MONORAIL: AN ALTERNATIVE TRANSPORTATION MODE FOR METU

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ABSTRACT

MONORAIL: AN ALTERNATIVE TRANSPORTATION MODE FOR METU

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The aim of this thesis is to investigate an alternative mode of transportation for METU and the impacts of spatial transformations generated by the proposed system in an architectural context. This study embraces modern concepts of space-time in the practice of architectural design, and involves a sensitive consideration of the perception of space relative to position, speed and movement. In an urban context, the thesis unfolds spatial transformations affected by new movement technology. While the notions of movement and speed fundamentally shape the image of the contemporary city, METU campus will be reanalyzed within this framework.

Key words: Monorail, Speed, Movement, Space, Time.

ÖZ

MONORAIL: METU İÇİN ALTERNATİF BİR ULAŞIM ÇÖZÜMÜ

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Bu tezin amacı, ODTÜ kampüsüne alternatif bir ulaşım modu önerisi getirmek ve mimari bağlamda, önerilecek sistemin oluşturacağı mekansal dönüşümleri irdelemektir. Bu çalışmada, zaman ve mekan gibi güncel kavramlar mimari tasarım pratiği içinde irdelenir. Kentsel bağlamda tez yeni ulaşım teknolojilerinin yarattığı mekansal dönüşümleri çıkarsamaya çalışmaktadır. Hız ve hareket nosyonları günümüz şehirlerinin resmini şekillendirirken, ODTÜ kampüsüde bu çerçevede değerlendirilmektedir.

Anahtar Sözcükler: Monorail, Hız, Hareket, Mekan, Zaman.

To My Niece Pelin Savacı

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TABLE OF CONTENTS

LIST OF TABLES

TABLE

LIST OF FIGURES

FIGURES

CHAPTER 1

INTRODUCTION

Architectural space could gain its definition within or from exterior impacts, of which-transportation technologies is one impact that effects its definition in varying scales. Today, due to technological developments in transportation, there have been important changes in urban life and urban form. Thus, “the expanded boundary of the contemporary city calls for the synthesis of a new spatial composition” (Holl, 1996: 51). All these changes have extended architectural discourse.

In the latter half of the 20th century, every metropolis and city has undergone morphological and spatial changes. As stated by Paul Virilio in 1997, with the development of transportation technologies, “a city which the geometric notions of urban center and urban periphery will gradually lose their social significance” (1997: 80).

Another notable consequence of urban expansion, which has been occurring for decades, is the increased density of transportation and communication networks in city centers. This transformation is a fundamental element in the composition of today’s and tomorrow’s cities. As a result of these transformations and increased difficulties in the circulations of cities, there have been important developments in transportation technologies in the last 30 years.

The point that all these various interpretations illustrate is the inevitable effects of the changing transportation technologies on spatial organizations. It can be said that new cities are growing silently on the transportation networks; and this is reshaping the topographies of the cities. These transformations of spaces are seen in different scale of the city parts, particularly public spaces, such as shopping centers, museums, entertainment centers. Considered a smaller version of the city, university campuses are one of the architectural developments affected by these changes. The above-mentioned spatial transformations in Middle East Technical University (METU), one of the most popular universities in Turkey, having a really large, defined and designed campus transportation, will be analyzed in this thesis.

The objective of this thesis is to investigate a new mode of transportation in METU and the impacts of spatial transformations generated by the proposed system in an architectural context. It embraces modern concepts of space-time in the practice of architectural design, and involves a sensitive consideration of the perception of space relative to position, speed and movement. The beginning of this study will be drawn by an architectural discussion about recent transformations of urban public space.

1.1 Problem

METU was built as a result of a competition in 1960. The winning project proposed a "*redburn*" system for vehicle transportation (a service ring and cul de sacs) and an alley for pedestrian transportation. In this structure, a pedestrian can walk around the campus without being hindered by any obstacles (Erpi, 1999: 158). At the turn of the century, as a result of increasing of campus population and extensions made in the last 40 years, accessibility from one edge to the farthest edge of the campus became a problem for pedestrian. Within this framework, METU campus transportation needs to be reanalyzed and also needs to be examined with alternative transportation solutions.

1.2 Objective

The aim of this thesis is to examine all current spatial transformations at METU, considering the scale from macro to micro and to look for new spatial organizations that flourish the campus life. The proposed design of this thesis will be based on a "monorail" system. A monorail is a single elevated rail that can also run at grade, below grade or in subway tunnels. Vehicles are either suspended from or straddle a narrow guideway. Detailed information on monorails can be found in chapter four.

The design of the elevated monorail project will be exploited as a means of making explicit the above issues in an architectural context. The goal is to create both organizational clarity as well as a dynamic aesthetic based on an explicit recognition of the movement of time through physical space. The thesis strives to resolve all these issues in architectural expression of space, time and movement.

1.3 Method and Domain

The city is the interface between technology and accelerating urban flow, says Benedikt (1993). Under the effect of technological developments, drastic changes are taking place in the way we understand and experience the cities. In this understanding, the concepts of the relation among boundary, space and time are redefined in exchange of the established concepts in architecture. The new transportation technologies contributing to these transformations in architectural space are the subject of this thesis. This study tries to explore the new transportation technologies and their effects on architectural space in a both theoretical and practical framework.

The potentials of transportation technologies within the field of architecture will be explored around the following questions:

- How do these new technologies reshape the meaning of architectural space, and change some concepts belonging in the field of architecture, such as space, time, movement, boundary, surface and interface?
- How will these technologies change spatial definitions, such as the changing of façade and boundaries in the campus?
- How these technologies will affect the perception of architectural space of the campus?
- How these technologies will affect today's campus structure based on pedestrian movement and social life?

This thesis aims to implement reflections of all these discussions grounded on architecture by proposing an alternative transportation system for METU, and to bring spatial re-organizations as a result of this proposal.

In the first two chapters, a conceptual analysis will attempt to be made, in order to interpret the changing concepts in architecture as a result of the new developments in transportation technologies. In the first part, all of these transformations are explored within the urban context, as the intersection point of technology and architecture.

Today, the notion of speed and movement has started to make profound shifts in urban perception and experiences. All the reflections of transportation technologies on the perception of architectural spaces are studied in the third chapter. To understand changing perception relative to position, speed and movement, this part is defined under the subtitles of 'The Effects of New Technological Development on Perception of Space and Time', 'Perception of Time', 'Perception in Motion' 'Rendering in Space and Time' and 'Implication on Architecture'.

In chapter four, the revolution of new transportation technologies, both in Turkey and the world as a whole, will be examined. In this chapter, monorail systems, a new transportation technology, will be explored in a wide context. Furthermore, station design will be studied, providing new readings in the light of the growing effects of the new transportation technologies. Then, the transportation structures of university campuses will be studied in order to form an input to the following chapter.

This study tries to explore reflections of all these previously discussed theoretical analyses to the application of architecture. The campus of METU is examined in this context in chapter five.

At the end of this study, all these data will lead to the selection of a proper approach for a transportation system in the METU campus area. The proposed transportation technology will be analyzed in order to:

- Reconsider the campus transportation in parallel to the transformation in architecture.
- Explore the spatial transformations as a result of this new transportation technology and even different future proposals.

1.4 Limits

Architecturally, the main structure of this thesis is composed of a threefold frame:

- The transformative effects of transportation technologies,
- The changing time, space and movement concepts in architectural readings
- Observing all of these alterations on the application of architectural fields.

Furthermore, it seeks to incorporate modern conceptions of space-time through a sympathetic understanding of unique and diverse user perceptions based on position, speed and movement.

CHAPTER 2

THE TRANSFORMATION OF ARCHITECTURAL SPACE IN URBAN CONTEXT

As we enter the 21st century, the new transportation systems - airplanes, high-speed trains and automobiles – have become the fundamental elements of urban life. When these technologies came into being, both the theoretical and practical domains of architecture started to consider their potentials and influences. In this chapter, the way in which new transportation technologies, especially high-speed trains, are altering the urban structure and architectural readings will be explored.

2.1 Technological Development in Transportation Technologies and Changing Spatial Boundaries

Melvin Webber, an American urban planner, stated that increased mobility, transportation and communication technologies had reduced the importance of distance between cities and centrality, which until then had been at the ideological base of urban spaces, was being eroded. The city, he mentioned, could no longer be defined as a static arrangement of objects in a unitary space, but had to be approached as a non-place urban realm, a giant grid consisting of near- invisible transportation and communication networks (quoted by Eeckout and Jacobs, 1999: 48).

The speed of modern transportation constituted the most important factor in the transformation of the urban landscape process. Robert Fishman (1987) mentions that at first the construction of railroads in the 19th century altered the spatial boundaries. Increasingly and especially since the 1980s, new types of suburban landscape have emerged, and have drastically complicated the traditional distinction between city and suburb, particularly in Europe (Eeckout and Jacobs, 1999: 19). Today, the networks are changing the land-use patterns. The fast transportation networks are carrying urban residents to new activity zones. Cities are changing from being essentially single-entered to becoming increasingly multi-centered. Transport patterns are changing accordingly, with multiple centers as destinations and multi-directional flows.

Not distance, but time has become the criterion that most determines the spatial transformations of the city (Eeckout and Jacobs, 1999: 47). With the new transportation and communication technologies, spatial limitations are diminished, which David Harvey names as the ‘annihilation of space through time’. Time and speed undermine the geographical definitions of a city. At Eura Lille, for instance, “Rem Koolhaas even went so far as to claim that Englishmen would massively start buying houses in Lille because they would be able to get to the center of London faster from there than from London’s own periphery” (quoted by Eeckout and Jacobs, 1999: 47). Thus, the new contemporary cities, no longer consist of physical proximity and spatial limitations. The cities are invisibly reconstructed by urban residents.

In the course of time, with technological development, this urban transformation reached another dimension. As stated by Virilio,

> We are effectively seeing the beginnings of a third revolution: following the transport revolution of the nineteenth century, which saw the flourishing of the railway system, followed by the automobile and aviation, we have, in the twentieth century, seen a second revolution, the transmission revolution, as a result of the implementation of the properties of instantaneous propagation of electromagnetic radiation in the form of radio and video (Virilio, 1997: 51).

As a consequence, the cities of the world are becoming increasingly linked by transportation and telecommunication networks. These new phenomena have rendered the new cities' boundaries more invisible. In "Open Sky", Virilio mentioned that with these technological alterations there would be "*world cities"* in the future: world cities center is everywhere, but its periphery is nowhere. According to him, in the future, some area will be not use, and some parts of world will be big suburb area (1997: 74).

2.1.1 Railway Technologies and Their Effects On the Transformation of Cities.

Although information technologies may receive the most attention in contemporary cities, transportation technologies have had the largest effect on the physical structure of landscape. The developments in the field of transportation technology caused a transformation in the new city form. The most important of these developments has been the railway, which is the main invention of the Industrial Revolution; and the private car, which started taking its place before World War I.

Streetcars, commuter trains and even the omnibus initiated metropolitan physical restructuring in the 19^{th} century, leading to dispersion along the city structure. In this way, the city forms started to re-structure and transform in relation to this dispersion. The railway technologies caused a rupture from the city center, but the new settlements were ordered towards the railway and massed around the stations (Tekeli, 1981: 67). In this context, it can be said that the structure of the modern city had its origins in the railway age. "Rail transport revolutionized local travel, creating a new class of commuters, confirming the dominance of capitals such as Paris London and Berlin - which became the hubs of national rail systems - over their provincial satellites and making the fortunes of other big centers", says Powell (2000: 13).

After World War I, electrical subways and double-storey busses increased in some city center of Europe. The construction of the streetcar, called the "light rail", and the elevated monorail, followed this development. The dynamic character of this revolution "is now being completed with the TGV and the hypersonic airplane, which have almost attained their maximum speeds"; as Virilio stated (quoted by Armitage, 2001: 90). This development acts as an initiator to the acceleration process in cities.

All of these alterations have not only physical, but also social effect. Marshall McLuhan stated that, "the railway did not introduce movement or transportation or wheel or road into human society, but it accelerated and enlarged the scale of previous human functions, creating totally new kinds of work and leisure" (1964: 8). Besides, if considered much more internally, it can be concluded that "with railways, motorways, bridges and large factories, technology spread over territory, but now it enters the innards of the human body" (quoted from Paul Virilio by Armitage, 2001: 49).

This development of railway technologies also had an affect on industry in the cities. Mumford states this reflection of transportation technologies on cities as, "It was in the railroad that the routing through of production and the timing and inter-relationship of the various parts of production took place more than a generation before similar tables and schedules and forecasts made their way into industry as a whole" (1934: 199).

Consequently, contemporary cities are reconfigured in interaction with these new railway technologies. The key to redefining the city of the future is revolutionized rail transport that changes the whole perception of the city and urban life.

2.1.2 The Increase of Automobile Usage

The contemporary age is referred to as the age of mobilization[*]. This label for our times is associated with the development of advanced transportation technologies. There are

[*] Netherlands Architecture Institute (NAI) organized an International Architecture Biennial about "Mobility" between the date of 7 May and 7 July 2003.

fundamental changes in the way people experience their world with the effect of these technologies. These transformations were embodied by a number of crucial phenomena; the first is the construction of railroads in the 19th century, and second is the enormous growth of automobile traffic in the 20th century. At the end of World War II, "railroads around the world were in steep decline, superseded by the private automobile" (Ringen, 2001) and this technology started the important change experienced in the city center.

Especially, in the modernist city, "the automobile implied a fundamental change in city organization" (Barnett, 1995: 193). According to the principal of the modernist design, the city has produced the familiar pattern of isolated elements strung out along the highway, and urban spaces are separated from the street (Barnett, 1995: 193).

In the end of the 20th century, this metaphor, which Henri Lefebvre calls "King-Object" and "Guide-Thing", has continued to restructure the city and our daily life. Lefebvre stated this issue thus,

> Automobile, in the simple and poor analysis of the society, occupies an important and precious place, gradually… In reality and genuine, the thing which the automobile has caught and "structured" is the everyday life, not the society (1998: 104).

