

Bike lockers are another example of storing bicycles at transportation stops. Pucher & Buehler (2009) mention that these bike lockers are sturdy metallic or plastic boxes which can accommodate one or two bicycles and usually rented for a monthly basis. There are also new generation of electronic lockers, which are started to be used by the notion of first-come and first-serve about its availability with daily or hourly rental possibilities. In North America, bike lockers are the main type of secured parking available in all cities.

Figure 2.14 Bike Lockers (intysons.com, 2015)

According to Pucher & Buehler (2009), bike lockers are much more secure as they provide each cyclists a unique key or lock to access the storage area, when compared to bike cages lockers. However, bike cages where all bicycles are staffed in the same place can be accessible by anyone who has a keycard. That’s why, bike cages are monitored by surveillance cameras to improve security of bicycles in some cities.

Bike rentals are also serviced at major public transportation stops as being a facilitator of integration of cycling with transit use. Cyclists generally use their bicycles to access main stations from their home like origin point. After a transit journey, they continue to their travel to complete egress distances with the help of bike rental facilities. Pucher & Buehler (2009) exemplify three ways of bike rental systems which are offered to cyclists including: (1) traditional hourly or daily bike rentals from rental offices with an attendant; (2) automated and/or discounted bike rentals using wireless GPS technology and/or membership cards with memory chips; (3) various kinds of public bikes sharing systems. However, there is one disadvantage of these bike rentals, which is that one usually must return the bicycle back to the station where he/she rented. Pucher & Buehler (2009) mentions the German Railways Call-a-Bike program in Berlin as being an innovative example of bike rental as it offers users the possibility of leaving the rented bike to many different locations in place of returning it to the origin point at the station center.

Figure 2.15 Call-a-Bike Program in Berlin (atravelbroad.com, 2014)

External bike racks placed generally at the front of a bus or allowing bicycles on boards are other ways of bicycle-transit integration specified among above mentioned options. Lee et al. (2005) state that there are some different ways to accommodate bicycles on buses and front-mounted bike racks are the most popular systems installed by transit agencies, which carry two or three bicycles with it. The users of the rack system have the responsibility of loading, securing and unloading their bicycles for this method. In North America, as most of the journeys about 60 percent of public transport trips are made by buses, the most common ways of integration are eventually the bike racks installed to the buses.

Moreover, allowing bicycles on board or at the storage areas under buses is another but a less frequent way of integration. Lee et al. (2005) mention that some transit buses are equipped with extra storage areas located in a compartment below the floor of the bus, which are for luggage and big-sized packages. Some transit agencies allow bicycles to be stored at these areas during a journey. The second way of accommodating bicycles on board has different standards and rules about convenience of the decision with permitting to it. Pucher & Buehler (2009) state that only few transit agencies allow bicycles to be taken on board unless they are compact and foldable bikes except during peak hours in order not to cause a crowded settlement in the bus. Lee et al. (2005) also explain that this type of allowance to bicycles on board are restricted to some extent. When faced with such circumstances, the driver of the bus has the authority of deciding whether it is convenient to permit or not according to inner density of the bus. If the external rack capacity is full when it is provided, it is dark or there is infrequent bus service at that time, the drivers tend most likely to allow bicycle to be taken on board.

Lastly, bike paths and specified routes for bicycles which have an access to transit stops facilitate bike and transit trips by leading cyclists to public transportation channels for a multimodal type of travelling and can be counted as another way of bicycle and transit integration. There is a table given in Appendix A to illustrate some data from all around the world about the scope of the ways of integration mentioned under this title.

2.3.3. Problems of Integration

Although integrating cycling with public transportation offers valuable benefits for both cyclists and transit agencies, there are still some problems to overcome in order to ensure an appropriate and effective integration process. These problems include bicycle availability at both side of the journey, capacity limitations with bike-and-transit system and some issues, which transit agencies deal with the integration concept.

Capacity restraint issue can be divided into two different types of integration which are taking bicycles on boards of transit vehicles and limitations with the capability of current used bike-rack systems installed on buses externally. Pucher & Buehler (2009) mention that surveys made in some cities show that some bike-and-transit riders prefer to carry their bicycles on boards of especially rail trains in order to use them at both sides of the travel, but this causes some capacity problems during peak hours when there is not extra space to allow bicycle inside of the vehicle. When the integration is provided with an external bike rack integrated to the vehicle, the space problem does not exist as the system does not decrease the "passenger-carrying capacity" of transit, yet especially during peak hours the rack system can be filled to capacity and make cyclists wait for the next transit. It can be inferred that the time between buses is a determinant factor affecting the decisions of cyclists about using parking spaces at public transportation stops. Capacity limitations of bike-rack systems are explored in detail at the next title as well.

Lastly, route delays are pointed by transit agencies as another problem of bicycle-transit integration. According to Hagelin & Datz (2005), loading and unloading a bike to/from the rack systems takes some time, which causes route delays of public transits. Although compared to placing wheelchairs, using a bike-rack system is faster and does not require that much additional time; the higher frequency of using bike-racks can affect the time to complete a total route cycle of a transit vehicle. However, it is also stated that the problem disappears, as the commuters are getting familiar to use the bike-rack systems installed on public transits.

2.3.4. Bicycle Capacity

Bicycle capacity of public transport vehicle is much-specified subject as being one of the bicycle and transit integration problems, which affects the substantial growth of cycling-transit ridership. Allowing bicycles on board of transit vehicles and providing external bike-rack systems are the keys of creating a combined structure for cyclists to be able to take their bicycles with them throughout a public transportation trip.

Krizek & Stonebraker (2010) state that bicycle capacity is restrained by all kinds of transit. All successful programs applied by transit agencies including permitting bicycles on inside of buses or under storage areas whenever available, separated areas for bicycles on trains and bicycle parking areas apart from car spaces on ferries tend to attract more riders to the public transportation system. Some transit agencies even permit to ten additional bicycles on buses when there is available space after serving for elderly and disabled people to be seated. However, allowing bicycles on board of buses can be restricted in order to prevent overcrowding and as a result of some safety issues. Hagelin & Datz (2005) state that for many agencies, bicycles accommodated in aisles and wheelchair areas of the buses have possibility to cause some incidents if not tied properly during a traffic accident. In the report of Integration of Bicycling and Transit (1994), *Pierce Transit* in Pierce County, Washington, the U.S. reported two accidents caused by onboard placing of bicycles that are soiling a commuter's clothes by a falling bicycle and an injury damage caused by again a falling bicycle during bus was moving. *Palm Tran* of Florida, the U.S. explains their concern about allowing bicycles on boards with the quote of "There are safety related issues. We are not able to secure the bikes properly. Our buses are not equipped with bracelets, or any kind of tie downs to secure bikes properly" (p.33, 2005).

Adding external bike rack system to buses by transit agencies is another solution to expand cycling and transit integration, yet this system also faces with capacity limitation problem. Hagelin & Datz (2005) state that the success of rack systems installed to buses is limited as most of agencies use two-bicycle capacity rack systems. It results in filled to capacity of racks most of the time for more cyclists who are waiting for bus to arrive at their stations. Hagelin & Datz also add that some agencies suffering from capacity limitation of their rack systems have started to purchase three-bicycle capacity rack systems to use at their most popular routes. Allowing bicycles on boards of buses is another option applied by some transit agencies although their buses are equipped with bike racks but during when there is no available space for more bicycle in the rack system.

Bicycle and transit integration via external bike rack system has gained the interest of more riders from which it can be inferred that three-bicycle capacity rack systems wouldn't be even enough which fosters cyclists to leave and store their bicycles at public transportation stops if it is available.

2.3.5. Cost of Integration

The bicycle-transit integration can be constituted in many different ways as mentioned in previous sections. However, the main investment made by transit agencies is related with providing more bicycle parking facilities and donating their buses with bike-rack systems. Hagelin & Datz (2005) state that the major capital investment is to purchase bike-racks installed at the front of buses. According to the survey made by nine Florida transit agencies in the U.S., total capital investment spent on providing over 2000 buses with bike-rack system cost $1 million dollars as about $500 for each rack system. In comparison to buying a new bus, this can be called as a small investment.

Lee et al. (2005) mention that most of the bicycle facilities provided by transit agencies do not require an additional fee for cyclist that makes cycling and transit integration preferable for them. Only some services like bike rental or renting bike lockers are charged fees by transit agencies. Pucher & Buehler (2009) state that most of studies which are related with bikes on board buses prove that earnings from more riders generated with the help of this integration system are much in revenue than investment made for installing bike racks on buses.

2.3.6. Training and Education

Training and education are the basic requirements of cycling and transit integration phase, especially on the topic of proper use and monitor with the bike-rack systems by both cyclists and drivers of buses. Lee et al. (2005) state that there are various ways used to educate cyclists about principles of using an external bike rack. The main method is explanatory videos and illustrations, which transit agencies shared through their websites. Some posters and educational materials are also offered at public transportation stops. Some transit agencies provide individual training and demonstrations at related public events as well. Moreover, bus drivers are trained with special sessions and courses of using bike-rack systems in terms of safety, regulations, restrictions, and adaptation to a longer bus which bike-rack apparatus is installed in order to ensure the system to be utilized properly and not to cause any undesirable incidents derived from miss-use of the system.

CHAPTER 3

METHODOLOGY

As stated in the introduction chapter, this thesis aims to create a means in order to promote the integration of cycling with public transportation. The starting point of this research is based on an idea came from *MAN Türkiye Research and Development Department* about a patent pending project proposal to be approved by either *SANTEZ* (Sanayi Tezleri) or *TÜBİTAK TEYDEB* (Teknoloji ve Yenilik Destek Programları Başkanlığı). The firm wanted to develop this idea further, however, they mentioned that they would not have limited the study with the notion of their proposed idea as there would be able to come out differentiated concepts with more convenient and better usage scenarios and much more appropriate structural layouts at the end. Their primary concern was to generating an applicable and feasible transit bike rack system which could be built as a working prototype for further mass production process with an investment that could be received from one of the above mentioned programs by working with a graduate student in parallel to his/her masters thesis.

Mentioning the ways of the integration in the Literature Review chapter, designing an external bike-rack system for buses is chosen to be explored. Such a system is improved in comparison to current models in the market of the brands like *Sportworks* and *Byk-Rak* which are the leading examples dominating the market. Designing an external bike-rack system is proved to be the most favorable solution, as cyclists prefer carrying their bikes with them during their travel in order to be able to use them at both sides of their trips.

As mentioned in the introduction of this thesis, action research is employed by following four stages in a circular structure, namely ‘planning, acting, observing and reflecting’. In the methodology section, through an action research based progress, several different techniques are applied to gather information from all related stakeholders such as drivers, cyclists, traffic planners and engineers with the consideration of approaching the problem from different perspectives in a broader manner. Firstly, information obtained from literature review is utilized for preparing the field studies in order to determine the key issues for building an appropriate design process. This process is defined in the form a two-stage field study. In the first stage, it consists of gathering data from different stakeholders with the help of questionnaires and interviews.

After formulating the field studies, the stakeholders of the problem are chosen to define the general outline of the problem area and to understand their desires and concerns for the integration problem with the help of their accumulated knowledge related to their experiences as a part of the first stage of action research which is ‘planning’.

These main actors interrelated with the subject include cyclists, bus drivers and traffic planners as policy-makers. Each of these actors is communicated with as ‘acting’ component of the method in order to explore their views about cycling and public transport integration. Furthermore, the data collected from these participants are used for designating the main features of an external bike-rack system by making analysis of them which can be called the ‘observing’ stage. After these analysis and observations of the system members in relation to the specified subject, three different design alternatives are created as ‘reflecting’ to the observations and impressions in the process.

Afterwards, the second stage of the field study starts in which these alternatives are evaluated with two focus group sessions, one of which was made with cyclists in which there was a presentation about the subject, the current transit bike rack alternatives, their usage scenarios and key issues about them. After the participants got familiar with the rack system, created three design alternatives were shown with the help of an animation prepared in regard to real life conditions in order to make a comparison through their advantages and shortcomings with the existing models. When the presentation of newly generated alternatives was over, a discussion session was held among the participants for obtaining much more sufficient and matured input with their feedbacks by a questionnaire. In this questionnaire, certain considerations related with cyclists as users of the transit bike rack system were supposed to be evaluated, and both desires and complaints of cyclists on the alternatives were examined. The second focus group session was held with the engineers from the collaborating firm, *MAN Türkiye* with a similar logic and scope, yet the pre-determined considerations to be evaluated regarding the bike rack system alternatives were different in order to utilize the firm's expertise on other issues such as, manufacturability, functional and mechanical properties of the system, estimated costs with the alternatives, etc.

Lastly, with the completion of the two-stage field study, in the form of an action research, secondary reflections are given as suggestions for the further development of the system. These reflections are built as a result of another action-reaction cycle applied in which the data obtained from the participants of focus group sessions are observed and analyzed.

From an entire view, the research is structured under mainly two parts including literature review and an intensive field study which goes over four basic components of an action research based methodology to be implemented, as shown in Figure 3.1. The first part includes a review of literature with related publications. The second part consists of two stages first of which includes a qualitative approach to collect opinions of cyclists, bus drivers and traffic planner. The second stage of the field study contains an evaluation made by cyclists and the collaborated firm to have an insight on efficiency of the proposed design solutions. The stages of the field research, which ensures an action-reaction cycle twice, are explained in detail in the following sections with the results and assessments of every step.

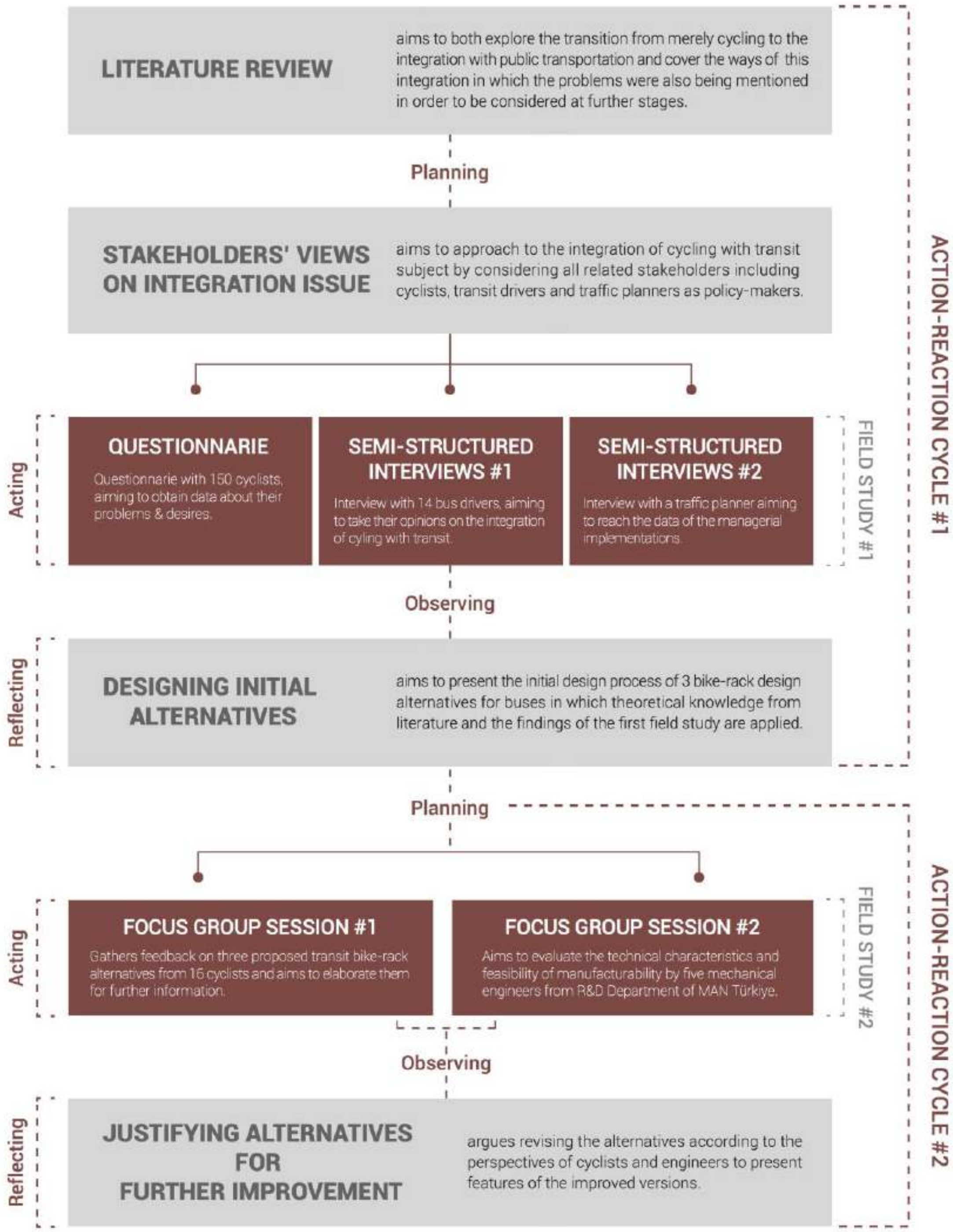


Figure 3.1 Overview of the Research Stages

3.1. Exploration of the Related Literature

At the beginning of the study, at first, the related literature is investigated under mainly three topics as phases of cycling, transition and integration. These phases covered an entire vision of why such integration is needed and how this integration is built in time with the help of an intense research made through related academic journals, books and reports prepared by transit agencies.

For the first phase, *'Cycling'*, issues such as value of cycling, cycling catchment area, the share of cycling transit users and the measures of promoting cycling are covered. This phase is mainly on the characteristics of cyclists, and the advantages and benefits obtained with cycling.

In the second phase, *'Transition'*, bike-to-transit journey, its history and key issues about the subjects are covered with the types of bike-carriers as individual car-based and carriers used on buses with their all aspects. This section exemplifies the transition from merely cycling to an integrated mode in which bicycle is accepted as a feeder mode of transportation.

Lastly, *'Integration'*, phase includes bicycle-transit integration, the ways of this union, problems and costs related issues about the subject. Most importantly, this section gives significant feedbacks about the knowledge built by current bike-carriers used all over the world which draws attention the handicaps and problems with them.

3.2. Design of the Field Study

Reviewing the related literature, the stakeholders affected from the integration problem are identified. The most associated one is clearly the **cyclist** who wants to use public transportation network with his/her bicycle.

Secondly, **bus drivers** are chosen as people who are dealing with the responsibilities brought by this new system. Lastly, **traffic planners** are the ones who decide on the principles of the integration of an exterior bike-rack system to buses. Moreover, they arrange related traffic conditions, such as bus schedules and make provisions about the possible circumstances as a consequence of applying this new system. The field study consists of two major stages, one of which includes data gathering to utilize in generating different design alternatives from mentioned stakeholders. These stakeholders and followed communication models consists of questionnaires with cyclists, semi-structured interviews with bus drivers and another interview with a traffic planner who is the transportation planning director of EGO Genel Müdürlüğü (Ankara Electricity, Gas and Bus Operations Organization) and an experienced city and regional planning graduate working as a traffic planner in Ankara Metropolitan Municipality.

Before the second field study stage, there is the generation of three design alternatives, which are created with the concerns and desires, reflected through gathered data from the first stage of the field research. The questions directed through both questionnaire and interviews are used to utilize of these stakeholders in a comparative manner with applications of current external bike-rack systems all over the world at this intermediate stage. The general aim while designing the questions was to gather the opinions of the stakeholders about existing systems and to define the conditions all three actors face with in order to serve for their mutual benefit.

Afterwards, these design created alternatives are evaluated and further suggestions are made in the second field study stage with the help of two focus group sessions. These two sessions are held for elaborating the design alternatives and reaching design considerations for a transit bike rack system. Cyclists are again the participant group of one of the sessions while the other one is made with engineers from the collaborative firm for expert opinions.

3.2.1. Questionnaire

Questionnaire, which is prepared for cyclists, consists of 17 questions in three different themes as separate pages (Appendix B). The questions on the first page of the questionnaire can be classified under three main titles according to the purpose of desired data to be collected in a multiple-choice response applied. The first title is generally about the information about cyclists such as their gender, age, how long they have been a bicycle rider, with what kind of a bicycle and for how long they ride in a day. The second title is about their relation with bicycle for example, why they choose bicycle, with what purposes, of what value they ride in a group with and in which type of road they prefer to ride. The third title can be sorted to identify characteristics of cyclists for instance, which type of public transport they prefer mostly, where they store their bicycles and which circumstances constrain them from cycling. Moreover, at the second page, the 4 questions are designed as open-ended questions to have their opinions about the subject without any word limitations. These questions include;

1. Can you use your bicycle integrated with public transportation? If yes, how often? If no, why?
2. Which problems do you face when you want to use public transportation with your bicycles?
3. Which one of the two do you prefer to integrate your bicycle in public transportation vehicles? Why? (Figure 3.2)
4. Which accessories do you have with your own bicycle?

Figure 3.2.a External Type Rack System (miwayblog.ca, 2015)

Figure 3.2.b Inner type rack system (monicag.com, 2000)

These four questions are prepared to measure the integration level of cyclists, who are involved in the questionnaire, to the public transportation channels and learn their opinions about providing a solution for taking their bicycles with them according to their concerns and desires about the subject.

Lastly, in the third page of the questionnaire, the respondents are asked to put in a rank order of eight different preferences. The aim was to get inspired of cyclists' priorities from these eight measures designated as basic design features to develop the new system under the guidance of them. In this section, firstly participants are given some pictures to figure out the external bike-rack systems (Figure 3.3) and their usage in a scenario as some of them may not be familiar with it (Figure 3.4).

Figure 3.3. External Bike Rack Examples Mounted on Buses
(citynews.com.au, 2015; dandyhorsemagazine.com, 2014)

(Participants are informed as: “you can see some examples of external bike-racks for buses”)

Figure 3.4 Loading Steps of a Bicycle to the Rack System (rtcwashoe.com, 2010)

(Participants are informed as: “you can see the usage scenario of a rack-system in three steps”)

Then, the respondents are given eight different features to arrange them in a sequence. They are also notified about that they should mark their primary preference as number one and less significant preference as number eight by arranging the other preferences accordingly. These features include;

- My bicycle should not be stolen.
- My bicycle should not be scratched or damaged.
- Loading and unloading a bicycle out of the rack system should be easy, quick and understandable.

- The rack system should protect the bicycle under bad weather conditions.
- I should not disturb the ongoing traffic order.
- Loading and unloading a bicycle should not cause any traffic accidents.
- I should be able to monitor my bicycle visually during a trip.
- The rack system should give me a feeling of durableness.

These features are ranked with an elevated matrix by participators of the questionnaire to determine their priorities of the proposed design solution for the rack system alternatives.

All questions are prepared with an online questionnaire platform, 'Survey Monkey' in Turkish. As selected questions are more than 10 in value and the expected results are higher than 100 responses, 'SELECT' option is chosen as a premium account with some extra features. The survey is made on-line with the help of three professional cyclists who are very active in cycling community and who gave the researcher the access to some open or closed groups via Facebook. These groups which the questionnaire is shared at their pages are '*Bisikletli Yaşam Derneği*', '*Bisiklet Forum*', '*Bisikletliler Derneği*', '*Bisikletli Ulaşım Platformu-BUP*', '*BGB | Doğa Sporları | Hearth Union with Bicycle*', '*Ankara Bisiklet Topluluğu*' and '*ODTU Bisiklet Topluluğu*'. The participants are informed with a statement like "would you like to be in part of designing process which will give you an access to buses?" There was an intense attention for supporting to fill out the questionnaire by cyclists at these groups that in only six days that the survey was open for access, 150 participants contributed to it. 150 of them filled for the first page of the questionnaire, 119 of them participated for both pages and 100 of them covered all three pages as a whole.

3.2.2. Semi-Structured Interviews

For the first stage of the field study, semi-structured interviews are made in two steps aiming to gain different knowledge from the other two stakeholders which are bus drivers and a traffic planner as a policy-maker. The semi-structured interview method is preferred to create an intimate research setting while also giving control to the researcher over the topics. The open-ended questions directed to these participants aimed firstly to measure the current public transportation system process and then the future projections and predictions about the integration of cycling with buses as a public transportation vehicle with an external bike-rack system. Their experience and mostly faced problems played a significant role while the new proposed bike-rack system is conceptualized by turning their responses to inputs to determine the main features of the related system.

3.2.2.1. Interviews with Bus Drivers

Fourteen EGO bus drivers participated in the semi-structured interviews. The number of interviewees is limited up to 14 when the responses to questions began to repeat themselves by reaching a saturating point. Arrangements for the right time and place for the meeting was set up a week before with the help of two friends of the researcher who are also bus drivers working for EGO. The bus drivers who are contacted were not provided with a consent form as the researcher was warned about that there is a cancellation of labor contract case for one driver as a result of his interview with a TV channel commentator recently and it might cause drivers to be reluctant in participating in the interview that requires signing a document. That is why, they are encouraged verbally by the researchers and his bus driver friends as being their colleagues verbally that there wouldn't be any problem and all the information they give would be confidential and wouldn't be given with their names. The bus drivers who participated in the study were also offered a package of cigarette which is long Marlboro and which is also known as the 'driver cigarette' in Turkish street jargon. It was a small gift but it became very useful for their willingness and contributed to the quality of answers that all contributors were smokers without any exception.

A total of 125 minutes and 20 seconds of recording is made lasting between a range of 06.24 and 13.37mins. The questions are designed to obtain direct and efficient answers in a limited time as these drivers have not much time for resting and eating at their service station. These interview questions inquire a general background of bus drivers in their profession, their working process with standard routines, responsibilities and troubles they deal with, and their opinions about bike-rack system (Appendix C). The 12 questions asked during the interviews are given in detailed below in a sequence;

1- How long do you drive as a bus operator in EGO?

2- How long do you work in a day and how much of this time do you drive the bus?

3- Which hours is there congestion inside of the bus?

4- Which are the most frequent two problems you face with the passengers?

5- How are passengers who are wheel-chaired, with a baby carriage and a big luggage being taken aboard of the bus?

6- Is there any passenger with a bicycle you come across? How often? What do you do in such circumstances?

7- Is there a standard of time limitation for approaching to or departing from the bus stops? Do you have any problems with this?

Before the 8th question, some pictures of the current front and back-mounted external bike-rack systems for buses are shown to interviewees and explained in detail about how they are used also with a scenario illustration given for the questionnaire.

8- What is your opinion about an external bike-rack which will be integrated at front of buses?

9- Does it effect of extending the total length of the bus at the front or back sides? Which one do you prefer?

10- How do you want to control such a bike rack system when applied to current buses you drive?

11- Can you leave the cockpit to help cyclist during loading or unloading their bikes when needed?

12- What type of a procedure is applied when the buses break down?

These all 12 questions which were asked gave also some directions to determine the main features of the proposed design solutions to be created like the answers gathered through the questionnaire. The problem is evaluated from a different perspective by bus drivers as being another related stakeholder associated with the problem.

3.2.3. Interview with the Traffic Planner

For the last stage of the first field study, an experienced traffic planner is chosen to be interviewed with. Appointment for this interview is arranged by Elmadağ mayor to visit the interviewee in his office at Ankara Metropolitan Municipality, *UKOME (Ulaştırma Koordinasyon Merkezi)*. It was hard to find the exact person who is capable of answering all the questions in the interview. When searching for the right person, *Bus, Signalization and Infrastructure, Statistics* and *Transportation Planning Departments* are visited. At last, at *Transportation Planning Department*, director of the department who is a traffic planner was interested in participating to the interview. The questions directed to the interviewee are mainly including about the subject related to general public infrastructure, promotion of cycling integrated with buses as being a public transportation vehicle and liabilities bring with the application of bike-rack system and possible solutions to them. Completed in about half an hour, the interview, given in Appendix D, is composed of these questions;

1- What is the position and weight of buses in public transportation system?

2- Is there a standard of time limitation for approaching to or departing from the bus stops? Do you have any problems with this?

3- What can be made for cycling to become widespread?

4- What is your opinion about an external bike-rack which will be integrated at front of buses?

5- What are the advantages and disadvantages of external bike-rack mounted buses? Could you explain it with scenario-based on loading and unloading?

6- Which responsibilities does the integration of cycling with public transportation encumber to bus drivers and EGO? How can these responsibilities be leveled down to a reasonable stage?

During the interview, the interviewee is also supported with some images which identify the current bike-rack systems like in the interviews with bus drivers. Indeed, the interviewee was familiar with the foreign examples but he had not a chance to use the system.

3.2.4. Sampling

Sampling was used to determine who should be the interviewees and participants of the questionnaire. As Schutt (2008) states, availability sampling is a non-probability sampling method which participants are selected due to their accessibility. This method is preferred as the researcher aims to explore the settings and the experiences of cyclists, bus drivers, and traffic planners. For questionnaire, the online-based questions are transmitted to websites of nongovernmental organizations and social platforms for cyclists in which quality discussions made by concerned members with the cycling subject. For the interviews with bus drivers, especially EGO drivers are chosen as they work for a corporate municipality and they have fixed and regulated standards than individual public buses. They can be classified as regular and professional workers whose workload and responsibilities are arranged by policy makers. For the interview which is made with a traffic planner, transportation planning director is qualified as the most important and experienced person about public transportation network and applications in Ankara.

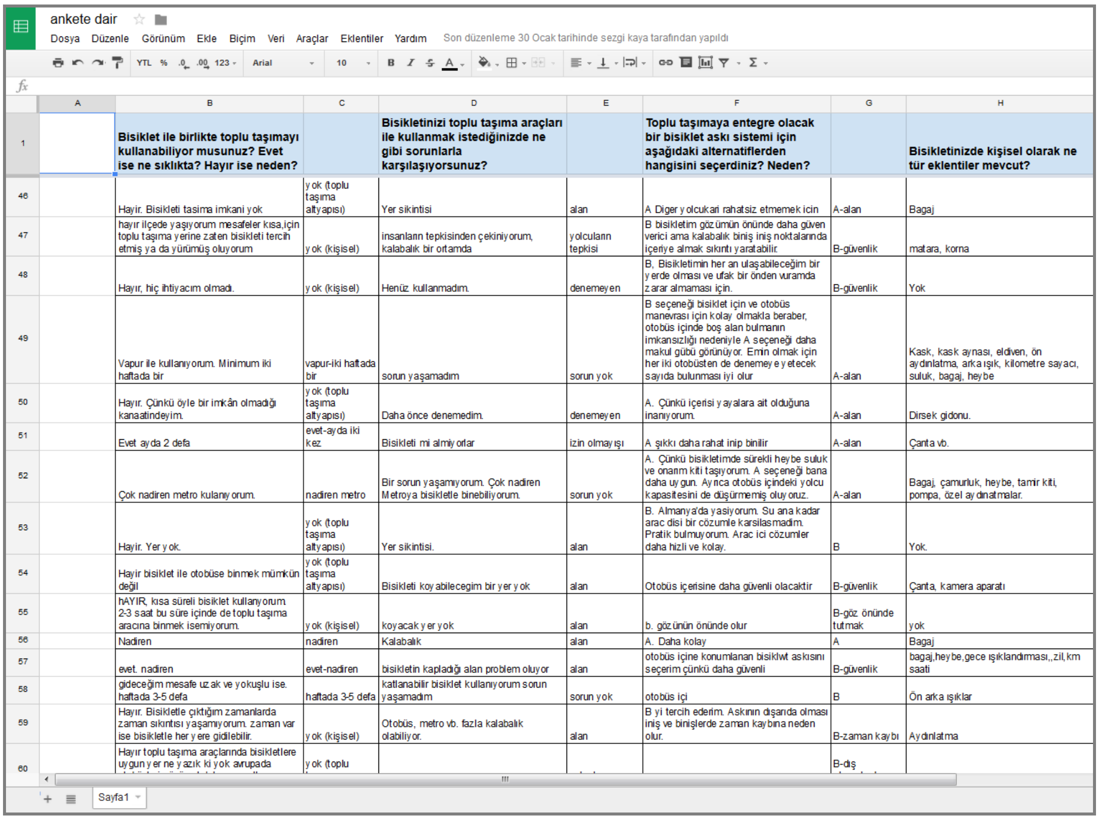
3.2.5. Venue and Equipment

During the field work, *survey monkey* website is used to prepare the proposed questionnaire. Its user-friendly interface was found ideal to create a survey and transmit it to the participants via Internet. It allows the user to separate each section of the survey as separate pages and also allows designing each question in every different type of measurement parameters. The most success of the website is giving the opportunity of accessing analysis of all responses for the questionnaire.

During the interviews made in other stages of the field work, *Sony ICD-UX200* digital voice recorder and *IPhone 5s* mobile phone were used together in order not to prevent the risk of any missing data and in order to ensure the best quality recordings. The interviews with bus drivers are made face-to-face in their resting office in a scheduled time to contact with them in their resting hours. This resting office is the main hub of fourth district, which is also known as Altındağ district, of five regional directorates of EGO, Ankara. It is said that almost 150 drivers visit this office in a day which made it easy to reach enough participants for the interview. For the second stage of the interviewing, the director of transportation planning of EGO, Ankara is visited at his own premises in Ankara Metropolitan Municipality.

3.2.6. Data Analysis

To analyze the outcomes of the field study, axial coding method is used in order to classify the raw data under certain titles and categories. Axial coding method is justified by Given (2008) and the method aims to reveal the relations among the categories varied around the one focal category (2008). Hence, questionnaire results are searched through two main analyses. Multiple-choice questions are converted into statistics by *Survey Monkey* analysis techniques which enable to use them in *Microsoft Excel* format with related graphics. For the open-ended questions asked in the questionnaire, all answers are transmitted to *Microsoft Excel* database by classifying each of the participants' responses in a column to compare them one by one in 119 rows (Figure 3.5). After categorizing each answer in different columns, every response is read several times to catch the common words and phrases which build the statistical results of each question.



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Dosya Düzenle Görünüm Ekle Biçim Veri Araçlar Eklentiler Yardım Son düzenleme 30 Ocak tarihinde sezgi kaya tarafından yapıldı

	A	B	C	D	E	F	G	H
1		Bisiklet ile birlikte toplu taşımayı kullanabiliyor musunuz? Evet ise ne sıklıkta? Hayır ise neden?		Bisikletinizi toplu taşıma araçları ile kullanmak istediğinizde ne gibi sorunlarla karşılaşıyorsunuz?		Toplu taşımaya entegre olacak bir bisiklet askı sistemi için aşağıdaki alternatiflerden hangisini seçerdiniz? Neden?		Bisikletinizde kişisel olarak ne tür eklentiler mevcut?
46		Hayır. Bisikleti tasima imkani yok	yok (toplu taşıma altyapısı)	Yer sikintisi	alan	A Diger yolcukari rahatsiz etmemek icin	A-alan	Bagaj
47		hayır ilçede yaşıyorum mesafeler kısa,için toplu taşıma yerine zaten bisikleti tercih etmiş ya da yürümüş oluyorum	yok (kişisel)	insanların tepkisinden çekiniyorum, kalabalık bir ortamda	yolcuların tepkisi	B bisikletim gözümün önünde daha güven verici ama kalabalık biniş iniş noktalarında içeriye almak sıkıntı yaratabilir.	B-güvenlik	matara, korna
48		Hayır, hiç ihtiyacım olmadı.	yok (kişisel)	Henüz kullanmadım.	denemeyen	B, Bisikletimin her an ulaşabileceğim bir yerde olması ve ufak bir önden vuramda zarar almaması için.	B-güvenlik	Yok
49		Vapur ile kullanıyorum. Minimum iki haftada bir	vapur-iki haftada bir	sorun yaşamadım	sorun yok	B seçeneği bisiklet için ve otobüs manevrası için kolay olmakla beraber, otobüs içinde boş alan bulmanın imkansızlığı nedeniyle A seçeneği daha makul gübü görünüyor. Emin olmak için her iki otobüsten de denemeye yetecek sayıda bulunması iyi olur	A-alan	Kask, kask aynası, eldiven, ön aydınlatma, arka ışık, kilometre sayacı, suluk, bagaj, heybe
50		Hayır. Çünkü öyle bir imkân olmadığı kanaatindeyim.	yok (toplu taşıma altyapısı)	Daha önce denemedim.	denemeyen	A. Çünkü içerisi yayalara ait olduğuna inanıyorum.	A-alan	Dirsek gidonu.
51		Evet ayda 2 defa	evet-ayda iki kez	Bisikleti mi almiyorlar	izin olmayışı	A şıkkı daha rahat inip binilir	A-alan	Çanta vb.
52		Çok nadiren metro kulanıyorum.	nadiren metro	Bir sorun yaşamıyorum. Çok nadiren Metroya bisikletle binebiliyorum.	sorun yok	A. Çünkü bisikletimde sürekli heybe suluk ve onarım kiti taşıyorum. A seçeneği bana daha uygun. Ayrıca otobüs içindeki yolcu kapasitesini de düşürmemiş oluyoruz.	A-alan	Bagaj, çamurluk, heybe, tamir kiti, pompa, özel aydınatmalar.
53		Hayır. Yer yok.	yok (toplu taşıma altyapısı)	Yer sikintisi.	alan	B. Almanya'da yasiyorum. Su ana kadar arac disi bir cözumle karsilasmadim. Pratik bulmuyorum. Arac ici cözumler daha hizli ve kolay.	B	Yok.
54		Hayir bisiklet ile otobüse binmek mümkün değil	yok (toplu taşıma altyapısı)	Bisikleti koyabilecegim bir yer yok	alan	Otobüs içerisine daha güvenli olacaktir	B-güvenlik	Çanta, kamera aparatı
55		hAYIR, kısa süreli bisiklet kullanıyorum. 2-3 saat bu süre içinde de toplu taşıma aracına binmek isemiyorum.	yok (kişisel)	koyacak yer yok	alan	b. gözünün önünde olur	B-göz önünde tutmak	yok
56		Nadiren	nadiren	Kalabalık	alan	A. Daha kolay	A	Bagaj
57		evet. nadiren	evet-nadiren	bisikletin kapladığı alan problem oluyor	alan	otobüs içine konumlanan bisiklwt askısını seçerim çünkü daha güvenli	B-güvenlik	bagaj,heybe,gece ışıklandırması,,zil,km saati
58		gideceğim mesafe uzak ve yokuşlu ise. haftada 3-5 defa	haftada 3-5 defa	katlanabilir bisiklet kullanıyorum sorun yaşamadım	sorun yok	otobüs içi	B	Ön arka ışıklar
59		Hayır. Bisikletle çıktığım zamanlarda zaman sıkıntısı yaşamıyorum. zaman var ise bisikletle her yere gidilebilir.	yok (kişisel)	Otobüs, metro vb. fazla kalabalık olabiliyor.	alan	B yi tercih ederim. Askının dışarıda olması iniş ve binişlerde zaman kaybına neden olur.	B-zaman kaybı	Aydınlatma
60		Hayır toplu taşıma araçlarında bisikletlere uygun yer ne yazık ki yok avrupada	yok (toplu				B-dış	

Sayfa1

Figure 3.5 A Snapshot from the Analysis of Open-Ended Questions in the Questionnaire

For the interviews, both made by bus drivers and the traffic planner, transcription technique is applied to convert the recordings in a written format by listening several times. Every single world through transcriptions is copied exactly to *Microsoft Word* format in order not to miss any information and not lose any emphasis made by interviewees’ speeches in their parlance manners.

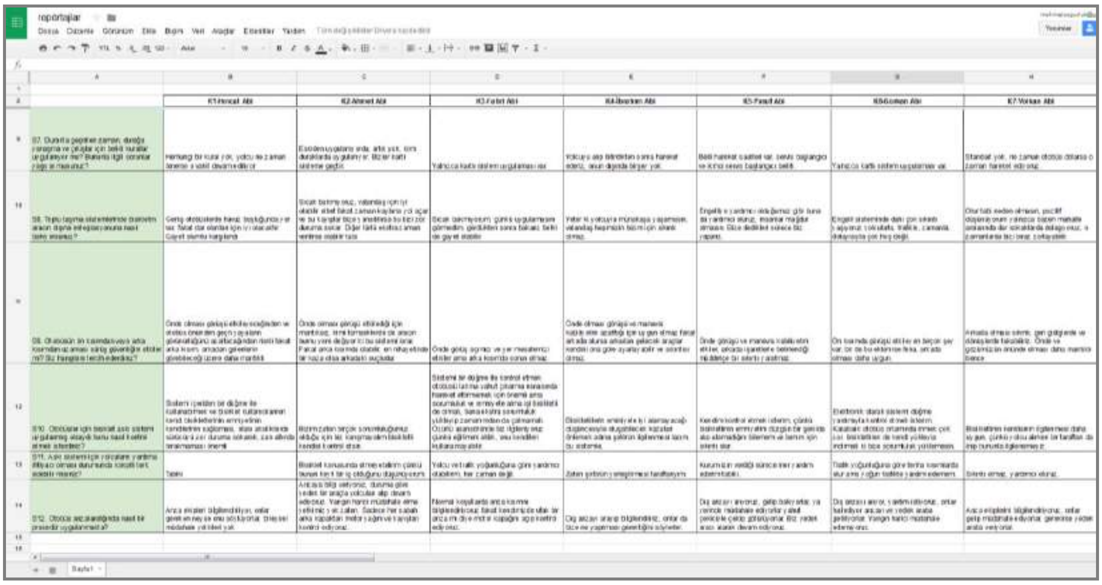

Figure 3.6. A Snapshot from the Analysis of Interview Results Gathered from Bus Drivers

After gathering the raw data that are transcribed for each of interviewees, all answers were transferred to *Microsoft Excel* and examined by reading several times. The repeating answers are classified and all responses are gathered to obtain the most comprehensive answers to each question without missing any opinion of drivers (Figure 3.6). A sample of interviews with a bus driver can be found in Appendix E.

3.2.7. Limitations of the First Field Study

The common known limitation through the questionnaire and the interviews was related with the variety of respondents in the sample. Sample size was sufficient for the questionnaire with a participation of 150 cyclists. However, as the questionnaire is transmitted via internet, the answers contain data from very different cities of Turkey which makes it hard to create a common pattern through the participants as they all use different public transportation systems in their cities. However, the responses showed similarities with a range of diverse perspectives.

The interview made with the traffic planner is limited in terms of sample size. As the interviewee works for EGO, Ankara, his answers and statistics he gave were generally associated with this city. That is why, to have a different perspective, another interviewee could be contacted from Ministry of Environmental and Urban Planning who is also experienced with general applications and processes implemented in all cities in Turkey. However; since the aim of interviewing the traffic planner was to consult him as an expert about the study, his views provided adequate information about the advantages and disadvantages of integrating bicycle racks into public buses.

With the interviews made with bus drivers, the fourth zone of EGO is contacted and the bus drivers linked to this zone were interviewed with. The ideal size of sampling is determined through saturation of data. After the participation of 14 interviewees, there was not any new or relevant data and at that moment the participants were limited with an opinion that the study has reached to its saturation level. However, sampling could be arranged with every five zone of transportation districts in order to have varied data through Ankara as a whole. Although the bus drivers who participated in the interview were from Altındağ district, the fourth zone, they mentioned that they also worked at other districts as there is a circular structure in EGO, enabling drivers to work for different routes. Thus, the interviewees had a general perspective of Ankara due to their past experiences, yet their knowledge of other districts were not up-to-date. The study could be repeated in other cities as well in order to make a comparison and to promote a general solution with the differentiated responses of other city public transportation drivers.

CHAPTER 4

FINDINGS OF THE FIRST FIELD STUDY

The questionnaire made with cyclists and the interviews made with both bus drivers and a traffic planner produced numerous findings that need to be examined separately for each question. Firstly, the questionnaire, which is filled by 150 cyclists via Internet, will be discussed one by one with the discussions through responses. The questionnaire includes mainly three sections in which the first 12 questions are of multiple choice type which aim to measure main characteristics and cycling habits of participants, and the second part consists of four open-ended questions to identify their perception of a bike-rack system and the subject of cycling-transit integration. The last part includes one major question through which cyclists suggest their priorities of features which a bike-rack system should have under eight different titles given separately.

For the interviews of the field study, firstly the responses of bus drivers to the designated questions will be analyzed one by one with the statistics obtained through their answers as classified under certain topics. Lastly the interview made with a traffic planner will be viewed in a broader sense, which covers the subject in every aspect from a perspective of a policy-maker.

4.1. Findings of the Questionnaire

The questionnaire is divided into three parts, which was explained before, and it will be mentioned through these categories with each question related to these three sections.

4.1.1. Characteristics and Habits of Cyclists

In this part 12 questions were asked to participants in order to gather their demographic information, their practices and activities through cycling, their limitations to perform cycling and their views on current public transportation systems. The first three questions are about to identify who are these participants generally.

4.1.1.1. Gender of Cyclists

In the first question of the first part of the questionnaire, cyclists' gender is asked. With the range which is constituted to that question, it can be inferred that most of the cyclists in Turkey is males. Therefore, the purpose is to design a rack system that is easy-to-use and also encourages female cyclists to extend the usage of Bikes-on-Bus system. The answers given to this question is shown in Figure 4.1.

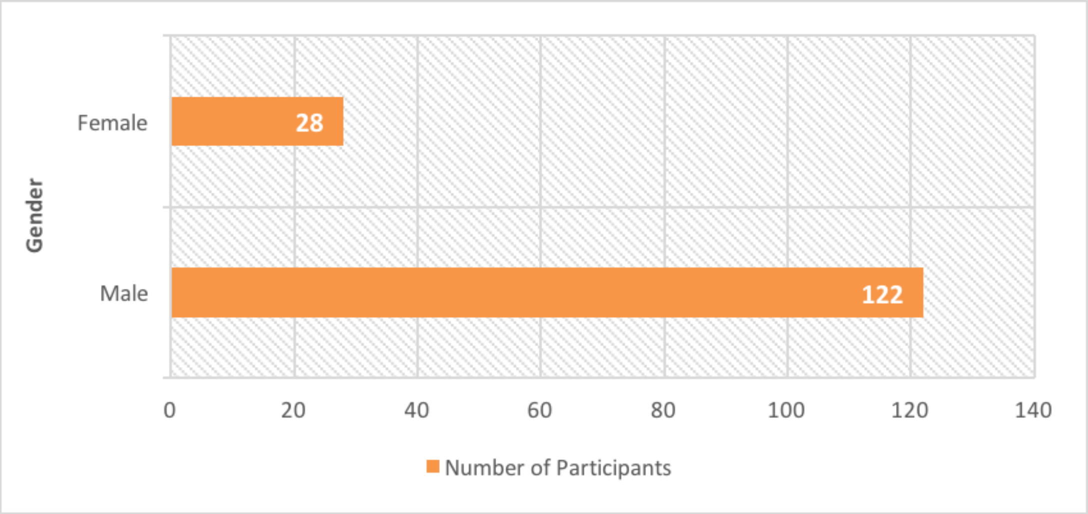

Figure 4.1 Gender Distribution of the Participants

4.1.1.2. Age

In the second question, it is asked how old these cyclists who contributes to the questionnaire are.

According to the gathered data, the sublimit of the ages of the respondents is 15 years old. The answers are distributed homogeneously with the most abundant range of participants centered on people in their 20s (Figure 4.2).

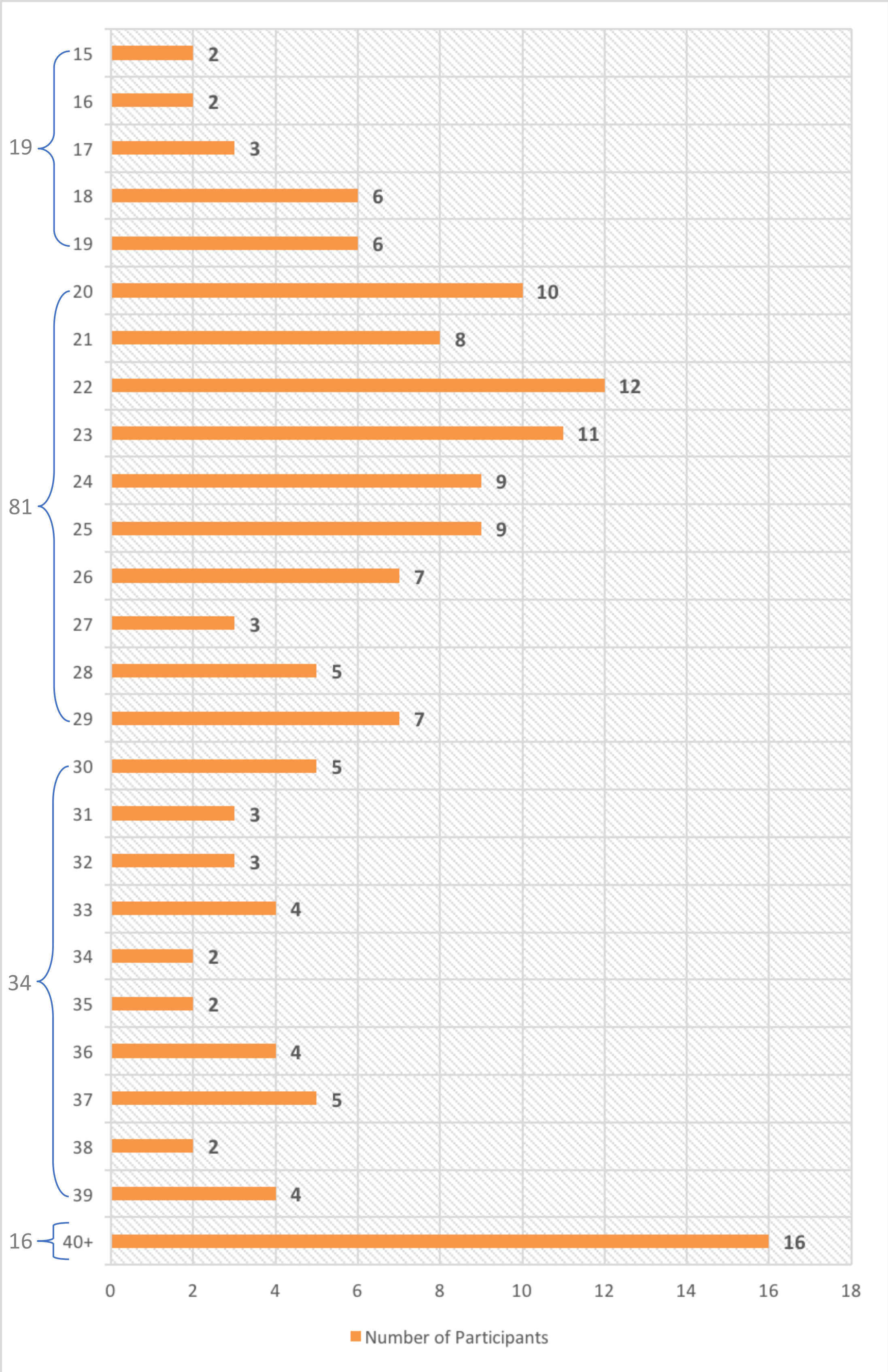

Figure 4.2 Ages of the Participants

4.1.1.3. Experience in Cycling

The third question is about for how long the cyclists have been riding a bicycle. The choices, which are given with the related question includes certain ranges of years to cover cyclists' experience in cycling. The most common range is given as 1-3 years with 47 participants. The aim with this question is to measure the practice level of cyclists who contributed to the survey. The responses are given statistically in the below Figure 4.3 (See Appendix F).

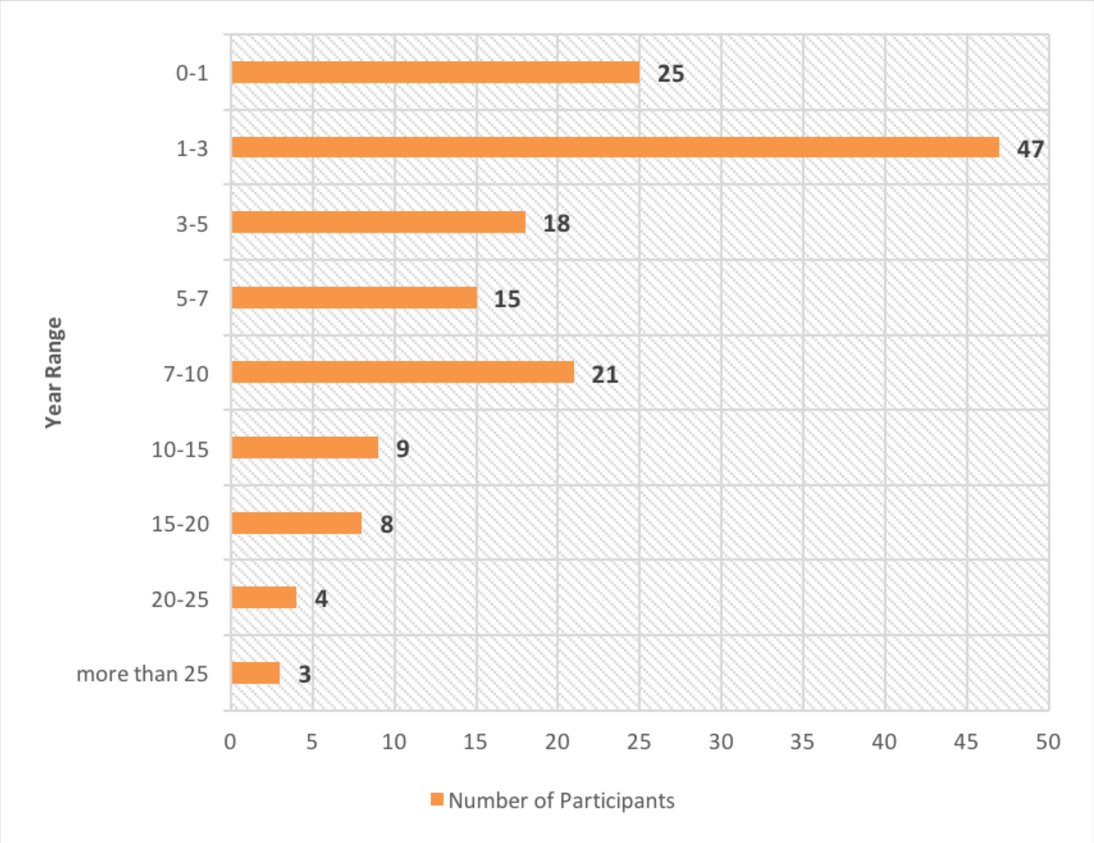

Figure 4.3 Bicycle Experience of the Participants

The fourth question of the survey asked that which type of a bicycle cyclists ride. The main purpose of this question is to determine a moderate physical characteristic of a bicycle in a common ground to design the bike-rack system as applicable for most of the bicycles used by cyclists. As stated in the literature review, an important feature of a bike-rack system is being available for most common bikes to be fitted as a basic rule of design criteria. In this respect, Lee et al. (2005, p.23) mention that some regulations have been made to prohibit certain types of bikes like recumbent, tandems, tricycles, unicycles, electric bicycles or any type of bicycle with a wheel less than 20 inches in diameter. The results show that the most common type of bicycle is mountain bike type with 59 participants through the survey (See Appendix

F). The foldable bike type is answered by seven cyclists, which is a type not convenient to be supported with current bike-rack systems. Although this type of bicycle cannot be accommodated in the bike-rack systems as a result of its smaller sized-wheels, it can be taken on board with the help of its foldable structure like a luggage.

To cover all types of bicycles used, in this question, there is also given a choice as others in which cyclist can specify the type of their bikes distinctly from the choices suggested. In this section four more bike types were referred to, including special versions of mountain bikes, which are mtb, cross bike, hybrid bike and rental bike. In Figure 4.4, the statistics can be seen with number in value of participant and in Figure 4.5, these mentioned bike types are given in a classification of their titles with images.

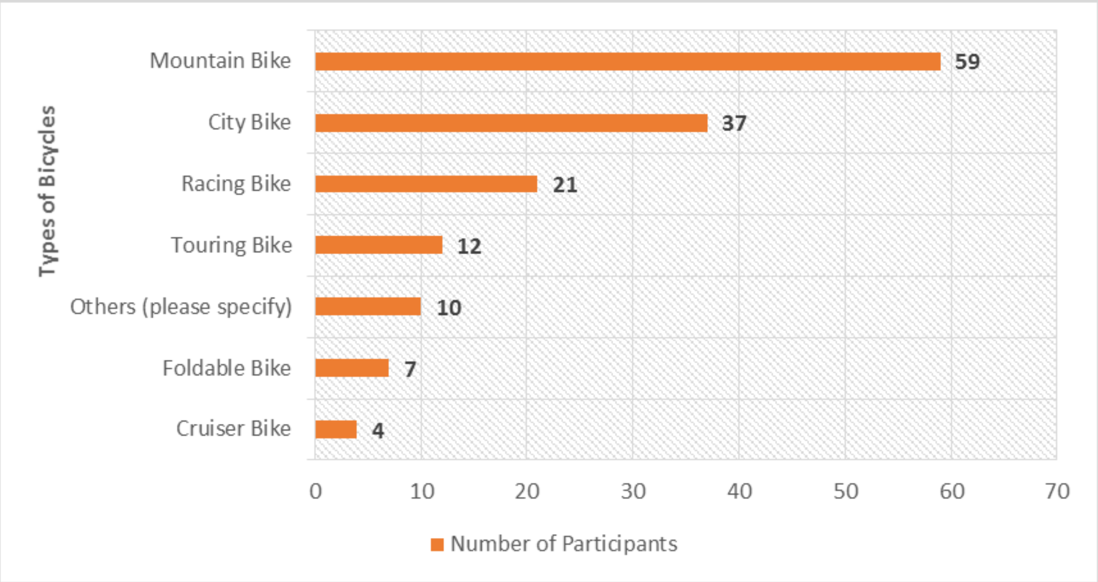

Figure 4.4 Bicycle Types of the Participants

Figure 4.5.a Mountain Bike (bikeandoutdoor.com, 2014)

Figure 4.5.b Racing Bike (turkbike.com, 2011)

Figure 4.5.c City Bike (senbisiklet.com, n.d.)

Figure 4.5.d Foldable Bike
(deltabisiklet.com, 2014)

Figure 4.5.e Cruiser Bike
(alalimburadan.com, 2014)

Figure 4.5.f Touring Bike
(deltabisiklet.com, 2014)

Figure 4.5.g MTB
(technopat.net, 2015)

Figure 4.5.h Cross Bike
(bisikletforum.com, 2009)

Figure 4.5.i Hybrid Bike
(donanimhaber.com, 2009)

4.1.1.5. Daily Cycling Activity

In the fifth question, "how much do you ride in a day averagely?" is asked to the participants. With this question, it is aimed to take a feedback about how much a cyclist spends time with his/her bicycle and usage frequency of bicycle as a transportation tool. The responses mainly ranged from 30 minutes to 2 hours as given in the Figure 4.6 (See also Appendix F).

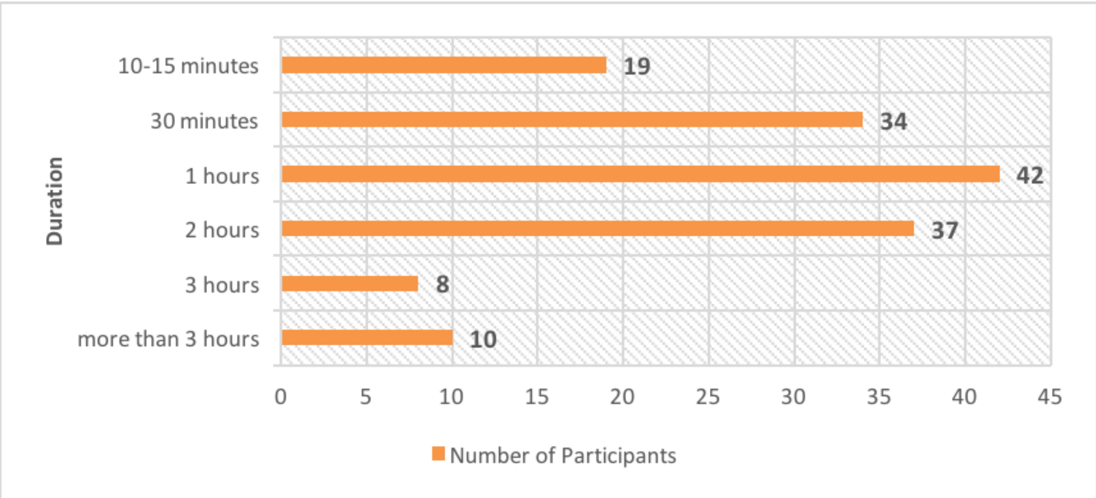

Figure 4.6 Average Time of Riding a Bicycle in a Day by the Participants

4.1.1.6. *Reason of Choosing Cycling*

For the sixth question, it is asked "why do you choose bicycle?" to cyclists. In this question, the underlying reasons of their motivations behind riding a bike are inquired. It is significant to identify these reasons in order to promote cycling and make it widespread. The statistics also provide data about which types of activities in which the bicycle is used with the characteristics and habits of cyclists. Through this question seven different items are specified and other comments allowed with an 'others' option. Each cyclist was expected to give multiple answers to the question and the results are very close to each other, yet the sportive activities lead the first choice among others. In the other option, there are some extra responses like feeling happy and peaceful and for the health considerations (Figure 4.7).

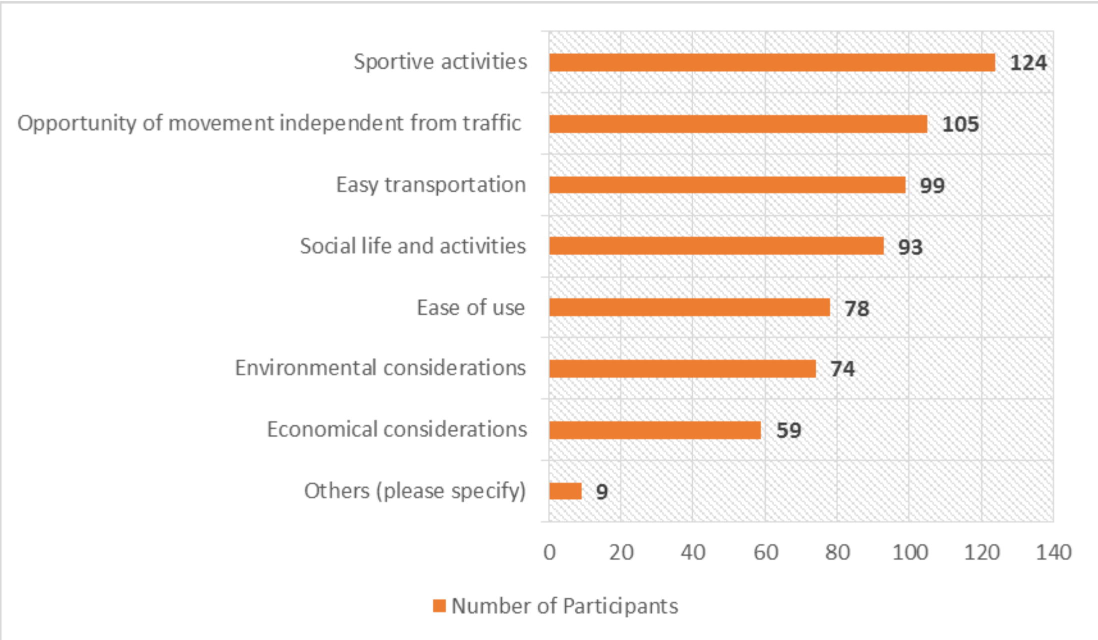

Figure 4.7 Reasons for Choosing Bicycle of the Participants

4.1.1.7. *Purposes of Cycling*

In the seventh question, "which purposes do you use your bicycles for?" is asked to participants. Four main subjects are classified and a comment choice is also given to cyclists. Sports is seen as the major topic of their priority of choices. However, other options can be called as important as sports with a close relation through answers. It can be inferred that only 'any access to services (like shopping)' option is less important in comparison to the others. When searched the comments at 'others' option, refreshing the body and the purpose of feeling peaceful are given by a few participants. The statistical data is shown in Figure 4.8.

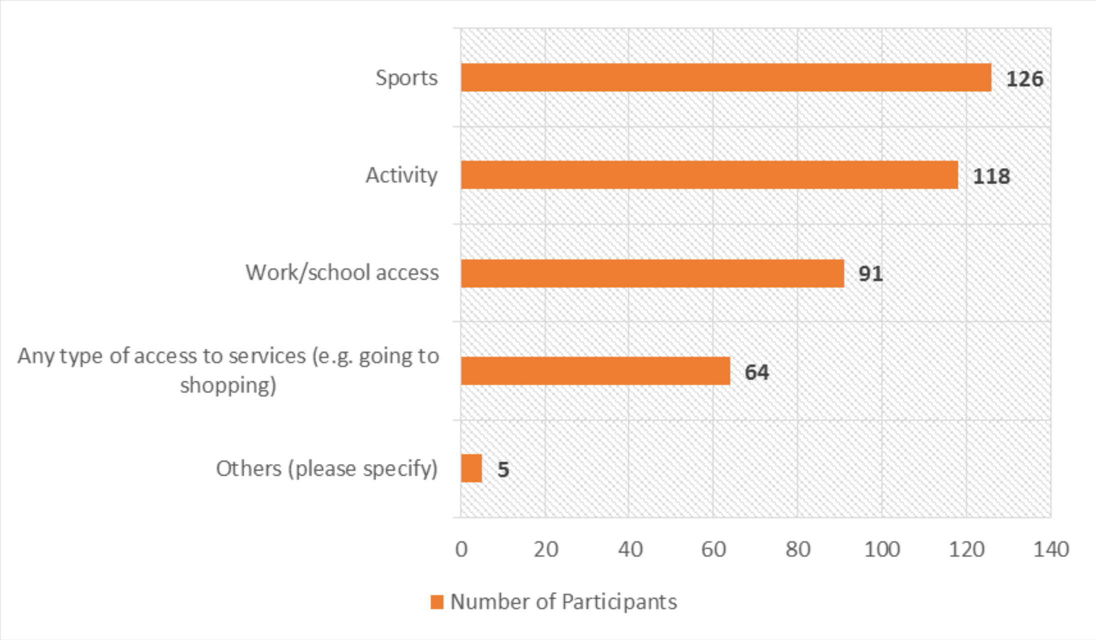

Figure 4.8 Distribution of Purposes Participants Ride Bicycles for

4.1.1.8. Group Riding

For the eighth question, "how many members do you ride with as a group generally?" is asked to determine the optimum range for the ones who will use the bike-rack system. Groups of two cyclists become a clear winner and 'more than 9' option shows an interesting data which is preferred by 25-cyclists from which it can be inferred that some activities take place with the participation of many cyclists. The others are shown in Figure 4.9 as well (See also Appendix F).

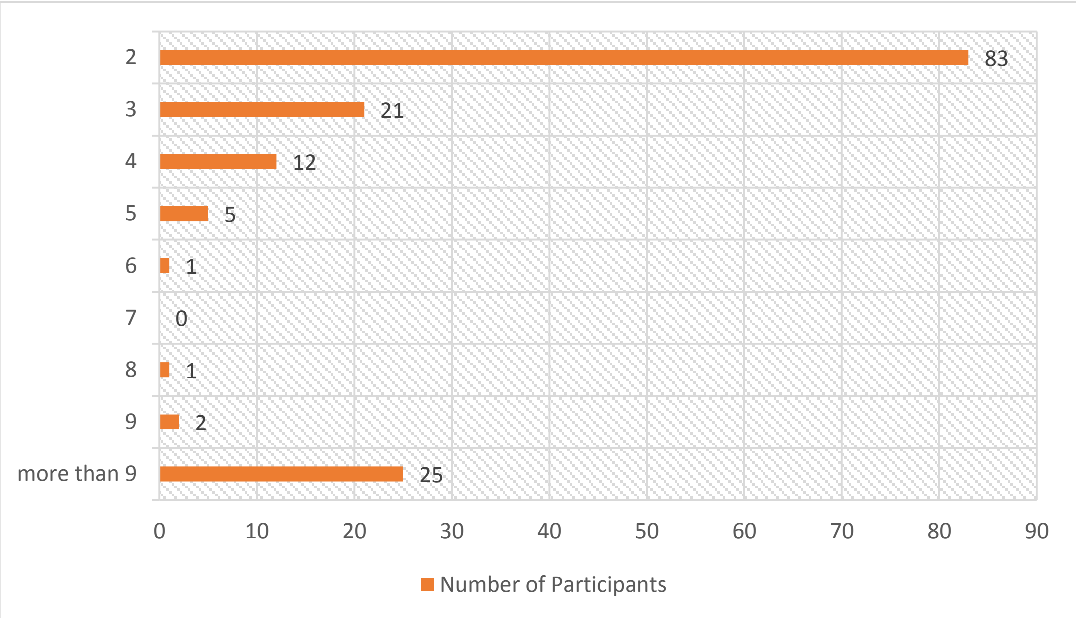

Figure 4.9 Grouping Measure of the Participants

4.1.1.9. Type of Route

In the ninth question, "which type of routes do you use generally during riding?" is asked to cyclists. The responses gathered for this question is quite surprising as most of the answers mention the main arterial roads. In urban areas these main arters is used by public transportation vehicles as well. Hence, most of the cyclists are actually riding in parallel to transportation routes. At this point, integration of cycling with public transportation will be valuable to extend cyclists' trips with the help of a rack system applied on buses. The statistics also show that there are certain limitations in public transportation infrastructure which provide bicycle roads for cyclists. In the 'other' option, some special places are referred to for riding a bicycle for recreational purposes like *Eymir Lake* or *METU forest area*. Most likely, this is the result of that the questionnaire has been published in the social media accounts of *METU Cycling Community*. All the responses for this question are given in Figure 4.10 with the weight distribution of participants (See Appendix F).

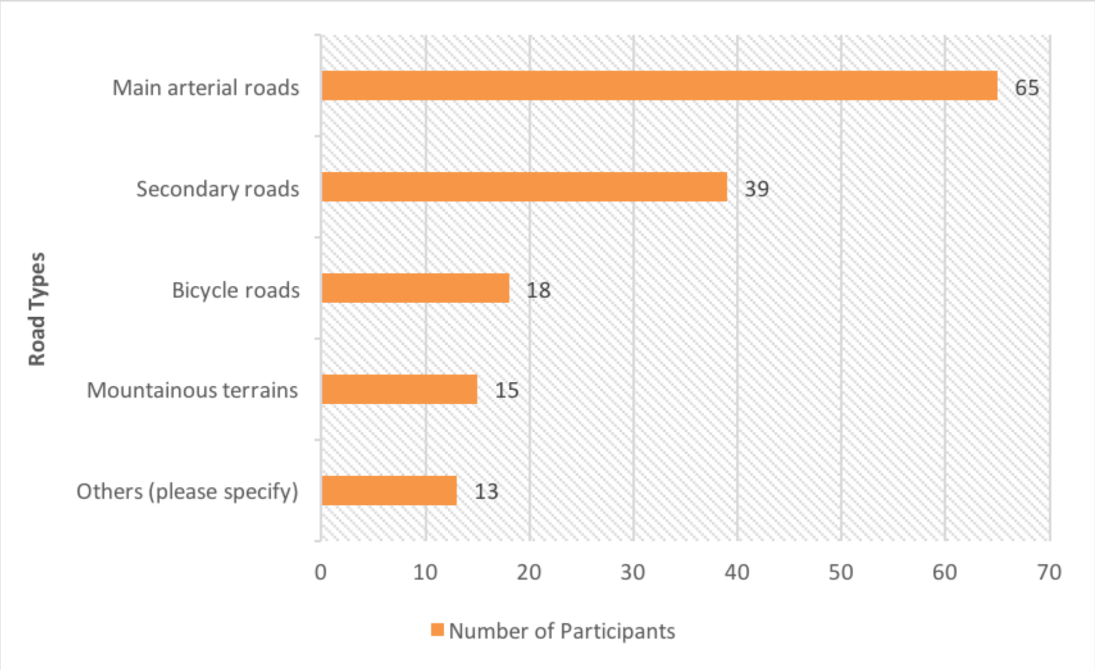

Figure 4.10 Road for Riding Bicycle Preferred by the Participants

4.1.1.10. Preference of Public Transport

In the tenth question, "which is your most frequent preference to use among public transport vehicles?" is asked to the participants. Almost half of the respondents mentioned bus as their first choice in comparison to other vehicles which makes the bus-rack system preferable for applying on buses. In this respect, it can be inferred that as a transit vehicle, buses have a great potential between public transportation modes and this brought a valuable data which confirms the appropriateness of the proposed solution for cycling and public transportation integration. The ‘others’ option gave some other modes like train, ferry, sea bus and a combination of few modes together. Although public transportation is specified for this question, a few answers on individual car use were reported (Figure 4.11).

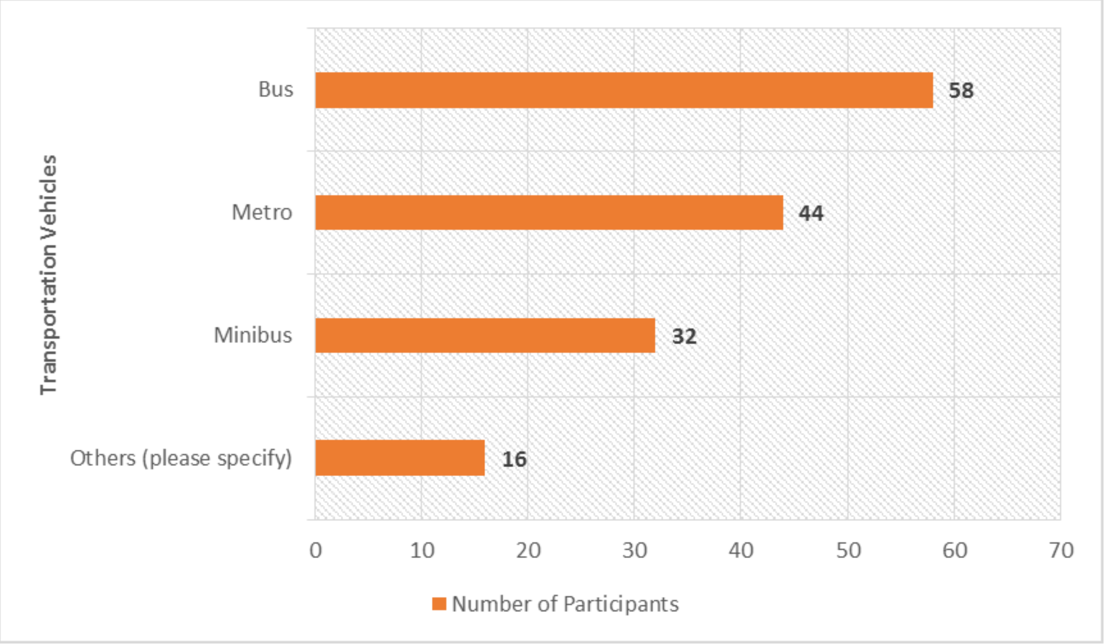

Figure 4.11 Favorite Transportation Vehicles of the Participants

4.1.1.11. Bicycle Parking

For the eleventh question, “where do you park your bicycle generally?” is asked about for the surveyors.

This question can be insufficient and too optimistic about its response range, because most of the participants mentioned their own solutions rather than given choices. It also represents that there are not enough parking areas where cyclists store their bicycles in the current public infrastructure system of Turkey. The ‘other’ choice includes a variety of different answers, which can be classified under eight main titles. The most popular answer for this question is electric pole, street light and trees mentioned by 17 participants (See Appendix F). Another common response is given by 15 participants, which is inside of a building including store, garden, room, office or an entrance of an apartment. Ten cyclists referred to a place which can be considered ‘safe’ and another ten cyclists prefer not to leave their bicycles anywhere as a result of concerns with theft and vandalism. Six of them stores their bikes at car parks and five of them explain the most convenient place is where they can have eye contact with their bicycles. Also two of them state that they leave their bicycles to a friend to keep an eye on it (Figure 4.12).

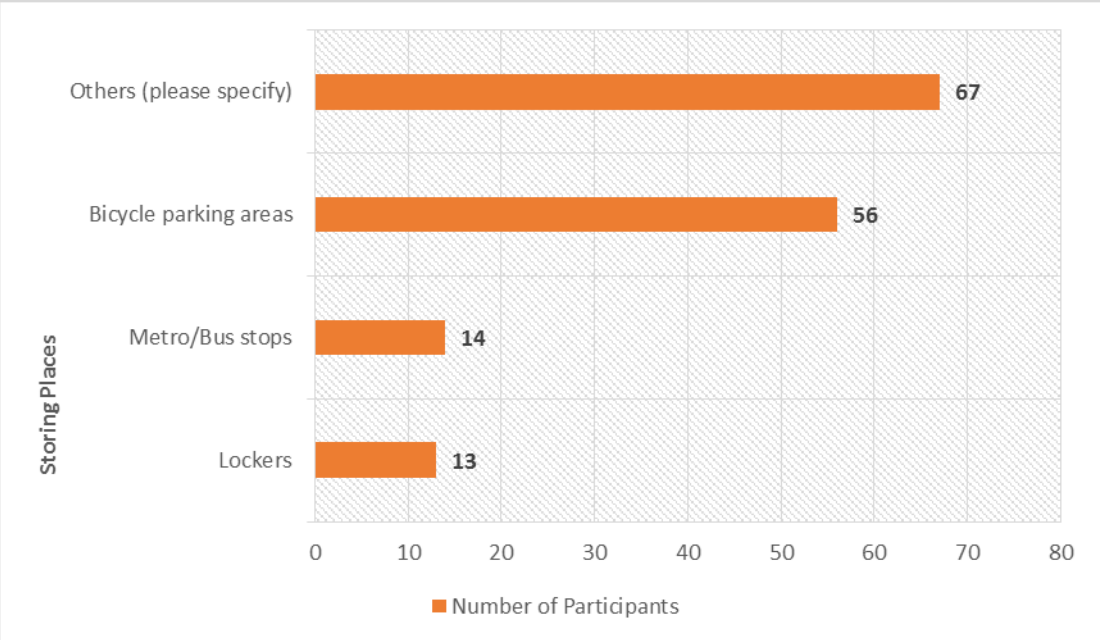

Figure 4.12 Storing Places of Bicycles Preferred by the Participants

4.1.1.12. Difficulties with Cycling

In the last question of the first part in the questionnaire, “what prevents you from cycling?” is asked. The designated choices for this question aim to measure the necessity of a bike-rack system in such circumstances. The answers given to this question prove that route characteristics, weather conditions, unsafe parking spots, longer distances and traffic conditions are really significant determinants of decisions of cyclists about whether riding is convenient or not (See Appendix F). Weather conditions and unsafe parking areas are main reflected responses for them as can be seen with the other options in Figure 4.13. In the ‘others’ option, four other factors are identified, which are traffic conditions by 15 cyclists, illness by six cyclists, and dogs by two. There is also an exciting response given by six cyclists that ‘nothing can prevent me from cycling’ in a proudly manner.

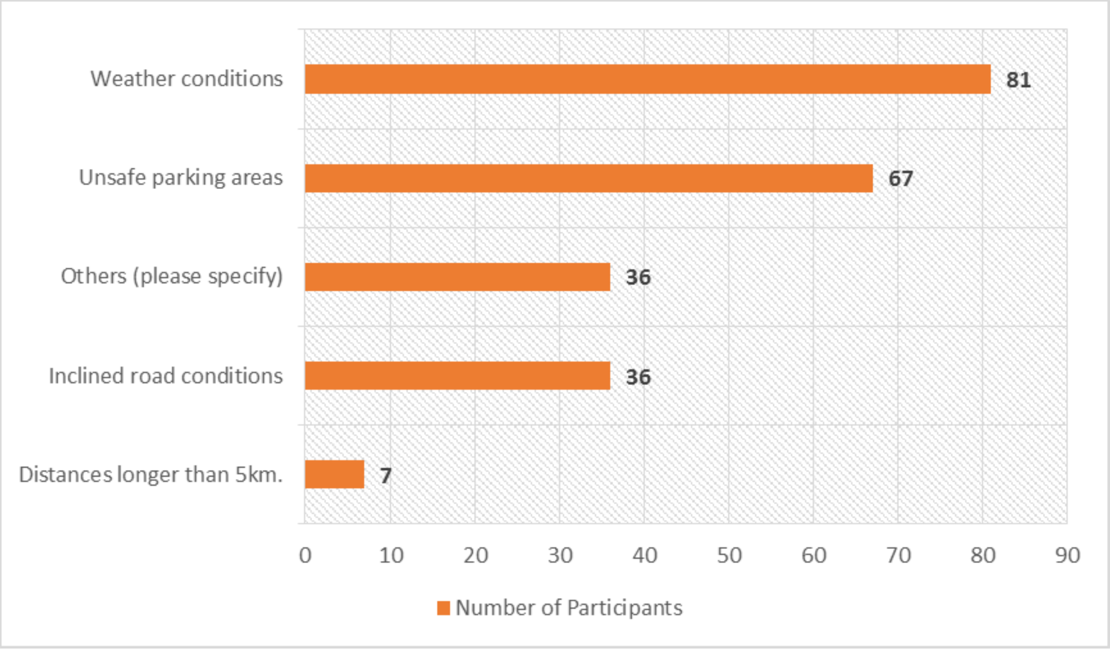

Figure 4.13 Reasons Keeping Cyclists from Riding Bicycles

4.1.2. Second Part of Open-Ended Questions

In the second part of the questionnaire four open-ended questions are directed to the participants of the survey. These questions are mostly about the problems cyclists faced when they want to carry their bikes on buses, their preferences about cycling and transit integration and the characteristics of their bicycles by accessories they equipped on them. 119 of cyclists answered this second stage of the questionnaire while the rest 31 ones skipped it.

4.1.2.1 Using Public Transportation with Bicycles

For the first question ‘can you use public transportation with your bicycles? If yes, how often? If no, why?’ is asked to measure the current integration level of cycling with transit and the ways of it. Four respondents’ answers were invalid and 69 of participants replied as ‘no’ to this question while 20 of them said ‘yes’ and 21 answered as limited with metro, ferry and sea bus but not buses (Figure 4.14). Almost all of the positive responses state in very rare occasions they bring their bikes on board and very few of them use public transportation with cycling in a daily routine.