Therefore, it can be said that the modern city is based on an automobile network. In metropolitan life, automobile usage is increasing more and more, "[n]ot only because they are a rational response to urban development patterns, but also because the automobile is more than transportation ---it is a symbol of personal freedom and affluence" (Wendell, 1996). Paradoxically, along with this personal freedom, density and congestions problems occurred in the city center. In spite of those problems, the totalitarian viewpoint offered by Hanns Adrian in which he "does not think of an ideal world with the car as possible", will rather bless us with a wrecked world than manage to remove the car (quoted by Gerkan, 2002: 50).

2.2 Changing Architectural Concepts And New Readings

2.2.1 Transformation of Space and Time Concepts

Today, drastic changes are taking place in the architectural spaces. These transformations are inevitably leading us to research definition of real spaces and time. Virilio explains this alteration as, “the unity of space, which formed the basis of architecture, modern architecture included, is deconstructed, fractionalized” (quoted by Armitage, 2001: 33). He emphasizes the point that “the geographical difference between “here” and “there” is obliterated by the speed of light” (quoted by Armitage, 2000). In contemporary architecture, time is added as a new dimension over the existing three dimensions. Besides, this new concept of time, “space is fractured too, from approximately the 1970s, onwards. Newtonian absolute space disappears with this break up, and by Einstein relativity in the first place” (quoted from Virilio by Armitage, 2001: 33).

In our day, space and time as synchronized concepts are redefined within the architectural context. They are also identified according to each other. Thomas Pynchon said that “Time is the space that is not seen”, to mean that time is a condition of space (quoted by Eisenman, 1999: 250). In the same view, Fredric Jameson mentions that “the postmodern condition involved the transformation of time into space” (quoted by Eisenman, 1999: 250). Time not only can manifest itself in materiality, but there is also an opportunity to understand time in a spatial sense as well.

For Tschumi, the object is to discuss the main transformations of today’s society, which can be stated as the “function of time”, where of simultaneities form the duration. While stating that, he comments, “for us, as architects, time is spatial because space is what we construct, and time is there to activate these spaces, occasionally to transform them by challenging the perception of their boundaries” (quoted by Virilio, 2000: viii).

Today, “because of increased speed of transportation, time is not constrained by location in space as it once was” (Eisenman, 1999: 250). Speed substituted the time concept, which Virilio names “space as speed-space instead of time-space”

Entering the notion of speed into our life, architectural space has started to transform and reconstruct. These are also results of technological developments in transportation, thus, the world has become smaller and the boundaries of the city are gradually blurred. On this issue, David Harvey points out that “many of the transportation and communication technologies advanced by capitalism have had the effect of shrinking space” (1989: 240). Spatial barriers have been destroyed by the acceleration speed of information and transformation. According to Harvey, as distance has been overcome, time too becomes compressed. He mentions the concept of "time-space compression" in order to indicate "processes that so revolutionize the objective qualities of space and time that we are forced to alter, sometimes in quite radical ways, how we represent the world to ourselves" (1989: 240).

In addition, the subway and the airplane, “[a]lso contributed to this disorienting time-space compression, it is especially the prototypically trans-metropolitan means of transport the car, that has affected changes in perception of the physical environment during the latter half of the century” (Eechout and Jacobs, 1999: 129).

Thanks to developments in transportation technologies, the best-known instance of which is TGV, we can travel all too rapidly across the time zones. With new high-speed trains, we can go wherever we want to go with shrinking space. It is like the fifth dimension that L’Engle talks about – a space, which is not really physical, though it certainly exists to be experienced.

Figure 2. 1 Accelerating speed with transportation technologies.

This means that the contemporary city, which has constantly accelerated from the railway to TGV or airplane; now gives new meanings to the "*phenomenology of acceleration*"*. Speed is the key concept in this process of acceleration. Lawrence Shapiro, in an article entitled "Architecture, History and the Embodiment of Speed" mentions of speed and "the perception of travel without actual movement" as "a perfect analogue to ideology that convinces us that we are doing one thing, while in fact we are doing quite another. We are held raptly in a state of attention – or distraction, …the sense that the speed of travel offers a kind of mastery of time and space" and so "As the redemption through technology presents itself: offering to collapse time and space, promising to unite us in one community, we should wonder about the social dimensions of the re-mapping of individual and environment" (quoted by Juintow, 2000).

Consequently, in the modern age, tremendous technological advances have collapsed space and time. These new technologies, in some ways, exposed new discussions, and brought new meaning to space and time concepts. Therefore, the new meaning of these concepts, which was named by Harvey as "Time space compression", is the characteristic of the contemporary cities' condition. Virilio mentions about the new time concept as,

* This terminology is used by Paul Virilio in his several articles.

> Today we are entering an era of intensive time: that is to say that new technologies lead us to discover the equivalent of the infinitely small in time. We are living in both the extensive time of the cities of stories, of memories, or archives, or writing, and the intensive time of the new technologies (quoted by Armitage, 2001: 71).

2.2.2 Border and Borderers

The invention of railway has started transformations in the nature of boundaries. With the technological developments in this technology, "national borders have ceased being continuous lines and became non-related set of lines and points situated within each country" (Andreu, 1999: 57). It is in this light that the borders and discontinuity are very important issues for contemporary architecture.

By the end of the 19th century, new transportation technologies, the electric tram, the electric commuter train, the underground railway, started a transgression process in cites' boundaries. By shrinking time and distance, improvements in these technologies brought points of the world closer. As a result of this process, the world has become smaller and the boundaries of the city have become gradually blurred.

While spatial borders are gradually blurring between cities, new invisible borders are replacing them. On the same point, Paul Andreu states his view on this transgression as; "the idea of indispensable borders is everywhere. Without it, the world can only confused…" (1999: 59). He stated that "when a border disappears, when it simply loses its symbolic import, or what constituted the rite of its transgression, another immediately takes its place because most often very different types of borders are superimposed upon a single site" (1999: 59). He continued this thought that, "The architects use these borders to form screens, filters and mirrors, discontinuities that lend themselves to the thoughts of another person about a world that is always individual and singular, a world yet to come" (1999: 61).

Today, invisible boundaries are spread all over the world that cannot be defined as physical. In "Invisible Architecture", Bouman Ole and Roemer Van Toorn mentioned about the transgression of the border phenomenon as follows, "Taking into account development in transport, telematics, genetics and politics, we can hardly believe otherwise than that today's acute awareness of a border is due to the fathomless crisis of the border itself assuming the term crisis is still appropriate in this new paradigm" (1994: 150).

Nowadays, The "border" concept is shaped with a different metaphysical meaning. This idiom is defined with terms such as "transgression", "difference", "excess", "fragmentation", (Bouman Ole and Roemer Van Toorn, 1994: 150) and also, in the architectural realm, it means the sites of passage from one point to another.

In the light of these discussions, Bouman Ole and Roemer Van Toorn pointed out that, "At the border, something ends and something else begins" (1994: 150). The railway terminal and airport is a good example of this. They are the sites of passage from one point to another. Andreu stated that: "the airport is the most visible meeting place between the natural and artificial, between what is local and particular and what is cosmopolitan and generic. All these transitions coexist" (1999: 59). The terminals have very important architectural potential from this point and it is for this reason that a terminal cannot be reduced to a functional description alone (1999: 59).

It can be said that, in confliction with the gradual disappearance of the 'border concept' in its predefined meaning, the reflection of this term can be seen in a different context in our life, such as in the railway and the airport terminal.

2.2.3 Modern Conceptions of Speed and Movement

2.2.3.1 Speed

> Movement transfers space into another existence without necessarily destroying it, as Heinrich Heine or Victor Hugo described the effect of railways. This why I understand speed as an environment. It is not a coincidence that I have called myself an urbanist for so long or that I have taught at a school for architecture for over thirty years. For me, speed is an environment, as that word is understood in the natural sciences. Speed is not simply a matter of time. Speed is also space-time. It is an environment that is defined in equal measure by space and time. In addition, architecture too, whether it is moving or not, is defined by the speed of movements in space (quoted from Virilio by Armitage, 2001: 61).

Recently, speed and movement has become increasingly important issues in relation to architectural context. Gradually, speed is reconstructing the cities today and human life. This dynamic acceleration process of cities is increasing through transportation networks.

Moreover, in an accelerated age of transportation, our current spatial definition and experience is one of distortion. Today, physical proximity loses its significance with this process, as Virilio mentioned. He said that, "[w]ith acceleration there is no more here and there, only the mental confusion of near and far, present and future, real and unreal…" (1995: 35). The new technologies in transportation are increasingly exerting the limits of space and its boundaries. The automobile, airplane and the train all combined mobility and also contributed to this distortion process via its increasing speed.

> When I stop to look at a tree, it is immobile. When I start walking again, the tree seems to pass by. This passing by is tied to the speed of the observer. If I pass the tree quickly in a car, the tree will become indistinct, and if I pass it very quickly, I won't see anything; I'll only see a blur, a fog. So speed is always a way of seeing the world differently. Means of transportation are not only a means of displacing oneself from one point to another (quoted from Virilio by Armitage, 2001: 88).

It is in this light that space and time have new meaning with effect of this acceleration phenomenon. As mentioned by Virilio, "space and time are not defined as Newtonian description… Our relationship to reality has been affected by the Einsteinian era, in which speed is essential, absolute, while space and time are relative; the tree can no longer be the same" (quoted by Armitage, 2001: 89).

Therefore, the speed of transportation, in some ways, is bringing new concepts and discussions to the architectural realm. In this context, Virilio described speed with two new meanings as relative and absolute speed. He explains the relation between relativity and speed as follows:

> The world is reduced, both in terms of surface and extension, to nothing and this results in a kind of incarceration, in a stasis, which means that it is no longer necessary to go towards the world, to journey, to stand up, to depart, to go to things. Every thing is already there. This is again, an effect of relativity …Our societies have used relative speeds by train, or the automobile and the airplane (quoted by Armitage, 2001: 31-92).

So to say, the contemporary city, what Koolhass describes as the '*generic city*', is represented by speed and motion. The cities are reconstructed and reformed as a result of this process. We know that "modern civilization would be impossible without speedy and efficient transport" (Davey, 2003: 42). Nowadays, this acceleration process has reached another dimension that made by virtual transportations. Virilio mentioned this issue that "transportation today is the machines that transport vision without transporting body" (quoted by Armitage, 2001: 88).

2.2.3.2 Mobility and Movement

In our day, technology has exploded so our mobility today cannot even be compared with that of only 20 years ago. The advent of new transportation technology has made our world increasing small and easier to travel within a few minutes. So to say, this 'accelerating mobility' describes the 'spirit of the contemporary cities'. In this way, with rail transportation, people can move around the city and the world at an increasing speed.

Without any doubt, "Mobility seems to be the principal characteristic of the urban phenomenon." (Roncayolo, 1998: 20). Similarly, it is proposed as the key concept for the transformation process in cities and social life. In this framework, "[i]n urban theory, mobility surfaces in a variety of contexts that relate it to, for instance, public space, social networks and disputes about access to urbanity through collective or individual transportation" (Albertsen and Diken, 2001).

Retrospectively, "social engineers and planners have always been interested in mobility, especially in the context of Modernity" (Albertsen and Diken, 2001). According to Le Corbusier, the modern city and modern life were to be shaped by the new criteria of speed, comfort and efficiency (quoted by Sennett, 1994: 349).

Consequently, cities have been dynamic constructs that have been supported by constant mobility since the industrial regime inserted the mobility concept into daily life. Therefore, "transportation has become an integral, taken-for-granted part of both planning processes and everyday activities since the 19th century" (Albertsen and Diken, 2001). Similarly today, the enormous influence of mobility technology on cities has been linked with the growth of power over modern life.

CHAPTER 3

PHENOMONOLOGY OF SPEED AND TIME

> The informational systems and transportational networks have had an important impact on traditional modes of perception. The development of systems of instantaneous information transfer has come to distort our conception of time, and our perception of place (quoted fromVirilio by Armitage, 2001: 75).

When geographical space has become less important and speed has become the inevitable component of progression in the 20th century, our consequences of perception started to drastically change. Speed not only deconstructs the nature of perception, but also entails a new way of lifestyle that is highly dependent on mobility. Virilio mentions that the world is reduced, both in terms of surface and extension, to nothing, and this results in a kind of incarceration, in a statis, which means that it is no longer necessary to go towards the world, to journey, to stand up, to depats, to go things. Everything is already there. According to him, this is an effect of relativity (quoted by Armitage, 2001: 31). As the material extensions of these conceptual transformations, motorways and railways provide “unlimited access to the world as the ideal of the movement” (Ibelings, 1998: 79).

In the course of 20th century, several theories have been introduced in which changed conditions of perception are grounded in the structural features of the contemporary cities. Speed and time henceforth accepted as the integral of modern life, have redefined the architectural space. Following the study of the ongoing spatial fragmentation of the architectural space in the second chapter, this chapter will discuss the perceptual transformations and technological effects on the space, time and movement concept.

3.1 The Effects of New Technological Development on Perception of Space and Time

> The increasing velocity that has been brought about, first by the railway, but mostly by automobiles and later by planes, dictates a higher level of control. The time-space of a city needs to be anticipated. In the beginning human vision was adequate. Later, cameras came in. the anticipation of space is a physiological reaction of our perception facing increasing velocities. The faster one moves, the more one must anticipate what is coming. The focus of our gaze is being consequently pushed forwards…The more the speed of a city increases-through automobile traffic, but also through telecommunications- the more it becomes necessary to anticipate appearances. This is a form of totalitarian control that relates to the contemporary transparency of architecture (quoted from Virilio by Armitage, 2001: p).

Architectural space is in the process of progression with all the transforming dynamics, such as speed, time and movement. Perception of space and time are gradually transforming with the effect of accelerated speed. Moholy-Nagy clarifies this issue with these words; "motion, accelerated to high speed, changes the appearance of the objects. There is clearly a recognizable difference between the visual experience of a pedestrian and a driver in viewing objects… The difference is produced by the changed perception caused by the various speeds" (quoted by Wenz).

Therefore, our experience and perception are ruptured and distorted by unstable space and time concepts. That is to say, our vision of the world depends on the interaction of our perception and the technology. As the rather physical component of this interaction, new technologies were introduced resulting in higher speeds in the wake of the Industrial Revolution. Technology became such a significant component that in the post-war metropolis, car-based perception was almost a visual default model (Eeckhout and Jacobs, 1999: 129). Furthermore, with the never-ending progress of technology, perceptions of speed are in a state of constant change. John Rachman announces new perception models, saying, “we’re not in the process of Kevin Lynch’s pleasant ‘grammar’ or ‘mapping’ of the post war world anymore” (1999: 160). This indicates that the contemporary cities seem to be continuously in motion. We experience space by constant motion while driving the freeway or by high-speed rails. While doing so, we loose our ability to distinguish one place from the other and to form spatial boundaries. As a result of this visual fragmentation, our memory cannot draw a distinct cognitive map. Rachman states this issue in his words that; “today we are witnessing unusual connections between image and city as if ‘time’ turned out to be free from memory.” (1999: 160).

Consequently, the urban phenomenon is no longer defined by the traditional linear perspective. Henceforth the structure of the urban space is more fluid and more temporal. The speed of transportation technologies changed perceivable form and definable boundary. Conceived in this way “the urban culture of stimulation is symptomatic of a new structure of perception. The central core of this perception involves a changed temporal consciousness-the consciousness of speed and uncontrollable metamorphosis” (Eeckhout and Jacobs, 1999: 111).

3.2 Perception of Time

The relations among space, speed, time and movement, that are previously mentioned, bring about new recognitions in the time concept. The dynamic character of this relationship is enhanced by technology in terms of different speed experiences. The experience of speed - whether in cars, buses, light rails, monorails, subways, planes or helicopters - creating a reformation in the structure of metropolitan space, has crucial effects in a more abstract way in the context of time. Eeckhout and Jacobs comment on this issue as follows:

> The vaster the metropolitan environment becomes, and the more the structure of metropolitan space is determined by the infrastructure of roads, the more circulation itself is subjected to a proper spatial logic that counteracts the intuitive physical experience of space. In outlying metropolitan areas, even vulnerable pedestrians are forced to fallow a track that is shaped by the course of uncrossable roads and freeways, prompting them to make endless detours in order to reached their destinations. Time instead of space determines distance, and the "annihilation of space through time" described by Harvey in the Condition of Postmodernity is nowhere as materially legible as in the new post urban environment (1999: 128-129).

This replacement of the perception of distance in urban space with the perception of time is exemplified by Robert Fishman; "[d]istance in the new cities is generally measured in terms of time rather than blocks or miles. The supermarket is 10 minutes away. The nearest shopping mall is 30 minutes in another direction…" (quoted by Eeckhout and Jacobs, 1999: 47).

The distance between two objects, henceforth defined in time concept, is relative, since it changes according to their motion. Parallel with this issue, motion is also measured relative to another motion. As a result of this perception, it can be concluded that: "Time is a coordinate of space. It is the 'fourth dimension' a physical measurement" (Nagy, 1961: 266).

The new definition of time as a "coordinate of space", changed the traditional chronological time concept. Speed introduced with new technology converts distances to time as phenomenal movement between objects. This conception of time distorts the linear chronology of past, in this synchronously experienced century of ours.

Besides these, time acting as a physical measurement reduced the need for physical proximity. The new transportation technologies make it available to contact even the most distant points of the world and hitherto unreachable destinations. This reduction in the need of physical proximity is defined by Virilio as the "shrinking effect" (1995: 35).

3.3 Perception in Motion

> Architects have been taught to eliminate questions of flow and motion from the rigorous description of space thus these qualities have been relegated to personal taste and casual definition. Architecture's present lack of experience and precedent with motion and force make it necessary to raise these issues from within the technological regimes of the tools rather than from within the history of architecture (Greg Lynn, 1998: 171).

The contemporary "reader" always experiences the world with in motion. This leads us to the idea that "the experience of space through motion is important because the order of presentation of spatial objects is an important perceptual experience in itself" (Pocock and Hudson, 1978). In this experience, motions perform as the basic necessity, providing different objects to enter the sensory field of the perceiver.

The nature of this field depends upon the various speeds and movements introduced with new technologies. Virilio points out the radical changes that are taking place since "[p]revailing rapid transport and transmission technologies have managed to mobilize our field of perception non –stop -not only within the artificial construct of the metropolis, but within the expanse of whatever vast territories are traversed thanks to the feats of earthbound or airborne motors" (1997: 96).

In the context of the city, the extent of the field of vision depends on the possibility of experiencing structures from various aspects. Donald Appleyard, Kevin Lynch and John R. Myer, observed in their famous book "The View From the Road" how the landscape one observes from the road defines spaces. In this reading, motion provides us with a sense of place: a road can take us on a journey through the historical layers of the city, and enables us to remain in contact with incremental, contemporaneous change in environments (Lynch, 1972).

Hence, with the effect of automobile, railway and airplane transportation, the perception of distance is started to be experienced temporally. These new technologies altered completely the way we produce and receive images. While traveling by these vehicles, images seem to be continuous by the effect of this motion.

The use of different transport modes is associated with different experiences of space. In this context, Ralph Waldo Emerson, an American philosopher, illustrated railroad travel "[a]s a salutary drug of sorts, disconnecting the traveler from place and loosening the perception of stability - or the stability of perception" (quoted by Bouman and Van Toorn, 1994: 429). While traveling by TGV, Virilio observed its effect on the countryside. For him, the image, when viewed from the train, is frozen and immobilized according to Newtonian rationalism, but in the Einsteinian era, in which speed is essential, absolute, while space and time relative, the image can no longer be the same (quoted by Armitage, 2001: 89).

By the end of the 20th century, the concept of perception was distorted and blurred by speed and motion. These concepts became important for experiencing a city in overview from a static points are rare, and even from such a vantage point one comprehensive image, like a photographic still, is inconceivable. Movement through the city is what enables us to create a 'movie' of experience:

> A property of the physical environment of distinct psychological importance is the fact that environment completely surrounds us. Thus it is not possible for us to experience or perceive all of it at any one instant …'representation' must amalgamate experience into a form which links discontinuities in perception and allows extrapolations to facilitate preparation for future action (Canter and Tagg, 1975: 59).

3.4 Rendering in Space and Time

> In our age of airplanes, architecture is viewed not only frontally and from the sides, but also from above ….The bird 's-eye-view, and its opposites, the worm's and fish-eye-views, have become a daily experience. Architecture appears no longer static but, if we think of it in terms of airplanes and motorcars, architecture is linked with movement. The helicopter, for example, may change the entire aspect of town and regional planning so that a formal and structural congruence with the new elements, time and speed, will manifest itself (Nagy, 1961: 245).

The accelerating pace and inclusivity of technological development is not limited to rendering architectural simulations or images, but architecture must adaptively consider the rapidly changing patterns of human interaction with the built environment. New architectural types are emerging and evolving within today's technologically developing society.

As mentioned above, acceleration of mobility and transportation have made architectural space more fluid and also cause the creation of the new programs. These new programs present practical architectural situations for unique and wholly unexplored applications that address today 's dynamic, flexible and constantly changing activities.

In our day, architectural design processes are rendering in space and time. Most architects conceptualize space in terms of volume, height and so on. Virilio discussed "[w]hether it might not be useful to look for some inspiration in the realm of choreography, in the notation of movement, and in the conception of space in terms of time. He believed "[t]hose established notations like plan, section and elevation have lost their general validity", and concluded, "One should search for a time based notation system that would permit us to factor in time of the built environment" (quoted by Armitage, 2001: 59-60).

3.5 Implication for Architecture

By the end of the 20th century, the urban experience of the contemporary self is one of instability and inconsistency. The acceleration of mobility has made the architectural space more dynamic. These new phenomena changed building types, materials, techniques, façades and also city shapes.

Virilio stated that a building today is not built to last forever. He continues as follows:

> Just as the vehicle in the course of ‘progress’ has been continuously gaining speed, the life span of buildings has also shortened, something that is manifest in their early ageing and swift deterioration. A building has ceased to be something lasting, something eternal, as it used to be. As its life span is now limited to fifty or hundred years, it has become something of a movement in time, a three-dimensional image that will vanish before long (quoted by Armitage, 2001: 58).

A few architects in the past have shaped their buildings according to the movements of their users, says Virilio. The examples of these are the Vasari’s Uffuzi buildings in Florence and of buildings by Bernini. These buildings “are also examples of spaces that are precisely defined in time. Those long covered galleries, which are running alongside the interior passageways of the Uffizi, have something of the stationary railway carriage about them, and their windows frame and therefore expose the landscape” (quoted from Virilio, by Armitage, 2001: 61). In this project galleries and arcades were inward looking and direct the spectator’s gaze to an inner courtyard (quoted from Virilio by Armitage, 2001: 61).

Coming to our age, there are few architects who have succeeded in providing a constantly changing environment to appreciate experiencing a building 4-dimensionally. One example is Frank Gehry. Frederic Jameson writes of Gehry ’s work, “[t]he world vanishes to a multitude of points, and he does not presuppose that any are related to the standing human being. The human eye is still of critical importance in Gehry’s world, but the sense of center no longer has its traditional symbolic value”(1991: 117). In

Bilbao Guggenheim, visitors climb around the building. The building has a perceivable registration plane, yet people are given the framework to visit from several angles and every possible elevation. Exhibition-goers queue up at the lowest level, while conference attendees mingle at the above-grade level. Perched on the highest level are lookout areas for visitors to see the city of Tokyo. A single ramp wraps around the perimeter of the building and multiple ramps criss-cross the upper space, connecting convention areas with bridges over to other buildings (1991: 117).

Figure 3. 1 Bilbao Guggenheim.

Like in Bilbao, there is no single view of the space. In the contemporary world, both space and time are the main aspects for the architectural design process.

CHAPTER 4

NEW TRANSPORTATION TECHNOLOGIES AND STATION DESIGN

While automobile phenomena is transforming spatial definitions in metropolitan cities, the emergence of the new high speed trains is doing far more than rearranging the spatial boundaries and limits of the cities. These new technologies give us new perceptions and possibilities that can undermine the physical limitations. Connected to this sense, in chapter two and three, it was studied how these technologies transform our perception and experiences, and their effects on spatial definitions.

After this study, it was seen that technological innovations and spatial transformations are inter-dependent. In the modern age of high-tech transport and increasing transformations of the city, it is hard to explain that which is the effected and which is the effect in this interaction. With the ever-increasing demand for speed and higher quality of transportation, it has become evident that the future cities will be restructured with in this interaction process. From the point of this perspective, in this chapter, the new technological developments in the field of railway transportation and the new discussions it has brought, such as station design as a transit space, will be studied.

4.1 A Recollection of Transportation Technologies

Mobility and ease of communication have had fundamental influences on the spatial characteristics of social networks and communities (Webber, 1964) and on the mental image individual constructs of space (Golledge and Stimson, 1997). These influences create a paradoxical relationship among the city, transportation and community in the metropolitan city.

Hitherto, the city has been surrounded by the transportation network, and urban landscapes have been increasingly affected by mobility. Moreover, in the future urban space and buildings will continue to be shaped via accelerating speed. According to the "Terminal-2 Theory" introduced by Martin Pawley; "throughout history, but with exponentially increasing force since the multiplication of roads, canals, railways, airlines and electronic communications to create the supra-national networks we possess today, there has always been "*Terminal 2*" theory for valuation of buildings" (Pawley, 1998: 86).

It can be said that; "Modern civilization would be impossible without speedy and efficient transport" (Davey, 2003: 42). These transport aspects are the instruments by which the modern city has been made. Since the 19th century, they had an influence on enlarging the cities and reconstructing them. In this chapter, the historical development of today's high-speed trains will be studied.

The first railway system, which ran using the steam train, was put into operation in 1860 in London. After London, this system was launched in Chicago in 1892, Budapest in 1896 and Berlin in 1897. Although different from these examples, the first railway system in Turkey was opened in Istanbul, between Karaköy and Şişhane in 1875 (Yaprak, 1996: 21). In this system, vehicles were propelled by cables.

Actually, before the arrival of the metro system, public transportation solutions were tried in some Europe countries. The first cable car, which itself had no motor and was propelled through the gripping into a cable with a metal arm, was used in 1830 in Britain. However, eventually in 1890, cable cars started to be replaced by electric streetcars - also called the electric railway, trolley, or tram (Black, 1995: 16-17). Following this progression, the first elevated line in the world was built in Chicago in 1895 (Black, 1995: 22).

Along with the construction of railroads in city center, the 19th century witnessed intercity railroad development. As Black states; "[t]he first intercity railroad service began in 1830 between Liverpool and Manchester in England" (1995: 21). Since this date, rail systems using steam trains became widespread, especially in England, connecting close cities to each other (Yaprak, 1996: 21).

Since the construction of this network, architectural space, in all its aspects (landscapes, cities and their boundaries) has been undergoing dramatic changes. Social life gained speed with these new public transportation networks. Black comments on this issue, saying some people started to go to work everyday from small towns near the large cities via public transportation vehicles (1995: 21). One notable consequence of this transportation network expansion, which has been occurring for decades, is that enlarged urban landscape and "pressure for homes and working spaces grows" (Richard, 1990: 1).

Public transportation prevailed during the first half of the 19th century. However, in the second half of the 19th century, the rapid spread of the bicycle that grew in popularity from 1895, and automobile invented by Carl Benz and Gottlieb Daimler in 1885, replaced railway transportation (Yaprak, 1996: 21). This century was defined as the starting point of the age of automobile domination. However, in the same period of time, transportation became a problem and main arteries began to be blocked by intense traffic. The automobile dispersed density at the city center, but this density spread towards the outer city. According to Tekeli, this spread was different from that of the railway' (1981: 67).

As an alternative to public transportation, the automobile led to a radical transformation of urban space and experience, emphasizing individualistic activity and privatized space (Wheeler, 2001). That is why at the beginning of the 20th century public transportation started to lose its importance with increasing automobile usage. As a result of this shift, "the role of railroads has declined even in cities where they previously had flourished… Even in the best instances, governments failed to sustain adequate investment in rail networks, forcing some lines to close and others to reduce the frequency of trains" (Lowe, 1994: 51-56). Many of the problems with which we are confronted today stem from the losing ground of the rail network in city centers.