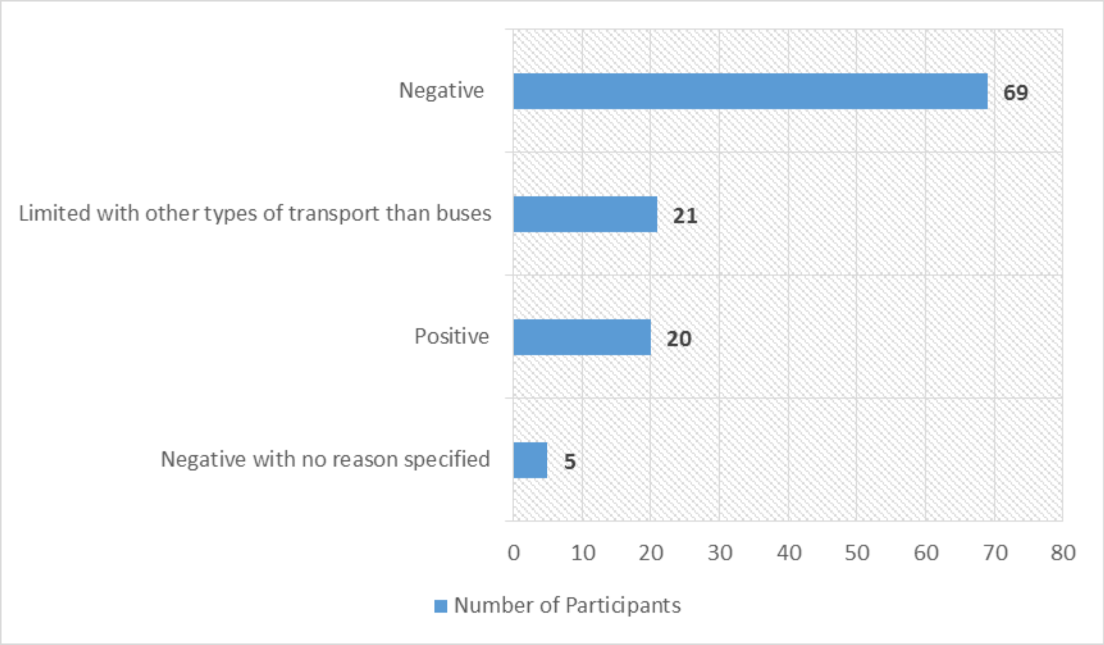

Figure 4.14 Possibility of Using Public Transportation with Bicycles

When the negative answers are evaluated, mainly four factors are reported as a result of them cyclist cannot use transit with their bicycles. The most common problem, which keeps them from this union, is public transportation infrastructure. Secondly, cyclists give the reason of bicycles' not being allowed to take on boards. The following reason is the ones who do not prefer to use public transportation with their bicycles by their individual perspective. Lastly a small portions of the participants stated that they had never experienced and tried to take part in such an integration (Figure 4.15).

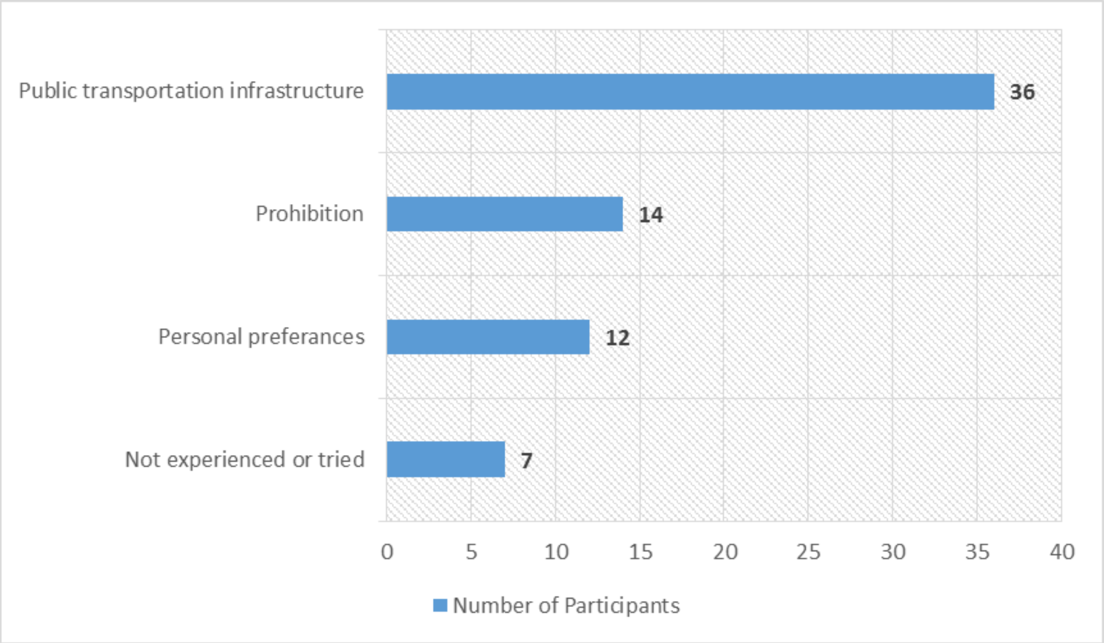

Figure 4.15 Reasons of the Participants not Using the Public Transportation with Bicycles

4.1.2.2. Problems of Integration

For the second question of the second stage of the questionnaire, it is asked to participants ‘which problems do you face while attempting at using public transport with your bicycles’. The answers are similar to gather them easily under five main issues. These issues are given with a chart in comparison to each other in Figure 4.16.

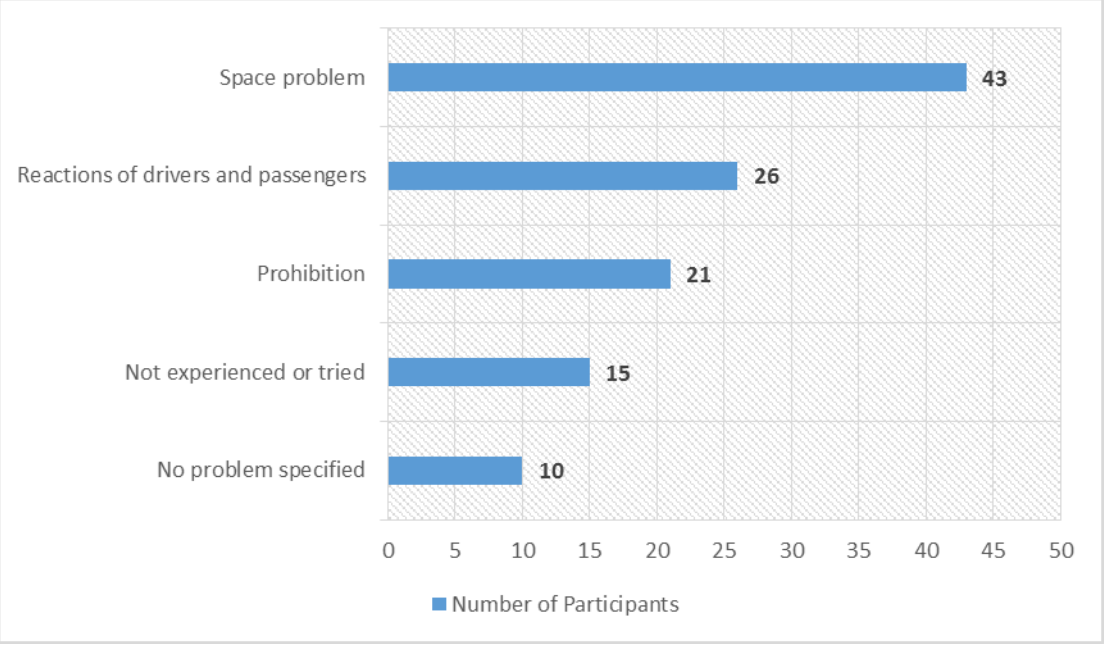

Figure 4.16 Problems the Participants Face While Using Public Transportation with Cycle

Here, it can be inferred that the top two reasons explain the inconvenience of a bicycle inside of a bus. The general concern is there is not enough room on board which hardly accommodates passengers especially on peak hours. Also taking bicycle inside of a public transportation vehicle causes other passengers and the driver to feel disturbed about the situation.

4.1.2.3. Bike-Rack Preference

In the third question, “which type of a bike-rack system do you prefer from external or internal-mounted types and why?” is directed to the participants. The question is important as it gives clues on the perception and desires of cyclists about the most appropriate placement of the system application. The answers are supported with the reasons of choosing their choices. In this respect, it will be more logical to evaluate the outcomes of these questions with its underlying reasons. In this question, the surveyors are provided with two images as given in the methodology chapter through which they are asked to select one of these two options. The results are surprising as conflicting with the previous question in a way that, at the second question the cyclists mentioned about the problems they face when they want to carry their bicycles on board under some themes like space problem and reflections of both other passengers and the driver, however, they still want to place their bicycles inside of a bus with some certain concerns. Another reason of their choice can be named as that almost all of the participants have not experienced using the current system, which makes them feel hesitated with this innovation and make them select the inner placement of their bikes with a common sense without considering its possible results in a public transportation system. The responses collected for this question are represented in two different charts one of which shows the distribution of their selections and the other one explains the reasons of their preferences as given in Figures 4.17 and 4.18. When the answers are discussed closely, all of the participants who prefer the external type of bike-rack system are concerned about the inner space problem of buses. Nonetheless, the reasons of 70 participants who choose the inner type are classified under mainly five issues. These include mostly safety concerns mentioned by 24 respondents, the other reasons are seen in a close range like protecting the bicycle from external conditions such as bad weather, the fear of bicycle's being damaged from external conditions or by an accident, the desire of keeping the bicycle closer to its owner in order to monitor it every time and waste of time for loading or unloading a bicycle to/from an external bike-rack system. Also, 41 of participants made their choices between the proposed two solutions yet did not give reasons to their choices. All concerns mentioned for the external bike-rack system can be approached by building a durable carrying system that gives the feeling and perception of durability, security and protection though. These concerns are dealt with the research through design process so as to make the proposed system convenient for cyclists and to change their views about it. The main purpose is to get the new system acceptable by all users without any hesitation.

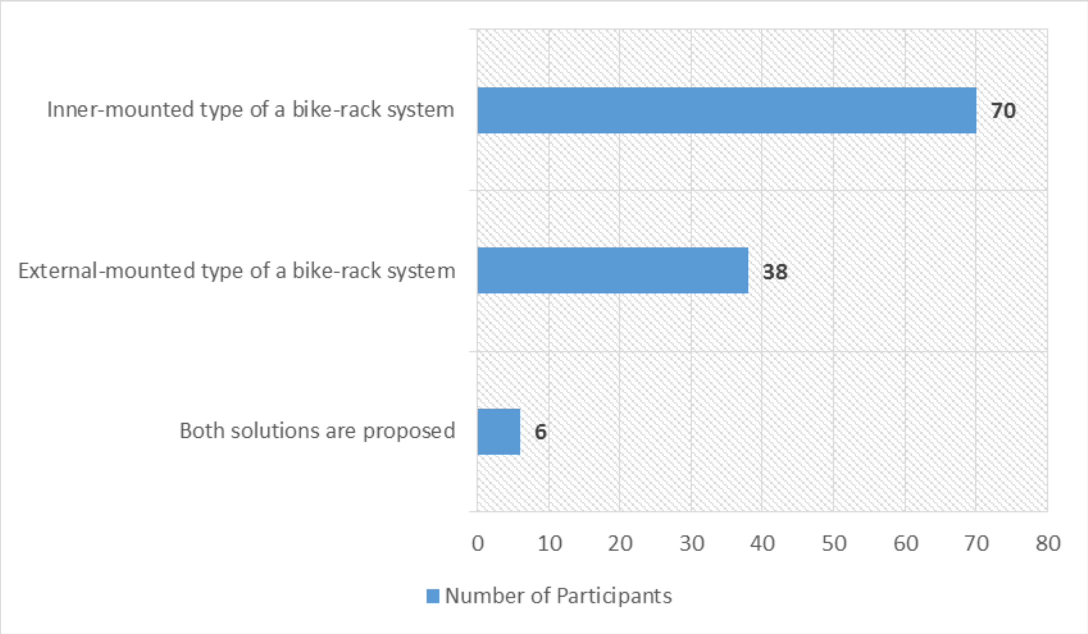

Figure 4.17 Preferences of Bike-Rack System Depending on Settlement

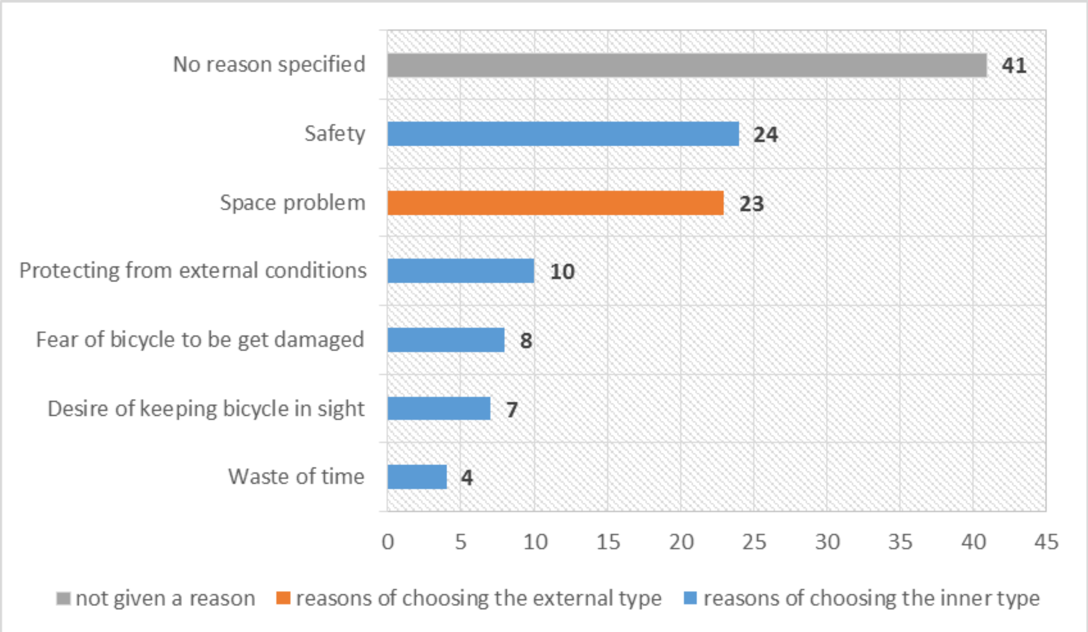

Figure 4.18 Reasons for Choosing Inner or External Type of Bike-Rack System

4.1.2.4. Extra Attachments

The fourth question aims basically identifying the extra attachments which are added by owners of bicycles through their individual needs and wishes. In this question, “which equipment are attached to your bicycle by you for customization of your bicycles?” is asked to participants. The responses are significant for designing the newly proposed solutions as these attachments play a significant role for alignment of a typical bicycle and will affect the decisions for making arrangements of both a covering design in which a bicycle can be fitted appropriately and determining the connection points through which the bicycle will be placed accordingly at the analysis stage. Twenty nine different attachments are mentioned by the participants which range from general applications to less preferred ones. These attachments are given in Figure 4.20 according to stated numbers by participants and identified with images about how they look.


lighting equipment


water bottle


front baggage


back baggage


speedometer


bicycle bell


bicycle bag


bag under saddle


bicycle pump

bicycle mudguard

bicycle tool kit

bag above bicycle frame

saddle bag

GPS

phone holder

bicycle helmet

bicycle basket

spd pedal

frame cover

barend

back-pack

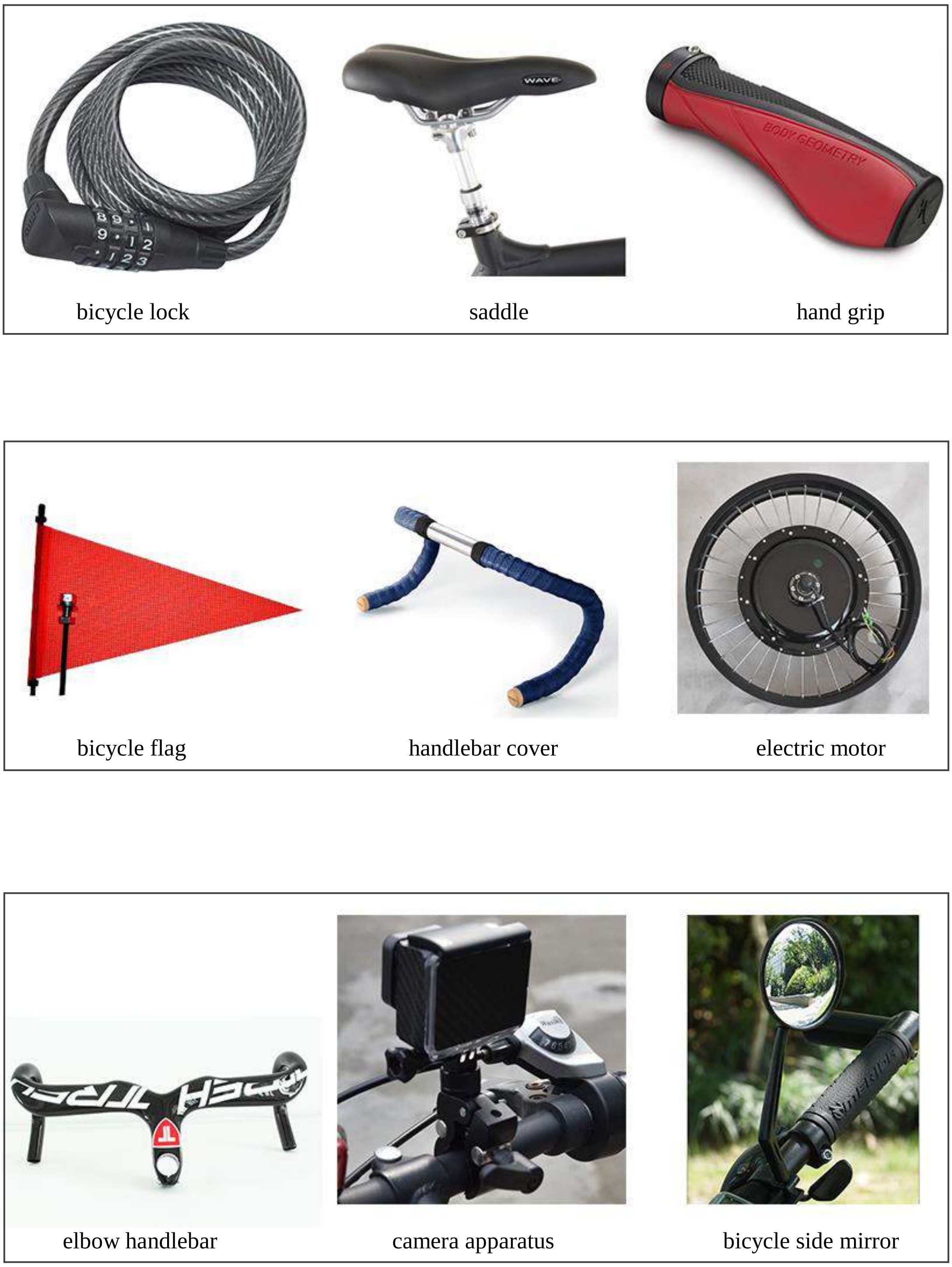

Figure 4.19 Different Accessories and Attachments Mentioned by Participants

(visuals are gathered from google images with keywords)

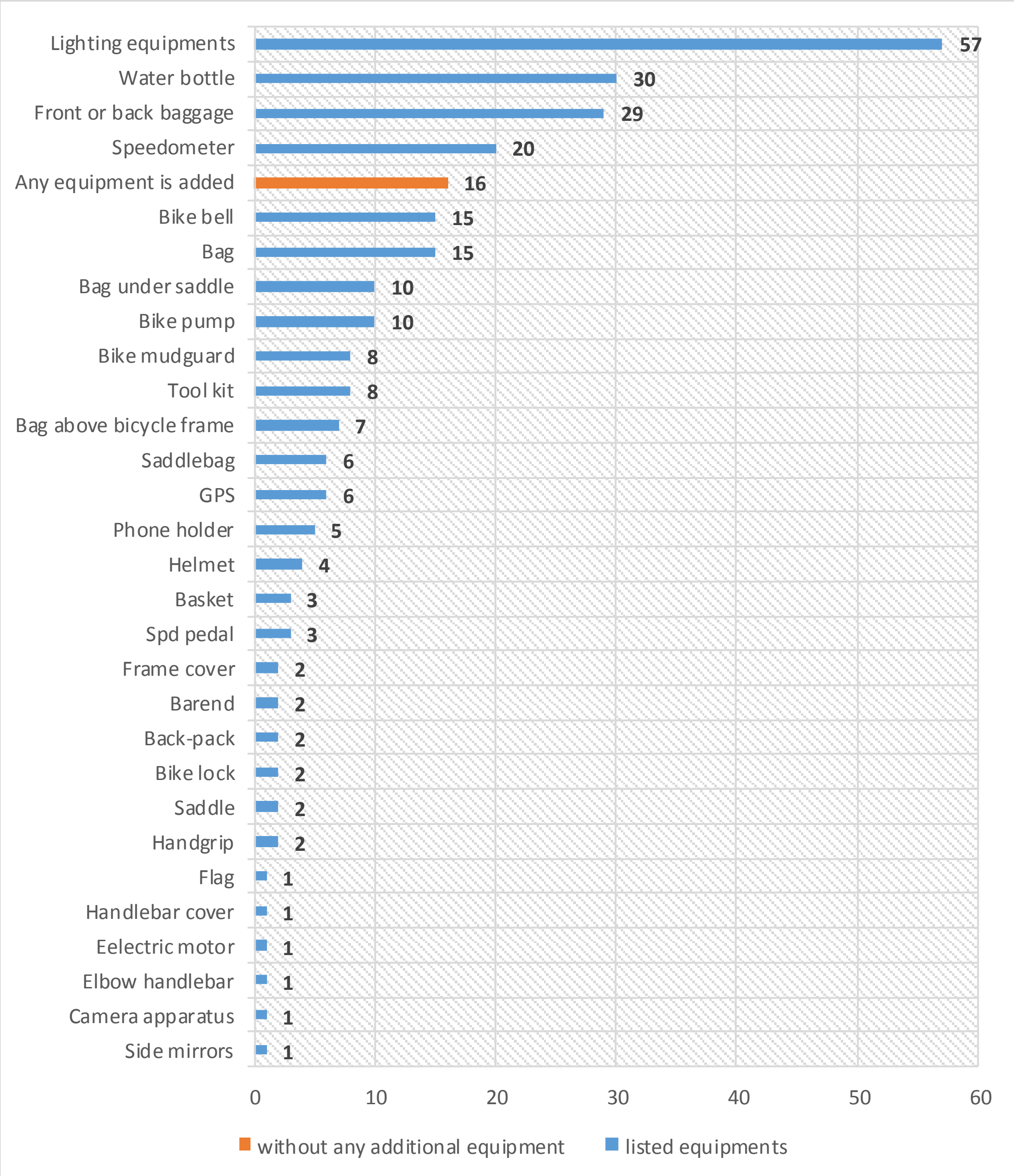

Figure 4.20 Extra Attachments Added on Bicycles through Cyclists' Individual Needs

4.1.3. Third Part of Elevation Matrix Question

In the third part of the questionnaire, eight different design considerations for a bike-rack system are identified and these considerations were put in an order by the participants according to their importance and priorities of them. They are asked to mark the first column of the question for their initial priority and to align the rest accordingly. Each consideration is represented with a chart below including the distribution of selections among 100 responses. These considerations were mentioned before in the methodology chapter and also they can be seen in the titles of related graphics. The importance of each consideration is reflected by multiplying the order from eight to one reversely through the marked selections. The purpose is to show the most favorable consideration with the highest score in a result of this multiplication. The results are shown with a table of scores (Tables 4.1 and 4.2), and also the chart versions of it (Figure 4.21-4.29). According to the derived answers, it can be easily inferred that the most important feature of a bike rack system should be the security of bicycle against any theft. When the responses are reconsidered with the questionnaire, it is reasonable that cyclists always want to keep their bicycles with them in a range where they can check it all the time. Being practical and user-friendly to lead cyclists about how to use a bike-rack system is the second priority of participants. For their third choice, again like the first priority, damages, which could affect the bicycles concern the cyclists mostly. Disturbing the ongoing traffic order and causing any traffic accidents while loading or unloading the system features have almost the same score. Hence, it can be inferred that for cyclists these considerations are perceived as similar to each other. Lastly, cyclists do not pay much attention to durableness of the system and checking their bicycles during the bus is going. This result certainly does not mean that these considerations are not important and ignorable, however, they can be thought as being less important for cyclists in comparison to other six features. All responses were utilized to build basic design decisions about the new proposed systems to cover all desires and concerns of cyclists in conceptualizing the design alternatives.

Table 4.1 Total Scores of Design Considerations

A- My bicycle should not be stolen.	515
B- My bicycle should not be scratched or damaged.	473
C- Loading and unloading a bicycle out of the rack system should be easy, quick and understandable.	488
D- The rack system should protect the bicycle under bad weather conditions.	427
E- I should not disturb the ongoing traffic order.	436
F- Loading and unloading a bicycle should not cause any traffic accidents.	437
G- I should be able to monitor my bicycle visually during a trip.	407
H- The rack system should give me a feeling of durableness.	417