Following the dominance of automobiles, since the second half of the 1950s, several significant developments contributed to the revival and expansion of rail transit systems in many cities around the world (Vuchic, 1994: 106). As indicated in the following quotation, these developments also include negative experiences lived along with widespread use of automobiles. However, "today's congested highways, worsening smog, and shortage of land for new roads are reviving official interest in railroads" (Lowe, 1994: 51). Eventually, at the beginning of the 1980s, railway technologies again started to gain significance, with the speed aspect being included as an integral. According to Peter Davey, "A few years ago, it was fashionable for a few moments in certain rather silly circles to suggest that airports were the new centers of civilization. Now, it seems much more sensible to make rail stations once again key parts of real city centers" (2003: 43). In this way, cities can be immensely enhanced by transport, as well as destroyed by it (Davey, 2003: 43).

Today, speed in modern cities is completely engendered by high-speed transportation technologies. The emergence of the railway "in the first quarter of the nineteenth century was a phenomenon of extraordinary importance, not only in the development of industrialization worldwide, but as one of the key new technologies without which much of nineteenth-century civilization as we came to know it could not have come about" (Cossons, 1997: 3). This new technology gradually gained accelerated ring speed, at the beginning of the 21st century.

4.2 New Rail Technologies as an Alternative to Airplane and Automobile

The modern era is an intriguing and complicated notion. Today we can travel from one part of the world to the next by plane, car or train. The concept of space seems to disintegrate. James Gleik stated that 'Railroads demanded punctuality – they forced people to be "on the clocker"or even "on time". Until they could ride on trains, few people traveled fast enough to notice clocks set differently at their destination" (Gleik, 2000).

Speed and punctuality is now a constant component of the contemporary cities, requiring the new high-speed technologies in transportation and also telecommunications. In this context, Virilio mentions that "politics of space" (territory, defense, urbanism) is being replaced by a "politics of time" (transport, communication, speed, networks) (quoted by De Cauter, 1999: 263). Likewise, Rem Koolhaas (1998), in his essay "Generic City", mentions a similarity between contemporary city and contemporary airport. For him, there are "strong parallel between the amorphousness and lack of place in the modern city and the modern airport." (quoted by Robbins, 2000: 45). Related to these two quotations, it can be said that, "The Generic City is the product of the network and thus of the politics of time" (De Cauter, 1999: 264).

While an airport is a metaphor for the contemporary cities according to Koolhaas, today, thanks to the high-speed rail transportation technologies, this process has started to reverse. Far from Koolhaas' idea, according to Edward Robbins, "modern cities must be the railway station rather than the airport and the car park" (2000: 45). Robbins explained necessity of railway technologies in a modern city as follows:

> We must stop devouring the earth's surface with such avidity; we must encourage means of traveling which are not so energy expensive as the aeroplane; we have to integrate transport and the city so that densities can be increased, land-take reduced, and natural resources conserved (2000: 45).

Nowadays, more important developments are observed in railway technologies; for example, "national travel in the most advanced countries like Germany, France and Scandinavia is often more convenient and quick by rail rather than air" (Robbins, 2000: 45). In more recent studies on the city, it has been analyzed that new high-speed trains will be fundamental elements of tomorrow's cities.

Today, important endeavors in this respect are intensified with new developments in urban rail transportation. New technologies in urban rail transport, like high-speed trains, elevated monorails, tramways and light rail transit are beginning to be implemented all over the world. In cities, such as Grenoble, Strasbourg, Karlsruhe and Nantes, light rail networks have expanded city boundaries and have trimmed down the differences between center and periphery. Similarly, "from Sheffield to Strasbourg, new tramway systems are improving city movement; London has the most ambitious plans for trams" (Davey, 2003: 43).

The growing significance of railway technologies for city development is increased to search new faster technologies in this realm. Especially in the 1960s, new high-speed technologies have begun to be implemented in the world, the TGV, first used in France, and the monorail, first used in Seattle, Washington. These new technologies engendered a new interpretation of cities and transformed their structures, like TGV project in Euralille. Frank Vermandel explained the effects of the TGV, "There is an increasing number of urban experiments, and with them, an ambitious network of projects is sweeping the land, lending a new dynamic to urban planning" (Vermandel, 1996: 12).

In addition to TGV technologies, new high-speed elevated monorail and sky train technologies have became widespread in the world. Vancouver's sky train is an important example of this. These new elevated technologies have some advantages: "they do not have to stop at road junctions for instance, so they can be faster than surface transport, but they can be hugely disruptive to the urban fabric, as shown for instance by the mighty Bangkok sky-rail system which tears apart a once delicate city" (Davey, 2003: 43).

Today, "most trains are electric, producing far less pollution than motor traffic" (Marcus, 1995: 9), and it is for this reason that railway transportation is preferred instead of airplane or automobile, especially in Europe.

4.2.1 The Improvement of Railway Technology as an Alternative to the Car

Although underground technology started to be used in 19th century, in fact, the very first idea as a solution of the problem of, - separation of pedestrian and vehicle traffic - was declared long before it occurred by Leonardo da Vinci in the 15th century. According to da Vinci, traffic had to be taken underground (Yaprak, 1996: 21).

In this period, the French had developed different utopias to the English' metro idea for decreasing traffic. The most interesting one is Henry Jules Borie's opinion declared in 1865. According to this suggestion, terraces would have been built above the streets for pedestrian movement and elevators run by steam energy would supply a connection between each street level. Another idea proposed by Eugéne Hénard in 1910 suggested that new roads would have been built above the existing roads. In his suggestion, the first of three platforms would be for the use of pedestrians and automobiles, the second one would have been for the tram and third one for cables (Yaprak, 1996: 22-23).

In our time, with increasing pollution and density, several architects and planners are searching for new solutions to decrease automobile usage in the city center. As Davey mentions, “As transport shrinks the world, we have choice between increasing pollution and destruction and enriched urbanity” (2003: 42). In order to reduce this negative effect of transportation, we should “[e]ncourage people to use public transport rather than private cars. One of the main factors for choosing the new public transportations instead of cars is gradually accelerated speed (Davey, 2003: 43).

> The new trains can travel at 200kph, far faster than other transport vehicles. Behind most arguments for traveling from individual vehicles to communal ones are rails. In Europe, few would now think of traveling by air for short or even medium journeys, from for instance London to Paris, or Paris to Berlin, now that train journeys from city center are quicker, more agreeable (Davey, 2003: 43).

4.3 An Alternative Transportation Technology: The Monorail System

4.3.1 Monorail Systems

Monorail is often included with futuristic technologies, but actually it has a considerable history. As indicated by its name, the distinguishing characteristic of monorail is that it uses one rail instead of two. There are two types: In one, the cars are suspended by sturdy hangers from an overhead rail; in the other, the cars ride on top of a concrete beam and wrap around it. Monorails are not a high-capacity system in a mass transit sense and no city in the world employs a monorail system as its comprehensive solution to public transit (Black, 1995: 163).

Monorails have been operating for about 100 years, the first constructed in Wuppertal, Germany in 1901. The technology is proven, but more importantly it is progressing with the development of lighter weight materials and more energy-efficient operation. An elevated full-scale monorail was built in Seattle, Washington, in 1962 and is still running.

Figure 4. 1 Monorail System.

An elevated monorail system requires much less infrastructure, and it is easier, less expensive and less disruptive to construct than elevated light rail or bus rapid transit. In addition, monorail technology is well tested in its switching capabilities.

4.3.2 The Advantages of Monorail

Monorails are proven: Most of the world's transit monorails exist in Japan, seven of which are full-scale urban transit systems. Several more are either under construction or in advanced planning. Walt Disney World's Monorail System near Orlando, Florida, has one of the highest riderships of all monorails. Well over 100,000 passenger trips are recorded each day on the 14 miles of beam ways

Monorails are safe: Whether they are of the straddle-beam or suspended variety, the nature of their design does not allow derailments. Conventional rail suffers this problem frequently. As monorail is elevated, accidents with surface traffic are impossible. Zero accidents translates to no system down time, less liability suits and most importantly, no injuries. However, light rail cannot boast of this.

Monorails are environment friendly: Since they are electric powered, monorails are non-polluting. Most run on rubber tires and are very quiet. Monorails are the most aesthetically pleasing of all elevated rail systems. Their sleek design blends in with modern urban environments. It can be constructed very quickly time.

Monorails are cost effective: Monorail is cost effective than heavy rail, light rail and also bus systems. The Tokyo-Haneda Monorail has been operating since 1964. This eight-mile dual-beam system is privately owned and turns a profit each year. A private corporation runs the Seattle Center Monorail, built in 1962 for the century 21 expositions. In return for the concession to operate the 1.2-mile system, the corporation pays the city $75,000 every year*.

Figure 4. 2 New Las Vegas monorail by Bombardier.

4.3.3 Monorail Technology

Some of monorail technology's attributes while offering a comparison to light-rail technology (a modern term for an 19th century technology, otherwise known as streetcars, trams or trolleys. The term light-rail is actually counter-intuitive and a misnomer, as light-rail is very heavy. The term refers to the fact that the system has frequent stops, and is less rapid than heavy rail.) However, monorail technology is lighter than light-rail (about 1/2 the weight).

* See in http://freewaymonorail.org/technology.htm

Monorail technology is:

- Most flexible in its ability to adapt to existing infrastructure and topography
- The least disruptive in its construction
- Light weight
- Less costly to build, and to operate and maintain
- Quieter and non-polluting
- Minimal in its material and infrastructure needs
- Provides very frequent service
- Rapid and reliable

Figure 4. 3 New Las Vegas monorail by Bombardier.

Light-rail technology has not shown itself to be compatible with topography and existing infrastructure. As 19th Century trolleys or streetcars, they are noisy, bulky and heavy. There are better transit technologies available and proven that are constructed of lighter-weight materials, more energy efficient in operation, quieter and overall less intrusive *.

* See in http://freewaymonorail.org/technology.htm

Ultimately, these technologies, such as the innovative urban monorail technology are more appropriate to the 21st century and to the west-coast city of Seattle a pioneer in technological innovation.

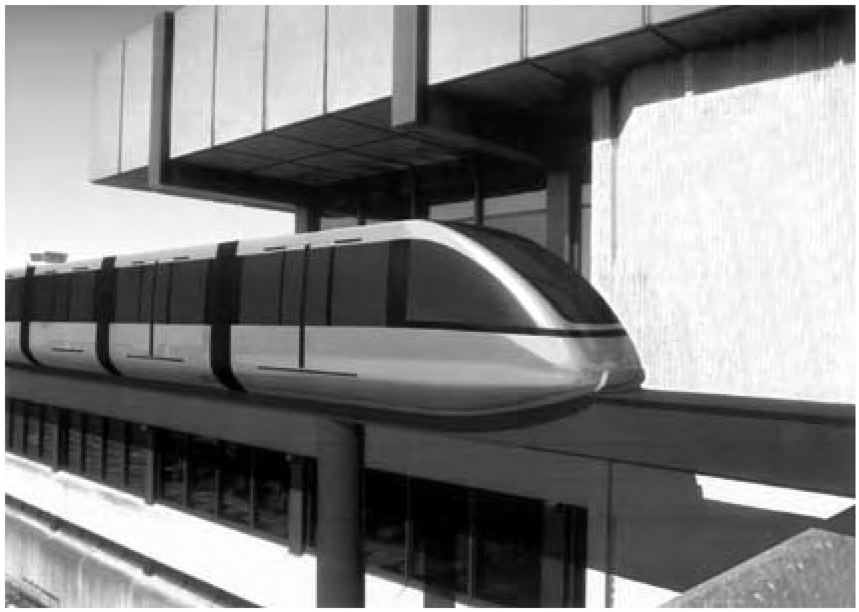

Figure 4. 4 New Las Vegas monorail by Bombardier.

4.3.4 Costs

Monorail systems can require lower capital costs to build and operate than light-rail systems. Because this monorail system would not involve tunneling, it will cost substantially less than a rail system based on subways. Monorail systems typically have lower operation-and-maintenance costs than light-rail systems, because they can be fully-automated, which requires significantly less operating costs. "Monorail is about half to one-third of LRT" according to Michael Crawford. The private sector almost always chooses to builds monorail systems rather than light rail, since they are cheaper to construct and operate, less intrusive on their property and customers, and provides a more enjoyable experience for its patrons. In addition, monorail systems represent one of the only transit systems that have operated at a profit, including both the Tokyo and Seattle monorails. In fact, all of Japan's monorails are said to run at a profit. And the Seattle monorail paid for itself within 2 years - the cost to the city was zero and, in fact, the monorail brings the city about $800,000 in tax revenue every year*.

4.3.5 Environmental Impact

Monorail is extremely quiet as it runs on rubber tires propelled by electric motors, and much quieter than steel-wheeled trains, like light-rail, and diesel buses. The Disney monorail, for example, travels through its hotel, some 15 feet from its guest suites, which go undisturbed by noise. Unlike surface rail systems, neighborhoods do not have to be torn up to build elevated transit. Most of a monorail system is prefabricated off-site and, therefore, on-site construction time, noise and disruption are minimized.

Figure 4. 5 Sydney monorail.

* See in http://freewaymonorail.org/technology.htm

4.3.6 Tubular, Dude

One of the best examples of monorail blending with a modern city is found in Sydney, Australia. This station is located above a sidewalk and takes up little space. The tubular design nicely offsets the many squared edges of a modern metropolis.

Figure 4. 6 Monorail in Australia.

4.3.7 Monorail Examples

4.3.7.1 Monorail in Asia-China Example

An Intamin People Porter minirail connects stations at this world-themed park. Eight small three-car trains run on the track, each with a capacity of 18 passengers. The success of this minirail has prompted the city of Shenzhen to install a larger Intamin monorail for a transit loop line downtown*.

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* See in http://mypro.ketis.or.kr/~stardate/worldmono/shenzhen.htm

Figure 4. 7 Monorail in China. It is opened in 1993, as 1.7 km and has 3 stations.

4.3.7.2 Sentosa Island, Singapore

During the past 25 years, the state of Singapore has progressed from relative poverty to become one of Asia's most dynamic newly industrialized economies. Key to Singapore's economic transformation has been the creation of a comprehensive and efficient transportation system (a network of superhighways and a new mass rapid transit system).

Monorail Technology (MRT) construction began in late 1983, forming a 51.6 mi, 48-station system that was completed 2 years. This new line connects resident of new housing area to urban centers. The Mrt's performance is impressive by any standard. Trains average speeds of 25 mi/h, 25 percent faster than the average car moves*.

* See www.monorail.com

Figure 4. 8 Monorail in Singapore.

Figure 4. 9 Monorail in Singapore.

Figure 4. 10 Monorail in Kuala Lumpur.

Figure 4. 11 Monorail in Kuala Lumpur.

Figure 4. 12 Monorail in Kuala Lumpur.

4.3.7.3 Alton Towers, England

The monorail system was opened on August 13, 1987. The seven trains carry up to 100 people each. System capacity is 4,800 passengers per hour. Top speed of this people mover class system is 27 kph.

Figure 4. 13 Alton Towers Monorail.

4.4 The Railway Development Process in Turkey

Beyond the century, railway transportation such as subway, trams, and elevated rail contributed to the development and expansion of a lot of cities. With regard to Turkey, most of these technologies have not as yet been used, and so this urban transformation process has not been seen in our country. The Karaköy-Taksim metro, a very small subway, opened in 1874, 11 years after the London metro (Alkışer, 2000: 63). In our country, the first railroad, tramway, tunnel and sea transportation network development was established in İstanbul and İzmir with the help of foreign capital. In time the tramway operations converted to buses and trolley buses.

The first railway station on the European side of İstanbul was located in Yedikule in 1871, the line was extended towards the Golden Horn and a new terminal station was built for the opening of the extension to Edirne. After this period, in 1906, two German architects, Otto Ritter and Helmut Conu, built Haydarpaşa station, which was surrounded by water on three sides.

Figure 4. 14 Sirkeci Station from the Street, early 1900 and 1999.

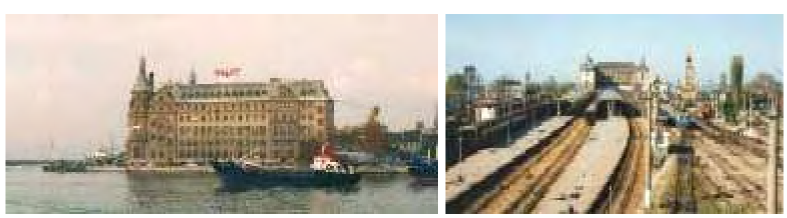


Figure 4. 15 Overall view of Haydarpaşa, from the sea, south side, 2000.

In spite of the development of the public transportation network on a city scale, on one side, the private car ownership process had increased and at the other side para transit public transportation models were developed in order to met the rapidly increasing urban transportation demands. These para transit models are composed of jitneys, mini buses and private busses.

Table 4. 1 Percentage of railway in transportation and the length of railway lines per km^2 in European countries.

Country	The number of passenger	Total Length of line per km^2
France	9.2	62 m
Italy	7.1	20m
Spain	7.6	24m
Germany	6.3	112m
England	5.4	125m
Turkey	4	10m

Table 4. 2 The Railway Capacities of Selected Countries.

Country	Area (km2)	Road (km)	Passenger (million person)	Load (million tone)
Germany	357.000	40.000	1.450	21.000
England	131.700	16.000	713	11.000
Italy	801.251	16.000	438	14.000
France	549.000	32.000	810	15.500
Turkey	814.578	9.400	146	1.500

4.4.1 Public Transportation Policies in Turkey

Unlike in Europe, the main transportation network is composed of highway transportation in Turkey. From the 1950s, the policy, which mostly depends on the individual transportation and highway transit facilities, has been continuing up to this point. The biggest share of urban transportation investment is constituted by highway construction, which is the symbol of "liberalism" (Görgülü, 1997a: 66), but in other countries from the 1970s in the urban transportation sector, new public transportation policies have been discussed.

Until now, transportation has constituted one of the most important problems among the various intra-urban public services in Turkey (EGO, 1987: 112). In recent years, however, it was realized that there is an obvious need for public transportation and new transit system solutions. It in this light that, new "Urban Transportation Studies" were prepared for many cities. In 1985 and 1995, the General Directorate of EGO and some academicians from the Department of City and Regional Planning in METU have prepared "Ankara Urban Transportation Study" to propose more effective, more comfortable, and more rapidly operating urban transport solutions.

4.4.2 Transportation Policies and Organization of Urban Transportation in Ankara

In 1923, Ankara was mainly a pedestrian city. In the course of time, demand for motorized trips increased, and this, at faster rate than the rate implied by the growth of population (EGO, 1995a: 11). The population of Ankara has reached from 30.000 to 2,5 million and parallel with this development, motorized trips increased from %15 to %80 (EGO, 1995b: 5). Insufficient and low capacity public transportation networks have caused transportation problem between the city center and the residential area.

One of the important reasons of transportation problem in Ankara is population growth. The development differentiation of employment structure and population growth is considered as major determinants of urban growth (EGO, 1995a: 6). Ankara has experienced rapid population growth after its declaration as the new capital, in the period 1927-1975 which tended to slow down by the late 70s (1995a: 6).

Another reason of this problem is that Ankara is a capital city and public services are crucial for this city:

> Ankara has played a minor role as a regional center. Therefore, the activities other than those that are associated with the function of being capital serve, to a large extent, for the urban population. It is clear that Ankara is a city characterized by a great degree of specialization in the service sector, that public services have the largest share, that industrial activities and regional distribution services are of secondary importance (EGO, 1995a: 8).

From this standpoint, parallel with population growth and increase of public services, public transportation sector became more important in recent years.

4.4.3 Historical Development Of Transportation Systems in Ankara

Before 1930s, the city of Ankara, which had a population of 25,000, was clustered around the Citadel, then the city started to grow towards Yenişehir and Cebeci. The transportation was supplied by buses, which were operating on a total of 12 miles and connecting the Ulus center to new development areas (EGO, 1995a: 14). The only contribution of public sector in this period was the 9 km long suburban railway line between Ankara and Kayaş (EGO, 1995b: 6).

In spite of problems came across in the provision of transport services during the Second World War, “[i]ncreasing urban population generated further demands as far as motorized trips were concerned" (EGO, 1995a: 14). In 1944, a new solution was used for public transportation, called "taksi-dolmuş". In this period the trip demand was met by transporting larger number of passengers through fewer number of vehicles. The first half of the 1950s is the period when the number of motorized trips grew most rapidly (EGO, 1995b: 7). In 1977, "[t]he public sector made a number of new attempts by purchasing new buses on a large scale and thus renewed the vehicle fleet and increased the number of vehicles in operation" (EGO, 1995a: 15).

The 1980s were the years when the public sector transportation was unable to maintain its development due to economic stabilization measures and despite the unchanging number of vehicles; the number of bus lines has continued to increase rapidly (EGO, 1995b: 8). Express buses were used for the first time in this period. Today, "insufficient urban transit services, rapidly developing automobile industry and government policies in favor of private transportation have led to growing private car ownership and increasing share of private cars in total motorized trips" (EGO, 1995a, 17). Consequently, Ankara has turned in recent years into a city where heavy traffic problems are experienced.

The 1976 Ankara Metropolitan Area Master Plan, which is currently in force, has identified the western corridors as the direction of development of the city in order to bring about a solution the problems associated with the urban development (EGO, 1995a: 46). According to this plan, a rapid rail transit system should be established between the city center and the two development corridors on the west.

On the contrary, the 1995 structural plan proposed that the city should be decentralized in a planned manner. In the light of Transportation Planning principles, heavy rail systems have been proposed in order to lead the urban macroform while light rail systems are considered for connecting existing residential areas to the city center (EGO, 1995a: 47).

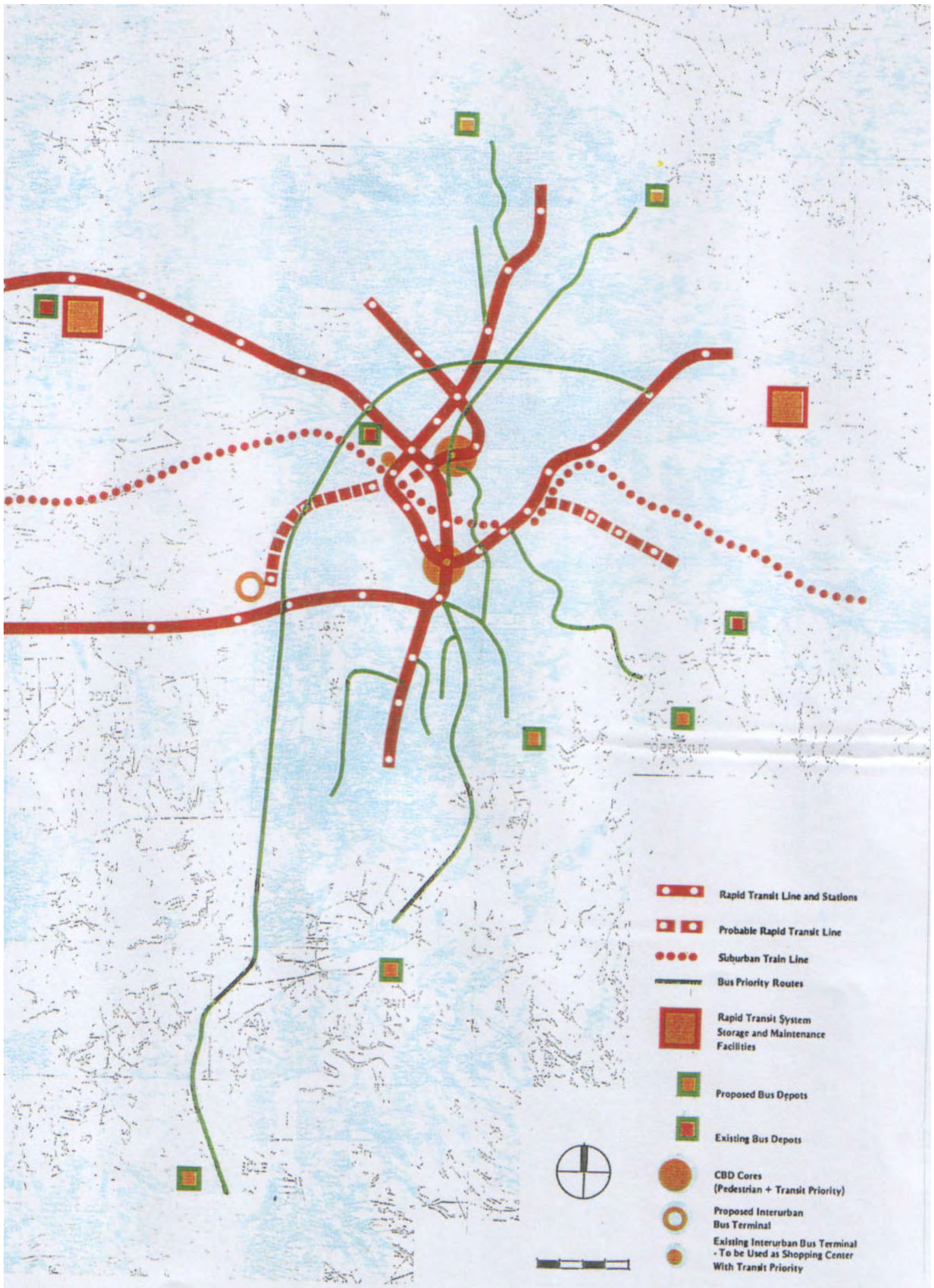


Figure 4. 16 Transportation Master Plan, proposed transit system, 2015.

4.4.4 Ankara-Light Rail and Subway Systems

Ankara subways consist of two lines: a heavy rail metro and a light rail metro. In 1996, a new light rail technology, named "Ankaray" derived from the worlds "Ankara" and "tramway" started to be used between the residential areas and the city center with the 11 station. It operates one 8.7 km line, of which .7 km is in tunnel. Three extensions are planned; Dikimevi-AŞOT, Kurtuluş-Siteler, Maltepe-Etlik.

Figure 4. 17 The Light Rail System and the Heavy Rail Metro in Ankara.

The heavy rail metro completed and opened for revenue service in 1997. It consists of 12 stations on 1 line. 5.4 miles of the 9.1 miles lines are in subway, 4.6 miles topside. The Ankara metro cars are modified H6 Toronto subway cars built by Bombardier. Ankara bus and metro operator EGO has plans for an 18km extension to the heavy metro from Kızılay southwest to Çayyolu. In addition to this line, four extensions are planned in total; Kızılay-Batıkent, Kızılay –Çayyolu, Ulus-Keçiören, TBMM-Dikmen.

Table 4. 3 The Features of Light Rail System in Ankara.

Start of Work	1995
Completion of Work	1996
Length of Line	8,7km
Number of Stations	11
Number of Vehicles	33
Passenger Capacity	16000 passengers/day
Platform Length	50m
Maximum Speed	40km/hour
Commercial Speed	20km/hour

4.5 Light Rail Solutions in Other Major Cities of Turkey

Similar growth in population and transport needs have been seen other major cities in Turkey. For this reason, new public transportation technologies, especially light rail, began to be applied in some cities, such as İstanbul, İzmir, Bursa, Eskişehir, Konya, Adana and Antalya.

4.5.1 İstanbul-Light Rail, Subway and Tramway

4.5.1.1 Subway

The first section of the Istanbul subway opened in August 2000 with 7.9 km and 6 stations. The second section, consisting of 5.4 km and 4 stations, is under construction. The system is entirely underground; however, section two will include a bridge. Eventually, this city of 10 million, which stretches for over 100 km east to west, plans on converting many of it's suburban lines to metro status, including a subway connection under the Bosphorus.

Figure 4. 18 The Subway in İstanbul.