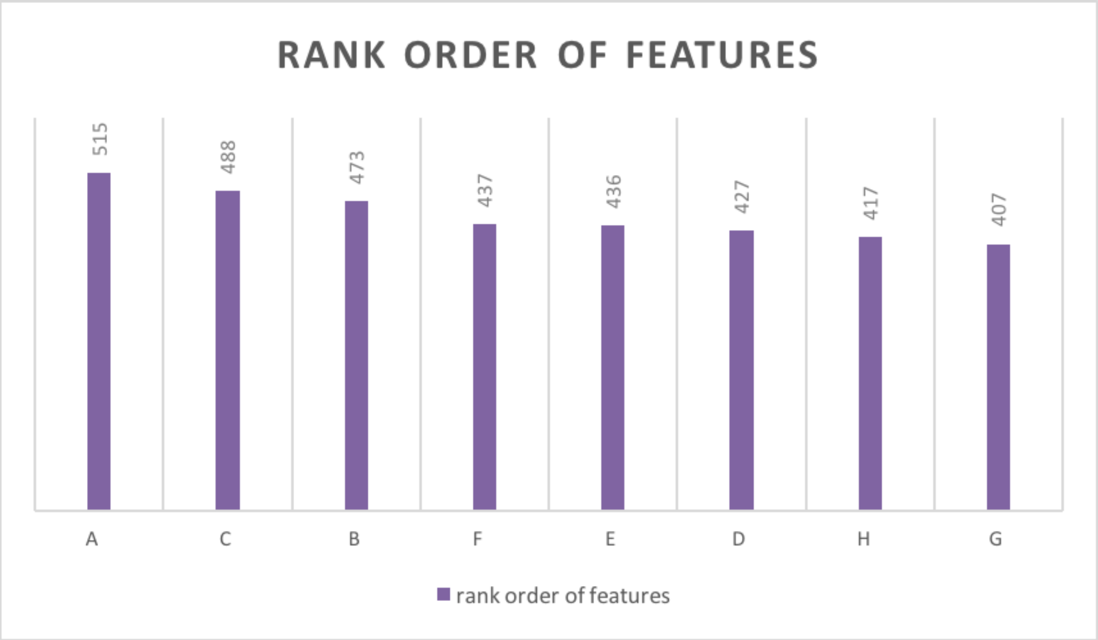

Figure 4.21 Rank Order of Given Features

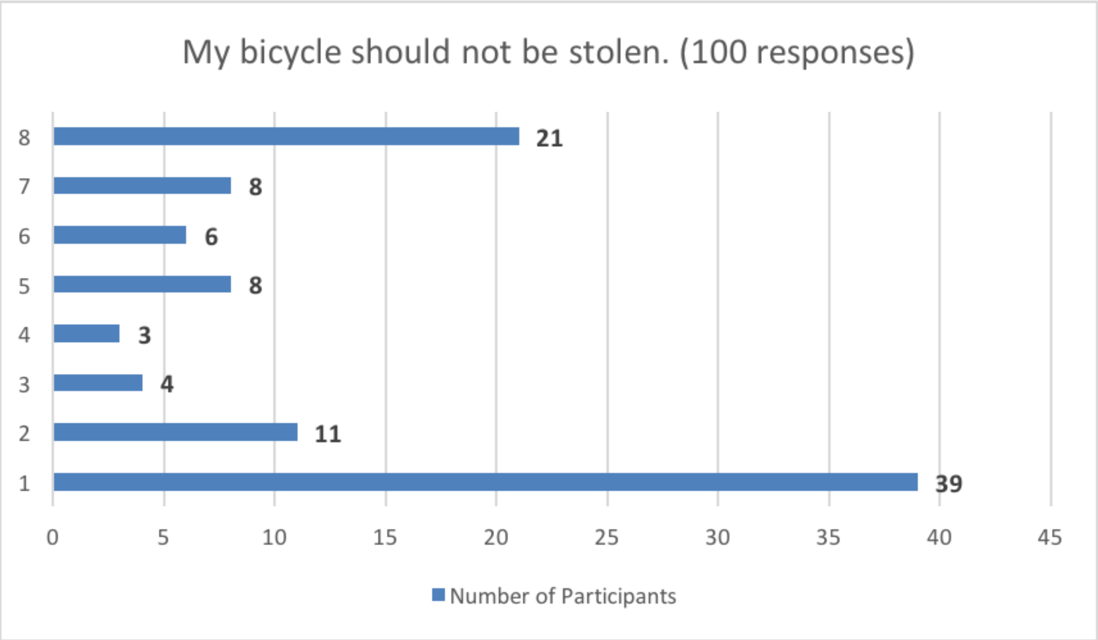

Figure 4.22 Theft Risk as Consideration

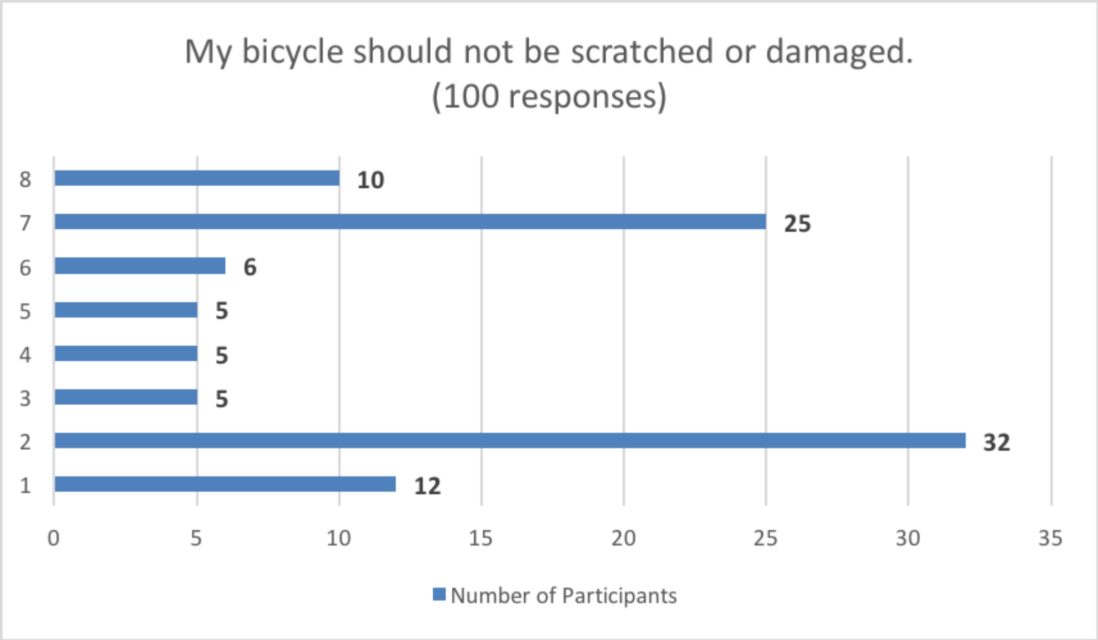

Figure 4.23 Damage Risk as Consideration

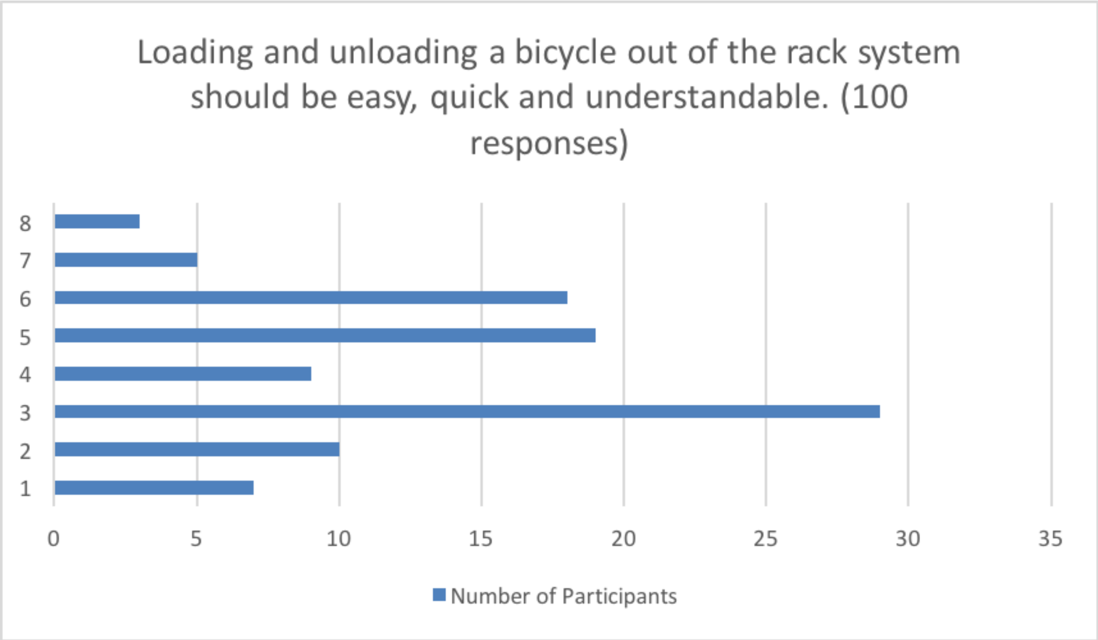

Figure 4.24 Practicality as Consideration

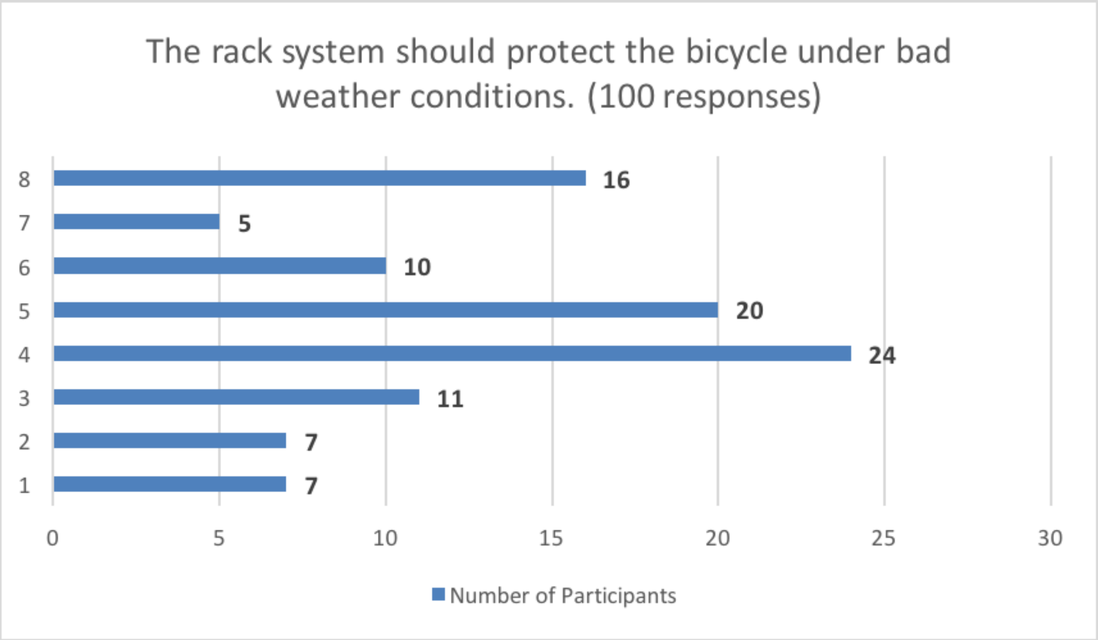

Figure 4.25 Protection as Consideration under Bad Weather Conditions

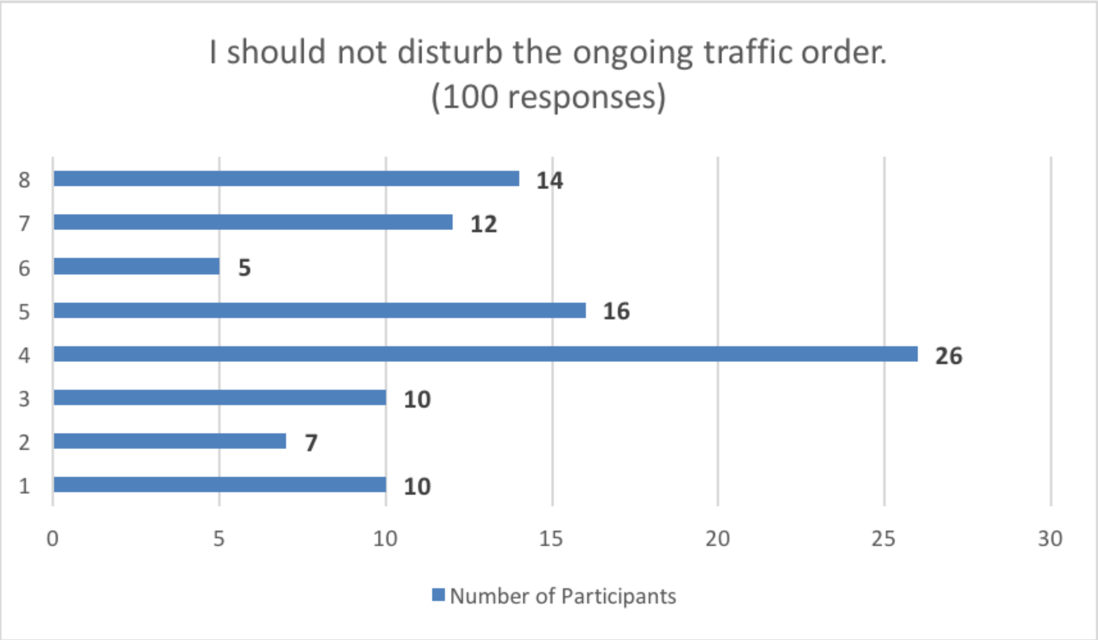

Figure 4.26 Impacts on Traffic Routine as Consideration

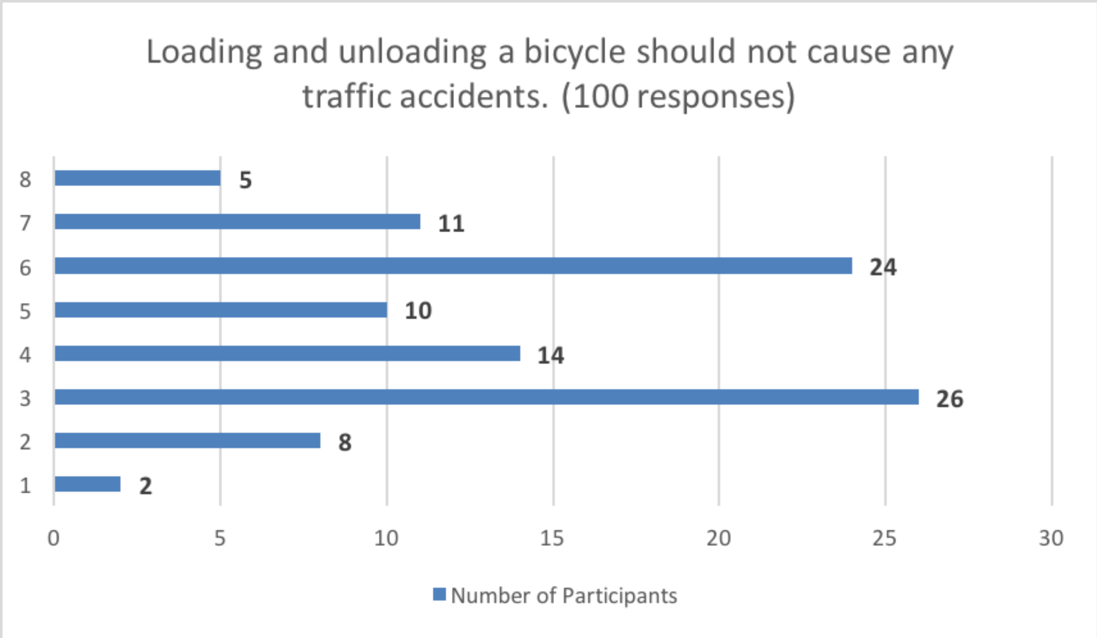

Figure 4.27 Safe Loading/Unloading as Consideration

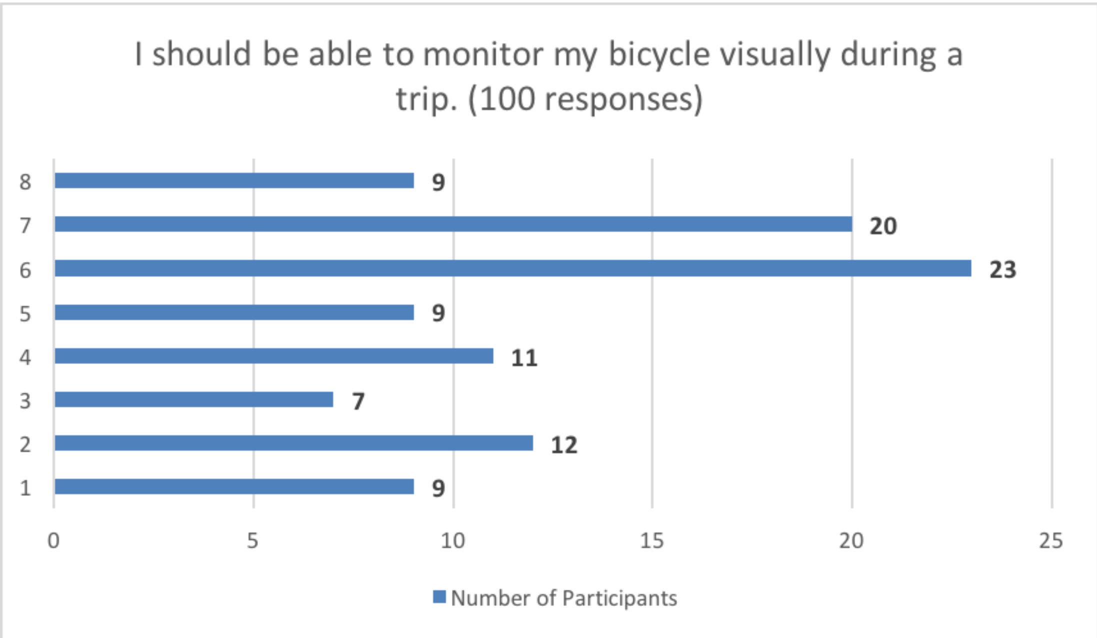

Figure 4.28 Monitoring the Bicycle during a Trip as Consideration

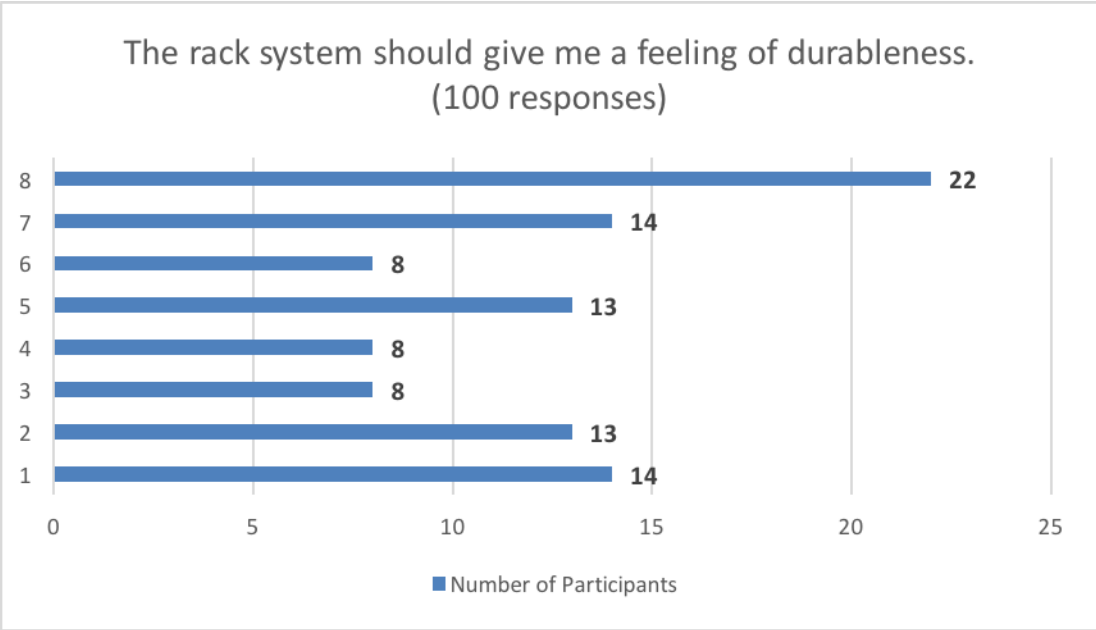

Figure 4.29 Durability as Consideration

Table 4.2 Rank Value of Given Design Considerations about Bike-Rack System

	1	2	3	4	5	6	7	8	Total
My bicycle should not be stolen.	**39.00%** 39	**11.00%** 11	**4.00%** 4	**3.00%** 3	**8.00%** 8	**6.00%** 6	**8.00%** 8	**21.00%** 21	100
My bicycle should not be scratched or damaged.	**12.00%** 12	**32.00%** 32	**5.00%** 5	**5.00%** 5	**5.00%** 5	**6.00%** 6	**25.00%** 25	**10.00%** 10	100
Loading and unloading a bicycle out of the rack system should be easy, quick and understandable.	**7.00%** 7	**10.00%** 10	**29.00%** 29	**9.00%** 9	**19.00%** 19	**18.00%** 18	**5.00%** 5	**3.00%** 3	100
The rack system should protect the bicycle under bad weather conditions.	**7.00%** 7	**7.00%** 7	**11.00%** 11	**24.00%** 24	**20.00%** 20	**10.00%** 10	**5.00%** 5	**16.00%** 16	100
I should not disturb the ongoing traffic order.	**10.00%** 10	**7.00%** 7	**10.00%** 10	**26.00%** 26	**16.00%** 16	**5.00%** 5	**12.00%** 12	**14.00%** 14	100
Loading and unloading a bicycle should not cause any traffic accidents.	**2.00%** 2	**8.00%** 8	**26.00%** 26	**14.00%** 14	**10.00%** 10	**24.00%** 24	**11.00%** 11	**5.00%** 5	100
I should be able to monitor my bicycle visually during a trip.	**9.00%** 9	**12.00%** 12	**7.00%** 7	**11.00%** 11	**9.00%** 9	**23.00%** 23	**20.00%** 20	**9.00%** 9	100
The rack system should give me a feeling of durableness.	**14.00%** 14	**13.00%** 13	**8.00%** 8	**8.00%** 8	**13.00%** 13	**8.00%** 8	**14.00%** 14	**22.00%** 22	100

4.2. Findings of the Interviews

Interviewing part of the field study includes two stakeholders which are mentioned before as bus drivers and the traffic planner. Each type of stakeholders' responses will be given under different titles.

4.2.1. Interviews with Bus Drivers

In this section, 14 EGO bus drivers were interviewed by a total of 12 questions. Through these questions, firstly they are asked about their experience levels and daily working routines. Then, the problems they face with and their reactions to them during their work practice. Lastly, the cycling and public transportation integration were evaluated by them with their point of view on the application of the proposed system. In this interview, as each question refers to various knowledge and input, the findings will be given one by one for each question separately. All the answers obtained from the drivers are collected in an excel document that shows the classifications and highlights the significant keywords and phrases.

4.2.1.1. Experience on Working for EGO

The first question is about how many years the drivers worked for EGO. Their work experience at EGO has a range between three years to eleven years among 14 drivers who contributed. The total average is 6.7 years.

4.2.1.2. Workload of the Drivers

In the second question, "how many hours do you work and how many hours do you spend on driving?" is asked to the interviewees. Drivers replied that, in normal circumstances they work eight hours in a day, however, almost all drivers mentioned that everyday they have to complete an extra shift about two hours additionally. This equals to 9.6 hours of work in average. Moreover, the break times change with these additional shifts. If it is not added, the average break time is about 30-40 minutes for a day but it increases up to two hours in maximum with an average of 64 minutes. Moreover, the traffic conditions and passenger density can affect drivers to be late for their other scheduled services which means the total delay is cut from their resting hours, sometimes up to a level in which they continue to drive without any resting.

4.2.1.3. Peak Times When Inside of a Bus is Crowded

Congestion inside of a bus differs according to routes of buses which is mostly affected by peak times. This gives an insight that most of the commuters taking a bus consists of students and regular workers. Among the interviewees, the earliest time for congestion to start is reported as 6:00-7:30 a.m. This congestion can last until 8:00 a.m. generally and in some routes even up to 10:00 a.m. On the other side, after work and school congestion inside of the bus starts generally 16:00 p.m. with a medium of 15:33 and it continues up to 19:00-20:00 pm.

4.2.1.4. General Problems Which Bus Drivers Face with Passengers

The problems mentioned by the interviewees can be classified under mainly five different subjects. (1) The most faced one mentioned by nine drivers is that the bus does not allow all passengers waiting at the bus stop to accommodate due to the capacity problem. The general procedure of boarding takes shape in pushing forward the commuters by a stowage manner to use maximum inner capacity. The common result of this process bring some concerns such that the passengers who succeed to board want the driver go on while the waiting ones are trying to get in. Normally, the capacity of solo type buses is limited to 80 passengers and the hooded types can provide 140-150 passenger space inside of a bus. However, it is mentioned that even that much capacity is not enough under some circumstances related with the volume of the bus stops. The bus cannot go on its trip when the doors are not closed and this brings with a chaos and debate occasions in which both commuters and the bus driver are involved. As a result of this, the boarding process grows longer which causes next stops also to get accumulated with more passengers and the total time of a route increases spirally. Because there is not a standard time arranged for each stop and the basic rule is to take all commuters and continue to the service for bus drivers.

(2) Another mostly mentioned issue by eight bus drivers as a problem being faced with passengers is the delay in scheduled times for specified stops in the route. This problem occurs in two forms, in one of which the bus reaches the stop with a delay as a result of some factors like traffic congestion, roadwork, and any failure with the bus, traffic accidents and crowded passenger cases. The other form of the related problem is about the delay with total cycle time of the bus due to similar reasons.

(3) Less significantly, two drivers stated the lacking ticket problem. Drivers explain that the other types of public buses have the same route parallel to the ones with EGO buses and the other types do not require special tickets. Typically, at a bus stop, a passenger waiting for a bus to arrive gets in a bus which comes at first whether he/she has a ticket or not with the wish of using another passenger’s multiple use ticket. However, the common habit through their action is to get ahead and do not use any ticket afterwards which leads to a debate when they are summoned by drivers with an attitude of feeling offended among other passengers.

(4) Furthermore, some of the passengers, especially elderly people want to get off the bus at places that are not specified as a stop. The bus drivers explain its reasons with that the other type of buses stops anywhere apart from the arranged stops which builds a custom for elderly people.

(5) Another problem stated by two drivers is that the way they drive is criticized by mostly passengers who stand in cases of sudden brakes and fast or slow driving of the bus.

4.2.1.5. Passenger Types Who Require Extra Space for the Utilization of Their Special Conditions

These passengers are those who have special conditions including wheel-chaired commuters, the ones with a baby carriage and a big-sized luggage. In this question, it is asked whether bus drivers have any problems during boarding of these passengers and how this process takes place. Bus drivers mention that almost 100 percent of current buses have disabled access ramp yet older model of buses has manual systems which are controlled by bus drivers themselves while the newest ones have electronical systems. The major disadvantage of the new type reported by interviewees is its being controlled with a button placed near the middle door of a bus instead of control panel. As the drivers were trained about how to use the system, they are the only ones in charge of activating the system. When they meet with a wheel-chaired passenger, they leave the cockpit and help these passengers during both boarding and leaving. The wheelchair is also secured with safety belts and made stable by the drivers. Disabled passengers push a button which gives different signal and visual to alert the bus driver when they want to get off the bus. This process of getting these passengers inside or out of the bus takes about 6-7 minutes. Bus drivers are concerned about the mud they deal with under bad weather conditions during operating the systems and sometimes, the mud causes the system fail which also puts drivers in trouble. Another complaint stated by the drivers is blocking the whole road in some narrow lines while taking disabled passengers inside the bus for a while which causes some quarrels with other drivers in traffic.

The process of boarding someone with a baby carriage and a big-sized luggage is held in the same way by using the middle door as it has not got any bars as an obstacle. Generally, other passengers help them to get in but when there is a need, drivers also leave the cockpit and help them. For the elderly people, the bus is lowered with adjustable suspension system in order to make the first step convenient for them.

4.2.1.6. Frequency of Cyclists Who Want to Use a Bus with Their Bicycles

Coming across with a cyclist depends mainly on the route the bus gives service through. For instance, eight bus drivers among the interviewed 14 as the members of 4^{th} zone, Altındağ district of EGO never came across a cyclist during their working experience. Three of them state that they did not allow cyclists to take their bicycles inside of the bus when they meet such a case. All interviewees mention that it is prohibited to take additional material with some certain features like crusher, diffuser, burnable, cutter, fragrant and space occupying with the directives applied by EGO. P2 (the second respondent) states that one bicycle covers a space in which four passengers could accommodate, that's why he does not prefer to take someone with a bicycle in order not to suffer other waiting passengers specially when he is driving a solo bus type. Four of the respondents replied that they allow bicycles as there is enough space to accommodate them in the buses. Four other drivers answered that they meet some passengers who wanted to carry bicycles in a box to transport them for their children. This is mostly related with the settlement of this district having a route on a main bicycle store which is *Yiba Çarşısı*.

4.2.1.7. The Applied Procedure about the Time Spent at Each Bus Stop and Related Problems

In this question, it is asked "Are there any rules applied while approaching or leaving the bus stop, and waiting in the bus stop? If there are, do you have a trouble related with them?" The current application for the arrangements of bus services are made with a card system. These cards, which are always updated and provided for the bus drivers, include a schedule containing a timetable only with starting of every service is specified. The bus drivers try to keep in step with the schedule given for each service and they generally drive faster to catch the schedule and they even renounce from their resting hours. The waiting of bus at a stop is only associated with completing the boarding of all waiting passengers. P2 states that they do not wait for the passengers like other public buses, yet the passengers wait for the bus.

The most common problem mentioned by the drivers is that the cards are arranged very strictly without any projection of undesired circumstances. Hence, this strict arrangement puts bus drivers into problematic situations with the lack of the flexibility of the implemented card system.

4.2.1.8. The Opinion of Drivers on Bike-Rack System

In this question, it is asked "What are the drivers' opinions about the exterior bike-rack systems mounted on buses?" Here, the drivers dissented with different points of view. Six of them exhibited positive attitude towards the proposed system, three drivers rejected it and three of them said that they would be positive only if they experience the proposed system as working in real life conditions and the bike-rack mounted buses provide them more flexible service schedules. The remaining two drivers were abstainer with the issue by mentioning that they would do anything as long as they are said to do by their chiefs. One of the drivers accepting the system also stated that the bendy type buses have enough spaces at the center corridor while it would be great for solo bus type with a limited inner space. Other positive responses are related with the need of developing empathy as their children may meet the same situation in which they want to carry their bicycles with them on buses and also the need of providing better quality of service to citizens all the time. P14 said "what is missing in our country when compared with Europe? We should be ahead of them on innovation". Negative attitudes of the drivers are based on some concerns like the increased risk of an accident and much more responsibilities to deal with in their workloads.

4.2.1.9. The Application Side Choice of the Drivers with a Bike-Rack System

In this question it is asked "at which side of the bus do you prefer a bike-rack system to be mounted?" Eight drivers stated the proper side as being back of buses while the remaining six of them stated front side. Firstly, the reasons of their back side choices are given as mainly that the system blocks the sight of drivers and decreases maneuverability of the bus specially for turning sharp corners. Another reason mentioned is passengers' lack of visibility who pass at the front of the bus in traffic lights which could cause undesired accidents. When there is a rear-end collision, according to the basic traffic rules, the entire responsibility belongs to the vehicle behind. Thus, some bus drivers believe that back-side application would be much more convenient for them. Moreover, some roads with damaged surfaces reserve deep holes which cause of the bus to rub its front bumper and may cause the bike-rack system to be broken. Furthermore, in the front panel there are already lots of various equipment which could disturb the concentration of drivers and this system will add more for their taught. Lastly, the drivers mention that following vehicles would arrange their distances in relation with the bus by seeing the system.

The bus drivers who preferred front-side rack system mentioned distinct reasons. The most common reason is given as that the drivers think they would have the control of the bike-rack when it is within sight. Moreover, they believe that they would have much more control to keep themselves from sudden problems occurring during ongoing traffic reflexively. Also, they are worried as they might not realize when a bike falls out of the system while bus is going as they could not check the back cameras all the time. Some drivers insist on that it is hard to associate footage with real image. The ones of this claim explain the situation in a way that bendy type buses have back camera but it does not offer an effective usage for them. The last problem is about skater who could hang on the bike-rack system which worries the drivers about undesired accidents and injuries.

Apart from these reasons, parking layout is mentioned as a significant consideration on the proposed system. Drivers state that the current parking area of buses is arranged of buses in a very tight order which enables buses hardly to be placed opposing to each other and a limited space for one bus could only pass in this narrow gap. That is why, extending the bus length with a bike-rack system would cause the whole layout to be changed accordingly.

4.2.1.10. The Control of the System

Nine of the interviewees responded that the system should be under the control of cyclists while the remaining five drivers think that the whole control should be on drivers' responsibility. Almost all of the drivers prefer a system which is controlled electronically by them with the use of a button placed on the dashboard (as mentioned before, the current activation button of disabled chair ramp is placed near the middle door) and some features such as different signalization and reviewing monitor are added. Drivers who prefer the system to be controlled by cyclists themselves have some reasons. One of the most mentioned is hesitation of taking responsibility, in case bicycles placed on the system accidentally fall or are damaged. Another reason is that bus drivers have heavy workload such as controlling ongoing traffic, passengers and tickets; that is why managing the system would increase their daily routines. In some circumstances when the inner population of the bus is crowded, drivers believe that they cannot leave the cockpit to help cyclists.

Five drivers replied that they would like to control the system by themselves. All of these drivers believe that the most appropriate solution is based on self-control as they do not trust cyclists with a hesitation of that they cannot secure the system as it should be. They give disabled chair ramp as an example by stating they are trained to use the system and therefore all responsibility is given to them.

4.2.1.11. Helping Cyclists Using the Bike-Rack System

In this question "Would you help cyclists who are not familiar with the system if they needed?" is asked. Ten drivers replied as they definitely would. Two of them mentioned they would decide whether they would help or not due to the traffic and passenger conditions at that time. The other two drivers answered that they would not help. One of them justifies his decision with his opinion of cycling as an arbitrary activity and the other one claims that he cannot leave the bus under any conditions.

4.2.1.12. The Procedure to be Applied during a Malfunction

Here, "What is the applied procedure during a malfunction?" is asked to learn the procedure applied is definite and known by all drivers, when a failure occurs about whether with ongoing bus. The basic rule is prohibition of any intervention by drivers except from a fire. Nevertheless, some experienced drivers mention that they try to solve less significant failures by themselves such as problems with doors or displacement of a simple socket at motor compartment in order not to suffer passengers in the bus. The general process with a malfunction case is informing trouble shooting department about the situation. The bus service comes and either solves the problem on location or carries the bus for further repair with the help of a tow truck. Another bus is substituted for the driver with which he continues his service by transferring passengers onto it. As a daily routine, each driver checks the motor compartment by opening its cover in order to see whether there is any problem with the oil level and motor belts or not. This gives a significant insight about that the proposed bike-rack system should not block the access to this section of the bus or it should be adjusted for instant interventions when needed.

4.2.2. Interview with the Traffic Planner

In the last part of the field study, a traffic planner is interviewed with six questions to inquire his opinions about the development level of current public transportation infrastructure, the position of a bus in this system, cycling-transit integration, promotional initiatives for cycling and the liabilities which should be considered after implementation of bike-rack system on buses. The major limitation with this interview is its being mostly related with the public transportation network of Ankara yet it has a significant potential as it brings with a different perspective of a policy-maker.

4.2.2.1. The Position of Buses in the Public Transportation System

The position of buses in Ankara public transportation network is defined with two types by the interviewee as being the buses under control of EGO and the ones under control of private sector enterprises. The overall weight of public transportation in Ankara is reported as 58.1% with the newest research and the rest 41.9% is constituted by private transportation in which it also includes transportation via taxi with 4.8 percent. 58.1% value of public transportation weight is distributed to transport vehicle types including Ankaray, Metro, suburban train, EGO buses, private buses, minibuses and school or work service vehicles. Only mentioning the buses connected to EGO, the weight is 22.5% while the private buses managed by transit agencies constitute 6.5% of total public transportation. The interviewee also mentioned that such a level of 58.1% is very high compared to other capital cities in the world such as in Barcelona where the ratio is 26%.

From the above mentioned statistics obtained through the interview, it can be inferred that bus is the basic means of public transportation volume in Ankara as being a clear leader among other types and buses are the most convenient form of transport through which such a system will bring enormous returns in an efficient manner.

4.2.2.2. The Bus Stops Features and Principles

In this question, it is asked about the standard procedures applied for bus stops like the one of the interviewed bus drivers mentioned before. The interviewee answered that there is not a time limitation for bus drivers on each bus stop but a total cycle time of their services. Most importantly, the structure of current bus stop infrastructure is explained as whether there needs an improvement with applying the bike-rack system on buses or not. It is stated that there is not any space problem with current bus stops. Either buses use lay-by if exists or approaches to bus stop if a lay-by is not available. The interviewee mentions that the bus drivers would be trained and warned for paying attention to stay in a relative distance from a bike-rack mounted bus. To give an example, he mentions that since the divided spaces for bus stops are much bigger than required in Demirtepe neighborhood, while there are 40 routes in which 40 buses stop by in a line, two buses come side by side very occasionally.

4.2.2.3. Initiatives to Promote Cycling

For the interviewee, the most significant starting point for extending cycling is heavily associated with the development of current public transportation infrastructure including developing more secured bicycle parking spots and divided road specified for use of only bicycles. Ministry of Environment and Urbanization has newly issued a circular letter about revising the current infrastructure to be made convenient for cycling. This initiative is expected to accelerate the spread on applications about cycling to be promoted. Moreover, the success of this initiative is affected mostly by the topography of the city. When Ankara is approached, there is an altitude that differs from 800 m to 1300 m which consists of steeps with an angle of 11% at Keçiören and 12% at Çankaya. In other words, Ankara is located in a place where north, south and east sides are surrounded by rugged terrains preventing ideal cycling conditions. Only the west side of the city has planer characteristics which makes the implementation of the proposed cycling infrastructure possible. For proper riding, the maximum inclination angle is limited with 3.5-4 degrees in the circular letter. In this respect, it explains why Konya has the highest rate of cycling in Turkey. From this point, the proposed bike-rack system can be inferred as being a valuable means for integration of cycling with transportation which would help the cyclist to keep up with obstacles related with the topography of the city. With the use of such a system, cyclists would have the opportunity of arranging their total travels combined with buses for challenging spots as a result of rough topographical layouts.

4.2.2.4. The Opinion about the External Bike Rack for Buses

In this question, the interviewee responds to the subject of applying external bike rack on buses from his point of view. He stated that he has seen examples of these systems mounted on metro his travels abroad but never seen the bus-type. It is emphasized by him that the major attitude of all passengers is based on making faster and more comfortable travels to their destinations. Hence, managing provisions for a better and more efficient service quality as being a manager, he pays very much attention on concerns and wishes of transit users. That is why, the interviewee firstly hesitated about whether this system requires extra time which causes route delays and causes other passengers and the driver to feel disturbed correspondingly, however, after seeing how practical the system is by a video recording, he became convinced that the system could be loaded or unloaded while other passengers are boarding and leaving.

He also mentioned that they have already made a major transportation plan of 2028 in which the cycling infrastructure constitutes a major part of it, yet the content of this plan was not explained in detail. Finally, he stated that a bike-rack system proposal would find place with the scope of *2028 Ankara Transportation Plan*.

4.2.2.5. Advantages and Disadvantages of a Bike-Rack System for the Interviewee

The interviewee stated that the functioning of public transportation system is measured through its effectiveness about the time notion. The calculation is made based on elapsed time for a passenger to board through which just a second makes a huge difference when nearly 9000 services are added to this conjecture. That’s why, he believes that the system is beneficial for encouraging more users as long as it does not cause any delay for the rest of passengers and scheduled structure of the service.

The interviewee also adds that the system is quite reasonable for a capital investment and it does not cause any visual pollution.

4.2.2.6. Effects of Cycling-Transit Integration on both EGO and Bus Drivers

Mounting a bike-rack on buses both concerned EGO as being the establishment which brings it into force and drivers who are responsible with all issues related with buses. The interviewee stated that the undesired circumstances such as bicycle's being damaged by some reasons could be compensated by EGO with a recovery of damage level through written regulations.

For the bus drivers, he mentioned that every group of them distributed to five zones of Ankara is trained and supplied with educational materials theoretically and practically on the usage of the proposed bike-rack system and on the ways controlling and operating it in their districts. The application would also be easier for the interviewee as buses are rubber wheel systems which makes them much flexible compared to other types of public transport such as trains and metro.

CHAPTER 5

ANALYSIS OF THE ELEMENTS AFFECTING THE DESIGN PROCESS

The applied action research process for designing a bike-rack system is managed by the analysis and exploration of major four related elements by defining all of them separately in order to take the proposed solution, which was created by *MAN Türkiye R&D Department*, forward in comparison to the current applications in the market. Both literature review and the first field study results are incorporated to the design process after being evaluated to utilize as basic design criteria for new bike-rack system proposals. Hence, the amount of data obtained both from different stakeholders in the first field study stage and from current bike-rack systems are combined so as to form three different design alternatives of a bike-rack system.

These related elements are (1) existing external bike-rack systems manufactured by two different companies, (2) the design proposal which is built by a mechanics expert who works in the *Research and Development Department of MAN Türkiye*, (3) basic structure of a bicycle and (4) Lion's City which is selected as a base model among the ones for inner-city public transportation, on which the new bike-rack system design is supposed to be mounted.

5.1. Exploring the Current External Mounted Type Bike-Rack Systems for Buses

As a result of a market research which is conducted to identify available examples of external bike-rack systems for buses in the world, two major companies have been found as being the dominators of the market located in the United States. In this section, product range of them with bike-rack systems will be given particularly for each company. General technical features, specifications and benefits of bike-rack systems which are proposed by these companies, implementation of them on buses and usage scenario will also be mentioned with separate titles, however, these issues are almost common in both company products as they function based on the same principle with similar layouts.

5.1.1. The Major Bike-Rack System Brands

These two American companies which are specialized mostly on bike-rack systems for buses are *Sportworks*, which is the pioneer on the subject and founded in 1990, and *Byk-Rak* which is relatively a new enterprise since 2002.

5.1.1.1. Transit Bike Racks by Sportworks

Sportworks transit racks are the most widely used bicycle transport systems in the market and over 500 transit agencies throughout North America use their products. In the latest collection of *Sportworks*, five different transit bike racks are offered with two layouts of accommodating either two or three bicycles. The working principles of all five models are the same while the most determined layout consideration is made relatively with the type of buses on which the appropriate model would be mounted at front sides.

The most common type is two-bicycle racks while the three-bicycle type has been gaining more importance lately in order to serve for against capacity constraints mentioned in the literature review chapter. *Apex 3* and *Trilogy* models are three-bicycle transit bike racks which are shown in Figures 5.1 and 5. 2. One of the most important disadvantages of the front-mounted type of carriers is blocking the headlights and side signals of buses which cause the system to be useless during night times as mentioned also in the literature review part. Although there are some certain differences between three-bicycle capacity models about their technical specifications, the most radical distinction is that their layouts are different as being arranged according to front panel layouts of specific buses which differ from each other and which are the specific brands commonly used as a public transportation vehicle in the North America. In *Trilogy* model of transit bike rack, it can be seen easily that the frame structure of this rack system is developed with the help of references based on curves with headlight placement of the bus front panel in order not to block headlamps when the rack system is stowed.

Figure 5.1 *Apex 3* (sportworks.com, 2016)

Figure 5.2 *Trilogy* (sportworks.com, 2016)

The working principle of all external bike-rack systems in the market are the same but differs on some details by each company. They are mounted at the front side from bumpers and ready to use after being turned at its pivot point in the level of bumpers to a horizontal position by releasing the locking mechanism. Bicycles are lifted to be put on housings of framed-structure in a vertical position and locked with the help of a support arm which catches bicycles from their front wheels and tightens up as stable without tying any extra belts or cords. The whole process is controlled by the cyclist manually in a very quick manner.

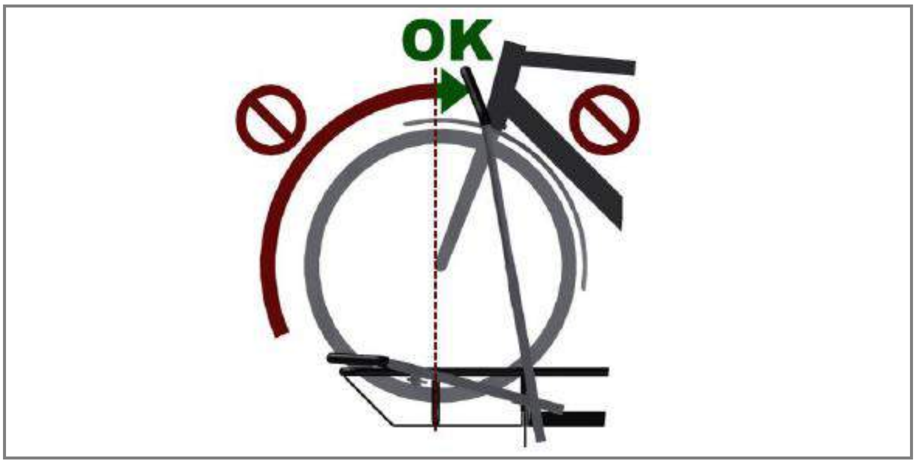

Figure 5.3 Locking Mechanism by *Sportworks* (sportworks.com, 2016)

In the product range of two-bicycle capacity carriers of *Sportworks*, three more alternatives are given by *Sportswork* which are *VeloPorter 2*, *DL2* and *DL2 NP* (Narrow Profile) (Figures 5.4-5.6). These models are preferred by the agencies who do not have high capacity demands and who operate smaller vehicles. *DL2* is the most widely used transit bike rack in the world which is started to be manufactured in 1992 and still in use by the majority of buses throughout North America.

Figure 5.4 *VeloPorter 2* (sportworks.com, 2016)

Figure 5.5 *DL2* (sportworks.com, 2016)

Figure 5.6 *DL2 NP* (sportworks.com, 2016)

5.1.1.2. Transit Bike Racks by Byk-Rak

Unlikely *Sportworks, Byk-Rack* develops only products with externally front-mounted bike-rack systems. The proposed solutions about a bike-rack system which is designed by *Byk-Rack* is suggested in four kinds. Three of them are very similar in both their layout and functioning with the solutions of *Sportworks*. These three types are classified by their bicycle carrying capacity which has a range between accommodating merely one bicycle up to three. *1 Position* type has a different feature through which the rack is always in a locked deployed position where only one bicycle can be placed and this type is used mostly on pick-ups and vans at their front sides. Other two types which are *2 Position* and *3 Position* are very similar to the ones of *Sportworks'* solutions with a capacity of two and three bicycles which are given in the below figures. The major difference is about the support arm mechanism which is given in Figure 5.7, illustrating its functioning from which it can be compared with the support arm solution of *Sportworks.*

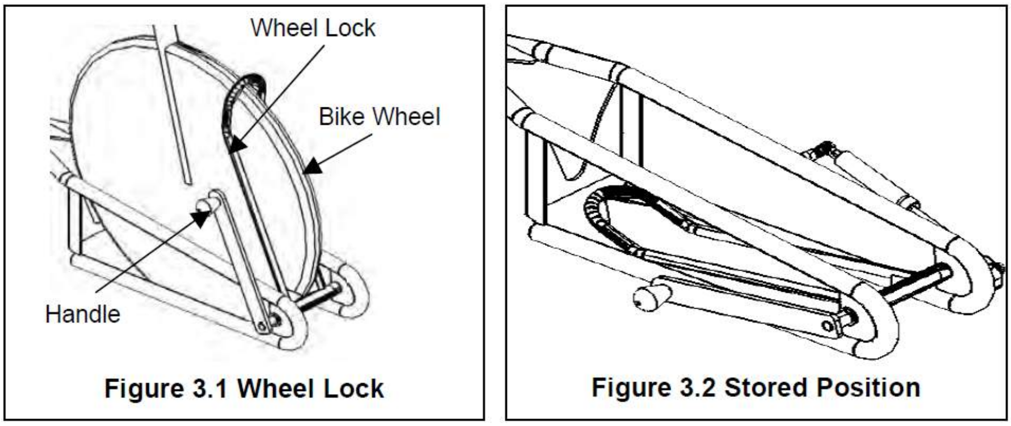

Figure 5.7 Locking Mechanism by *Byk-Rak* (bykrak.com, 2015)

Moreover, the common characteristic of these three types is stated that they are cost-effective and they also function in a very fast way which would not slow down bus schedules.

The fourth type which is *Activator X1* is the most innovative approach on such a system which differs from its counterparts as its being controlled semi-electronically by bus drivers with the help of a button placed on the dashboard. The system can be stowed when it is empty by the driver through an electro-hydraulic actuator helping structure turned at its pivot automatically. The images are given in Figures 5.8 and 5.9.

Figure 5.8.a *Activator X1* (bykrak.com, 2015)

Figure 5.8.b *3 Position* (bykrak.com, 2015)

Figure 5.9.a *2 Position* (bykrak.com, 2015)

Figure 5.9.b *1 Position* (bykrak.com, 2015)

5.1.2. Common Technical Features and Specifications of Transit Bike Racks

In order to give some measures applied by transit bike rack manufacturers about the features and specifications with this system, relevant design considerations were searched through product manuals which are available at websites of mentioned companies and combined in list generalizing common features with their benefits in the list of Table 5.1.

Table 5.1 Technical Features and Advantages of Current Bike-Rack Systems (sportworks.com, 2016; bykrak.com, 2015)

Technical Features	Advantages
• The rack system is 30 inches deep by 55 inches wide. *(these values can change with the capacity of the rack system)*	• The rack system is large enough to hold adult-sized bikes (excluding tandem and recumbent) and designed to hold smaller bikes—down to a children's size of 16" diameter wheels.

Table 5.1 Continued

Technical Features	Advantages
• The rack system weighs less than 30 pounds. *(these values can change with the capacity of the rack system)*	• The rack system meets OSHA standards for lifting by a single individual, and anyone can raise or lower with one hand, ensuring convenient operation.
• The rack system can be lowered or raised with one hand.	• This leaves the other hand free to stabilize the bike so the rider can operate the rack system independently.
• All moving parts on the rack system are made of stainless steel.	• Stainless steel is corrosion resistant and will not chip like plated or coated steel.
• The rack system is mounted to the front of the bus.	• Front-mounting the carrier increases driver visibility, safety, and security.
• The rack system has two locking positions, stowed and deployed.	• In the stowed position the rack system protrudes minimally for increased maneuverability.
• The rack system has rounded outside corners, smooth welds, and few 'pinch' joints.	• These safety features lessen the likeliness of an operator being injured.
• The rack system does not block wipers or access panels in the stowed position.	• The carrier mounts to right to the bumper and bikes are held far enough away to not interfere with wipers or access panels.
• Bikes can be unloaded from the sidewalk side or front of the rack system.	• Bikes never need to be unloaded from street side so the user is not exposed to traffic.
• Bikes can be independently loaded or unloaded.	• This allows either bike slot to be accessed at any time.
• The rack system is constructed to support over 250 pounds in the central portion. *(these values can change with the capacity of the rack system)*	• This allows the carrier to easily hold heavy bikes and provides for misuse, such as someone climbing on to it to reach a mirror or window.
• Bikes are secured solely by the front wheel lock.	• This means loading and unloading times are under 10 seconds so use of the rack system will not affect scheduling.
• The rack system only makes contact with the tires of the bicycle.	• Bike frames or other parts will not be scratched or damaged.
• The rack system accepts bicycles without any orientation of the pedals.	• This speeds up loading times because the user need not adjust the pedals to miss any part of the rack system.
• The rack system has no pins, clips, or straps.	• There are no loose parts to break down or become lost. This also contributes to the fast loading time.

Table 5.1 Continued

Technical Features	Advantages
• The rack system has few parts.	• A simple construction ensures ease of use and high reliability.
• The wheel lock folds away when stowed.	• The wheel lock folds into the center of the rack system automatically so it will not damage the front of the bus.
• The bumper mounting bracket is adjustable via multiple bolt-holes.	• The rack system's height can be adjusted for different buses or routes.
• The Hinge Bracket is designed to attach to all mounting brackets similarly.	• The rack system can be installed on any bus through the use of different mounting brackets.
• The bicycle rack can accommodate tire widths up to 2.35 in.	• Accommodates most mountain bike tires.
• Continuous support is provided for the rear wheel of the bicycle allowing it to be rolled into the position closest to the bus without lifting	• Allows the rider to easily load and unload a bicycle in the position closest to the bus by rolling it into position rather than being forced to lift it into position risking possible back injury.
• All outside corners of the bicycle rack is preferred rounded.	• Rounded corners are friendly to users' legs when loading and unloading their bicycle. This also reduces wear on bus washing systems.
• Attaching a bicycle to the rack is not require the use of any straps or cords.	• No straps or cords to wear out during the service life of the unit, further minimizing maintenance costs.
• The bicycle rack is compatible with a mounting bracket that can be completely removed from the bus in less than ten seconds.	• Allows the rack with the bracket attached to be quickly removed from the bus in the field for towing or in the shop for seasonal removal or repair.
• Maintenance of the bicycle rack does not require the use of any surface lubrication.	• Eliminating the need for liquid lubricants greatly reduces the likelihood of binding due to road debris build-up on moving parts.
• The bicycle rack shall is designed specifically for commercial transit use and not for consumer use.	• The transit environment might destroy a rack made for occasional consumer use.
• The bicycle rack is clearly marked with easy to follow instructions for operation.	• Educates the user as to the correct orientation of the bike when loading, further ensuring the shortest loading and unloading time possible.

Specifications of the current transit bike racks are determined by consulting transit authorities in order to assess the compatibility of the systems provided by *Byk-Rak* as mainly having four qualities mentioned in 2016 *Byk-Rak* manual which are "easy operation, economical choice, durable construction and bus wash compatibility of transit bike racks” (p.1).

Two illustrations are given in Figures 5.10 and 5.11. In the first one *Apex 3* type by *Sportworks* is seen with its specifications and in the second one, a typical system by *Byk-Rak* is shown by each of *2 Position* type components. These components and their relations to each other are the same with all current transit bike racks, yet distributed in different layouts of structural frames.

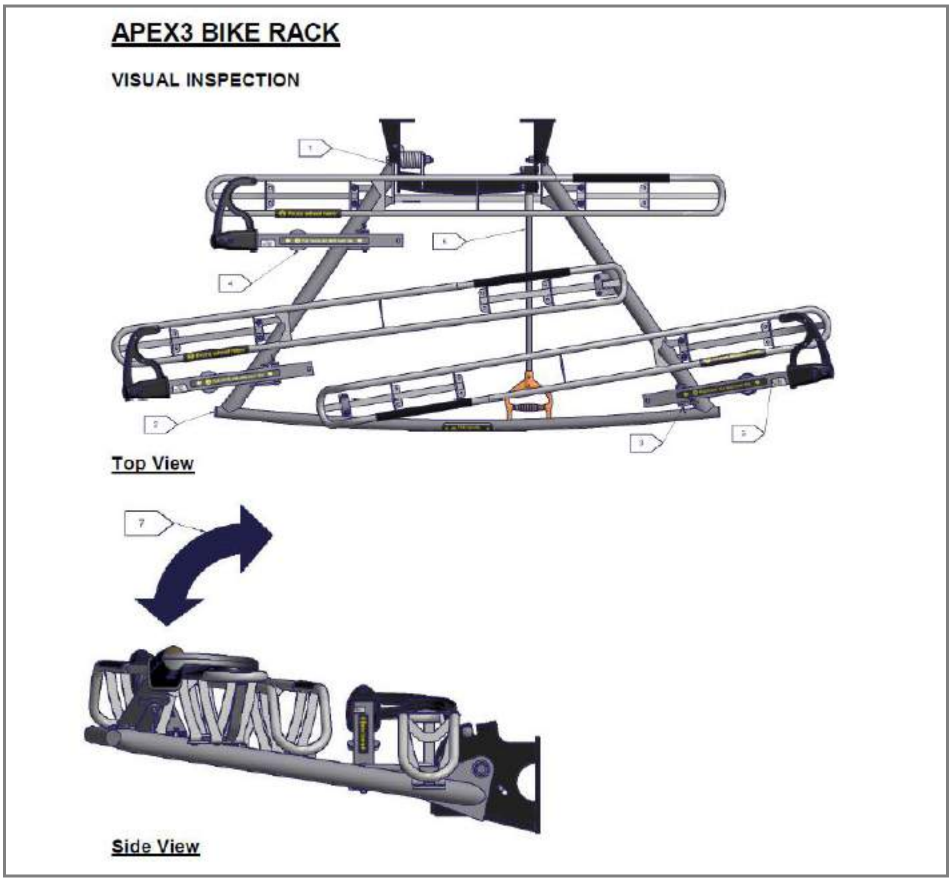

Figure 5.10 Specifications of *Apex 3* (sportworks.com, 2016)

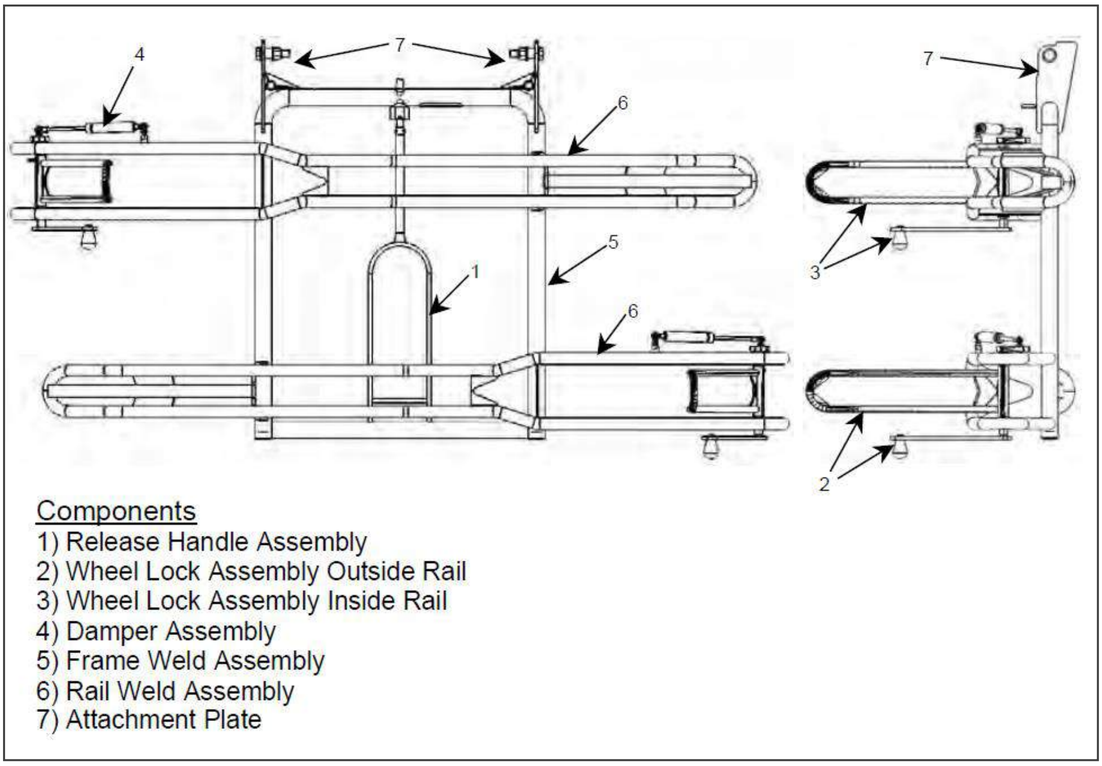

Figure 5.11 Components of *2 Position* (bykrak.com, 2015)

5.1.3. Key Features of Transit Bike Racks

Seven key features of the transit bike racks are mentioned by both manufacturers. These key features are mostly related with the issues of ease of use, safety, practicality and bicycle compatibility:

(1) **Independent loading and unloading** is aimed as multiple bicycles are placed side by side relatively to each other in an array on the rack systems. The most critical problem about this issue is providing a convenient access to the bike placed inside during loading or unloading process without removing the bike(s) placed outside. The current rack system models are approached from street-side to the inner housing which requires much effort and time for the usage of the system relatively.

(2) **Safe use for bicycles** is about preventing the bicycle from damages that could arise during the usage of the rack system. Hence, the bicycles are fixed to the rack system from their wheels which is implemented by all current bike rack system types eliminating any chance of scratched paint or other damages.

(3) **Convenient, secure wheel lock** is a major component of a rack system which enables bicycles to be secured after loading. It is a spring loaded lever which is

swung around the front wheel and locks the wheel at a point which could differ based on various types of rack systems.

(4) **Load/unload speed** is a major issue which is aimed to be solved as fast as possible in order not to cause route delays. In the *Byk-Rak* manual 2016, it is stated that even cyclists who had no experience with the rack system were invited to use the system for both loading and unloading process in order to test the speed of the system. This testing proved that the bike rack system sample by *Byk-Rack* operates with an average time for either loading or unloading of 10 seconds or less.

(5) **Operation with one hand** is one of the very essential features of a rack system as cyclists should hold their bicycles while locating the locker lever or releasing it during loading and unloading processes.

(6) **No loose parts and simple construction** is aimed by rack system manufacturers to lower costs with a simple system structure. Loose detachable parts such as straps, belts or pins are not preferred by them as they could be lost.

(7) **Bicycle Compatibility** as a rack system feature is arranged in a flexible manner through which the system would compensate the size differences of the placement for various bicycle types.

5.1.4. Application Procedure of Transit Bike Rack Systems

All external bike rack systems consist of body and bracelet. Bracelet is fastener of the other body part which is connected to the bus from a bumper level. Mounting an external bike rack system on the front side of buses has a three-stepped progress in which firstly bracelets are connected to the bumper, yet they might also be attached to the front of the bus itself depending on the bumper type. Secondly, both the height and position of the system can be arranged according to left/right positioning and desired height level which is appropriate for the bus with the use of proper segmented holes for the hinge bracelet. Lastly the body of the structure is installed easily on before adjusted hinge bracelet by fastening with bolts.

The effectiveness and safety of the rack system are mostly affected by proper installation. Hence, during a bike rack system installation, there mentioned four factors in *Byk-Rak 2016* manual which should be considered when setting the system. (p.2)

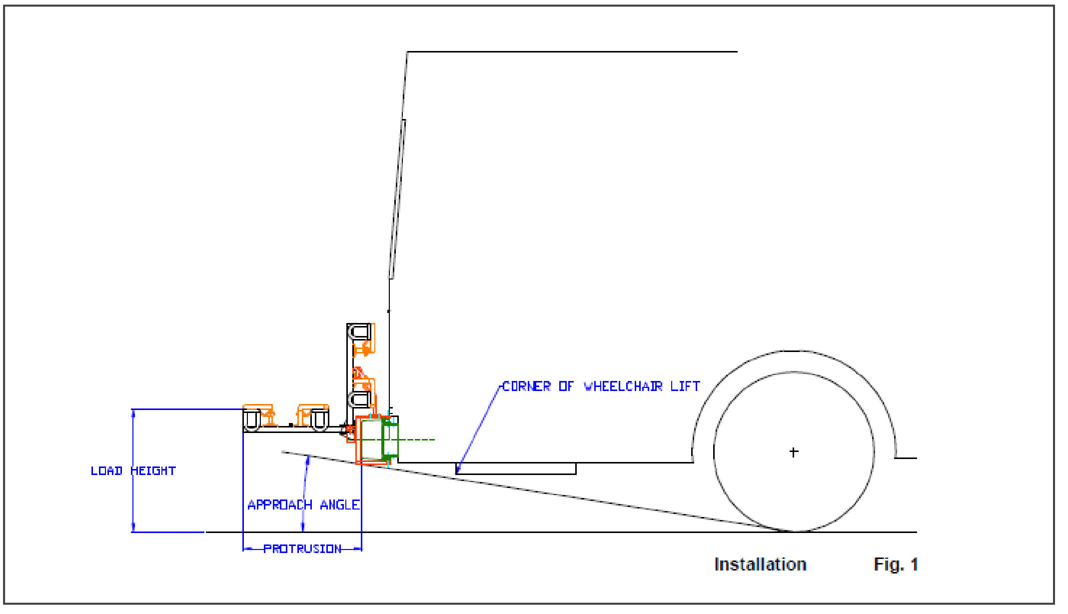

Figure 5.12 The Diagrammatic Representation of Key Factors (bykrak.com, 2015)

Three of these factors are given with an illustration in Figure 5.12 and the remaining one is shown in Figure 5.13:

(1) **Approach angle** is defined with the relation formed by a line starting from the front tire to the first obstacle ahead of it with ground level. This angle refers to the degree of inclination in which the bus could drive. That is why the rack system should not be installed too low as it would affect the approach angle of the bus.

(2) **Loading height** means the vertical distance through which the bicycles should be lifted onto the bike rack system by the users. Hence, the system should not be mounted too high as it would make the loading process much more difficult.

(3) **Protrusion** is the added distance with the installation of the rack system from the bumper to the furthest edge of the system when it is open as being in a deployed position. This factor should be arranged reasonably by the bike rack system manufacturers as the increase in this distance would also raise the turning radius of the bus while both decreasing the maneuverable skills of the bus and the approach angle. Moreover, increased protrusion would cause the system block of the viewing of the bus driver so that it can interfere with the windshield area when it is in stowed position. Lastly, it is reported in the manual that “bike rack protrusion is limited by many state Departments of Transportation such as California’s limit is 36 inches” (p. 13).

(4) Final factor which should be considered is **footprint** which is outline of the bike rack system when it is in stowed position parallel to the bus vertically. In this respect, the system should be installed carefully in order to avoid blocking the headlights and signals of buses.

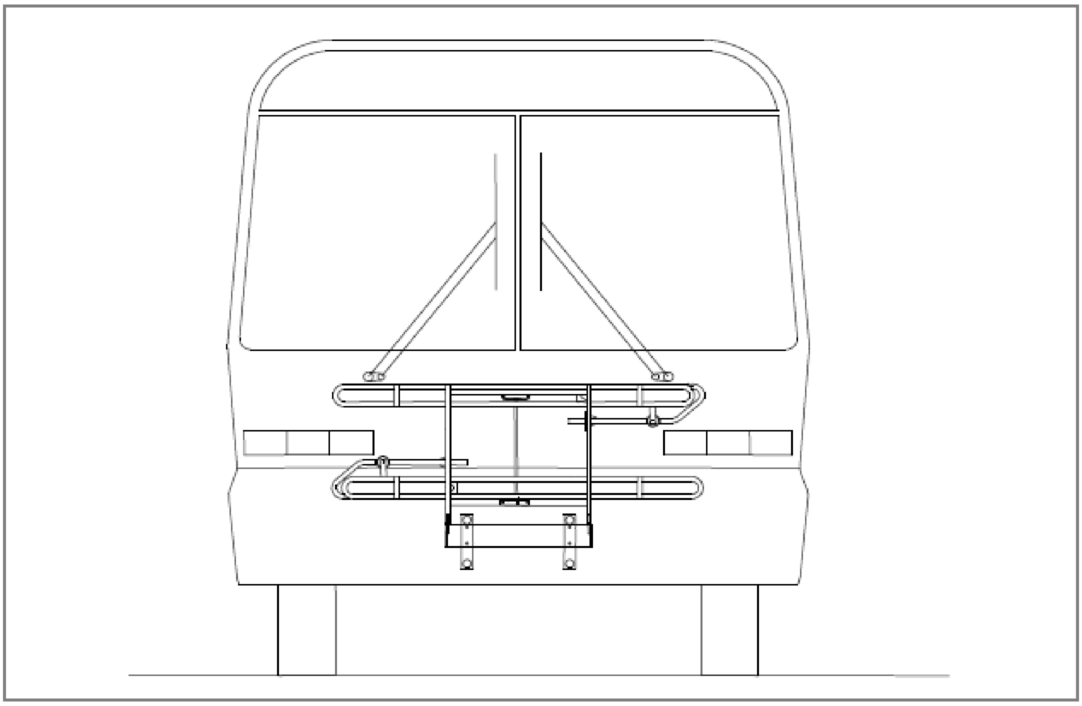

Figure 5.13 Footprint of the Bike-Rack System (bykrak.com, 2015)

5.1.5. Usage Scenarios of Loading and Unloading the Bicycle

The current bike rack systems which are mounted at external front side of buses are used in three steps for loading the bicycle into it (Figure 5.14). Firstly, approaching from the curbside, the position of the system is turned from stowed to deployed position by pressing the lock handle which would release the main housing tray to be turned about 90 degrees. The rider lowers the rack with one hand while supporting the bicycle with the other hand.

Figure 5.14 The Stages of Loading the Bicycle (sportworks.com, 2016)

Secondly, the rider lifts the bicycle to place it into one of the available housings on the tray. The existence of another bicycle in the system does not affect the loading, but some types of bike rack systems require a reverse placement of bicycles in relation with each other.

Finally, placed bicycle into the bike rack tray is secured with the help of a support arm mostly returning the lever over the top of the front wheel. The lever should be closer to the head tube than the peak point of the wheel for ensuring the stability and security of the bicycle.

5.2. The Proposal Suggested by MAN Türkiye

As mentioned in the beginning of this chapter, the externally back-mounted bike rack system proposal which was developed by a mechanics specialist working for *R&D Department* of *MAN Türkiye*, initiated the process of this research.[1]

5.2.1. General Characteristics of the Proposed System

The proposed solution was based on the idea of mounting the rack system at the back side of buses as an application for a patent and it was a rough conceptual set up of the system which was not elaborated much in details, yet some certain features were identified. These features and proposed characteristics about the bike rack system can be listed as:

- Five bicycles capacity.
- Easy and fast connection of the system constructed by steel with bracelets mounted at four points of the back surface of buses.
- Additional headlights which are located at the system frames in order to make the system visible for following vehicles in traffic.
- Vertical alignment of bicycles side by side.
- Signalization of operating system with auditory warning for pedestrians.
- Controller for the bus driver with an interface which is located in dashboard if the system is decided to be work electronically.
- Providing access to the motor compartment of buses by the rack system's being turned around hinges pivoted from one side.
- Locking sensors for ensuring of appropriate loading of each bicycle.

[1] The mechanics specialist who works for R&D Department of MAN Türkiye is Oğuz Ünal.

This bicycle rack system proposal was also illustrated which defines its layout and relation with the bus. These visuals are given in Figures 5.15, 5.16 and 5.17 to address the above mentioned features in the application of the system conceptually.

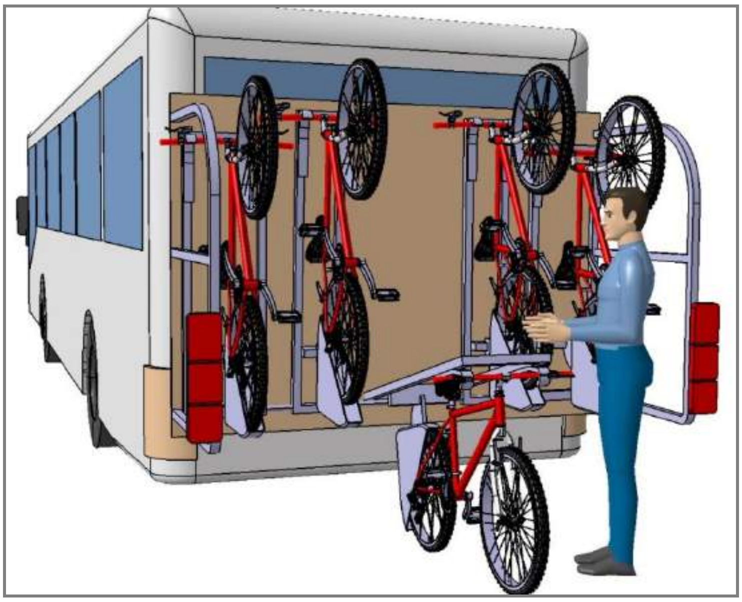

Figure 5.15 Loading Process of the Bike-Rack System

Proposed by the Company

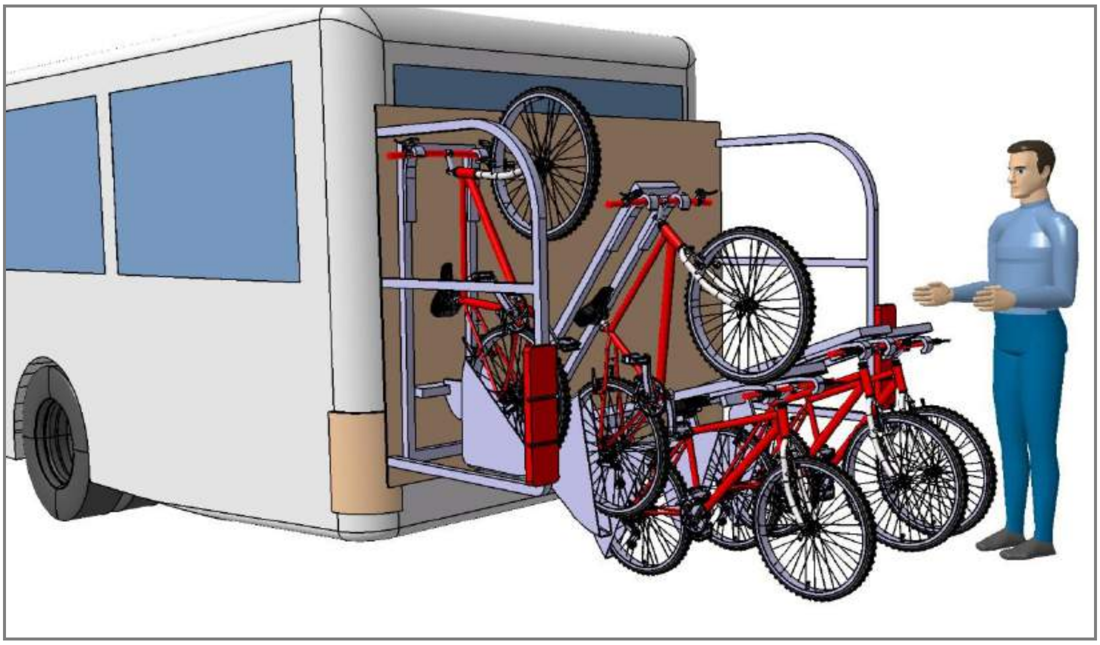

Figure 5.16 Unloading Process of the Bike-Rack System Proposed by the Company

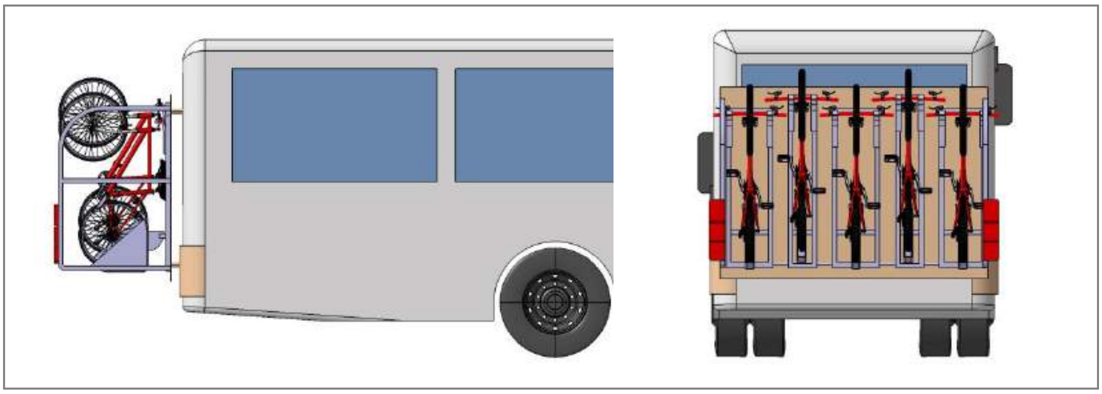

Figure 5.17 Storage Position of the Bike-Rack System Proposed by the Company

5.2.2. First Assessments on the Proposal

The major features which are the back placement of a rack system and the vertical alignment of bicycles against backside of buses differentiate this idea from current transit bike rack systems which are mentioned before. Mounting the rack system at the back side of buses proved to be convenient as most of the interviewed drivers in the first field study preferred the back side of buses for the system to be mounted. Proposing the placement of the rack system at the back side effects and makes the other major feature of such an alignment possible with the use of entire surface to the full extent limited by the furthest edges of the bus. In respect to this issue, one of the most significant limitation of current front-mounted rack systems is their capacity which is an issue also mentioned in the literature review section several times. As buses have large windshields for enabling bus drivers' larger field of view, front-mounted rack systems cannot exceed the limit so that the system can interfere with windshields in its stowed position. That is why, maximum three bicycles can be crammed in into the limited area of front side of buses. However, back sides of buses are suitable and even rear windows do not constrain the use of the entire space. The possibility of blocking rear windows can be illustrated by many buses whose rear windows are covered with advertisements.

As all details with the proposed rack system were not solved, it can be criticized on what it comes to through the figures above. From these visuals, it appears that the system is too heavy which would cause problems of maintenance and it seems very bulky. Another problem with this system to be solved in the design process is that it blocks the access to the motor compartment. The proposed solution for this issue is turning the whole plate on which the rack system is connected at one side of the bus, like opening a door. Nonetheless, it can clearly be stated that, such a solution would not be appropriate for carrying that much weight by hinges. Lastly the proposed system is aesthetically poor and it has not a visual integrity with the bus on which the system is mounted.

5.3. Analysis of Bicycle Stereotype

Before starting to the design process of a new bike rack system, all bicycle types and characteristics are searched and analyzed as bicycles are very significant keys of this system to be considered. Technical details of bicycles in terms of dimensions and the overall layout of bicycles are analyzed for arranging the dimensions and proportions of the system and also for specifying appropriate connection points on which bicycles are being loaded to the system and made stable.

5.3.1. Technical Properties of Bicycles

There are many different types of bicycles in the market, however the mountain bike type is the most used one as mentioned in the literature. Although these types slightly differ from each other about their dimensions, an average range can be determined to be used in the design process except some models which are very different in their characteristics like folding-bicycles with smaller wheels.

As mentioned in the literature, extraordinary types with a less frequent use cannot be the reference for designing the rack system and they are excluded for consideration about compatibility with the rack system. The standard bicycle dimensions is dependent and identified on the wheel-sizes of bicycles. Most mountain bikes use 26-inch (665 mm-outside tire diameter) bicycle wheels and the other wheel dimensions include 29-inch (724 mm), 27.5-inch (695 mm) and 24-inch (610 mm) as common. “Wheels come in a variety of widths, ranging from standard rims suitable for use with tires in the 26 in x 1.90 in to 2.10 in (559 x 48 to 53 mm) size, to 2.35 and 3.00 in (60 and 76 mm) widths” (Sutherland, 2004). Other basic dimensions are also given in Figure 5.18 for a mountain bike type whose dimensions are applied by a random mountain bike. As these dimensions vary through different models and brands, the exact values are not essential as the bike rack system is designed through approximate dimensions by allowing tolerances for different sizes of bicycles with adjustable features.

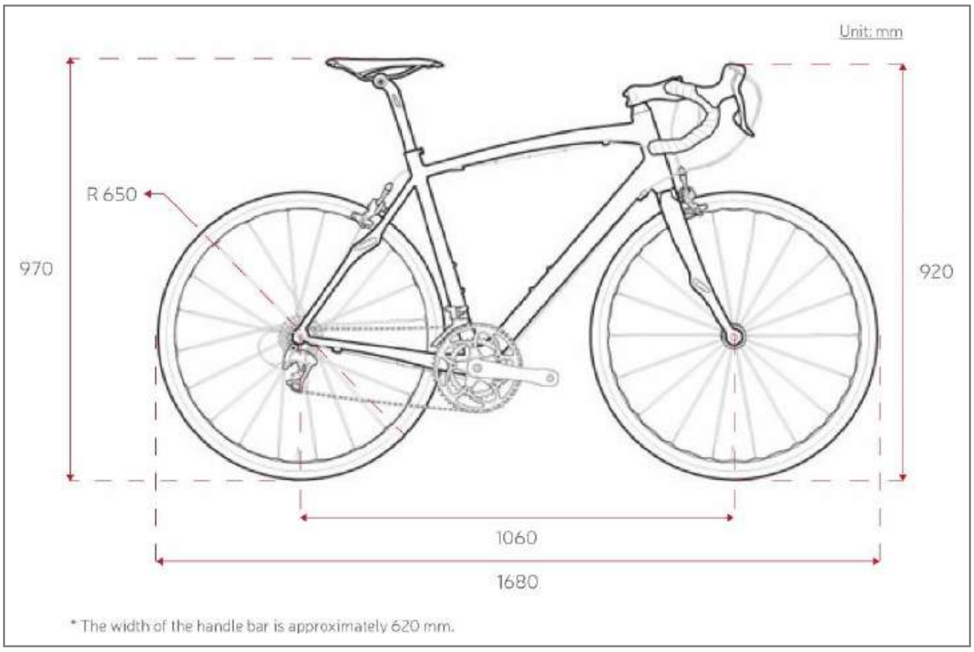

Figure 5.18 General Bicycle Dimensions

(adapted from the image of the website; cornwallcycletours.com, 2014)

5.3.2. Component Analysis of Bicycles

As in the technical properties, components of bicycles also differ from each other in their sizes and proportions related to other parts. These differences result from both type of the bicycle and brand model of it. In order to determine the connection points through which the bicycle would be held and secured during loading to the bike rack system, the most typical component should be chosen so as to make various bicycles compatible with the system and to avoid bicycles from being damaged by the system.

For managing these connection points, additional equipment and accessories, which are applied by cyclists to customize their bicycles due to their desires and needs, are also taken into consideration. In Figure 5.19, a typical bicycle is given and it is shown by specifying some areas for the attachment of additional items. In the questionnaire of the first field study, additional items are asked to the participants and these items are distributed to the specified areas. Mentioned additional items are shown according to where they are mostly installed on the bicycle in Table 5.2.

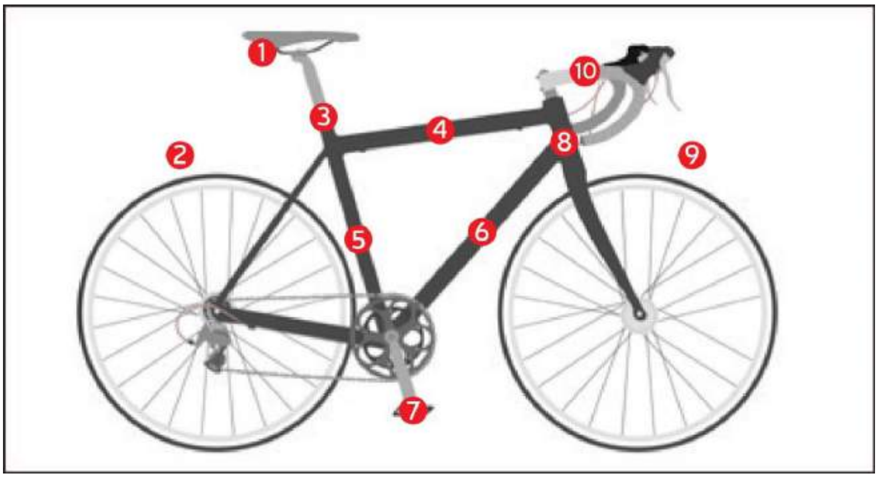

Figure 5.19 Structural Frame Types of the Bicycle

(adapted from the image of the website; dribbble.com, 2013)

Table 5.2 Additional Items Mostly Installed on the Bicycle

area - 1	bicycle / bag bag under / saddle
area - 2	back baggage / bicycle / mudguard
area - 3	lighting equipment / water bottle
area - 4	bag above bicycle frame / bicycle tool kit
area - 5	bicycle tool kit / bicycle pump /water bottle
area - 6	bicycle tool kit / bicycle pump / water bottle
area - 7	spd pedal
area - 8	lighting equipment
area - 9	front baggage / bicycle mudguard / bicycle basket
area- 10	speedometer / bicycle bell / GPS / phone holder / barend / hand grip / elbow handlebar / camera apparatus / bicycle side mirror

After searching all defined areas and structural frame types which differ by length, width, diameter and cross section properties with different bicycles, the wheels can be clearly defined as the most typical components of bicycles. The rubber material of the wheels also confirms compatibility of the wheels' being suitable for using during locking bicycles in the system as other metallic parts could be damaged or scratched while the system is holding bicycles.

5.4. Analysis of Lion's City Bus Model

After analyzing the bicycle, back side of the related bus model is searched for obtaining inputs to be considered in the process of arranging the bike rack system accordingly as to be mounted properly. All necessary documents, specifications and three-dimensional data are provided by *MAN Türkiye*. In Figure 5.20, a photograph of the bus which was captured during a factory visit is given to show the components of the back side and the relevant dimensions are shown and in Figure 5.21.

Figure 5.20 MAN *Lion's City Bus* Model

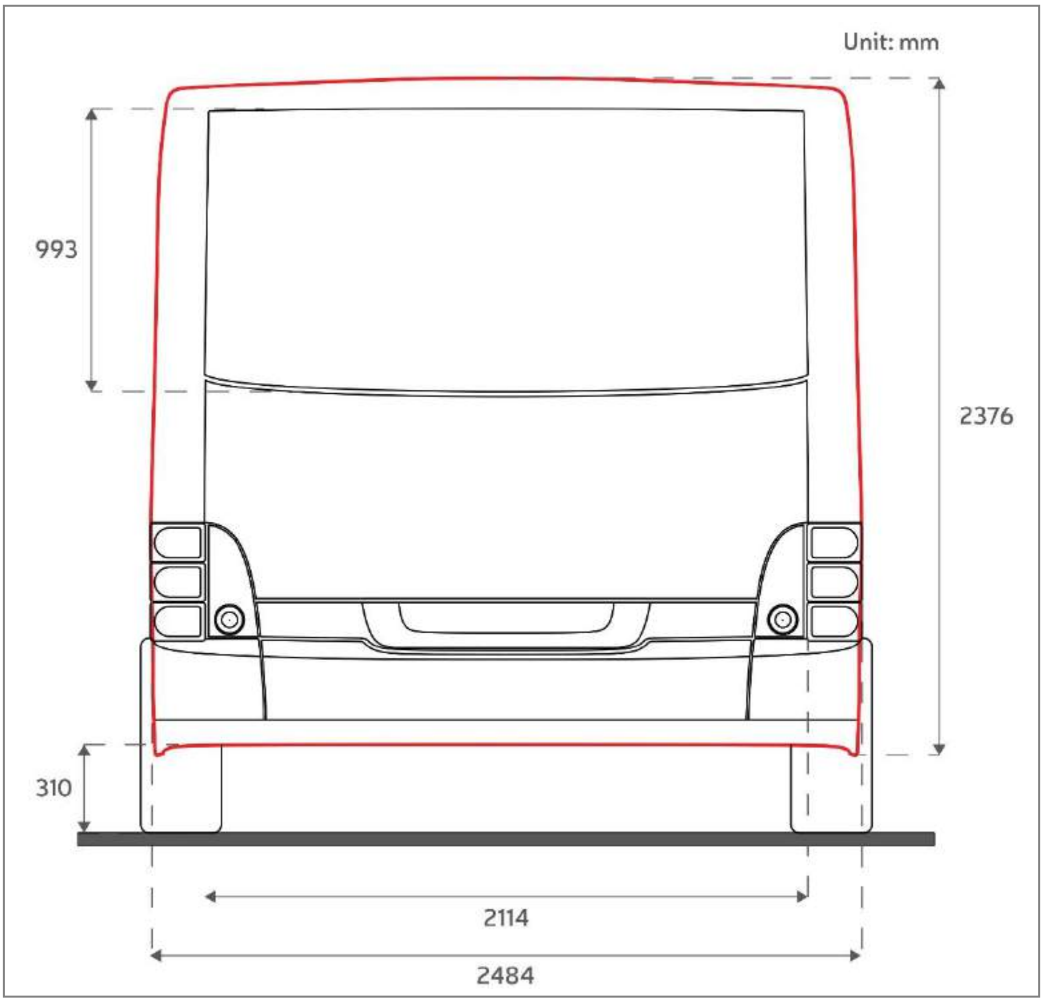

Figure 5.21 Identification of the Outer Curvature of MAN *Lion's City Bus* Model

During the visit to the manufacturing facilities of the firm, it was mentioned by the advisor, who is associated with the project, that the system could also be installed to other models of long-distance buses which are bigger in their dimensions. One of the other models, shown in Figure 5.22, which has four connection pins on which the ski box is installed. These pins are arranged during the manufacturing process as being optional like factory settings and they could be utilized for the transit bike rack system to be connected to as well. These highly improved bus models provide electrical outlets for the back side of the bus which would enable the bike rack system to be controlled electronically without any labor for building infrastructure of electricity. These features are seen in detail in the given pictures.

Figure 5.22 Back Connection Pins & Electrical Outlet of a Long Distance Bus Model

Main considerations which are specified about the bus to be utilized in the design process are motor compartment access, back border of the bus and backlights. As a system feature, all design alternatives should allow the motor compartment to be opened and accessed easily. Moreover, the bike rack system measures should be in the limits of back frame of the bus and should not cross the borders. Lastly, backlights should stay visible after the bike rack system is installed for security reasons by designing the layout of rack system structure accordingly.

Apart from these features, the design alternatives for a bike rack system are built by considering using the back side area in its maximum capacity with an efficient manner. Protrusion of all alternatives are also tried to be kept in a minimum level. Aesthetic concerns and the unity of the bus with the rack system are other main considerations as besides functional properties during generation of bike rack design proposals.

CHAPTER 6

DETERMINED CONSIDERATIONS BY DIFFERENT STAKEHOLDERS

In this chapter, considerations for designing a bike rack system for buses are gathered to utilize in the designing process. The design process is also explained through the stages based on the considerations.

6.1. Determined considerations

Thus far, the integration of cycling with public transportation is searched through the literature and opinions of stakeholders who are in relation with the subject of a transit bike rack system for buses is gathered in the previous sections of the thesis. In this part, major concerns and desires about the bike rack system are given from the findings of literature review, questionnaire which is made with cyclists, interviews with the bus drivers and the interview with the traffic planner separately under different titles. These findings about the problems of the current bike rack systems, desires of cyclists and concerns of bus drivers are integrated to the design process in order to develop better solutions and to satisfy all related stakeholders about the designed bike rack system.

6.1.1. Considerations about the Bike Rack Systems in the Literature Review

In order to define the problems and deficiencies of existing bike rack systems, all related information compiled from the literature review is given under this title. Throughout the literature, some problems are mentioned about both front and back mounted bike rack systems.

Compatibility of current bike rack systems with different types of bicycles and extra equipment attached to them are mentioned. Current systems are not suitable for accommodating bicycles which have wheels sized less than 20 inches and some extra features like crates and baskets are prohibited in these systems so that they could block the visibility of the bus driver. Another problem with the current systems is capacity limitation of racks with maximum three bicycles. Moreover, route delays of bus schedules are referred to as a result of loading and unloading of bicycles into the rack systems.

There are also explained the problems related with the back mounted bike rack systems applied by San Diego Transit. The major problem of this system is given as safety and security of cyclists who are hard to be seen and checked by the bus driver during loading and unloading process. Another problem about the back side rack system is mentioned that it blocks the access to the engine which is located at back side on buses. Lastly, exhaust gas, which is released from the back side of buses, causing bicycles to become dirty is stated in the literature review section.

These concerns are referred to as phrases which could also be used as essential features of an ideal bike rack system to be taken into consideration in the design process. These are aligned accordingly through the given scope as features to be improved which are *compatibility, larger capacity*, *fast operating, followability, engine accessibility* and *protection.*

6.1.2. Considerations Mentioned in the Questionnaire by Cyclists about the Bike Rack Systems

Throughout the analysis of all responses for the questionnaire which was participated by cyclists, opinions and perspectives of cyclists about the bike rack systems are inferred. In the first part of the questionnaire, types of bicycles used by participants are asked from answers of which revealed 10 different bike types whose compatibility with the bike rack system should be ensured as a design criterion. Moreover, when it was asked from participants to make a selection between the inner and external bike rack systems, most of them preferred the inner type. The reasons of this selection are used to detect why cyclists are concerned about the external type bike racks. It can be relevant to mention that if these concerns are considered and eliminated through the design process, cyclists would change their minds trusting the designed external bike rack system. The major concern which is mentioned was safety of bicycles. Unguarded structure of the external bike rack systems against bad weather conditions and fear of bicycles to get damaged were secondary reasons of their concerns. Other less mentioned explanations were made on need of keeping the bicycle in sight and concern about waste of time for loading and unloading operations.

Like in the inferences through literature, above mentioned concerns and desires are referred with the phrases that are *compatibility, bicycle safety, protection, checking the bicycle* and *fast operating*.

6.1.3. Considerations of the Bus Drivers about the Bike Rack Systems

When all responses given by the bus drivers who were interviewed in the first field study of the research are analyzed, back-mounted bike rack system is proved to be the most appropriate placement solution by the interviewees. Having complete authority on the rack system is mentioned as desired by the bus drivers and also electronically controlled system is preferred like wheel chair ramps applied in the new type of buses, yet with a controller which is located on the dashboard. The drivers wanted to control the rack system electronically while operating it, whereas they believed the cyclists should perform the loading and unloading processes during which they should secure their bicycles. Moreover, signalization for the system was stated as being a requirement to warn pedestrians and closer vehicles to the bus during operation of the rack system and also certain warnings were required by sensors to ensure the bicycles are being loaded appropriately and to notify the possible unexpected matters with the system like falling off a bike out of the system as the drivers mentioned that they could not check the back side camera all the time. Furthermore, the drivers were concerned that there would be some undesired accidents while some skateboarders and rollerbladers are hanging to the bike rack system when the bus is moving. Lastly, protrusion with the system was expressed to be as minimum as possible in order not to cause any problem when the bus is being parked in tightly-arranged layout of bus parking area.

From the views of the bus drivers on the bike rack system, some more criteria are built from the above mentioned opinions for the rack system design process which are *electronically controlled, loaded/unloaded by users, signalization, not allowing to hang on* and *short protrusion*.

6.1.4. Considerations of the Traffic Planner about the Bike Rack Systems

Four issues were considered to be worth mentioning by the traffic planner who is interviewed with for the managerial issues. The most emphasized concern was related with the convenience and the speed of transportation services that the quality should not be affected by the applied system in terms of time lag for both transit riders and bus schedules. Another expectation was a cost-efficient system which would require reasonable capital investment for implementation of transit bike racks on buses. Visual pollution was mentioned finally as such a system should not ruin the public transportation image.

Fast operating, *cost-efficient* and *aesthetically pleasing* are the features which are derived from the perspective of the traffic planner as being authorized for policy-making.

6.1.5. Gathered and Generalized Criteria for Designing the Bike Rack System

By assessing the mentioned concerns of different stakeholders of a transit bike rack system, 15 different criteria are determined through some certain considerations as being measures to be utilized for constituting of initiating the design process accordingly and for evaluation the system efficiency. These features are collected in Table 6.1, in which *fast operating* was stated three times, *compatibility* and *protection* were mentioned two times.

Table 6.1 Design Criteria Gathered from All Stakeholders

1) fast operating	2) compatibility	3) protection
4) larger capacity	5) followability	6) engine accessibility
7) bicycle safety	8) checking the bicycle	9) electronically controlled
10) loaded/unloaded by users	11) signalization	12) not allowing to hang on
13) short protrusion	14) cost-efficient	15) aesthetically pleasing

6.2. Design Process of Alternative Transit Bike Rack Proposals

After completing research tasks and assessments up to this point, design alternatives of a back mounted bike rack system are started to be shaped conceptually. This stage is completed in four steps which are the brain storming session, evaluation and revision of initial ideas, three-dimensional modelling of elaborated alternatives and lastly the animation process to make the alternatives easily understandable for introducing at further focus group sessions.

6.2.1. The Brain Storming Session

This session was held with participation of three experienced product designers among them the researcher was also included in the researcher's house.[2] The location and timing of the session were arranged according to availability and convenience of other two designers. All necessary documents and equipment were prepared as ready to use before the session was started.

The aim of the session was to create alternatives which differ from each other from various perspectives. Before the session, other two designers were informed about the current examples and key considerations which were mentioned by different stakeholders. Visuals and videos about the specifications and usage scenarios of common transit bike rack system were also presented to make other two designers familiar about the subject.

The session took about one hour to be completed and initial ideas got sketched and some discussions were made to clarify the issues which were faced through the process as well. During this session, each participant was expected to create one distinct concept about a transit bike rack system. Only one participant is assigned to develop the proposed design alternative which came from *MAN Türkiye*. All three participants communicated each other with both the initial sketches they made and verbally throughout the session. After three alternatives each of which was developed by different designers were matured, one of the designers who was thought as a better drawer about embodying the ideas, conceptualized all three proposals in a sketched format for further development. When the session was finished, there were three distinct alternatives conceptualized in regard to the characteristics and operating logic with newly designed proposals on the bike rack system (Figures 6.1, 6.2 and 6.3). This brain storming session proved to be successful about different alternatives that were not affected from each other. When this session was finished, there needed another elaboration session in which the initial three ideas were criticized by all three designers one by one in order to improve them in details.

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[2] The other two designers, who participated in the brain storming session, are Anıl Ercan and Alper Karadoğaner. Anıl Ercan works as an industrial designer with a nine-year of experience at Etap and Futerodesign. During both sessions, all given drawings were made by him as well. Alper Karadoğaner is also an industrial designer with a ten-year of experience and works at METU ID workshop facilities as specialist since 2013. The researcher himself has also eight-year of experience in various sectors in industrial design and he works as a research assistant at METU ID since 2012.