4.5.1.2 Light Rail

In 1989, a light rail line was built from Aksaray towards the western suburbs. Until 1995, it was extended to Yeni Bosna. It has a total length of 18 km with 16 stops, running underground for 4.4 km through the city center. In the 1990's also a modern tramline was put into service through the older parts of the city. An airport extension from Yeni Bosna station is under construction. An extension from Taksim to Yenikapı is also underway, with a planned opening in 2003 or 2004.

Figure 4. 19 The Light Rail in İstanbul.

Table 4. 4 The Features of Light Rail System in İstanbul.

Start of Work	1986
Completion of Work	1994
Length of Line	18km
Number of Stations	16
Number of Vehicles	67
Passenger Capacity	22000 passengers/day
Platform Length	100m
Maximum Speed	80km/hour
Commercial Speed	40km/hour

4.5.1.3 Tramway

Aksaray-Sirkeci tram System opened in 1991 with the 10.3 km and 19 stations. Built along the alignment of an old tramline system in the Historical Peninsula of İstanbul, the tramway line runs from Eminönü-Sirkeci station via Aksaray to Zeytinburnu, just outside the South-Western city walls. The Tramline System daily serves 250,000 passengers.

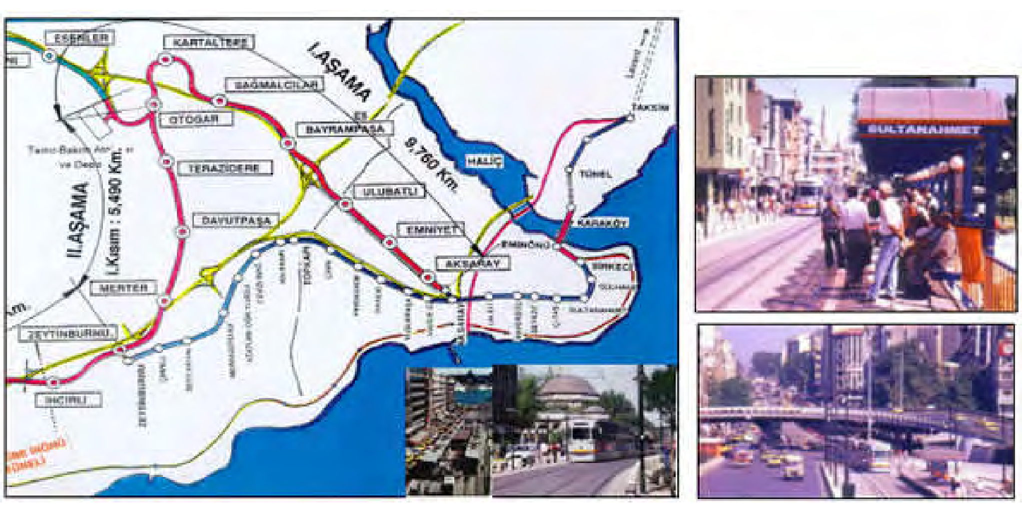


Figure 4. 20 Tramway in İstanbul.

Table 4. 5 The Features of Tramway in İstanbul.

Start of Work	1991
Completion of Work	1992
Track Length	10,320m (level line)
Number of Stations	20
Number of Vehicles	38
Passenger Capacity	8,350 passengers/hour/direction
Platform Length	50m
Maximum Speed	40km/hour
Commercial Speed	20km/hour

4.5.1.4 Beyoğlu Heritage Tramway

Heritage Tramway line opened in 1990 with the 1.6 km. The tramway runs along a single line along the length of İstiklal Street, Beyoğlu, which was dedicated to the pedestrian only.

Figure 4. 21 Heritage Tramway in İstanbul.

Table 4. 6 The Features of Heritage Tramway in İstanbul.

Start of Work	12.04.1990
Completion of Work	01.12.1990
Track Length	1,626m (level line)
Number of Stations	3
Number of Vehicles	2x2
Passenger Capacity	15,000 passengers/day
Platform Length	8.5m
Maximum Speed	50km/hour
Commercial Speed	20km/hour

4.5.2 İzmir-Light Rail System

İzmir metro line opened in 1990 with the 1.6 km. The new line have 10 stations and the number of vehicle is 45.

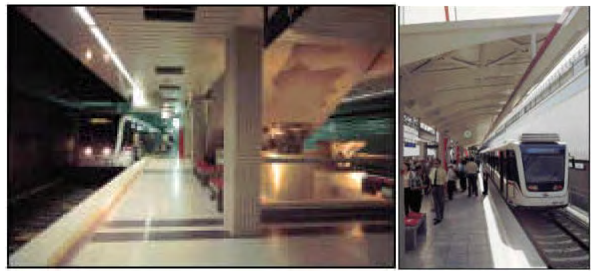


Figure 4. 22 The Light Rail Metro in İzmir.

Table 4. 7 The Features of Light Rail System in İzmir.

Completion of Work	1990
Length of Line	11,5km
Track Length	11,600m (level line)
Number of Stations	10
Number of Vehicles	45
Passenger Capacity	45,000 passengers/day
Platform Length	125m
Maximum Speed	80km/hour
Commercial Speed	40km/hour

4.5.3 Bursa-Light Rail System

A 23 station, 20.6 km subway has been under construction for many years in Bursa. The planned system will consist of 55 km, built in 4 phases. In the first phase, 3.7 km and 3 stations will be underground.

Figure 4. 23 The Light Rail System in Bursa.

Table 4. 8 The Features of Light Rail System in Bursa.

Completion of Work	2001
Length of Line	20,6km
Track Length	27m (level line)
Number of Stations	23
Number of Vehicles	45
Passenger Capacity	45,000 passengers/day
Platform Length	125m
Maximum Speed	80km/hour
Commercial Speed	40km/hour

4.5.4 Eskişehir-Light Rail System

Eskişehir light rail line began construction in 2002 with the 2 line 14.5 km. Line 1, 9.8 km, run from Anadolu University to the Otogar. Line 2, 4.7 km, run from Osman Gazi University to Muttali. The two lines, DBMed in part by Bombardier, interchange at Çarşı in the city center.

4.5.5 Konya-Light Rail System

Konya light rail line opened in 1992 with 18km long line and 20 stations. Most of the route is street running, with a few grade-separated sections. There are currently plans for 4 more lines covering 58 km.

Figure 4. 24 The Light Rail System in Konya.

4.5.6 Adana-Light Rail System

The Adana metro is scheduled to open in 2003. The initial 13.5 km line will consist of 13 stations.

Figure 4. 25 The Light Rail System in Adana.

4.5.7 Antalya-Light Rail System

The construction works of Antalya Tramline System has started on February 1998 and completed on December 1998. A 41 km LRT network is under study. The line covers 5.1 miles through the city center and was opened in 1999. It is planned to provide safe and efficient service to 21 000 passengers daily.

Figure 4. 26 The Light Rail System in Antalya.

Table 4. 9 The Features of Light Rail System in Antalya.

Start of Work	20.02.1998
Completion of Work	24.12.1998
Total Length	5,055m (level line)
Number of Stations	9
Number of Vehicles	6
Passenger Capacity	944
Platform Length	35m
Maximum Speed	60km/hour
Commercial Speed	20km/hour

Table 4. 10 Railway Examples in Turkey.

City	Type of system	Opening year	Status
Adana	heavy rail		Work in progress, inauguration set for end of 2002
Ankara	1 line heavy rail metro 1 line light rail	30 August 1996	in operation
Bursa	light rail		Work in progress, inauguration set for end of 2001
Eskişehir	2 lines light rail		Work in progress for a 14,5 km LRT opening in 2004
İstanbul	1 line heavy rail metro 1 line light rail 1 line tramway 1 funicular (Opened 1875)	1989	in operation
İzmir	heavy rail	25 August 2000	in operation
Konya	Light rail (tramway)	September 1992	in operation
Antalya	Light rail	1999	in operation

4.6 Transformation of Station Design

> Few buildings are vast enough to hold the sound of time, and now it seemed… that there was a superb fitness in the fact that the one which held it better than all others should be a railroad station (quoted from Thomas Wolfe by Matthews, 2002).

"Railway terminals are to the 19th century what monasteries and cathedrals were to 13th century", says Meeks (1956). As stated by Jean Dethier, they offer both a 'recurrence of ritual' and 'the opportunity for 'quietude and consolation' (1981: 6). It is the 20th century, when romantic notions of the railway station has crucially changed, and "as the clarity of the function of the station is blurred, its form has become more complex" (Edwards, 1997: 174). Today, the function of the station is broadened, so it became an interaction and overlapping activity point for a city.

Previously, the station was only a transitional space through which travelers passed en route to the train (Edwards, 1997: 173). In the contemporary city, stations are defined not only as a transitional space; but have also changed into a small version of the city. Hence, "they accommodate a multitude of commercial activities and have therefore become extremely complex amenities" (Roncayolo, 1998: 24).

4.6.1 Shaping the Train Station with Motion and Speed

The notion of speed has added new meanings to the station design principle. This new phenomenon breathed the new approach into the railways; "it was the speed, rather than the distance covered, movement itself, rather than the journey undertaken" (Fortier, 1998: 36). In this century, the programmatic context of the train station is the integration of both space and time. Lawrence Shapiro, in an article entitled "Architecture, History and the Embodiment of Speed" talks about the speed and "the perception of travel without actual movement "as;

> [A] perfect analogue to ideology that convinces us that we are doing one thing while in fact we are doing quite another. We are held raptly in a state of attention – or distraction, …the sense that the speed of travel offers a kind of mastery of time and space ….As the redemption through technology presents itself: offering to collapse time and space, promising to unite us in one community, we should wonder about the social dimensions of the re-mapping of individual and environment (quoted by Juintow, 2000).

In this context, train stations as the intersection points of the diverse functions, flows of people and modes of transport, blurring time and space concepts, needs to be reanalyzed. In Zaha Hadid's Strasbourg project, all of the transportation modes are seen as flows of motion and the station is planned as an interaction, overlapping and tension point. The station on the Strasbourg tramline is the symbolic high point of the city's policy to encourage the use of public transport to try and lighten traffic in the city center. Zaha Hadid draws on the invisible traces of roads, pedestrian ways and bicycle paths, to construct a design based around a series of superimpositions. The design is like a carpet woven out of different fields of relations. The vectors of motion trace out a design constructed like a three dimensional shell that seems to encompass the synchronicity of different means of transport (Hadid, 2000: 68-69).

Figure 4. 27 Strasbourg tram project.

With the growing significance of different modes of motions and flows of people, the formation and distribution of the lines, paths, and stations, their borders, edges and forms, became subject to architectural debates. As Michel Serres remarks: "Stations and paths together form a system. Points and lines, beings and relations. What is interesting might be the construction of the system, the number and disposition of stations and paths" (quoted by Allen, 1999: 1).

4.6.2 Design of the Transit Space

During the acceleration of the transportation age, transit places became an important issue for architectural discussions. Some architects make a point of these places, along with bringing new meaning, such as Rem Koolhaas who has created transit places that are destinations, while at the same time express a phenomenon of our social life by finding liberation in the various speeds and scales of movement possible today. In the contemporary city, it is possible that increased mobility makes the world not only more accessible, but also makes urban space more fluid and temporal. Layers of interpretation have stripped down understandings so that there are few areas for interaction in cities. Massive transit and commercial centers such as Eurolille create a place that is enclosed together with interaction and transition. It truly contains the mobility and the idea of passage in the city.

Moreover, in an urban context, the transit center was defined as a modern marker of motion in the city, creating paths with fluid and coherent movements of people through space. Norman Foster’s design for the subway in Bilbao is very simple and yet evocative, some how expressing a dynamic connection of the street with the subterranean.

Figure 4. 28 Norman Foster’ Bilbao project.

4.6.3 The Station as a Gate to the City

Today, railway stations as a part of the city have a new function: that of an urban doorstep and gate to the city. Along with being transitional spaces or spaces of interaction, stations are a "gateway for entering and leaving the city, a perceptual focal point leaving an indelible trace in the memory of visitors", such as in the Stuttgart Central and the EuroLille Stations (Ingenhoven, 2000: 32). In addition, architectural expressions of modern railway stations and trains are taking new meanings and are entering another dimension;

> [t]hat of travel, which turns a passenger into the spectator of a kinetic landscape and allows him to discover a land in which he remains a stranger. A stopping place and a gate to the city, the station is also an inevitable point of passage, which reveals urban life upon the traveler's arrival. Upon leaving the spectacle-environment of the voyage, the traveler enters the material landscape of the city via a transitional space: the station (Duthilleul and Tricaud, 1998: 19).

4.7 University Campuses and Railway Networks

A diagnosis of contemporary cities emphasizes the expanding boundaries with transportation technologies. Gradually, transportation networks are surrounding all of the city structure. In addition, each part of this structure, particularly public spaces, such as museums and shopping centers, became the station point of this transportation network. Especially in Europe, university campuses are located within this network. Inevitably, this progress will radically alter the physical form of the university campuses of the future. For this reason, university campus planners and designers are now reanalyzing the campus settlement, and transportation planning within this transformation context.

In this sense, this part of the thesis explores university campus planning, campus transportation and alternative planning for campus transportation, such as bicycle and rail solutions. Under the title of the new transportation technologies and campus planning, this chapter will lead to the following chapter of the study.

4.7.1 University Campus Planning

All of the transformation that occurs in cities also affects to the structure of the university campuses. Today, along with expanding boundaries, accessibility has become a problem with pedestrians' average walking speed in many university campuses. This situation brought about the problem of orientation between different parts of the campus and perception of the whole campus space. All these problems, which are frequently come across in university settlements, show that the university and campus-planning concept should be interrogated for the present conditions. At the end of the 20^{th} century, the planning and design of university settlements, which form the physical structure of campus environments, began to be reconsidered because of these transformation processes.

First of all, recent campus planning and settlement types should be determined according to their morphological structures. In this part, the university campuses, depending upon their location and physical structure, are studied.

The universities can be classified as city universities and campus universities depending upon their location. City universities are located in the cities. The buildings may be organized in a same area or may be scattered throughout the city. Dormitories are located at different locations of the city in the latter situation. Campus universities are often installed in a place far from the city. They include all the human needs within their area, such as educational buildings, social centers, cafeterias, sport area complexes and residences. METU is one of the best examples of the campus university type.