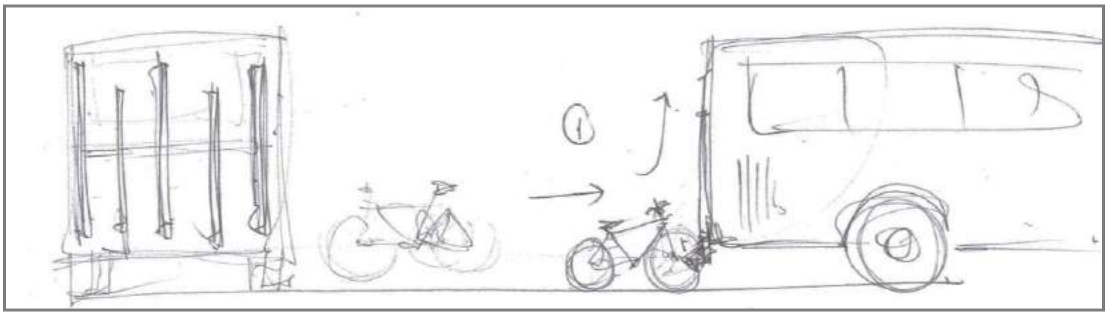

Figure 6.1 Sketch of a Five-Bicycle Capacity Bike-Rack System (idea by Anıl Ercan)

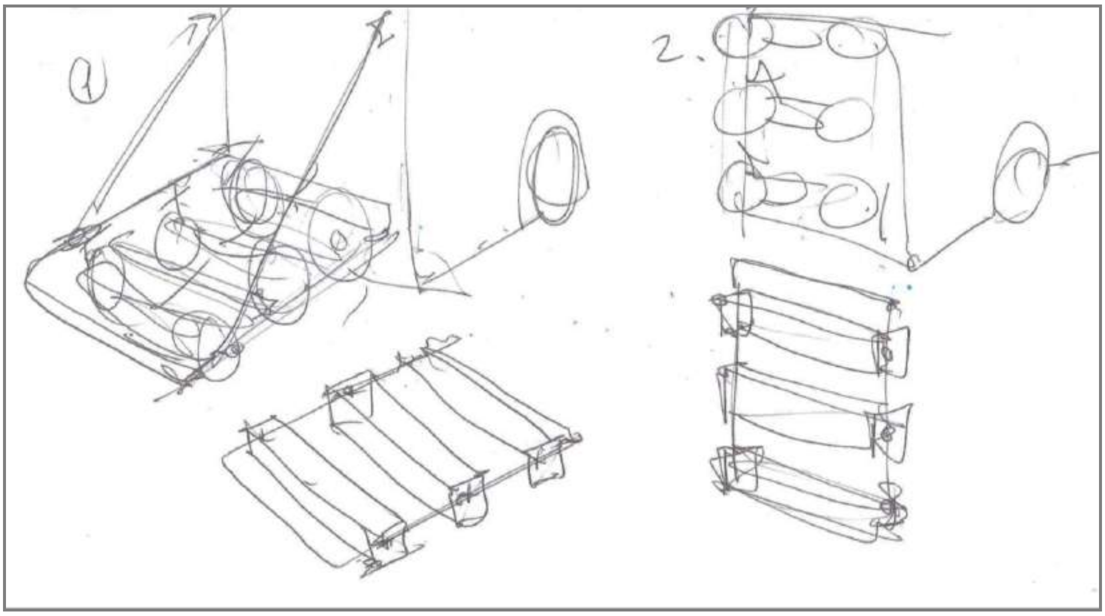

Figure 6.2 Sketch of a Three-Bicycle Capacity Bike-Rack System (idea by Alper Karadoğaner)

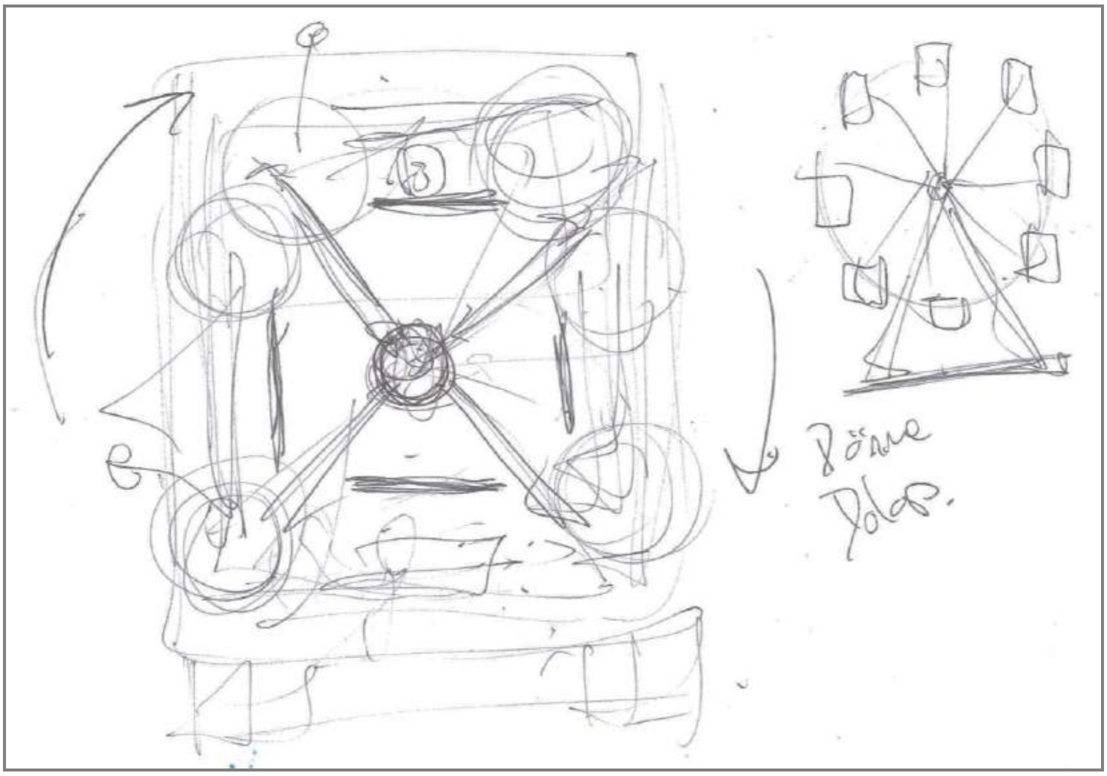

Figure 6.3 Sketch of a Four-Bicycle Capacity Bike-Rack System (idea by the researcher)

6.2.2. Evaluation and Revision on the Alternatives for further Improvements

After brain storming, as mentioned another session was performed again by the same designers which took also about an hour for developing each initial idea by critics from three designers at the same time. This session was held at the same place right after the brain storming session was completed. This elaboration session provided a great and fast progression with the project as all participants spotted the missing or deficient features during furthering the suggestions of others. All three alternatives were detailed in regard to key issues which were mentioned before the brain storming session. Considering also the current transit bike rack systems in the market, all alternatives were developed to emphasize their distinct features and characteristics. Each initial design alternative were passed over by taking notes of every critics stated by all three designers.

These critics were noted and revised with each different alternative afterwards. All alternatives were detailed to the some extent and proper materials were offered for each related components of the structures. During this detailing stage, real dimensions of the proposed bus model and a typical bicycle were taken into consideration in order not to face any trouble at 3D modelling phase about feasibility of the design alternatives. In Figures 6.4, it illustrates the connection detail which supposes to hold the bicycles from their front wheels to pull them into the bike-rack system and Figure 6.5 illustrates a solution which was offered for an optimum protrusion length with the placement of three bicycles in a leveled manner.

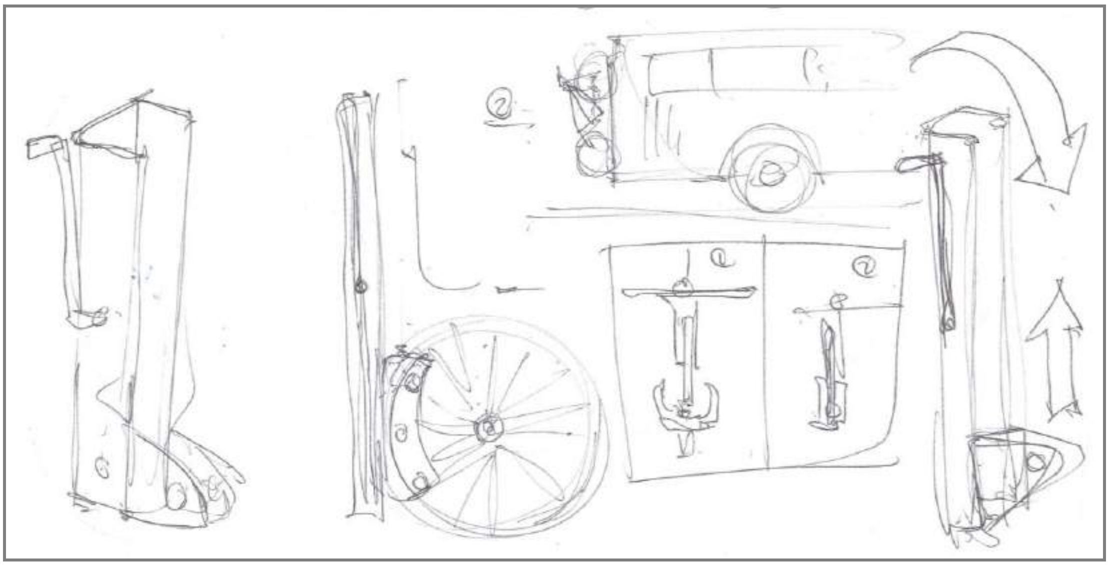

Figure 6.4 Further Sketch of a Detail with the First Bike-Rack System Concept (idea by Anıl Ercan)

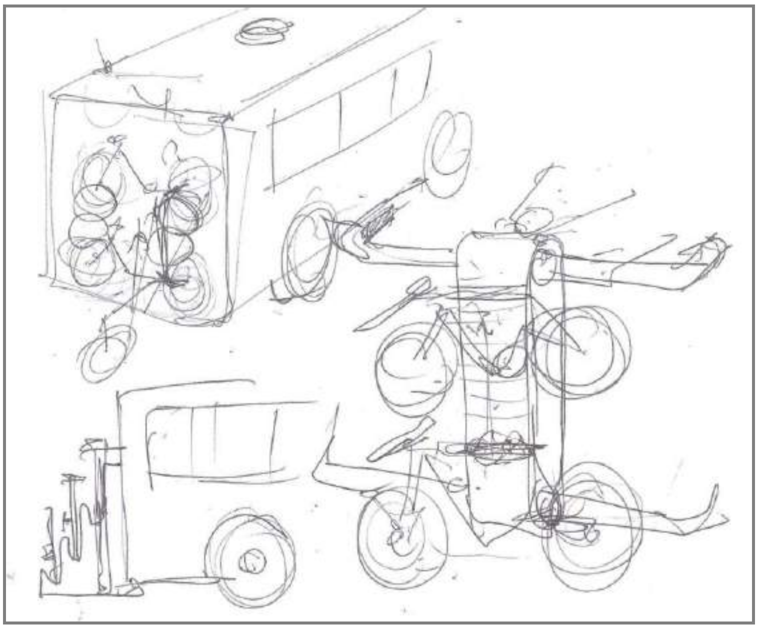

Figure 6.5 Further Sketch of a Placement Solution with the Second Bike-Rack System Concept (idea by Alper Karadoğaner)

6.2.3. Modelling of Alternatives Elaborated

As it is mentioned before, three-dimensional data of back side of *Lion's City* model bus is provided by the collaborated firm. All alternatives were transformed by the researcher to the three-dimensional modelling base by considering real life dimensions obtained from analysis with the help of *Rhinoceros* which is a surface modelling program. As back side data of the bus is highly complicated which is prepared for mass production, it caused the modeling to last longer than expected. The back side model of the bus is given in Figure 6.6.

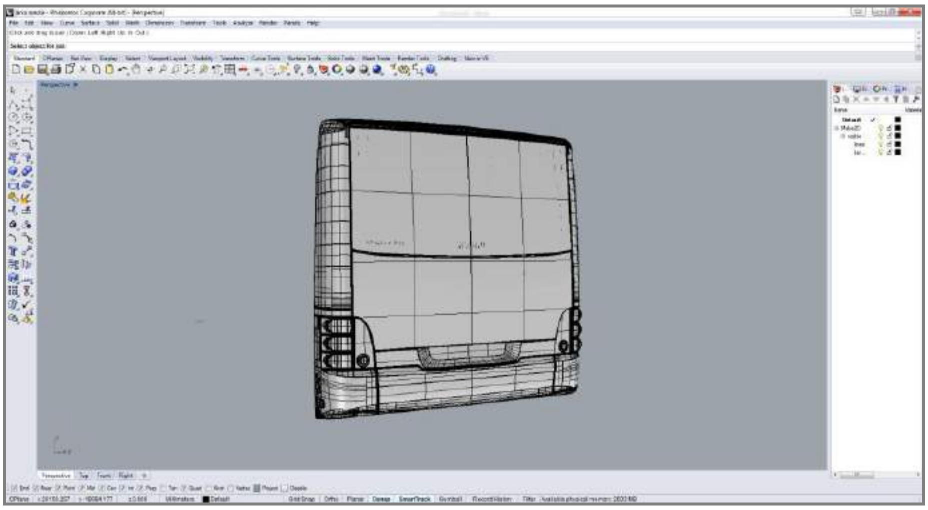

Figure 6.6 3D Data of Back Side of the Bus

A typical mountain bike type 3D data was also accessed with the help of an open-sourced sharing community via Internet. It is considered the bike model to be realistic in order to match up with its exact dimensions and propositions about all components. This model is also given in Figure 6.7.

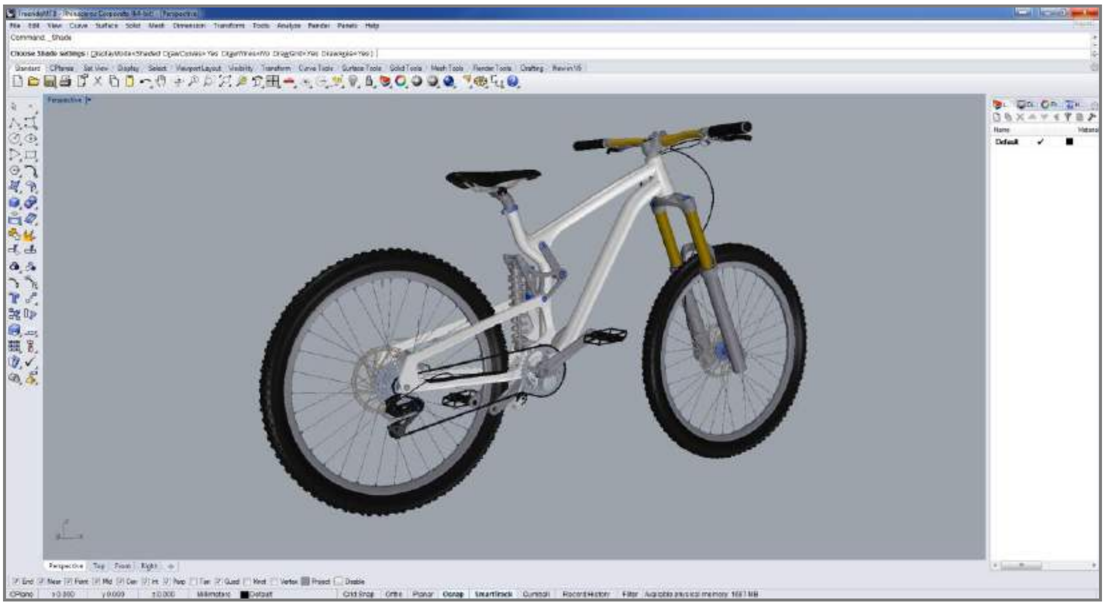

Figure 6.7 3D Data of a *MTB*

Throughout all process for 3D modelling, the alternatives were also developed and there were ensured all dynamic parts run smoothly without any logical mistake or imaginary suggestions. Each alternative is given with images which are taken from the frames of animation scenes in order to specify the material choices with them.

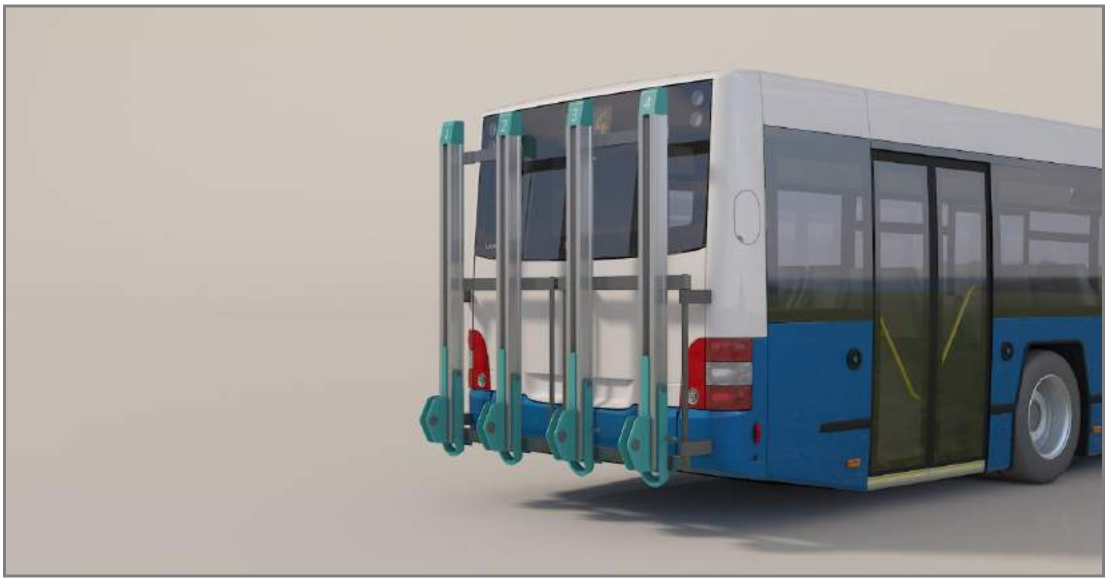

Figure 6.8 The First Design Alternative, *Lift*

As it can be seen from Figure 6.8, the first alternative has a structure which consists of steel support frames, aluminum extrusion vertical columns for mounting four bicycles at each, front-tire locks which catch the bicycles and pull upward electronically, back-tire locks which hold the bicycles stable after they are pulled through the system and lighting units which are located at the top of each columns as communicative means of the proposed rack system. The system allows very different types of bicycles and wheel sizes even below 20 inches. The access to the engine compartment of the bus is easy with the system and it is taken place of rotating both two columns at each side of the bus like a double door (Figure 6.9).

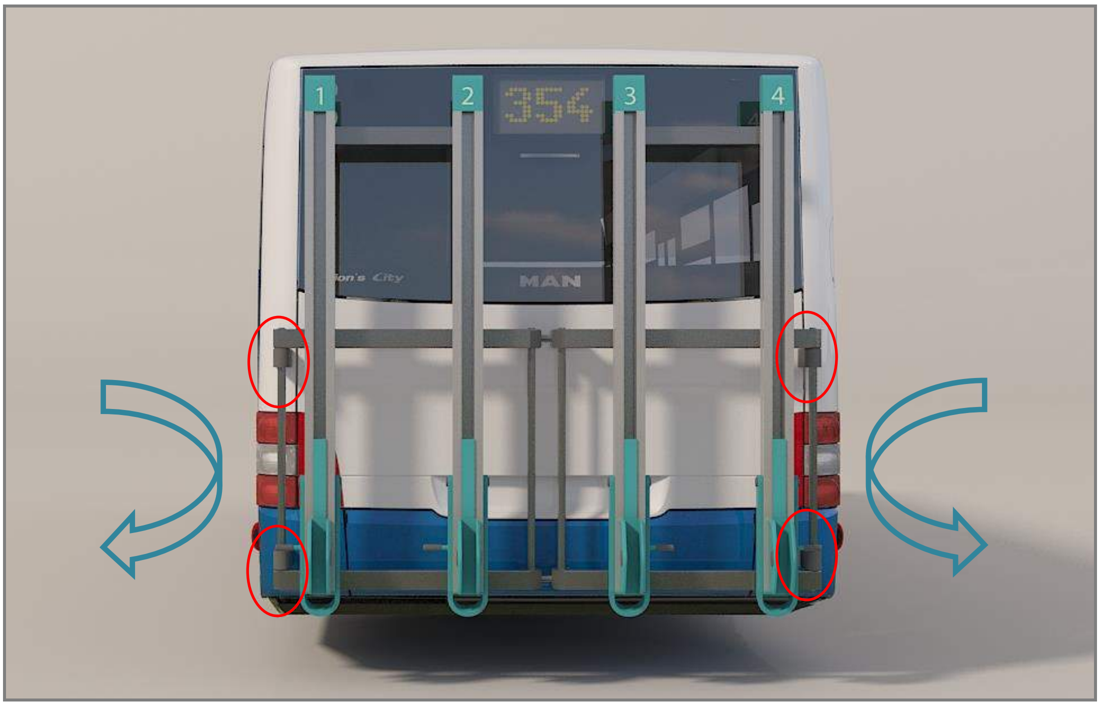

Figure 6.9 The Diagram Shows the Opening Mechanism of the System from Connection Points

Protrusion is kept minimal which ensures the maintenance of system as it would not be exposed to vibrations derived from the movement of the bus. The scenario of loading a bicycle into this system is illustrated with several steps below completed in only 8 seconds which was confirmed by the one-to-one calculations from the animation of the operating scene with the system. In the four images in Figure 6.10, three-step loading scenario is explained with the first design alternative of bike rack system design. Firstly, the bicycle approaches the backside of the bus in a vertical manner, then the system catches it from the front wheel of bicycles and pulls upwards automatically with an appropriate speed. Lastly, the support for the rear wheel locks and secures the bicycle. All bicycles which are aligned side by side at the rack system could be loaded and unloaded independently.

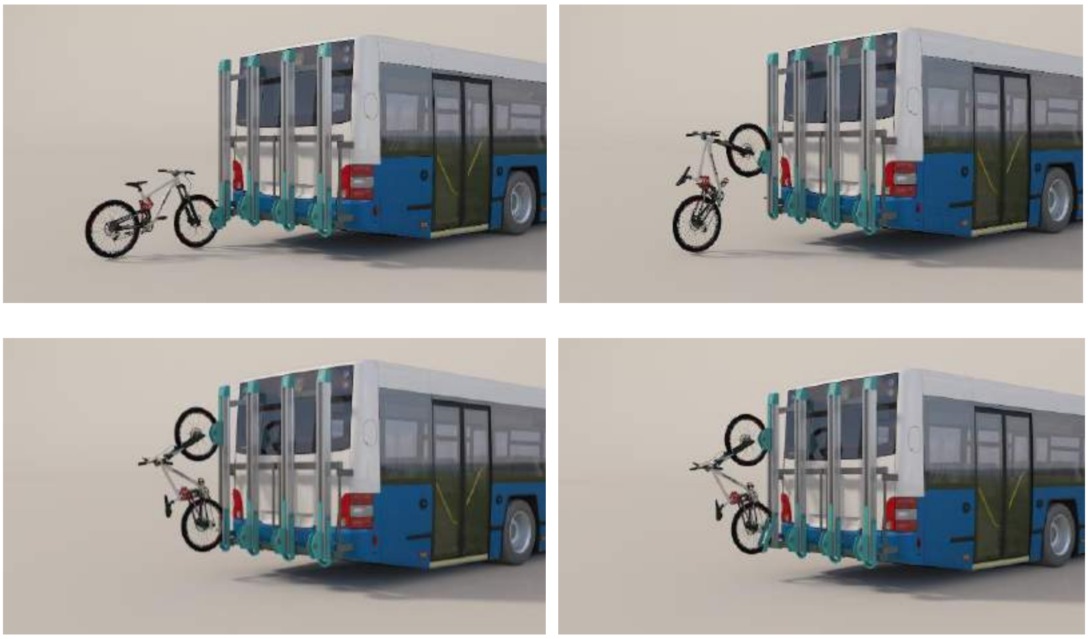

Figure 6.10 Loading Scenario of the First Design Alternative

In Figure 6.11, the first design alternative can be seen with all slots occupied by bicycles.

Figure 6.11 The Representation of the Full Capacity of the System

The second design alternative for the transit bike rack system which is mounted at back side of the related bus is shown in Figure 6.12.

Figure 6.12 The Second Design Alternative, *Pivot*

The main system feature of the second transit bike rack system is its two-leveled structure. This system has a similar layout with the current rack system solutions, yet it could accommodate four bicycles in a shorter protrusion. When the first level is filled with two bicycles, the upper level is moved to the ground level automatically for two more bicycles to be placed into the system and afterwards the upper level returns to its stowed position by lifting the two bicycles loaded lately. Hence, this alternative has two different loading times which is 6 seconds for the first level and some longer for the upper level with 22 seconds. Another significant characteristic of this second alternative is that the frame layout of the structure is arranged accordingly to the back array of components of the bus. That is why the system does not need to be displaced for accessing the engine compartment as the cover could move independently even when the system is installed with its all components. Loading bicycles for this system is also shown with the storyboard in Figure 6.13. For the first stage in which two bicycles are loaded, the only thing for a cyclist to do is to place the bicycle and secure by locking the front wheel with an adjustable spring loaded lever. The same procedure is applied also for loading bicycles into the upper level. As this system has a jointed feature, auditory signalization is decided for warning pedestrians and following cars at the back side of the bus. These stages of loading the bicycles through two different cases are explained in steps by images in an order which are seen in Figure 6.13.

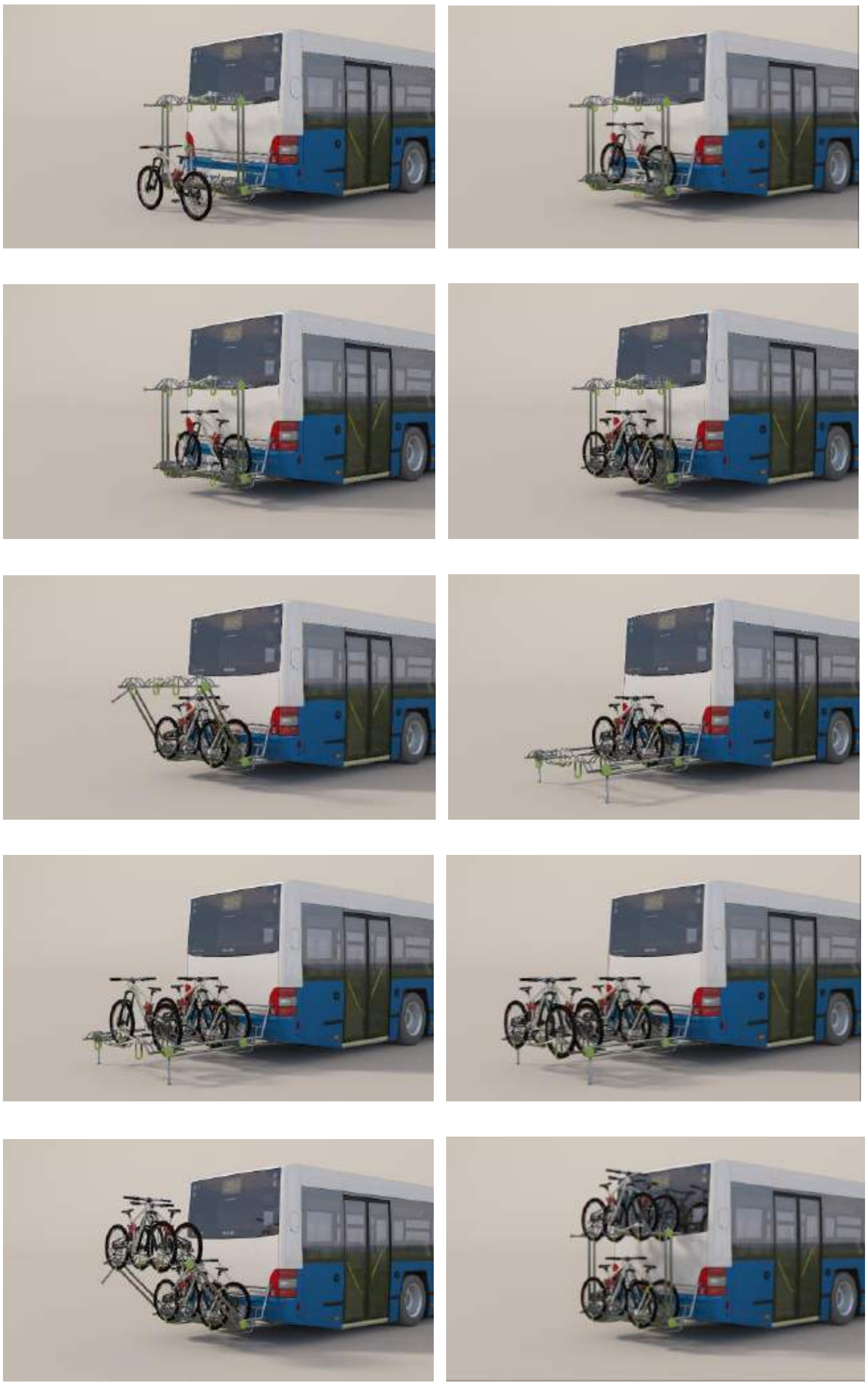

Figure 6.13 Loading Scenario of the Second Design Alternative

The third design alternative is completely different and very distinct in regards to its exciting feature which is inspired by amusement park gadgets by its designer who is the researcher himself (Figure 6.14). For the proposed design alternative, two leveled structure is applied like in the second one but in way which has a relation of distance towards the length of the bus. Bicycles are loaded into this rack system from their both wheels very quickly and easily, the system senses of its being loaded with a bicycle with the help of sensors applied and turns 90 degrees to make the next empty slots available for loading of another bicycle to the system. The total duration of a bicycle to be loaded to this system is 8 seconds.

Figure 6.14 The Third Design Alternative, *Ring*

This alternative is arranged with four arms which are located very far away from the headlights not causing any interference which causes blocking their visibility. For enabling accessing through the engine compartment, the whole system is turned around the side on which the carrying connection arms are linked (Figure 6.15).

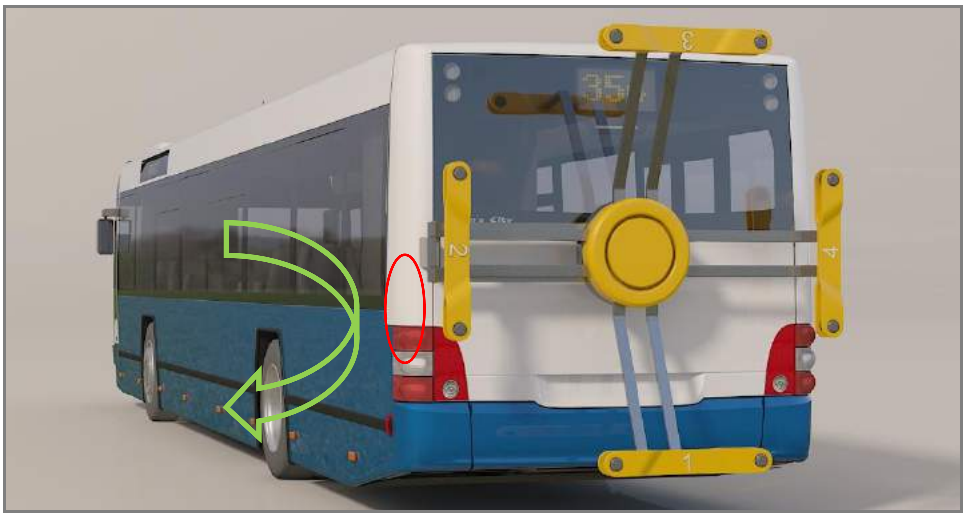

Figure 6.15 The Opening Mechanism of the System from Connection Points

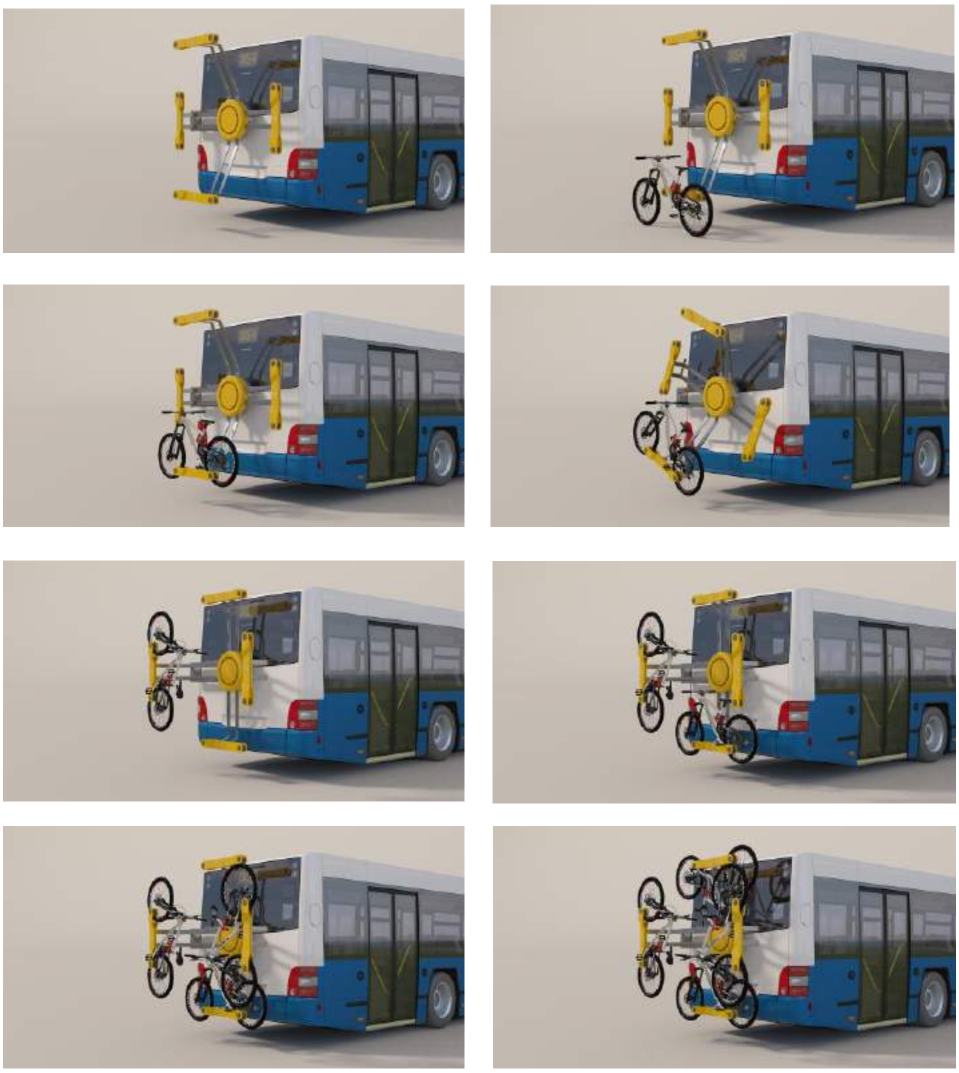

Figure 6.16 Loading Scenario of the Third Design Alternative

6.2.4. Animation Preparation to Offer Participants through Further Focus Group Sessions

All design alternatives are animated in order to explain the ways they perform the loading and unloading operations. These animations were done with a collaborative work under the guidance and supervision by one of the researcher's under graduate friend.[3] The total duration is also measured for each system as the operational time is a very significant issue for measuring the system efficiency. For the setup of the scenes, firstly the 3D model data of back side of the buses was placed in the scene. The rest of the body of bus model is completed by another ready to use low-poly bus

[3] This friend of the researcher is Esat Can Meker who is also the general manager and co-founder of Fraktal Project, Ankara, Turkey since 2013. Besides his industrial design background, he has also certain expertise on using 3D Studio Max for both exterior and interior renderings and animation works in architectural major.

model which was accessed in the transportation volume of *Evermotion Catalogue* so that the exact data of the whole model could be too high-poly to be processed through animations which would cause renderings to last much longer. After some make-ups the adopted body was combined with the related back side model. The EGO buses were taken as a reference and materials and colors of the bus model are arranged accordingly but not much detailed for the scene to become basic and clean. Tires of the bus were changed and adopted from a truck model in the same volume of catalogue with the bus model as these new tires fit better with the EGO buses. There is given an image from an initial stage of applying materials with it in Figure 6.16.

Figure 6.17 3D Model of an EGO Bus

After completing the bus model, the bicycle was imported to the scene and its materials were applied. White color with the bicycle was chosen as the most appropriate for bicycle to be seen neutral and not to disturb the flow of operations causing them hardly understandable by the people who would watch the animation. It was tried to make the design alternatives shown as the most dominant element among the bus and bicycle in the scene setup. The bicycle sample is also given in Figure 6.17, with materials and colors were applied.

Figure 6.18 3D Model of a Typical Mountain Bike

Lastly the design alternative models prepared in Rhinoceros platform were imported one by one to the scene in *3D Studio Max* program and materials were applied with colors there.

Afterwards, the scenario was defined with a collaborating work by the camera movements that were being recorded. The stable scenes of introducing the system first time were rendered by two work stations available. The remaining dynamic scenes were sent to the render farm which is *Fox Render Farm* and completed by a mutual rendering made by 50 more computers.

In the final progress through the animation, all frames were gathered and formatted to a single video in mp4 format with a resolution of 1920x1080 pixels in the *Adobe After Effects* program. The related headings, introductions and ending notes were arranged with the flow of the video through which a soft music was also adopted. This movie about the three design alternatives and showing how they perform lasts about three minutes and it can be found attached to the back cover of the thesis copy written in a compact disc.

CHAPTER 7

EVALUATING PROPOSED ALTERNATIVES WITH FOCUS GROUPS

In this chapter, three design alternatives of transit bike rack systems are aimed to be evaluated to identify their strengths and deficiencies as in relation to set design criteria. For this evaluation, two different focus group sessions are organized in which some questions differ from each other according to professions and relations of participants with the bike rack system. Cyclists who are the main users of the system and engineers who are qualified about technical details and manufacturability are chosen as participants of the focus groups. Bus drivers are determined as being less closely involved with decisions about this system that is why they are excluded for this stage. Because, their opinions and considerations about the system features were shallower in comparison to other stakeholders and their perspective through desires about this system were taken into consideration in the first field study and utilized for developing these concepts.

Focus group sessions are favored for the evaluation and justifying stage as there would be many valuable critics which come from discussions made among participants about the issue. For the participant sample in two focus group sessions, the scope was kept similar in a way that firstly, the current examples of transit bike rack systems were shown to participants with video clips and supporting images by being reflected to the screen with a projector. This stage was for describing the transit bike rack systems for the participants who were not familiar with this product and to help participants for making comparisons between the designed alternatives which would be shown in the next step. While participants were following basic explanations about the system and its common usage scenario, they were also supplied with additional information verbally by the researcher about the key points to be considered with the system. Afterwards, the research process up to that point was shared with participants by findings through literature and the first field study. The next step was the presentation of a three-minute animation about three design alternatives proposed. A discussion phase about half an hour was held after participants saw the animation. In this stage all participants mentioned different issues about alternatives and these issues were discussed by the full contribution of participants collaboratively and the researcher also contributed to highlight and explain the issues with these discussions in order not to interrupt but further the discussions. When this session was over, lastly, the participants are given three-page questionnaire with both multiple-choice questions and open-ended ones in order to receive feedback from them in a written format.

The first focus group session held with the participation of 16 cyclists took place at a class of the Department of Industrial Design in METU which is equipped for enabling visual media. The participants were also provided with pens and offered water and cold coffee during the session.

The second focus group session was held at a meeting room of the *Research and Development Department of MAN Türkiye* which five engineers participated in. This session was conducted in the same way with the first one but with different questions through the questionnaire.

This chapter continues with the findings of each focus group session under different titles. Lastly reviewing these both findings, further improvement suggestions are explained with the three design alternatives to be developed with some more considerations and desires by eliminating their initial deficiencies.

7.1. Focus Group Sessions for Evaluating the Proposed Alternatives

As mentioned in the beginning, data were collected through these focus groups by slightly different questions according to type and profession of participants in a written format. The scope of the questions specified for each session are given in the next stage.

7.1.1. Focus Group with Cyclists

In this session, firstly 10 different criteria which are prepared with the help of analysis gathered by various stakeholders were created in order to measure and evaluate each alternative's success and efficiency with the specified criteria each of which are:

1) Concern of damage for bicycles related with the system,

2) Practicality of loading/unloading processes,

3) Negative affect on traffic,

4) Comprehensibility of the system by cyclists,

5) Perception of durability,

6) Safety,

7) Capacity sufficiency in relation with current examples,

8) Aesthetical value,

9) System operation speed, and

10) Desire for usage.

These questions were prepared for offering slightly different weight for evaluation to be made precisely in a five-rank of scale about the related criteria. In the second stage of the questionnaire, five open-ended questions were asked to participants. In the first three questions in this stage, advantages, disadvantages and suggestions for developing the alternatives for each of them were asked. The forth question asked the views of participants regarding all three design alternatives and lastly, the fifth question was about just putting the three alternatives in an order according to preferences of participants in regard to success with previously mentioned criteria and characteristics.

This focus group took place in two sessions in different days. For the first session, *METU Cycling Community* and president of *Cycling Association of Ankara* were informed to gather participants for an arranged time in a weekend and six cyclists participated in this session. The second session was held with the participation of ten people, who are industrial design students and research assistants in Industrial Design Department of METU and are interested in cycling in order to get feedback from both professional cyclists and again cyclists having design awareness as well.

Setup of one of the sessions and a moment from questionnaire answering stage are given in Figures 7.1 and 7.2.

Figure 7.1 Focus Group Setting

Figure 7.2 A Scene from the First Focus Group Session

7.1.2. Focus Group with Engineers of Collaborated Firm

In the second focus group session, five engineers who work for *Bus Technic Department* of the collaborated firm participated. The process was similar, yet the location of session and scope of the first set of multiple choice questions was different from the other one. These criteria about the transit bike rack system depend on mostly technical, functional and manufacturability issues of three alternatives and consist of:

1) Estimated cost,

2) System efficiency,

3) Manufacturability value,

4) Compatibility of materials,

5) Product-vehicle relation,

6) Convenience with the firm infrastructure,

7) Safety,

8) Aesthetical value,

9) Perception of durability, and

10) System operation speed.

7.2. Evaluation of Findings

For the first multiple choice questions section, all criteria for each design alternative are arranged to be evaluated by a rating scale of five grades which has a weight to be considered in a range of -2, -1, 0, 1, 2. The aim is to obtain a total value for each answer and to determine the success rates of design alternatives for each design criterion. The answer choices for each criterion with the largest total value is considered as the most successful alternative and the values under "0" are considered as failure of the related alternative with the given criterion. For both tables of focus group sessions with cyclists and engineers, red cells represent negative values, the greens are positive and the grays are neutral ones and the colors also applied in different shades to emphasize the weight of value as being darker or lighter.

The open-ended questions are analyzed by reviewing the questionnaire sheets and specifying the keywords and phrases with markers by color-coding. All repeating responses are listed under the same subject title with a calculated value and all these mentioned issues are gathered and presented in this findings section for each question separately.

7.2.1. Findings of the Focus Group with Cyclists

As scope of the questions differs to gather various information about the proposed design alternatives, two parts of the questionnaire are given under different titles as follows.

7.2.1.1. Success Values of Design Alternatives According to Design Criteria

At the first stage, a total of 10 criteria with their weight for each alternative as responded by 16 cyclists and the total values of these criteria are calculated and given in Table 7.1.

Table 7.1 Success Values of the Design Alternatives According to Participants

		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	TOTAL
Concern of damage for bicycles related with the system	A1	1	2	1	-1	-2	1	1	0	-2	1	2	-1	2	0	2	2	9
	A2	0	1	1	1	1	-1	-2	2	0	0	0	1	1	-1	1	2	7
	A3	0	1	1	1	-2	-1	-1	1	1	0	1	0	0	-2	-1	1	-2
Practicality of loading/unloading process	A1	2	2	2	1	0	1	2	2	-1	2	2	2	1	2	2	2	26
	A2	-1	0	0	-1	1	-1	-2	-1	1	1	0	-1	-2	1	-2	-1	-8
	A3	0	-1	1	-1	1	-1	1	-1	1	1	2	0	-1	0	-1	-1	0
Negative impacts on traffic	A1	0	0	1	1	2	1	1	1	-2	1	0	1	2	2	2	1	14
	A2	0	0	-2	1	-1	0	1	1	-2	2	0	0	-1	-1	-2	-1	-5
	A3	0	-1	-2	-1	1	-1	0	1	0	2	0	1	-2	-2	-2	1	-8
Comprehensibility	A1	2	2	0	2	2	0	2	0	-2	2	2	0	1	1	2	0	16
	A2	0	0	1	0	-1	1	0	0	0	2	1	2	-2	-1	0	-1	2
	A3	1	0	0	0	1	-1	2	-1	1	1	1	1	1	0	0	-1	6
Perception of durability	A1	1	2	1	0	2	-1	1	-1	0	2	2	0	0	-1	2	1	11
	A2	1	1	0	-1	-1	0	-1	2	0	2	0	1	0	2	2	0	8
	A3	2	0	1	-2	1	-2	-1	-1	0	1	-1	0	-2	-2	2	1	-3
Safety	A1	1	2	0	1	1	-1	1	-1	0	2	2	1	1	1	2	0	13
	A2	1	1	0	0	-1	0	-1	2	1	2	1	0	-1	-1	2	0	6
	A3	1	0	1	-1	2	-1	-1	-1	0	1	-1	1	-1	-2	2	-1	-1
Capacity sufficiency	A1	2	0	0	0	0	0	-1	0	0	0	1	0	0	0	0	0	2
	A2	2	0	0	0	0	0	-1	0	0	0	1	-2	0	0	0	1	1
	A3	2	0	0	0	0	0	-1	0	0	0	1	0	0	0	2	0	4
Aesthetical value	A1	1	2	1	2	1	1	1	1	2	0	0	1	1	2	2	0	18
	A2	0	-1	0	0	0	-1	-2	0	-1	0	-1	0	0	-1	0	-1	-8
	A3	0	2	-2	-1	-1	0	1	2	1	0	1	2	-1	2	2	-2	6
System operation speed	A1	0	2	1	1	1	0	2	2	2	2	2	2	1	2	2	0	22
	A2	-1	1	-1	-1	0	-1	1	-2	-1	0	0	-1	-2	-1	-2	-1	-12
	A3	0	2	-2	0	1	-1	-2	-1	-1	2	-1	1	-1	-1	2	0	-2
Desire for usage	A1	2	2	1	2	1	1	1	2	0	1	2	2	0	1	2	2	22
	A2	1	-1	0	0	-1	0	-2	2	0	1	2	-2	0	-1	-1	0	-2
	A3	1	0	0	-1	1	-1	1	-1	0	-1	-1	1	-1	0	2	-1	-1

Capacity sufficiency criterion is expected to be answered by comparing of the current bike rack system examples and four bicycle capacity is kept the same for all alternatives in order not to affect the evaluation. However, some of the participants made comparisons between the given alternatives. That is why this criterion is excluded from the evaluation.

When all scores are considered, the first design alternative (A1), *Lift* is proved that it is the most successful alternative for all criteria without any exception and it succeeded to be satisfactory with total values of all criteria above "0" level. *Practicality of loading/unloading process* is the most powerful criterion according to the responses. Although all criteria are satisfying, concern of damage for bicycles related with the system needs to be improved as being the least scored value for A1.

The remaining two alternatives which are A2 and A3 are compared to each other. Throughout the whole table, A2 failed at five different values while A3 failed about six. Although A3 failed more, the weight of values through given criteria are not satisfactory but very close to the "0" level when searched in detail. *Negative impacts on traffic* seems the least scored criteria stated in the table. The reason of this could be explained with concerns which would be mentioned in the disadvantages of alternatives question with the fear and hesitation of falling bicycles out of the system as the bicycle mounted at the top slot would be in upside down position. A2 is given as being the most troubled alternative by participants with the criteria specified. At four criteria which are *practicality of loading/unloading process, aesthetical value, system operation speed* and *negative impacts on traffic,* it failed too badly as being far away from the "0" level. *Perception of durability* is the most favored criterion with it but not much.

7.2.1.1. Open-ended Questions to the Cyclists

1) Disadvantages. In this question, disadvantages of the design alternatives is asked to the participants for each alternative separately. With the first alternative, mostly mentioned disadvantages are the feeling of the system having a weak locking system which might not ensure bicycles to be secured after loading and protrusion is mentioned as being long. Four disadvantages are stated twice which are limited capacity of four bicycles, feeling of too exposed, falling of accessories after bicycles are loaded like water bottle, and trust issue about bicycles which are positioned perpendicular to the bus with the system. Moreover, using the system for the first time and unloading process are mentioned once as being difficult.

For the second alternative, the time spent for the operation of the upper floor is criticized as the most important disadvantage by seven participants. It is stated that this long structure has safety problems and seemed insecure for six respondents. Although this system works in a similar way with the current rack system examples, being difficult to use it for the first time and being complex with its structure are stated as secondary disadvantages. The remaining ones are about the layout and alignment with the bicycles which are the difficulty of loading bicycles as reverse to each other in a way that the front wheels are directed to the securing levers and difficulty of loading inner bicycles for the ground level.

Design alternative A3 could be given as one the most criticized alternatives. Firstly, it can be referred that this alternative was not accepted and perceived as right through its distinct characteristics, which is why most of the participants mentioned that they were not assured by the system. The concern of falling bicycles out of the system, perception of huge apparent size of it, poor aesthetical image and inconvenience of loading more than one bicycle at a time are given as secondary disadvantages with A3. Lastly, complexity of the system, limited capacity with four bicycles, long lasting operation of unloading and blocking off the bus schedule number at the top of rear window are mentioned once. A distinct disadvantage which could not be foreseen easily was stated that upside positioning of bicycles lead hydraulic system of mountain bikes to leak oil which affects the brake system.

2) Advantages. As expected, lots of advantages were mentioned for the first design alternative. Automated system being electronically controlled, easy and fast loading of the bicycles, pleasing regular alignment of bicycle slots, being practical and independently loaded bicycles are mostly mentioned advantages with A1. The participants also stated efficient use of space, being innovative and understandable, durability, safety and vertical loading of bicycles are other mentioned features and advantages with A1.

For the second alternative, familiar usage of the system and placement of bicycles which are similar with current bike rack systems is given by most of the participants as a major advantage. The system has shorter protrusion and the upper level is offered only when needed which is another mostly mentioned advantage with A2. Easy loading of bicycles and reliability of the system are stated once by the participations.

Regarding the third alternative, space-saving characteristic, distinct image and easy loading of the bicycles are given as mostly related advantages with it. Simple structure of the system, being fast and innovative are mentioned once for this design alternative.

3) Suggestions. In order to improve the design alternatives further, suggestions and solution proposals were expected from the participants with this question. Increasing the safety feeling for the system and increasing the capacity with a reverse positioning of the bicycles are major suggestions made through A1. Improving efficiency of unloading, safety protection bars, storage for accessories which could fall after bicycles are loaded, protection shade for bad weather conditions and manual control are the other suggestions with this alternative.

Suggestions which are made for A2 are not repetitive and are separate from each other which are increased reliability and capacity, further solution for upper compartment with the system and shortening this arm, faster operation, improvement about reverse positioning of the bicycles and easy access to the inner bicycle in the ground level.

With the third alternative, improving aesthetically, larger capacity, developing the connection detail, upside down positioning of the upper bicycle and safety issues with it are given considered in need of further development. Also moment effect of dynamic forces created by loaded bicycles and the weight of the system itself wanted to be reduced and foldable structure for the support arms of bicycle slots when they are empty were offered as space-saving features for A3.

4) General opinions for all alternatives. For the general thoughts about all design alternatives, while A1 is given as the best choice among others, all alternatives are said to be successful and needed for such a system to be applied. Larger capacity than current transit bike rack systems is also mentioned as a better advantage by the participants. Electronical performing property of all structures is evaluated as distinct and valuable with requiring less effort for both loading and unloading a bicycle into the systems. However, for this reason, there is a concern that such systems take long development processes for ensuring their applicability. The suggestions are also given for further improvement of the system alternatives like applying warning reflectors to the systems for increasing visibility with safety concerns and a solution for protecting bicycles from external conditions to which the bicycles are exposed like bad weather.

5) Order of preferences. For the last question with the given questionnaire, the participants were asked to order their preferences regarding their answers and thoughts with the alternatives in the previous questions. The total of averages made through their choices are put in an order by calculating the sum of multiplied columns by three for the first preference, two for the second and one for the last choice (Table 7.2). The surprising result with the A2 and A3 alternatives are having same scores exactly.

Table 7.2 The Order of Preferences

Rank Order	P1	P2	P3	P4	P5	P6	P7	P8
First Choice	A1	A1	A1	A1	A1	A1	A1	A1
Second Choice	A2	A3	A2	A2	A3	A2	A2	A2
Third Choice	A3	A2	A3	A3	A2	A3	A3	A3
Rank Order	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**	**P16**
First Choice	A2	A1	A1	A2	A1	A1	A1	A1
Second Choice	A1	A3	A2	A1	A3	A2	A3	A2
Third Choice	A3	A2	A3	A3	A2	A3	A2	A3
TOTAL	**A1→46 A2→21 A3→21**							

7.2.2. Findings with the Second Focus Group

As mentioned before the second focus group session which was made by five engineers has a similar questionnaire, only the first part of it which consists of rating options is slightly different with the specified features about the design alternatives.

7.2.2.1. Ranking Questions with the First Part of Questionnaire

For this focus group session, firstly, values which are gathered from five engineers on 10 specified criteria of the first rating question are given in Table 7.3.

Table 7.3 Rank Order Provided by the Focus Group Session

		P1	P2	P3	P4	P5	TOTAL
Estimated cost	A1	0	0	0	0	1	1
	A2	-1	1	-2	-1	1	-2
	A3	-2	0	-1	-2	-2	-7
System efficiency	A1	2	2	1	2	2	9
	A2	-2	0	2	1	1	2
	A3	-1	-1	0	-1	-2	-5
Manufacturability value	A1	2	2	1	2	2	9
	A2	0	2	0	1	1	4
	A3	-1	0	2	1	-2	0
Compatibility of materials	A1	1	2	2	1	2	8
	A2	0	2	2	0	1	5
	A3	0	0	2	-1	-1	0
Product-vehicle relation	A1	2	1	2	2	2	9
	A2	0	2	-1	1	1	3
	A3	-1	0	0	0	-2	-3
Convenience with the firm infrastructure	A1	1	1	2	2	2	8
	A2	1	2	2	-1	1	5
	A3	1	0	2	-2	-2	-1
Safety	A1	2	1	1	1	1	6
	A2	0	2	0	-1	0	1
	A3	1	0	0	0	-2	-1
Aesthetical value	A1	2	2	2	0	2	8
	A2	-1	2	0	2	1	4
	A3	0	-1	1	1	-1	0
Perception of durability	A1	2	2	2	2	2	10
	A2	-1	1	0	0	1	1
	A3	1	0	0	1	-2	0
System operation speed	A1	2	2	2	2	2	10
	A2	-1	1	1	0	-1	0
	A3	0	0	1	1	0	2

According to the ratings made through criteria for each alternative, A1 is marked as the best option for all criteria among others like in the first session with cyclists. System operation speed and perception of durability criteria are fully scored by all participants as being the top ones while all features also have very high and satisfying values. With the remaining alternatives, A2 failed only at estimated cost criterion which has a great influence of decision whether the firm would have an investment on the proposed alternative or not. Nonetheless, compatibility of materials and convenience with the firm infrastructure are evaluated as being the highest properties with the system. A3 is the least favorable solution through responses and it failed at five criteria. Estimated cost of A3 is seen of being the least valued criterion as A2 and only system operation speed reaches to the top value than other feature options, but very slightly favored.

1) Disadvantages. A1 is evaluated as having a few disadvantages about reliability and long protrusion which would cause difficulties for buses during maneuvers. Three engineers did not specify any disadvantage with it. For the second alternative, the arms of upper level which are not fixed and move freely from the hinges it is connected was stated that it would affect product-life span and maintenance as a result of vibrations created when the bus is in action. Longer operation time with this upper level and its being too long when opened are other mentioned issues with A2. Lastly, complex and multipartite structure and aesthetical value did not satisfy the participants. In the third alternative, the support arms were claimed to be weak, so that they would be bended or broken as a result of the moment created by vibrations and the rotating mechanism would be forced to fail about its motion effectiveness. Bicycles in the slots would pose a danger as they are mounted as high during a falling bicycle by vibration. It is both a risky solution and not aesthetically pleasing as referred also by the participants for A3.

2) Advantages. Many advantages with A1 are mentioned such as; appropriate material selections, cost-efficient, reliability, time-saving, independent loading of bicycles, easy and fast loading, safety, aesthetically pleasing and good designed image. For the second alternative, short protrusion, innovation, reliability, convenience for increasing capacity and flexibility are the stated advantages. For the last alternative, there is not mentioned any advantage with it in an unsatisfied manner.

3) Suggestions. Four participants skipped to suggest any improvement with A1, only combining it with A2 is stated. A2 is needed to be made faster about its second level operation and placing two bicycles to be made easier according to participants' opinions. A3 is evaluated to be developed for reliability issues and to be supported for its arms. One last suggestion is offered which is very striking as "not to be used".

4) General opinions for all alternatives. General opinions of participants about all alternatives were asked and the given answers are gathered which are simple, direct and developed designs, producible, easy and cheap maintenance and repair, result-oriented, and A1 being the best alternative. One statement is also added by one of the participants which is "the less time consuming alternative should be chosen".

5) Order of preferences. In the last question of the questionnaire, the order in regard to preferences of the participants is asked and the scores given in Table 7.4 show A1 as being the most favored as no surprise.

Table 7.4 Order of Preferences

Rank Order	P1	P2	P3	P4	P5	TOTAL
First Choice	*A1*	*A1*	*A1*	*A1*	*A2*	A1 → 14 A2 → 10 A3 → 6
Second Choice	*A2*	*A2*	*A2*	*A3*	*A1*	
Third Choice	*A3*	*A3*	*A1*	*A2*	*A3*	

7.3. Further Improvement Suggestions

Under this title, the aim is to define and propose suggestions for the initial versions of three alternatives to be taken forward in regard to findings and considerations of mostly relevant stakeholders who are cyclists and experts with the manufacturing processes. The first thing to decide for further suggestions is either trying to find out solutions for all deficiencies with each alternative or continuing with a most favored alternative on which some compatible outstanding features of the remaining two alternatives would be converted if applicable.

The second option would be more appropriate to follow a progress with the improvement of A1 as other two alternatives failed about many features specified for both cyclists and engineers. Most of the problems with A2 could be solved through the two-sided structure with it, yet, changing this feature would mean creating a completely new transit bike rack system design. With A3, there are much more troubles mentioned during the sessions and most importantly the feasibility of it was criticized with lots of comments as being too fictional which makes it not to be conceived for adapting to real life conditions.

For further improvement, A1 could be taken into consideration clearly as an alternative which proved its success by meeting all features specified both for users of a transit bike rack system and experts who would work for its manufacturing process. For making improvements on this alternative, all opinions about it are listed by reviewing both the findings through focus group sessions and the field study made earlier, also the literature is considered. These measures and considerations are;

- Concern of bicycles are being damaged by external conditions as the system seems too exposed regarding bicycles loaded into it.
- In respect to same reason, the need of some protection from outside conditions such as bad weather which could affect the operating mechanisms of bicycles and make them dirty.
- Concern of bicycles' falling off the system and of other accessories with the bicycle like water bottles as locking system did not seem ensuring a hundred percent reliability.
- Long protrusion derived from positioning bicycles perpendicular to the bus for safety issues about bus moving.
- And, familiar details with the usage scenario of the system with references from current transit bike rack systems in the market for helping cyclist use the system easily at even their first time.

These determined five issues about the first design alternative could be the guides of improving it further with better solutions offered through these specified subjects in the next version of A1 as much more close to be compatible with the mass production process of it.

CHAPTER 8

CONCLUSIONS

In the conclusion chapter of this thesis, research questions which are mentioned in the introduction chapter are answered one by one regarding all findings from literature review, the first field study with cyclists, bus drivers, and the traffic planner, accumulated knowledge through current manufacturers of transit bike rack systems and the second field study with cyclists and engineers, which are combined in a broader sense to address entire considerations about the system. The role of the researcher in the process is given to evaluate how he positioned himself and influenced the stages he was involved throughout the entire study. Moreover, reflections from the stages and how these reflections converted into acquisitions are mentioned. Afterwards, the limitations faced through implementation of an action research process are stated. Lastly, a brief overall summary is explained and suggestions for further studies is the last title given under this chapter to make the thesis available for utilization of other researchers about the integration of cycling with public transportation by given insights of specified considerations as references.

8.1 The Results of the Research Questions

The questions which are prepared at the beginning of the research are answered as follows in a sequence:

How can integration of bicycles with inner city buses be achieved?

After receiving the design proposal of a transit bike rack system from MAN Türkiye, the study to be applied was designed in order to correspond to the research questions for the subject starts with this one as being the major research question of the study.

In this study there are different ways of integration of bicycles with buses which are specified under four types as external front or rear mounted bike rack systems on buses, trailers which accommodate many bicycles pulled by buses, foldable and removable seats to place bicycles inside of buses and bicycle storage areas located under buses.

Which is the most appropriate way of integration?

Four types of integration were analyzed to address the most efficient way. Front and back mounted bike rack system are searched separately so as to compare issues related with implementing them on buses. For the front-mounted type of bike racks, there are some problematic conditions derived from the usage of them. Firstly, most of the front-mounted bike racks have limited capacity of two bicycles to accommodate on and very few examples among current manufactured systems could provide capacity for three bicycles in maximum. As the protrusion of the system does not allow much length which cause the system interfere in windshields in its stowed position, it is limited with a length of distance from the bumper level of connection points to below margin of windshield start with the specified bus model. This protrusion has also negative effects on decreased maneuverable skills of buses by increasing the swept area accordingly and constrained by an optimum value of legal limits by some states in the U.S. Another disadvantage of the system is its blocking the headlights and even signals with some models which creates difficulty of using it at nights. The reflections created from handle bars of placed bicycles into the system also cause to distract the attention of bus drivers sometimes in day light. Moreover, in a case of an accident when the rack system is occupied with bicycles, they are being damaged as being exposed at front side. The rack system is stated by some bus drivers in the first field study that deep holes reserved through some parts of bus routes could cause the system to be damaged or even broken as bottom bumper surface sometimes sweeps the ground when tires fall in these holes. Lastly, passengers passing by the front of buses for instance while the bus is waiting for traffic lights would not be noticed sometimes by bus drivers and would lead to undesired injuries and incidents. For evaluating the back-mounted type in comparison to the front type, there are not any problem which could not be solved through some improvements. The first problem is the different location where bus drivers are disconnected to check and control the system about safety of both cyclists and bicycles. Another issue is blocking of access to the engine compartment of buses in case of an emergency or for checking the belts and oil level as a daily routine of the drivers, and this section is also located at the back side of buses. Lastly, exhaust gas released from the back side of buses is showed as a problem of making loaded bicycles dirty during longer trips. When compared these two bike rack systems which are externally mounted at the reverse locations of buses, rear available area consists of entire back surface while the front face is limited up to the level of windshields of buses.

Trailers pulled by buses could be seen as efficient solutions among integration ways of cycling with buses by a larger bicycle capacity of accommodating many bicycles, however, they are very separate from buses with a certain gap and it is hard to secure and control the bicycles. Moreover, these trailers are more convenient for long distance travels as public transportation vehicles have some safety measurements and they move through in a congestion most of the time.

Foldable and removable seats which offer additional space inside the buses are considered to be used by wheel chaired passengers with first priority. It is stated that the inner area is most of the time occupied with the crowd of commuters and one bicycle cover about four passenger-space, hence they are not preferred or even prohibited by most of the transit agencies to be taken on board. At the buses of transit agencies which do not forbid bicycles to be accommodated inside, the drivers are authorized for deciding whether the bicycle would be allowed or not, yet still in the peak hours, it is impossible. Only foldable bicycles are allowed if they are in a closed form like a luggage.

Lastly bicycle storage areas under compartments of buses are used as a way to integrate bicycles with. However, these stores are not convenient and available with all buses. They are also not specialized to secure the bicycle with necessary fixing equipment. Suitable storage places are used mostly in long distance buses rather than inner-city public transportation vehicles.

What are the major advantages and drawbacks of the current suggestion?

The main drawback of the suggested solution by *MAN Türkiye* is its being located at the back side of buses unlike the current transit bike rack systems. This different positioning of the system could cause communication problems between bus drivers and the cyclists who load or unload their bicycles into the system. Bus drivers also could not check the system always as they do in the front-mounted types. Another drawback with the suggestion is that it costs much more than the current manual structured bike rack systems as it has an electronically controlled base. Lastly, the unfinished details with the system and aesthetical value could be criticized about it as other drawbacks.

However, there are lots of advantages with the development of such a solution which could cover these mentioned drawbacks. Firstly, it is clear that the back-side positioning of the system would be difficult for a healthy communication among drivers, cyclists and bicycles, nonetheless, this communication would still be ensured with the help of a rear camera recording the bike rack system all the time and providing simultaneous real-time video for bus drivers by the screen located at dashboard. Drivers would not need to check this screen all the time, as lockers on the system would have sensors which would warn drivers in case of an undesired condition about bicycles' safety and would ensure their proper protection. Apart from these solutions, the backside mounting of the bike rack system proves its convenience and compatibility from the bus driver point of view by many advantages which would be mentioned further.

The suggested system's estimated cost is about four times as more than the current examples in the market. Nonetheless, its operation is electronically performed instead of being hand labored. Such an application would reduce the risk of any accidents or operational disorder sourced by human mistakes. It would require less effort for loading or unloading bicycles as well. These newly added features would possibly attract new transit riders and the system would compensate the initial investment made for installing the system on buses easily.

Lastly, the aesthetical value could be changed into a desirable and pleasing level with the use of different materials and finishes after the whole system becomes detailed as to be mass-produced. The current transit bike rack system model consists of merely colored or unpainted one type of metal which presents just a metallic frame look, on the other hand, applying new materials like plastics would change this perception by giving a user-friendly look for cyclists using the system.

Which criteria will determine the design features of a transit bike rack system?

In order to answer this question with the broadest scope as much as possible, many stakeholders including the literature about cycling and public transportation integration, cyclists, bus drivers, traffic planners, current transit bike rack manufacturers and engineers, are included and utilized for determining design features covering the transit bike rack system subject, from all relevant perspectives gathered of various sources which are cyclists, bus drivers, traffic planners, designers and engineers with supported by the reference data of literature, specifications and characteristics of current rack systems in the market, bus itself as a vehicle, a common bicycle as a means of the system component and compatible manufacturing processes.

Reviewing all processes which are completed up to this point throughout the thesis, many features are considered and defined as measures of the design features which could be given as basic and desired properties including **safety** as the major one for both cyclists to keep them from involving in an undesired injury or accident and for bicycles which should not be scratched or damaged during being loaded or unloaded with the related transit bike rack system.

Fast operational speed of loading and unloading of bicycles with the system is mostly concerned by various stakeholders. Before these bike rack system are applied on buses, the manager who lead the public transportation infrastructure wants to be certain about the system is fast enough in order not to extent service schedules of buses and not to cause route delays accordingly with the consideration of providing a fast and comfortable way of transportation for passengers to be satisfied and not to be disturbed. This feature is also related with bus drivers as longer services cause reductions with their resting hours in order to complete their daily scheduled workloads as determined without a flexible manner arranged for regular circumstances.

Capacity value of the transit bike rack systems are considered significant as well, because the mentioned integration has been gaining importance nowadays with the participation of new transit riders to the integration system. Nonetheless, current available bicycle capacity is limited with two bicycles and in extraordinary examples of major manufacturers up to three bicycles maximum as a result of their being located at front side of buses with the reasons and limitations mentioned in detail above.

Fear of bicycles to fall off the system, to be stolen and to be faced with **vandalism** are reported by cyclists as one of the major concerns with the system, because bicycles are too exposed when loaded to the rack systems without covering partially but only tied and fixed to the system with little basic details. This exposure with externally placed bicycles is criticized for that the bicycles are affected by external conditions such as bad weather conditions.

User-friendly nature of the system is also required for cyclists to use it easily during loading their bicycles even in the first time they meet the system. They desired to put less and reasonable effort for loading and unloading processes in which they lift a bicycle about 15 kg for a relevant height with the system. While expecting larger capacity for more bicycles, cyclists demand an independent way of loading and unloading processes through which they do not need to deal with the other bike(s) to reach their bicycles or to place them. Automated electronical base platform for the operational structure with the system is desired by both cyclists and bus drivers for easy, fast and secure placement of bicycles which is controlled with a remote command from the dashboard of buses by bus drivers and responsibility of securing the bicycles in case of an inappropriate integration is wanted to be taken by cyclists themselves.

According to the set criteria what is the most preferable transit bike rack system for users?

In the justification of three proposed design alternatives section, each transit bike rack system alternative was evaluated by different stakeholders which are cyclist and engineers about different criteria in ranked values of a total from all participant responses. When considered all criteria with the given alternatives, the first design proposal proved to be the most preferable transit bike rack system for both users and the engineers. Elaborating this alternative, firstly safety issues both for cyclists and bicycles stated to be improved further with the suggestions which were given under *further improvement suggestions* title before. Fast operating time is accepted convenient as another criterion by lasting only 8 seconds which would not cause any route delay for scheduled bus services. With the capacity of four bicycles, given alternative is furthered to offer more bicycles for loading which is a mostly mentioned concern about the current bike rack systems of having capacity in a range of 2 to 3 bicycles. Lastly, as a distinct and innovative approach which is missing with the current models as they are controlled completely manually by cyclists, having an automatic structure controlled electronically which also eases the loading and unloading processes of bicycles by requiring less effort to lift the bicycles is desired by different stakeholders.

How can such a system be developed regarding users' and experts' opinions based on the set criteria?

For providing substantial solutions and propositions for developing the selected design alternative through the preferences of different stakeholders, opinions and suggestions are gathered by focus group sessions in which related questions were directed to the participants. The findings gathered from these focus groups with the participation of different stakeholders which are cyclists and mechanics experts from the collaborating firm and as mentioned before these criteria are repeated as follows but in a not detailed manner as it was done before;

- concern of bicycles' are being damaged by external conditions,
- the need of some protection from external conditions such as bad weather,
- concern of bicycles' falling off the system and of other accessories with the bicycle like water bottles in regards to the perpendicular positioning of loaded bicycles in the rack system,
- long protrusion derived from positioning bicycles for safety issues through bus moving, and
- familiar details with the usage scenario of the system with references from current transit bike rack system models.

8.2 The Role of the Researcher

In an action research design process, the researcher who conducts the study should position himself/herself as isolated from the progress of each step in order not to intervene and affect the conditions as mentioned in the introduction. There are also various roles the researcher should play so as to conduct the each specified step with its necessary progression. In this study, the researcher tries his best to position himself out during the four specified phases in an action-reflection cycle which are planning, acting, observing and reflecting with an objective approach. However, while planning and observing phases are truly transparent and objective, acting and reflecting phases could include some intervention as a result of being involved in decision making processes, yet he treats others' opinions involved in the research with respect and included all entries from these stakeholders. Also, his limited interventions are tested in other stages and converted into proven contributions which are objectified.

Throughout the study, the researcher plays very different roles as expected which include major planner of the study, survey conductor, interviewer, facilitator, specialist, observer, analyzer, synthesizer, designer, arguer, presenter and reporter. It is hard for one to act differently from his/her original profession and to reach a reasonable level of authority for ensuring every minor step which requires to act like that become successful, however, an actual commitment to the study is the only key to overcome these difficulties and makes the researcher easily get used to such a positioning of himself/herself.

8.3 Reflections and Implications of the Study

During the conducted study, action-reflection cycle is completed twice in each of which there are generated new information about the specified subject. In the first reflecting process, the gathered data from the members of the transit bike rack system is turned into the tangible product system outcomes which have original characteristics and very differentiated from the existing examples in the market. Creating three alternatives which completely differ from each other offers various structural layouts with the system and a valuable insight for users' enlarging visions on the subject touched upon very limited so far. A completely different electronical platform is used through all alternatives which comes with significant advantages and solutions and with also changed dynamics in the nature of the system's usage scenario.

At the second reflecting phase, many basic and essential design considerations are accumulated from the point of different stakeholders' views about the transit bike rack system. These considerations are neat and respectable which could also be used as performance measures for the same subject to be explored later on by other researchers. The main considerations could be repeated as *safety, fast operational speed, capacity value, fear of bicycles to fall off the system and user-friendly nature.*

The remaining considerations are still also significant which are given in table 8.1.

Table 8.1 Gathered Secondary Design Considerations
about a Transit Bike Rack System

a) negative affect on traffic	b) desire for usage	c) practicality of loading/unloading processes
d) comprehensibility of the system by cyclists	e) perception of durability	f) aesthetical value
g) estimated cost	h) system efficiency	i) manufacturability value
j) product-vehicle relation	k) compatibility of materials	l) perception of durability
	m) convenience with the firm infrastructure	

8.4 Overall Limitations of the Study

During conducting the research, the main problem was to set up the real life conditions in which the system is experienced by members of the system. In order to obtain directed and to-the-point feedbacks on the success of each step, the project should be covered from all dimensions in its real sizes and proportions in regard to be evaluated in real life situation with all dynamics included. Hence, for the second reflection stage which is the elaboration of three design alternatives by both cyclists and engineers, there could be prepared an exact set up consisting of one over one scale working prototype of the products for contributors' evaluation. However, some economical and time constraints this set up could not be constituted. Instead of such a set up an animation movie is prepared as very close to the real life conditions showing each alternative's performing scenario in an appropriate propositional characteristics through all relevant dimensions with the transit bike rack system.

The number of continuum about the action-reaction cycles could be increased from twice to triple times adding another iteration. At this third stage, the most preferred design alternative (A1) would be developed further with the implementation and improvement of all mentioned design considerations which are built as a result of focus group sessions by the cyclists as users and engineers as experts' opinions. In that case, all effort would be used for one selected alternative in order to make them superior with all its details are solved properly.

8.5 Summary and Suggestions for Future Studies

In the literature review most of the related publications issued through academics journals, general frame and the scope of the subject with the integration of bicycles and public transportation from which bus was selected as being the relevant vehicle component of the system were determined at the first stage of the thesis. Afterwards, the information through accumulated knowledge and experiences which were reported by transit agencies located mostly in the United States and some parts of Europe applying the specified variations of transit bike rack systems with their buses for years were gathered to utilize for determining the stakeholders and the setup of questions which would direct them in order to obtain the most appropriate and necessary inputs to take inferences about furthering the action research design process. After building the borders of the problem, the first field study in which opinions of three mostly associated stakeholders with the system consisting of cyclists, bus drivers and a traffic planner initiated of starting the design process. The findings taken from the each type of participant were analyzed and transformed into contemporarily usable data by recent and valid perspectives about the transit bike rack system and initial ideas on different design alternatives were created collaboratively with the participation of three product designers. Furthermore, these alternatives were developed and detailed to some extent and they were presented to two types of stakeholders one of which was cyclists as users of the system and the other was engineers as developers of the system for manufacturing regarding their association with the subject. Lastly, evaluation of the designed alternatives were analyzed and expectations of the stakeholders were compared through their performance measures about the success level by previously considered various design criteria. Suggestions were also asked to the participants with weak and strong points of the each design alternative. In respect to these analyses, further improvement suggestions were specified to utilize in future studies.

Throughout this study, there accumulated plenty of exact and speculative data, sources, images, analysis, tables and graphics which could be put to good use for future studies which would be available to give reference to other possible studies to be conducted by others as a compatible source about the transit bike rack system design process. As a method, the processes in which there are countable and qualitative data gathering techniques and their reflections on the product design process with its further evaluation stages, could be utilized for similar products or systems which are different stakeholders involved in the usage scenario.

As a further stage of this study, a prototype can be developed and tested with wider group of representative users in different cities of Turkey. For this project, before applying TÜBİTAK 1505 funding, a very detailed report was also prepared including every steps to be followed during the building a testable working prototype. These steps can also be mentioned briefly for the utilization of other researchers who would conduct a similar study.

After finalizing the selected design alternative, details related with the system would be solved and improved considering certain universal standards about bike racks for cars as there are not a specified standard convenient for bike racks on buses yet. These standards are as follows;

- “German Standard DIN 75302 of February 1991 on roof load carriers for cars,
- International Standard XP IS O/PAS 11154 of September 2007 on Road Vehicles - Roof Load Carriers, replacing French standard NF R 18-903-2 on roof load carrier units,
- French Standard XPR 18-904-4 of June 2008 on Road Vehicles - Rear Load Carrier Devices - Part 4: rear bike carriers,
- International Standard NF EN ISO 4892-1 of December 2000 on Plastics - Methods of exposure to laboratory light sources,

- German Standard DIN 50021 and ISO 9227 of March 2007 on Corrosion tests in artificial atmospheres - Saline fog tests, and
- International Standard ISO 612 of January 1978 on Road vehicles - Dimensions of motor vehicles and towed vehicles - Terms and definitions (Weiss & Cedex, 2012, p.11)”.

After detailing is completed regarding key issues through the scope of above mentioned standards, 3D models would be converted to a much more professional platform which is *CATIA V5*. It enables making simulations and real-life tests on the transit bike rack system by various analysis for avoiding certain malfunctions before the system is ready to be mass produced. Moreover, these converted 3D models in *CATIA* would be evaluated for ergonomic analysis with the help of *IC.IDO* virtual reality system. In this evaluation, all human related forces with using the transit bike rack system would be measured and anatomical muscle points on users’ bodies having excess difficulty during performing an action with using the system would be addressed for further improvements. Afterwards, the rack system would be tested for its endurance level to the extent of resistance constraints with preferred materials. This test would be made through using *ANSYS Workbench* in order to check the rack system’s behavior under dynamic forces it would face during operating through its product life-span. Lastly, electronical components of the system would be modelled and integrated by using *RUPLAN*.

Completing all these analysis which would be held in virtual reality conditions in a successful way, the prepared data would be converted to manufacturing drawings so as to constitute a working prototype in the collaborated firm, *MAN Türkiye* manufacturing facilities. In this stage, this working prototype would be tested as well, through real usage setups which are prepared for checking the rack system in multiple performing cycles according to its estimated usage times in a pre-determined product life-span, such as that how many times the moving parts would open, close or turn in the system. After all these stages are accomplished with necessary revisions, the system would prove its success and be ready for mass production in the final stage.