According to physical structure, university campuses are separated five groups as being of:

- Linear organization
- Centralized organization
- Non-linear and Decentralized organization
- Molecular organization
- Grouping and Zoning Organization

4.7.1.1 Linear Organization

In this architectural form, a linear pedestrian way occurs between the facilities, being the academic, social, administrative, sports and residential areas. The buildings are located on either side of this pedestrian way, in other words each side of this ‘alley’. In this schema, vehicular traffic is separated from pedestrian, especially with service ring. Linear organization can be realized in an unlimited area and expanded infinitely in a horizontal direction. The best example for this solution is METU.

There are two types of linear organizations in campus design. “One is an alley and on both sides of this alley the academic buildings are situated” (Zengel, 1998:95). In the second linear organization type, an alley exists, on one side of this alley the academic buildings are situated; on the other side of this alley social buildings are gathered. This solution is longer than the first type of linear organization (Zengel, 1998: 95).

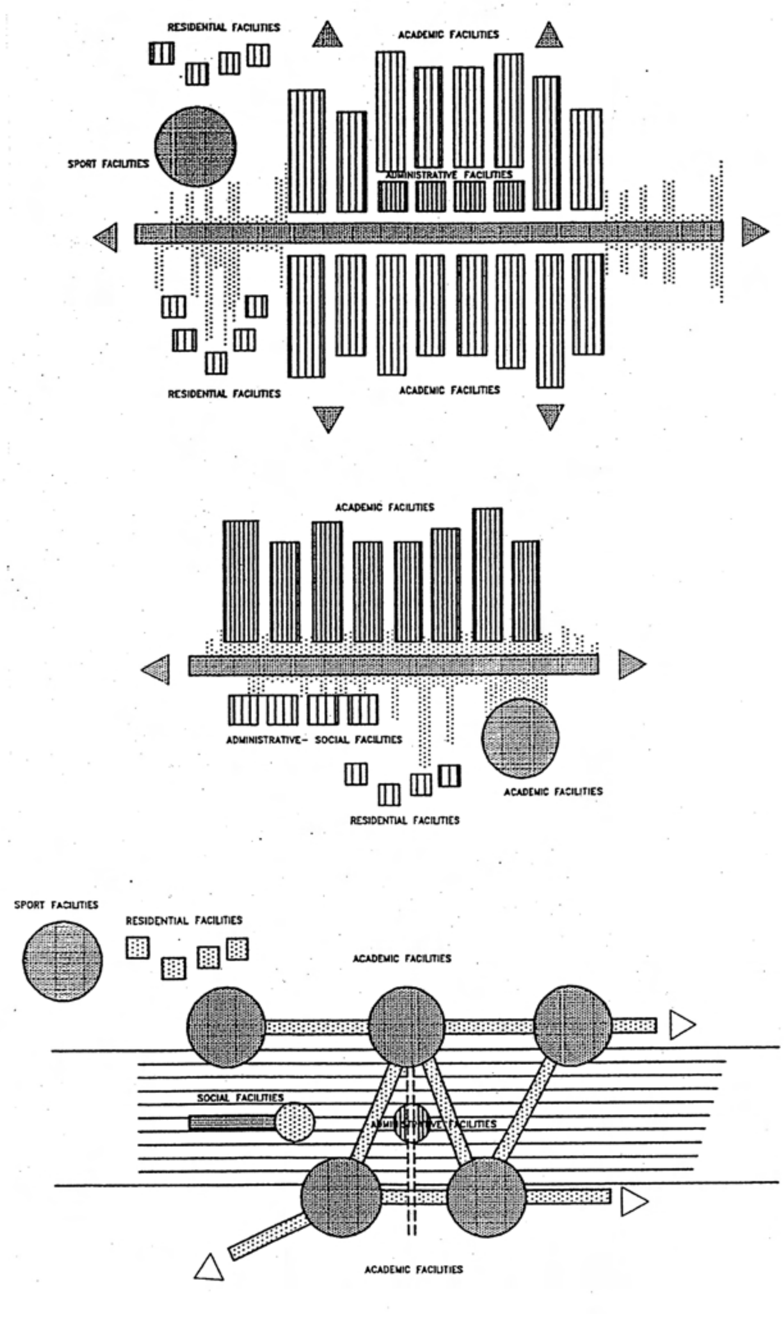


Figure 4. 29 Linear Organization.

4.7.1.2 Centralized Organization

In this settlement type, all academic patterns and all functional facilities are gathered as a whole. The centralized scheme is a concentration of functions and facilities (Zengel, 1998: 96). This type is not flexible in its ability to change its form. Centralized schemes also have the problems of high concentration of students in a minimum land area. The expansion of the center is difficult as a result of surrounded buildings. Centralized schemes also provide for vertical expansion into high-rise buildings (Zengel, 1998: 96). University of East Anglia (in England) is planned according to the same scheme.

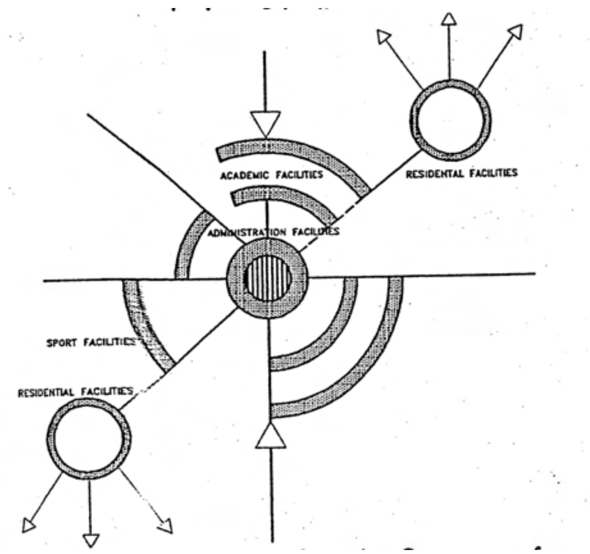


Figure 4. 30 Centralized Organization

4.7.1.3 Non-linear and Decentralized Organization

In a non-linear organization, all functions are distributed throughout campus area. The scheme consists of separate buildings situated in a green area. The decentralized scheme is also a physical division and distribution of the functions and facilities which have been concentrated. Expansion of the design is dependent on the boundaries of the urban land. In some examples of this scheme, pedestrian and vehicular traffic is separated from each other.

4.7.1.4 Molecular Organization

This campus pattern is composed of diverse structural and organizational units, which may consider different planning systems. Each unit is a complex within itself (Benli, 1998: 72). A hierarchy and a growth are provided for in campus design. Molecular organization gives a limited flexibility and division of a unit into new units provides minimum growth possibilities. The communication and interrelation in a group of units are provided and encourage contact between people. For easy accessibility, each molecular cell should be at most 10 min or 15 min average walking distance to the closest major socialization area (Benli, 1998: 72). Istanbul Technical University Ayazağa Campus is planned according to the same scheme (Benli, 1998: 41).

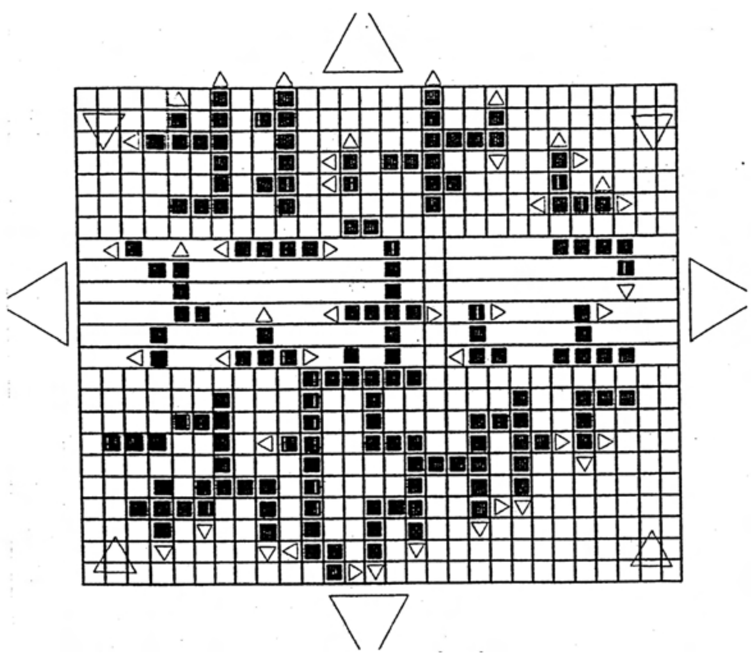


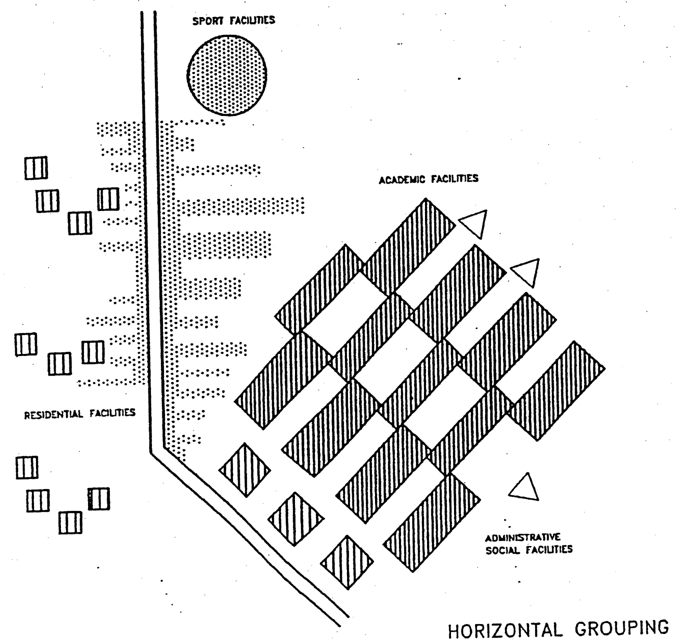
Figure 4. 31 Molecular Organization.

4.7.1.5 Grouping and Zoning Organization

This planning type includes variation of activities, relations and structural form. Moreover, both horizontal and vertical planning is used in this scheme. In horizontal grouping, functions are placed in separate buildings, but in vertical grouping the relation between different functions is strengthened. In this respect, a horizontal scheme is more expandable and flexible than a vertical. According to Caudill Rowlett, “the limit to this type of lateral expansion is reached when the agricultural lands become so diminished that the teaching and research needs are not met” (1959: 41). The best example of this scheme is Gaziantep University.

On the contrary, vertical grouping scheme is not suitable for expansion. The structure is composed of an overlapping of functions. Vehicular and pedestrian circulation can be separated from each other easily. “Vertical expansion into high rise buildings reaches its limit when the density becomes too great for the amount of land available” (Caudill, 1959: 41).

Another classification of university campus design is made according to formal structure, as monoforms, metamorphorics and mosaics. While monoform contain overall visual impression, a singular style dominates on campus space (Dober, 1992). METU is a good example of the monoform style as its Brutalist approach. The other type is called as metamorphos composed of different forms. The external pressure or effects cause a change in structure or substance of campus (Dober, 1992). The last type is mosaics form that has no singular style. Similarly, this type has different visual impression (Dober, 1992).



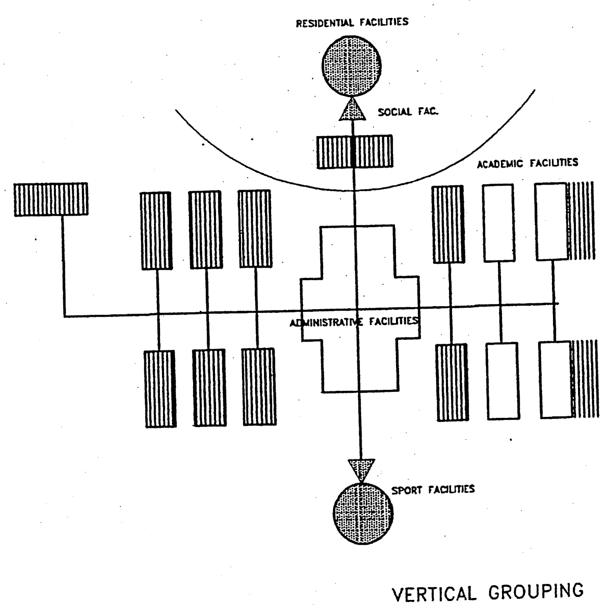


Figure 4. 32 Grouping Organization.

4.7.2 Campus Transportation

While many university campuses are situated in similar locations in most urban areas, their physical forms and transportation networks are different from each other. However, almost all of the campus structures are designed prioritizing pedestrian and rather than vehicular traffic. The main objective of this structure is to provide rapid circulation within the campus area. For this reason, the main traffic roads are separated from the pedestrian routes.

In the context of campus circulation, the vehicular traffic axis can be designed in an elliptical or circular loop surrounding the faculty buildings. In the hierarchical order of campus structure, a vehicular loop is used as the main traffic road. This road is connected to pedestrian paths and parking lots with secondary roads, known as "cul de sac". In the separated circulation system, a pedestrian can walk throughout the campus area without crossing any vehicular traffic. All these solutions are produced in order to reduce the negative effects of vehicular traffic on campus life. As stated by Caudill (1959); campus planning should be designed also for the separation of urban and campus vehicular traffic, for the separation of pedestrian traffic from vehicular traffic, for inter-campus and intra-campus movement and for pedestrian traffic needs. For him, the best campus circulation is provided by:

> [T]he separation of pedestrian and vehicular traffic.
> The separation of urban and campus traffic.
> The development of adequate parking facilities.
> The creation of more pedestrian pathways and fewer streets.
> The development of density standards of use for various areas (Caudill, 1959: 4).