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APPENDIX A

THE SCOPE OF THE WAYS OF INTEGRATION

Parking at public transportation stops		
Description		**Examples and extent of implementation**
Train stations vs. bus stops		
Parking at rail stations	Bike racks, lockers, cages, or bike stations next to or inside rail or metro stations in cities as well as outlying stations along the rail network.	Most important form of integration with public transport in Europe and Japan, with large amounts of bike parking at most suburban rail and many metro stations, often in form of bike stations: • 800.000 bike parking spaces at metro and suburban rail stations in Tokyo • 325.000 bike parking spaces at Dutch train stations; 76.000 at Danish train stations • 32.000 bike parking spaces at commuter rail and subway stations in Berlin; 45.000 in Munich • 38.000 bike-and-ride parking spaces in the United States, 26.500 of which are at rail stations • 1.100 bike parking spaces at transit stops in Vancouver, Canada
Parking at bus stops	Usually simple, but sometimes sheltered bike racks at bus stops. Typically provided at major bus terminals, route interchanges, and key stops.	Less common in North America and mostly restricted to northern Europe, due to lack of bike racks on buses in Europe
Types of parking facilities		
Unsheltered/ sheltered	Unsheltered bike parking without roof to protect bikes from weather. Sheltered bike racks with simple roofs, but also bike lockers, bike stations, and bike parking within rail station buildings.	Most parking in unsheltered bike racks on sidewalks, plazas or open parking lots Trend toward sheltered parking, at least covered with a roof of some sort • Chicago offers sheltered or indoor parking at 83 of its 143 subway and elevated rail stations
Guarded	Improved security of bike parking facilities featuring guards and often video surveillance.	Trend in northern Europe (esp. The Netherlands, Germany, Denmark) toward guarded parking to prevent theft, both in special facilities such as bike stations as well as outdoor parking that is guarded by attendants: • 85.000 guarded bike parking spaces at Dutch train stations • 11.000 guarded bike parking spaces near three train stations in Groningen
Bike lockers	Box-like metal or plastic containers for secure bike storage, often at rail stations, usually rented on a monthly basis. Typically holding one or two bikes per container Never fully electronic lockers can be rented without subscription.	Usually at train or metro stations, especially in North America, where it is the main form of sheltered, secure bike parking: • 2.100 bike lockers including 330 electronic bike lockers at rail stations in the San Francisco Bay Area • 1.300 bike lockers at Washington's 86 Metrorail subway stations • 15.500 bike lockers at train stations in the Netherlands
Bike cages	Secure, covered, locked cage with fencing for safety and sometimes camera surveillance. Electronic key card Access available without subscription. Can hold hundreds of bikes.	Many rail stations in northern Europe provide such bike cages: • 82 bike cages in Denmark, of which 42 are in Copenhagen metropolitan area • Some in North American and Australian cities: 9 in Boston, Massachusetts (about 900 spaces), 5 in Portland, Oregon (344 spaces), and Melbourne, Australia (910 spaces)

Bike stations	Full-service facilities offering secured, sheltered bike parking in addition to bicycle repairs, showers, accessories, bicycle washes, and bicycle touring advice. Bike stations are usually adjacent to train or metro stations, but sometimes in commercial districts of city centers.	• 98 full service bike stations (85.000 spaces) at rail stations in the Netherlands; new bike station at Amsterdam's Central Station accommodates 10.000 bikes • 106 bike stations (32.000 spaces) in Germany; 3.300 spaces in Germany's largest bike station in Muenster • 28 bike stations in Switzerland (7.783 spaces) with 12 more bike stations planned • 15 bike stations in North America, with largest in Chicago (300 spaces); 6 bike stations in San Francisco Bay Area • Bike stations next to main rail terminals in Washington (150 spaces) and Toronto (180 spaces) • 2 bike stations with 1.200 spaces in Brisbane, Australia, including 1 at downtown transport hub with 420 parking spaces, 35 showers, and laundry service • Technologically advanced bike stations with automatic deposit and retrieval of bikes in Tokyo

Taking bicycles on vehicles		
Description		**Examples and extent of implementation**
Bike racks on buses	Device on which bikes can be mounted, typically on the front of buses. Some buses provide special space for bikes on board buses (mainly for folding bikes), in luggage compartments, or separate bike trailers.	Bike racks most common in North America, with 72% of American and 80% of Canadian buses equipped with bike racks • 100% of buses with bike racks in Vancouver, Portland, Chicago, San Francisco, Minneapolis, and Washington, DC • No bike racks on buses in Montreal and New York City Bike racks are rare in Europe and Australia
Bikes on rail cars	Often special space on rail cars reserved for bikes, sometimes with bike racks or hooks. Many systems prohibit bikes during peak hours. Some systems charge special fees for bike transport.	Bikes usually permitted during off-peak hours on most suburban rail, metro, and light rail systems in Europe, North America, and Australia Fees for bringing bikes on board rail vehicles are rare in North America but usual in Europe • In the San Francisco Bay Area, Cal train's lead cars provide special accommodations for 16-32 bikes, depending on time of day and direction of travel; most ferry lines in the Bay Area also permit bikes on board with no extra fee • Berlin allows bicycles on trains at any time, but charges a fee (€1.70/$2.20) • All 27 light rail vehicles in Minneapolis equipped with onboard interior vertical racks that accommodate 4 bikes per vehicle

Renting bicycles		
Description		**Examples and extend of implementation**
Bike rentals	Traditional bike rental at counter in train stations. Separate contract for each rental. Rental periods range from one day to several weeks.	• Provision of traditional bike rentals at virtually every major Dutch, Danish, German, and Swiss train station and many suburban stations; especially in regions regularly frequented by tourists
Public bike rentals	Short-term bike rentals at train stations to extend catchment area of public transport. Often membership based or with discounts for public transport passengers with monthly and annual tickets.	• Most widely implemented in Europe, using Smart Card technology, with OV-Fİets public transport bicycle rentals at 200 Dutch rail stations and Call-a-Bike rentals at 50 German train stations • In the Netherlands, payment is made via a special account linked to a season ticket for public transport or a special OV-Fiets membership car • In Germany, bikes can be rented by cell phone at public transport stops, paid for by the minute, and left at any busy intersection in the city • 5.000 rental bikes at train stations in Tokyo
Bike sharing	Short-term bike rental with pickup and return at special bike kiosks distributed across cities and often close to public transport stops. Typically membership based, but sometimes one-day guest passes also available. Often the first 30 minutes are free, but fees increase sharply with length of rental period to incentivize short-time rentals.	• New generation of bicycle rental systems such as Velib' in Paris, Velo'v in Lyon, Bicing in Barcelona, Bixi in Montreal, Nice Ride in Minneapolis, and Capital Bikeshare in Washington, D.C., with many rental stations near metro and train stations

Coordinating bike routes with public transport		
Description		**Examples and extent of implementation**
Bike routes leading to public transport stations/stops	Bike paths, lanes, and on-street routes that lead to public transport stations and stops, thus facilitating the bike's role as feeder and collector for public transport.	• Large bike route networks in European cities typically include easy access to public transport stops; less common in North America and Australia • The routing of on-street bikeways in Chicago and the Washington, D.C., bike plan took the location of transit stations into account • Bay Area Regional Bicycle Plan as well as the Bike Plans of BART and Cal train encourage coordination of bike routes and facilities with public transportation • Explicit coordination of bike routes with public transport stops with the goal of establishing a seamless link between the two modes in Portland
Bike routes that parallel public transport routes	Bike paths, lanes, and on-street routes that parallel public transport routes. Bike routes parallel to public transport routes can facilitate Access to transit stops and can help avoid conflicts between buses and bicycles.	• Hiawatha LRT line parallels and off-street bike path for most of its length in Minneapolis • Waterfront Trail in the Greater Toronto Area parallels the busy GO Rail Lakeshore corridor • Bike routes often parallel San Francisco MUNI bus routes and intersect with transit stops • In Vancouver, the construction of the Millennium, Expo, and Canada SkyTrain lines included traffic-protected, parallel bike routes to foster cyclist Access to public transport • TransLink in Vancouver promotes cycling in central corridors where bus and rail vehicles are the most crowded and where cycling has the potential to divert some of the overload and thus reduce crowding
Shared bus-bike lanes	Bus-only lanes usually in downtown environments that allow bicycle travel and sometimes allow Access for taxis. Private cars and trucks are banned from these lanes.	• Shared bus-bike lanes have been used in many European cities • Extend of shared bus-bike lanes: 308 km in London, 210 km in Paris, and 80 km in Berlin • There are also shared bus-bike lanes in Australian cities including Melbourne and Sydney and North American cities including Toronto, Philadelphia, and Washington, D.C.

APPENDIX B

QUESTIONNAIRE FOR CYCLISTS

Toplu Taşıma Araçlarında Bisiklet Taşıma Sisteminin Geliştirilmesi

Bisiklet kullanıcıları anketi - çoktan seçmeli sorular

Lütfen aşağıdaki sorular için size en uygun seçeneği işaretleyiniz.

1. Cinsiyetiniz

2. Yaşınız

3. Kaç yıldır aktif bir şekilde bisiklet kullanıyorsunuz?

4. Ne tür bir bisiklete sahipsiniz?

- ◯ Dağ bisikleti
- ◯ Yarış bisikleti
- ◯ Şehir bisikleti
- ◯ Katlanabilir bisiklet
- ◯ Gezi bisikleti
- ◯ Tur bisikleti
- ◯ Diğer (lütfen belirtin)

5. Günlük ortalama kaç saat bisiklet kullanıyorsunuz?

6. Neden bisikleti tercih ediyorsunuz? (Birden fazla seçenek işaretleyebilirsiniz)

- ☐ Ekonomik kaygılar
- ☐ Çevresel kaygılar
- ☐ Kullanım kolaylığı

- [ ] Kolay ulaşım
- [ ] Trafiğe bağımsız hareket imkanı
- [ ] Sosyal yaşam ve sosyal faaliyetler
- [ ] Sportif faaliyetler
- [ ] Diğer (lütfen belirtin)

7. Bisikleti hangi amaçlar için kullanıyorsunuz? (Birden fazla seçenek işaretleyebilirsiniz)

- [ ] İş/okul ulaşımı
- [ ] Herhangi bir servise ulaşım (ör:alışverişe gitmek)
- [ ] Aktivite
- [ ] Spor
- [ ] Diğer (lütfen belirtin)

8. Genellikle kaçlı gruplar halinde seyahat ediyorsunuz?

9. Genellikle ne tür yollarda seyahat ediyorsunuz?

- ○ Ana arterler
- ○ Tali yollar
- ○ Bisiklet yolları
- ○ Dağlık araziler
- ○ Diğer (lütfen belirtin)

10. En sık hangi toplu taşıma aracını tercih ediyorsunuz?

- ○ Otobüs
- ○ Dolmuş
- ○ Metro

11. Bisikletinizi genellikle nereye park ediyorsunuz?

- ◯ Metro/otobüs durakları
- ◯ Bisiklet parkları
- ◯ Kilitli dolaplar
- ◯ Diğer (lütfen belirtin)

12. Hangisi sizi bisiklet sürmekten alıkoyar? (Birden fazla seçenek işaretleyebilirsiniz)

- ☐ Yokuşlu yollar
- ☐ Hava koşulları
- ☐ Güvenli olmayan park yerleri
- ☐ 5 km'den uzun mesafeler
- ☐ Diğer (lütfen belirtin)

Toplu Taşıma Araçlarında Bisiklet Taşıma Sisteminin Geliştirilmesi

Bisiklet kullanıcıları anketi - yorum soruları

Lütfen aşağıdaki soruları kısaca yanıtlayınız.

13. Bisiklet ile birlikte toplu taşımayı kullanabiliyor musunuz? Evet ise ne sıklıkta? Hayır ise neden?

14. Bisikletinizi toplu taşıma araçları ile kullanmak istediğinizde ne gibi sorunlarla karşılaşıyorsunuz?

15. Toplu taşımaya entegre olacak bir bisiklet askı sistemi için aşağıdaki alternatiflerden hangisini seçerdiniz? Neden?

A- Otobüs dışarısına konumlanan bisiklet askısı

B- Otobüs içerisine konumlanan bisiklet askısı

16. Bisikletinizde kişisel olarak ne tür eklentiler mevcut?

Toplu Taşıma Araçlarında Bisiklet Taşıma Sisteminin Geliştirilmesi

Bisiklet kullanıcıları anketi - otobüs dışına takılan bisiklet taşıma aparatı değerlendirme matrisi

Resimlerde otobüs dışına yerleştirilen mevcut bisiklet taşıma sistemi örnekleri gösterilmiştir.

Resimde, otobüsün ön kısmına takılan mevcut bir bisiklet askısının kullanımı 3 aşamada gösterilmiştir.

17. Bisikletinizi, otobüs dışarısına konumlanan bir bisiklet askısına takarken sizin için öncelik taşıyan değerleri önem sırasına göre işaretleyiniz. (Sizin için en önem verdiğiniz değer 1, en az önemsediğiniz değer ise 8 ile derecelendirilmiştir.)

	1	2	3	4	5	6	7	8
Bisikletim çalınmamalı								
Bisikletim çizilmemeli/zarar görmemeli								
Askıya takma/ çıkarma işlemi kolay, hızlı ve anlaşılır olmalı								
Kötü hava koşullarında bisikletimi korumalı								
Trafiği aksatmamalıyım								
Takma/çıkarma işlemi kazalara yol açmamalı								
Seyir halinde bisikletimin durumunu görsel olarak takip edebilmeliyim								
Askı sistemi bende sağlamlık algısı yaratmalı								

APPENDIX C

INTERVIEW GUIDE FOR BUS DRIVERS

1. Kaç yıldır otobüs kullanıyorsunuz?

2. Günde kaç saat çalışıyorsunuz? Kaç saat otobüs kullanıyorsunuz?

3. Günün hangi saatlerinde otobüs içerisinde yoğunluk yaşanıyor?

4. Yolcularla sıklıkla yaşadığınız sorunlar hangileridir? Kısaca değinebilir misiniz?

5. Tekerlekli sandalyeli yolcular ile bebek arabalı ve büyük bagaj taşıyan yolcuların otobüse alınması ne şekilde gerçekleşiyor?

6. Hiç bisikletli yolcu denk geliyor mu? Ne sıklıkta? Böyle durumlarda ne yapıyorsunuz?

7. Durakta geçirilen zaman, durağa yanaşma ve çıkışlar için belirli kurallar uygulanıyor mu? Bununla ilgili sorunlar yaşıyor musunuz?

INTERVIEW GUIDE FOR BUS DRIVERS (continued)

8. Toplu taşıma sistemlerinde bisikletin aracın dışına entegrasyonuna nasıl bakıyorsunuz?

9. Otobüsün ön kısımdan veya arka kısımdan uzaması sürüş güvenliğini etkiler mi? Siz hangisini tercih ederdiniz?

10. Otobüsler için bisiklet askı sistemi uygulanmış olsaydı bunu nasıl kontrol etmek isterdiniz?

11. Askı sistemi için yolcuların yardıma ihtiyacı olması durumunda kokpiti terk edebilir misiniz?

12. Otobüs arızalandığında nasıl bir prosedür uygulanmakta?

APPENDIX D

INTERVIEW GUIDE FOR TRAFFIC PLANNER

Part 1: In this part of the interview, the focus will be on the subject related to general public infrastructure, promotion of cycling integrated with buses and liabilities bring with the application of bike-rack system and possible solutions to them.

1. Otobüsün toplu taşımada konumu ve ağırlığı nedir?

2. Durakta geçirilen zaman, durağa yanaşma ve çıkışlar için belirli kurallar uygulanıyor mu? Bununla ilgili sorunlar yaşıyor musunuz?

3. Bisikletle ulaşımın yaygınlaştırılması için neler yapılabilir?

INTERVIEW GUIDE FOR TRAFFIC PLANNER (continued)

Part 2: In this part of the interview, the focus will be learn to the traffic planner's attitutde towards bike-rack systems including existing examples by the help of images.

4. Toplu taşıma sistemlerinde bisikletin aracın dışına entegrasyonuna nasıl bakıyorsunuz?

5. Bisiklet askılı otobüslerin sizce avantajları ve dezavantajları nelerdir? Durağa yanaşma, yükleme ve indirme senaryosunu baz alarak açıklayabilir misiniz?

6. Bisiklet ve toplu taşıma entegrasyonu EGO'ya ve otobüs sürücülerine ne gibi sorumluluklar yükler? Bu yükler nasıl makul bir seviyeye çekilebilir?

APPENDIX E

TRANSCRIPTION SAMPLE OF THE INTERVIEW WITH ONE OF BUS DRIVERS

S1. Kaç yıldır otobüs kullanıyorsunuz?	11
S2. Günde kaç saat çalışıyorsunuz? Kaç saat otobüs kullanıyorsunuz?	11:00'den alıyoruz işte akşam 24:00'e kadar çalışıyoruz. Ortalama işte istirahat saatleri şu ara biraz sıkıntı, pek istirahat saati yok da yaklaşık olarak 10 saat çalışıyoruz yani. 10-11 saat direksiyon üzerindeyiz.
S3. Günün hangi saatlerinde otobüs içerisinde yoğunluk yaşanıyor?	Valla eskiden belli saatlerdeydi de, Pazartesi ve Cuma özellikle fakat şimdi hemen hemen hergün yoğun. Genelinde sabah 06:00'dan 08:00, 09:00'a kadar, akşam da işte peak saat dediğimiz, memur işçi çıkışı, öğrenci çıkışı 16:00'den 19:00'ye 20:00'e kadar. O aralarda aşırı derecede bir yoğunluk var zaten.
S4. Yolcularla sıklıkla yaşadığınız sorunlar hangileridir? Kısaca en fazla iki soruna değinebilir misiniz?	Valla yolcularla şimdi başkana kızan direk muhattab olarak bizi alıyor, direk heralde söylüyorlar yani, daha biraz önce bir arkadaş bahsetti, küfür etmişler, hakaret etmişler. Yaşlılar daha yeni ben yaşadım, hiç derdi çekilmiyor, yani şurda her yerde inelim, her yerde binelim diye söylüyorlar yani durak murak takmadan inip binelim diye. İndirip bindirmezsen sıkıntı yaşıyorsun. Belli mahallelerde diyelim, şimdi bizim genelinde 5 tane durağımız varsa, 52 tane hattımız var bildiğim kadarıyla yani bunun nerden baksan 40 tanesinde şimdinin genci afedersin çakal çukal olmuş. Her yerde bir sıkıntı yaşıyoruz yani. Belli yerlerde mesela yukarının ismini Kobani koydurlar, orda çalışan arkadaşlar günlük rezillik yaşıyor. Kart basmama konusunda, işte içerde soruyum deyip de arka tarafa geçip de kart bulamayan, çağırdığın zaman da beni neden rencide ediyorsun diyen. Genelinde sıkıntımız çok yani.
S5. Tekerlekli sandalyeli yolcular ile bebek arabalı ve büyük bagaj taşıyan yolcuların otobüse alınması ne şekilde gerçekleşiyor?	Anlaşmamız eskiden güzeldi, diyorum ben 11 senedir çalışıyorum. Eskiden bir yolcu şoför diyaloğu vardı. Şoför şoförlüğünü biliyordu, yolcu yolculuğunu biliyordu. Son zamanlarda insanlar biraz çığrından çıkmış gibi. Yani ben şu ana kadar ufak tefek yaşadım da, dün gene bir arkadaşla konuştuk, özürlüyü durak harici aldığı halde, adamla tartışma yaşamış. Şimdi demin de dedim ya adam başkana kızıyo, belli semtlerde mesela oy vermeyen yerler gibi, adam kızıyo senlen muhattab oluyor. Yani sana olmadık hakaretleri yapıyor, ya hemşerim muhattab olacağın kişi biz değiliz ama sen geliyorsun bize söylüyorsun. Ama yardımcı oluyoruz yani, sonuçta herkes bir engelli adayı. Hepimizin başına gelebilir. Biz elimizden geldiği kadar yardımcı olmaya çalışıyoruz. Mesela şimdi asansörlü araçlarda, bu araçlarda ayda yılda bir tane bindiği için köylere de gidiyorum toz toprak oluyor, asansörler çalışmıyor bazen. Şimdi dışarı çıktığı zaman içeriye sokamıyorsun, içeriye sokamadığın zaman trafiği allak bullak ediyorsun. Arkadaki insan senin durumunu pozisyonunu bilmediği için sana hakaret ediyor. Bu da stres yaşadığın zaman herkese yansiyor. Yoksa ben zannetmiyorum ki şurda bizim gibi çalışan en az 300-400 tane arkadaş var, hiç birinin yaşlıyla, özürlüyle, şunlan bunlan sıkıntıya girecek şeyde değil zihniyetde değiller yani. Mercedesin Manın bu yeni çıkan sistem çok güzel. İkincisi bizim şeyimiz yok, sağ tarafa yanaşıp bu asansör 1,5 m'ye kadar açılıyor bildiğim kadarıyla, duracak yerimiz yok, mecbur yolu kapatıyoruz. Arkadaki adam işte diyorum ya sizin poziyonunuzu bilmiyor, korna çalıyor ne bekliyorsun hesabına. Ya arkadaş bu toplu taşım aracı, birşey var ki bekliyor, keyfine beklemiyor.
S6. Hiç bisikletli yolcu denk geliyor mu? Ne sıklıkta? Böyle durumlarda ne yapıyorsunuz?	Yok, bisikletli yolcu öyle denkgelmedi ama şöyle denkgelen var. Adam çocuğuna bisiklet almıştır, bisikleti içeriye koymak istiyor, yoksa öyle bisikleti koyayım diyen bir yolcu denkgelmedi.
S7. Durakta geçirilen zaman, durağa yanaşma ve çıkışlar için belirli kurallar uygulanıyor mu? Bununla ilgili sorunlar yaşıyor musunuz?	Biz de o var zaten, şuan kartlı sistem çalışıyoruz. Kartlı sistemde zaten kalkış saatiyle geliş saati diye karta koymuşlar. O saat içerisinde gelmem lazım. Bir ara çıkmıştı şurda şu saatte olacaksın diye olamadı. Kalkış-geliş ve ikinci servisin başlangıcı.

APPENDIX E

TRANSCRIPTION SAMPLE OF THE INTERVIEW WITH ONE OF BUS DRIVERS (continued)

S8. Toplu taşıma sistemlerinde bisikletin aracın dışına entegrasyonuna nasıl bakıyorsunuz?	Biz şimdi toplu taşıma aracıyız bu bizi yavaşlatır. Sistem yarın birdi, ikiydi, üçtü derken çoğalır. İkincisi, bizim vatandaşımız iyi niyeti her zaman suistimal ediyor. Bir tane arkaya kondu, bir tane öne kondu yarın adam der ki rampayı çıkamıyorum ben de binecektim. Bisikletimi koyacağım, nereye koyacak, üçüncü bisikleti mesela? Adam gelecek, yaygınlaşacak bu, art niyetli insanımızda çok yani. Yaygınlaştığı zaman adamla bu sefer tartışma yaşayacaksın, e sonra şikayet verir, zaten şikayeti kaale alıyorlar, bunu vardığın zaman söylüyorsun adam tamam dese suçsuz olsan dahi bile benim zamanım gidiyor. Bugünümde izin günümde oraya gitmek, ifade vermek, gidiyorum benim 3-4 saat zamanım gidiyor. Hani turistik yerlerde felan olsa yolcunun az olduğu yerlerde, trafiğin az olduğu yerlerde olsa belki derim turistik alanlarda ama bu bizim şehiriçinde biraz mantıksız geliyor. Biz şimdi engelli için en az 5-6 dakika uğraşıyoruz, düşünsene şimdi bisikletiydi, şunuydu bunuydu zaten zamanımız kısıtlı, biz gaz basıyoruz, bunlar bize sıkıntı olur.
S9. Otobüsün ön kısımdan veya arka kısımdan uzaması sürüş güvenliğini etkiler mi? Siz hangisini tercih ederdiniz?	Sürüş güvenliğini mutlaka etkiler, şimdi mutlaka dalgın olduğun pozisyon felan olabilir, şimdi buna alışmak biraz zaman sürer, önde olsa aniden adam duruyor, ona vurabilirsin. Arkadaki insan mesela fark etmeyebilir, dalgın olabilir. Sürüş güvenliğini o açıdan engelleyebilir yani. Biz zaten trafiğe girdiğimiz zaman arçları birbirine dayaya dayaya gidiyoruz yani. Trafik kurallarına göre şehiriçinde 6m yahut 10m gibi bir mesafe açamıyoruz. Yani bir de araç kaygan olduğu zaman frene atıyorsun kaydırıyorsun, kaza sebebiyeti çok olur. Şimdi şoför olarak düşünürsek ben arkayı tercih ederim ne oldu ne olmadı hesabı da. Şimdi önde olduğu zaman zaten aracın kör noktası çok, virajları alırken mesela o önlerdeki direk seninle birlikte virajı alan küçük arabaları görmeni engelliyor. Arkada olması daha mantıklı ama arkada da şimdi düştüğü zaman bunun farkına varamazsın. Kamerayla takip edebilirsin de şimdi biz durmadan ekrana bakamıyoruz. Ona bak buna bak dikkatimiz dağılıyor.
S10. Otobüsler için bisiklet askı sistemi uygulanmış olsaydı bunu nasıl kontrol etmek isterdiniz?	Sorumluluk bizde olmadığı müddetçe yolcu kendi indirip bindirsin. O daha mantıklı yani.
S10. Otobüsler için bisiklet askı sistemi uygulanmış olsaydı bunu nasıl kontrol etmek isterdiniz?	Sorumluluk bizde olmadığı müddetçe yolcu kendi indirip bindirsin. O daha mantıklı yani.
S11. Askı sistemi için yolcuların yardıma ihtiyacı olması durumunda kokpiti terk edebilir misiniz?	Tabi mutlaka yardım gerektiği zaman vatandaşa yardımcı olmak gerekir. Yardımcı oluruz yani.
S12. Otobüs arızalandığında nasıl bir prosedür uygulanmakta?	Ufak tefek bildiğimiz arızalar, işte hareret yapmışsa gibi bu durumlarda müdahale ediyoruz ama bizi aşan konularda müdahale edemiyoruz. En uygun yere çekip, bilir kişileri, üst memurları arayıp, haber veriyoruz yani.

APPENDIX F

FINDINGS OF QUESTIONNAIRE with CYCLISTS

Experience in Cycling

Answer Choices	Responses	
0-1	16.67%	25
1-3	31.33%	47
3-5	12.00%	18
5-7	10.00%	15
7-10	14.00%	21
10-15	6.00%	9
15-20	5.33%	8
20-25	2.67%	4
more than 25	2.00%	3
Total		**150**

Type of Bicycle

Answer Choices	Responses	
Mountain bike	39.33%	59
Racing bike	14.00%	21
City bike	24.67%	37
Foldable bike	4.67%	7
Cruiser bike	2.67%	4
Touring bike	8.00%	12
Others (please specify)	6.67%	10
Total		**150**

FINDINGS OF QUESTIONNAIRE with CYCLISTS (continued)

Daily Cycling Activity

Answer Choices	Responses	
10-15 minutes	**12.67%**	19
30 minutes	**22.67%**	34
1 hours	**28.00%**	42
2 hours	**24.67%**	37
3 hours	**5.33%**	8
more than 3 hours	**6.67%**	10
Total		**150**

Reasons of Choosing Cycling

Answer Choices	Responses	
Economical considerations	**39.33%**	59
Environmental considerations	**49.33%**	74
Ease of use	**52.00%**	78
Easy transportation	**66.00%**	99
Opportunity of movement independent from traffic	**70.00%**	105
Social life and social activities	**62.00%**	93
Sportive activities	**82.67%**	124
Others (please specify)	**6.00%**	9
Total Respondents: 150		

FINDINGS OF QUESTIONNAIRE with CYCLISTS (continued)

Purposes of Cycling

Answer Choices	Responses	
Work/school access	60.67%	91
Any type of access to services (like shoping)	42.67%	64
Activity	78.67%	118
Sports	84.00%	126
Others (please specify)	3.33%	5
Total Respondents: 150		

Group Riding

Answer Choices	Responses	
2	55.33%	83
3	14.00%	21
4	8.00%	12
5	3.33%	5
6	0.67%	1
7	0.00%	0
8	0.67%	1
9	1.33%	2
more than 9	16.67%	25
Total		150

FINDINGS OF QUESTIONNAIRE with CYCLISTS (continued)

Type(s) of Routes

Answer Choices	Responses	
Main arterial roads	**43.33%**	65
Secondary roads	**26.00%**	39
Bicycle roads	**12.00%**	18
Mountainous terrains	**10.00%**	15
Others (please specify)	**8.67%**	13
Total		**150**

Preference of Public Transport

Answer Choices	Responses	
Metro/bus stops	**9.33%**	14
Bicycle parking areas	**37.33%**	56
Lockers	**8.67%**	13
Others (please specify)	**44.67%**	67
Total		**150**

FINDINGS OF QUESTIONNAIRE with CYCLISTS (continued)

Difficulties with Cycling

Answer Choices	Responses	
Inclined road conditions	**22.67%**	34
Weather conditions	**54.00%**	81
Unsafe parking areas	**44.67%**	67
Distances longer than 5km	**4.67%**	7
Others (please specify)	**24.00%**	36
Total Respondents: 150		

APPENDIX G

OPERATION OF BIKE RACK

These are the steps that should be followed when using the bike rack.

Loading Bikes

1. Prepare your bike for loading. Remove water bottles, pumps and other loose items that could fall off while the bus is in motion.

2. Inform the bus driver that you will be loading your bike. You must load your bike from the curb or in front of the bus. Do not step into oncoming traffic to load your bike.

3. Squeeze handle up to release latch, then fold down the bike rack. You only need to use one hand to unlatch and pull the bike rack down, so you can hold your bike with your other hand. It is not necessary to lean your bike against the bus.

4. Lift your bike onto the bike rack, fitting wheels into proper wheel slots. Each wheel slot is clearly labeled for the front wheel. The purpose of the directional placement is to make the bike nearest the bus easier to unload.

5. Raise the support arm over the front tire. The support arm's number one purpose is to add lateral support for the bicycle when the bus is in motion or at rest. Many bikes will sit in the wheel well without the use of the support arm, but the rack must not be used without the support arm. Bikes with especially thin rims and tires will sway back and forth without its use.

6. Board the bus and enjoy the ride! Choose a seat near the front of the bus to keep an eye on your bike. DON'T FORGET you have a bike with you when you get off at your stop. New riders often do!

Unloading Bikes

1. Inform the bus driver that you will be unloading your bike as you approach your stop. Use the front door to exit the bus. Unload your bike from in front of the bus or from the curb, not from the street.

2. Raise the Support Arm off the tire. The Support Arm automatically folds down to a secure position.

3. Lift your bike out of the bike rack.

4. Fold up the Bike-Rack-for Buses if there are no bikes on the rack and no one else is waiting to load their bike. The bike rack locks in place.

5. Step away from the bus with your bike.

PLEASE NOTE THAT LOADING OR UNLOADING A BICYCLE FROM THE STREET SIDE MAY CAUSE INJURY OR DEATH.

APPENDIX H

CONSENT FORM FOR FOCUS GROUP PARTICIPANTS

Orta Doğu Teknik Üniversitesi (ODTÜ)
Mimarlık Fakültesi Endüstri Ürünleri Tasarımı Bölümü
Dersin adı: ID 500 M.S. Tez
Proje konusu: Şehir içi otobüsler için harici bisiklet askısı tasarımı

Ocak 2016

Görüşme için katılımcı izin formu:

Bu araştırma ODTÜ Endüstri Ürünleri Tasarımı Bölümü yüksek lisans öğrencisi tarafından yapılıp, yüksek lisans tezi için bir araştırma niteliğinde olup, şehir içi toplu taşıma otobüslerinin dış kısmına konumlandırılacak olan Bisiklet taşıma aparatı projesine dair üç farklı tasarım alternatifinin değerlendirilmesi ve alternatifler üzerinden geri bildirim ve önerilerin toplanmasını amaçlamaktadır. Görüşme sırasında elde edilen veriler yalnızca bilimsel amaçlarla, tasarım sürecinde, tez araştırmalarında, bilimsel yayınlarda ve sunuşlarda kullanılacaktır. Katılımcıların kimlik bilgileri saklı tutulacaktır. Konuşulanları daha sonra tam olarak hatırlayabilmek ve gözden geçirebilmek için görüşme kaydedilebilir. Görüşme sırasında fotoğraf makinesi, video ve ses kayıt cihazı kullanılabilir. Görüşme yaklaşık bir saat sürecektir.

Bu formu imzalayarak yapılacak araştırma konusunda size verilen bilgiyi anladığınızı ve görüşme yapılmasını onayladığınızı belirtmiş oluyorsunuz. Formu imzalamış olmanız yasal haklarınızdan vazgeçtiğiniz anlamına gelmemektedir; ayrıca öğrencinin, ilgili kişi ve kurumların yasal ve mesleki sorumlulukları devam etmektedir. Çalışmaya katılım gönüllülük esasına dayanır. Araştırma, katılımcılar açısından herhangi bir risk taşımamaktadır. Görüşme sürecinin başlangıcında veya herhangi bir aşamasında açıklama yapılmasını veya bilgi verilmesini isteyebilirsiniz. İstediğiniz zaman gerekçe belirtmeksizin görüşmeyi sonlandırmayı talep edebilirsiniz. Araştırmaya katkıda bulunduğunuz için teşekkür ederim.

Katılımcının adı soyadı	**İmza (zorunlu değil)**	**Tarih**

Araştırmacının adı soyadı	**İmza**	**Tarih**
Mehmet Erdi Özgürlük		

Araştırmadan sorumlu öğretim elemanları:
ODTÜ Mimarlık Fakültesi Endüstri Ürünleri Tasarımı Bölümü
Tel: 0312 210 22 14

Prof. Dr. Gülay Hasdoğan — hasdogan@metu.edu.tr

Araş. Gör. Mehmet Erdi Özgürlük — ozgurluk@metu.edu.tr

Bu formun bir kopyası katılımcıya verilmelidir.

APPENDIX I

FOCUS GROUP TRANSCRIPTION #1: CYCLISTS

S1: Aşağıdaki kriterleri mevcut çözümlerin sizin üzerinizde bıraktığı izlenime göre değerlendiriniz.

a. Bisikletin çizilmesi, zarar görmesi endişesi

A1:	☐ çok fazla	☐ fazla	☒ normal	☐ az	☐ hiç
A2:	☐ çok fazla	☐ fazla	☐ normal	☒ az	☐ hiç
A3:	☒ çok fazla	☐ fazla	☐ normal	☐ az	☐ hiç

b. Takma/çıkarma işleminin pratikliği

A1:	☒ çok fazla	☐ fazla	☐ normal	☐ az	☐ hiç
A2:	☐ çok fazla	☒ fazla	☐ normal	☐ az	☐ hiç
A3:	☐ çok fazla	☐ fazla	☒ normal	☐ az	☐ hiç

c. Trafiğe olumsuz etkisi

A1:	☐ çok fazla	☐ fazla	☐ normal	☐ az	☒ hiç
A2:	☐ çok fazla	☒ fazla	☐ normal	☐ az	☐ hiç
A3:	☒ çok fazla	☐ fazla	☐ normal	☐ az	☐ hiç

d. Anlaşılırlığı

A1:	☐ çok fazla	☐ fazla	☐ normal	☒ az	☐ hiç
A2:	☐ çok fazla	☒ fazla	☐ normal	☐ az	☐ hiç
A3:	☐ çok fazla	☐ fazla	☒ normal	☐ az	☐ hiç

e. Sağlamlık algısı

A1:	☐ çok fazla	☐ fazla	☐ normal	☒ az	☐ hiç
A2:	☒ çok fazla	☐ fazla	☐ normal	☐ az	☐ hiç
A3:	☐ çok fazla	☐ fazla	☐ normal	☐ az	☒ hiç

f. Sistemin güvenilirliği

A1:	☐ çok fazla	☐ fazla	☐ normal	☒ az	☐ hiç
A2:	☐ çok fazla	☒ fazla	☐ normal	☐ az	☐ hiç
A3:	☐ çok fazla	☐ fazla	☐ normal	☐ az	☒ hiç

g. Kapasite yeterliliği

A1:	☐ çok fazla	☐ fazla	☒ normal	☐ az	☐ hiç
A2:	☐ çok fazla	☐ fazla	☒ normal	☐ az	☐ hiç
A3:	☐ çok fazla	☐ fazla	☒ normal	☐ az	☐ hiç

h. Görsel estetiği

A1:	☒ çok fazla	☐ fazla	☐ normal	☐ az	☐ hiç
A2:	☐ çok fazla	☐ fazla	☐ normal	☒ az	☐ hiç
A3:	☒ çok fazla	☐ fazla	☐ normal	☐ az	☐ hiç

i. Sistemin hızlılığı

A1:	☒ çok fazla	☐ fazla	☐ normal	☐ az	☐ hiç
A2:	☐ çok fazla	☐ fazla	☐ normal	☒ az	☐ hiç
A3:	☐ çok fazla	☐ fazla	☐ normal	☒ az	☐ hiç

j. Kullanma isteği

A1:	☐ çok fazla	☒ fazla	☐ normal	☐ az	☐ hiç
A2:	☐ çok fazla	☐ fazla	☐ normal	☒ az	☐ hiç
A3:	☐ çok fazla	☐ fazla	☒ normal	☐ az	☐ hiç

S2. Belirtilen tasarımların sizce dezavantajları nelerdir?

A1: Hiç güven vermiyor, pahalı bir bisikleti asmaktan çekinirdim. Dik durması sebebiyle sabit olmayan aksesuarlar düşebilir. (termos vb) otomatik yüklemenin öğrenme gereksinimi olacak.

A2: Yukarıdaki rafı indirmek zor olabilir, (kirli falan olursa) ayrıca inebileceğinin öğrenilmesi lazım.

A3: A1'den daha da az güven veriyor :) tekerlek kilitlerinin otomatik olması nedeniyle öğrenmek lazım. A1'e yazdığım her şey geçerli.

FOCUS GROUP TRANSCRIPTION #1: CYCLISTS (continued)

S3. Belirtilen tasarımların sizce avantajları nelerdir?

A1: Tüm bisikletlere anında ulaşım var. Yükleme boşaltmayı hızlandırabilir. Hem dolu, hem boşken estetik görünüyor.

A2: Mevcut bir sistem olduğu için, bisikletçiler hemen alışır. Bisikletleri ters çevirmemesi de bir avantaj.

A3: Dolu ve ~~boşken~~ boşken, farklı ve ilginç görünüyor. Yüklemesi kolay görünüyor.

S4. Belirtilen tasarımların geliştirilmesi için önerileriniz nelerdir?

A1: Arkadan gelen araçların ne kadar yaklaşabileceklerini daha net gösteren bir uzantı olmalı gibi. Özellikle gece o gidon yığını hiç görünmeyecek gibi. (A2'deki gibi uzantılar)

A2: Arada bir panel olsa son kullanıcı olarak daha mutlu olurdum, ya da hep üste asmak isterdim, alttakine hep çamur akacak gibi  , şöyle gibi

A3: Tekerlek kilitleri sağlam herhalde ama hiç güven vermiyor. Belki mevcut sistemdeki gibi yaylı bir tekerlek kapağı olsa güvenlik algısı artardı.

S5: Tasarımların tamamı hakkında genel görüşleriniz nelerdir?

Otomatik olanlarda hem nasıl çalıştığını iyi bir öğrenmek lazım, hem de şoförle inişte iletişim kurmak lazım. (Kaptan 2'yi bıraktı gibi) Kalabalık otobüslerde sıkıntı olur gibi geliyor. Bir de A1 ve A2'de bisiklet/~~raf~~ yavaş yavaş inerken kalabalık bir durakta, arkaya otobüs yanaşmaması lazım. Yani raf/bisiklet inmeye başlamadan önce sanki bir reflektör çubuğu falan inmeli.

S6: Tasarımları yukarıdaki kriterleri göz önünde bulundurarak sıralayınız.

A1: 1 A2: 2 A3: 3

...Teşekkürler!

APPENDIX J

FOCUS GROUP TRANSCRIPTION #2: ENGINEERS

S1: Aşağıdaki kriterleri mevcut çözümlerin sizin üzerinizde bıraktığı izlenime göre değerlendiriniz.

a. Tahmini maliyet

A1:	☐ çok fazla	☐ fazla	☒ normal	☐ az	☐ hiç
A2:	☐ çok fazla	☒ fazla	☐ normal	☐ az	☐ hiç
A3:	☒ çok fazla	☐ fazla	☐ normal	☐ az	☐ hiç

b. Sistemin verimliliği

A1:	☒ çok fazla	☐ fazla	☐ normal	☐ az	☐ hiç
A2:	☐ çok fazla	☒ fazla	☐ normal	☐ az	☐ hiç
A3:	☐ çok fazla	☐ fazla	☐ normal	☒ az	☐ hiç

c. Üretilebilirlik değeri

A1:	☒ çok fazla	☐ fazla	☐ normal	☐ az	☐ hiç
A2:	☐ çok fazla	☒ fazla	☐ normal	☐ az	☐ hiç
A3:	☐ çok fazla	☒ fazla	☐ normal	☐ az	☐ hiç

d. Malzeme seçiminin uygunluğu

A1:	☐ çok fazla	☒ fazla	☐ normal	☐ az	☐ hiç
A2:	☐ çok fazla	☐ fazla	☒ normal	☐ az	☐ hiç
A3:	☐ çok fazla	☐ fazla	☐ normal	☒ az	☐ hiç

e. Ürün-araç uyumu ilişkisi

A1:	☒ çok fazla	☐ fazla	☐ normal	☐ az	☐ hiç
A2:	☐ çok fazla	☒ fazla	☐ normal	☐ az	☐ hiç
A3:	☐ çok fazla	☐ fazla	☒ normal	☐ az	☐ hiç

f. Firma altyapısı ile uygunluğu

A1:	☒ çok fazla	☐ fazla	☐ normal	☐ az	☐ hiç
A2:	☐ çok fazla	☐ fazla	☐ normal	☒ az	☐ hiç
A3:	☐ çok fazla	☐ fazla	☐ normal	☐ az	☒ hiç

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g. Sistemin güvenilirliği

A1:	☐ çok fazla	☒ az	☐ normal	☐ biraz	☐ hiç
A2:	☐ çok fazla	☐ az	☐ normal	☒ biraz	☐ hiç
A3:	☐ çok fazla	☐ az	☒ normal	☐ biraz	☐ hiç

h. Görsel estetiği

A1:	☐ çok fazla	☐ az	☒ normal	☐ biraz	☐ hiç
A2:	☒ çok fazla	☐ az	☐ normal	☐ biraz	☐ hiç
A3:	☐ çok fazla	☒ az	☐ normal	☐ biraz	☐ hiç

i. Sağlamlık algısı

A1:	☒ çok fazla	☐ az	☐ normal	☐ biraz	☐ hiç
A2:	☐ çok fazla	☐ az	☒ normal	☐ biraz	☐ hiç
A3:	☐ çok fazla	☒ az	☐ normal	☐ biraz	☐ hiç

j. Sistemin hızlılığı

A1:	☒ çok fazla	☐ az	☐ normal	☐ biraz	☐ hiç
A2:	☐ çok fazla	☐ az	☒ normal	☐ biraz	☐ hiç
A3:	☐ çok fazla	☒ az	☐ normal	☐ biraz	☐ hiç

S2. Belirtilen tasarımların sizce dezavantajları nelerdir?

A1:

A2: ilk iki bisiklet yerleştirildikten sonra, diğer iki bisikletin yerleştirilmesi için harcaması gereken süre daha uzun olacak.

A3: Bisiklet sahibi için riskli görülebilecek bir sistem.

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S3. Belirtilen tasarımların sizce avantajları nelerdir?

A1: Daha basit bir çözüm. Herhangi bir bisiklet yerleştirmek için diğer bisikletlere bağımlı kalınmak zorunda değil.

A2: Yenilikçi ve yaratıcı bir çözüm.

A3:

S4. Belirtilen tasarımların geliştirilmesi için önerileriniz nelerdir?

A1:

A2: Son iki bisikletin mekanizmaya eklenmesi için kolaylaştırıcı bir sistem geliştirebilinir.

A3: Bisiklet sahibinin bisikletini daha güvende hissedebilmesi için ek güvenlik önlemi alınabilir.

S5: Tasarımların tamamı hakkında genel görüşleriniz nelerdir?

Tasarımların hepsi gelecekçi ve sonuç odaklı çözümler. 2. ve 3. tasarımlar estetik açıdan daha iyi olmakla birlikte güvenlik ve basitlik açısından 1. tasarım diğer iki tasarıma göre daha avantajlı görünmektedir.

S6: Tasarımları yukarıdaki kriterleri göz önünde bulundurarak sıralayınız.

A1: 1 A2: 2 A3: 3

...Teşekkürler!