In this way, some alternative solutions for campus circulation are produced as three types; the outer loop, the inner loop and the spine (Caudill, 1959). In the outer loop, urban vehicular traffic is separated from campus traffic. It should be either supplemented with feeder streets, which penetrate close to destinations and terminate in parking facilities, or with a transit system that can shuttle people to the heart of the campus. The outer loop can preserve the campus as a pedestrian world (Caudill, 1959). Different form the outer loop, which is an inner-feeding vehicular system, an inner loop can be double-loaded to minimize feeder roads to destinations. The inner loop relies more on the urban system to serve peripheral areas of the campus adjacent to the urban vehicular loop. It may become a barrier to on-campus pedestrian traffic and tends also to divide the campus into smaller parts. The inner vehicular campus loop is suitable for double use with a transit system. It may be possible to confine its use to transit only, in the case of a centralized plan. Campus vehicular traffic would terminate in parking facilities reached directly by short feeder streets from the urban system (Caudill, 1959). The spine is the most direct system for serving east-west or north-south destinations. It relies on the urban system to provide access to other destinations. It does not separate urban and campus vehicular circulation, but does provide more service with less length of road. Since it has limited point access, the spines' limitations are proportional to the load put upon it. In other words, the spine might well develop into a six-lane highway if people were allowed on it without control (Caudill, 1959).

Another important matter, which should be considered in campus transportation, is designing a campus structure around the average pedestrian walking speed. For this reason, university campuses are planned with a separated pedestrian "*alley*". In this schema, the alley that is the main pedestrian road connects all the functional facilities. The buildings are situated on either side of this pedestrian way. The basic principal of this alley is to strengthen social relations and to connect the faculties in a short distance.

4.7.3 An Alternative Transportation Mode for Campus - Cycling Transportation

As mentioned above, in a campus structure, the majority of the traffic should be pedestrians or cyclists. Richard Dober asserted that, "properly handled, the automobile is not an impediment to creating a well-designed campus plan" (quoted by Markowitz and Estralle, 1998). He proposed the following circulation planning goals for campus design, "creating traffic-free pedestrian precincts, segregating travel modes, servicing buildings away from pedestrian entrances, grade separations between major roads and pedestrian paths, smooth traffic flows from major to minor roads, optimizing parking location" (quoted by Markowitz and Estralle, 1998).

More recently, some university campuses have used alternative solutions, such as bicycle or rail transportation, to reduce automobile dominance in the campus area. Bicycle transportation plays a critical role in this process. Related to this issue, Ciccarelli stated that "bicycles are ideal vehicles on campus, where parking is frequently too distant and inconvenient, and it often takes too long to walk between buildings" (quoted by Markowitz and Estralle, 1998).

In this way, the design of cycle routes became the key concept of campus transportation. The most important question is how bicycles traffic can be separated from motor vehicle within this structure. John Forester, in his book "Bicycle Transportation", pointed out that, the problems, "as they actually exist, are keeping the cyclists away from the pedestrians and getting the cyclists to act like drivers of vehicles" (1994: 274). According to Forester, the campus should obviously distinguish between the roadways and walkways. At the same time, cycle routes should have bicycle-permeable barriers to block motor vehicles (1994: 274).

To reduce vehicular traffic on campus, "the best design would probably be a one-way traffic circle, because that would both keep conflicts between cyclists to a minimum and would retain the center space for pedestrians" (Forester, 1994: 274). Forester mentioned the design code of the cycle route connected with campus transportation majority, such as pedestrian or vehicular. If the campus is designed as a pedestrian space, cyclists must dismount and walk their bicycles across it, this is commonly called the '*Dismount Zone'* (Forester, 1994: 274).

In the vehicular cycling principle, a cyclist can travel almost everywhere the road system goes. This system has several advantages, such as "lower travel times because of faster safe speeds, fewer delays, and shorter distance; greater accessibility to desired destinations and a lower accident rate" (Forester, 1994: 1).

In the framework of campus transportation, the bicycle solution as an alternative movement system in campus should be studied comprehensively. In this context, the decisions regarding the cycle route are an important issue in this study. Forester also asserts the design criterion for the cycle route as "a roadway with wide outside lanes (14-15 feet) is simply one that is good for all types of traffic, motor and bicycle. The bike-lane strip should be placed 12 feet to the right of the left hand lane strip of the outside through motor vehicle lane" (1994: 262). In this thesis, the limited features of this system were explored.

Table 4. 11 Lane widths required for lane sharing on two-lane roads.

Speed of Motor traffic (mph)	Width of lane (ft)
25-44	14
45-65	16

4.8 Transportation in University Campuses and Railway Solutions.

Campuses are important places to experiment with alternative vehicle technologies aimed at reducing automobile usage. In the present day, especially in Europe, some new technologies have already been deployed extensively in the university campus space. In addition, rail networks in the surrounding city have passed through the university campus area.

Like in the city, the new campus transportation structure has increased the efficiency of circulation, access and mobility as a means of stimulating further growth, activity and diversity. So to say, most universities in Europe have been transformed by the new railway technologies and their speed. These technologies; such as light rail, monorail, tram and monobeam, are rapidly spreading through the university campuses. The light rail and the tram especially run over a long distance when compared to monorails and monobeams, and are usually implemented as an extension of the city railway line. The University of Nantes, the University of Utah and the University of Washington Tacoma can be given as examples of these.

4.8.1 The Light Rail Extension to the University of Nantes

Fifteen years ago, Nantes, with a population of 550,000 opened France's first modern tramway. The tram - or light rail network - is composed of three lines that carry 175,000 passengers per day. In 1993, this network, which is the backbone of the development of the city, was extended through Nantes' large university campus. This line orientated in a north-south direction transmits 95,000 passengers per day, many of them students on their way to and from the university campus. In the campus area, the road splits into two lines, as an automobile road and light railroad. Architecturally, after the extension of the light rail line, some transformations were observed in the campus space. The new technology with new speed created new activity and interaction points for the campus inhabitants. Furthermore, large campus area are perceived and experimented by the inhabitants and campus visitors more easily. This example shows us that the spatial features of the contemporary university campuses are in a transformation process. Inevitably, the new transportation technologies passing through campuses are the most important reason behind this alteration.

Figure 4. 33 Light Rail in The University of Nantes.

In addition to the expansion solution, some alternative rail projects are suggested to serve only inside the campus area. For instance, in Texas A&M University, a light rail solution has been proposed to connect the east and west campus and solve the time problem for students moving between buildings to different classes. According to its designer, a three-mile looped light rail system is shown as an alternative to the existing bus system. For them, the light rail system will provide efficient and timely travel within the campus and also will reconstruct the campus structure.

4.8.2 A Monorail Example in Campus

With regard to monorail and monobeam transportation, they are implemented especially for short distances and so are particularly used in small parts of the city, such as the entertainment centers or university campuses. Dortmund University in Germany and Old Dominion University in Virginia are important examples of monorails running in campus regions. In Dortmund University, the initial line, which opened in 1984 as “H bahn”, was only 1 km long, but connected two segments of the University separated by a valley and a major roadway. After it was observed that students preferred this technology instead of other transportation modes, a new 1.2 km line is currently being added, with a top speed of 65 kph[1]

Figure 4. 34 Monorail in Dortmund University.

Figure 4. 35 Monorail in Old Dominion University.

[1] See http://www.monorails.org/tMspages/Dortmnd.html

CHAPTER 5

DESIGN PROPOSAL

5.1 Design Intension

Today, the speed of the city increases through automobile traffic, parallel to human life gaining speed without control. The effects of this accelerating speed are seen in different scales of the city part in means of social and architectural transformations. Considered as a smaller version of the city, the structure of the university campuses are also affected by these transformations. In our day, old campus schemes are not adequate for accessibility from one edge to the farthest edge of the campus, and also interactions between different faculties. On the other hand, for a campus inhabitant, it is very difficult to reach one of the major groups of functions from the center of the settlement at an average walking speed. It can be said that the traditional approaches to the university campus design are insufficient, parallel to these developments.

In traditional approaches, the campus was designed according to human interactions and functions. One of these *ecole* that imply the principles of the Athens agreement (C.I.A.M.) was applied according to "hierarchy of function", second, that implies the TEAM X principles was applied according to "hierarchy of human interactions" (Kortan, 1981: xv).

In 1981 Enis Kortan claimed that;

> Since the interdisciplinary and transdisciplinary concepts of the educational system of our day is gaining importance, in the design process of the University Campuses it has also become important that a student should be able to walk the distance between the two extreme faculty buildings during a 10-15 minute break between lessons. This distance which is not more than 800-1000 m should determine the maximum length of the ‘pedestrian factor.
>
> (Kortan, 1981: XV).

At the end of the 20th century, contemporary architecture can equally well appear to be a criticism of the inherited planning principles of CIAM and Team X as faithful elucidation and extension of the same principles achieved after several years of uncertainty. Today, we cannot keep the distance defined by Kortan in horizontally growing campuses.

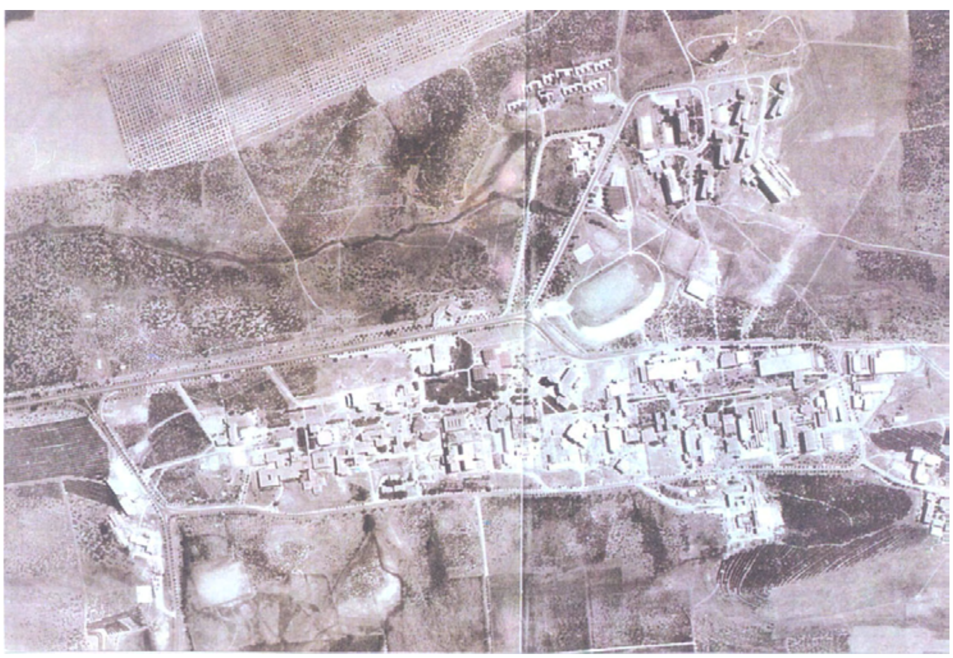


Figure 5. 1 Arealphoto of METU in 1970s.

Figure 5. 2 Arealphoto of METU, 2003.

METU is one of these universities experiencing similar transformations. In the case of METU, as a reflection of radical changes in the choice of transportation, both from the city to campus and inside the campus itself caused by new transportation technologies, the balance of pedestrian and automobile traffic that was the planning principle of the campus has been ruined. On account of this formation, the increasing number of private cars brought about the problem of parking and traffic. In fact, this problem arises from speed becoming an integral of campus life and horizontal growth of the campus with the new added faculties and recreation spaces. As a result of continuously added faculties and facilities, the scale of the campus grows too large to be perceived and experienced by pedestrian movement. Although Behruz Çinici designed the spatial organization of the campus complex based on pedestrian transportation, today this organization is gradually distorting with a growing campus area. In the original plan, academic and residential areas were arranged as near as possible to each other for 15,000 students, without preventing further spatial development. In this plan, the walking time between the academic and residential zone was planned as 20 minutes. A pedestrian was walking the campus area in 10 minutes (Çinici, 1999: 40). Today, as a result of the shifting of pedestrian transportation to automobile, the spatial structure of the campus has been transformed and has affected the walking time around the campus.

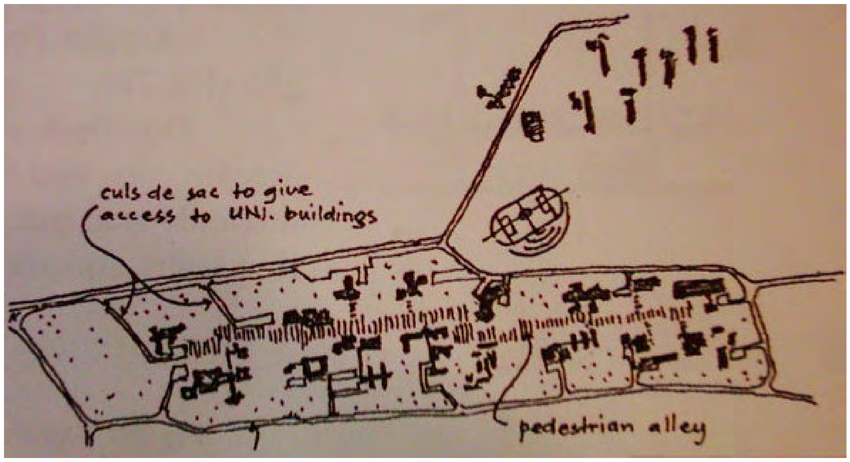


Figure 5. 3 METU transportation structure was designed with pedestrian alley and *cul de sac.*

On the other hand, the city of Ankara is rapidly developing and changing with new transportation technologies. In the city, the physical urban setting and the boundaries are affected by these radical changes. In such a scenario, the physical properties of the METU campus, which is still based on pedestrian and automobile transportation, should also be reconsidered, while the city has been increasingly growing with developing railway systems such as Ankaray and Metro. This requires a re-evaluation of the boundaries between the city and METU, and between the ill-defined land-roads and METU.

Figure 5. 4 Metro System, which will pass through to A1 and A2 gates, is under construction.

This re-evaluation of campus transportation is also necessary for the increasing interdisciplinary relations between different faculties. With the distortion of campus' pedestrian alley and "*cul de sac*" structure, accessibility between faculties has become more difficult; it has also created a time problem for students and academicians.

It is therefore crucial to use new movement systems in the campus in order to integrate the influences of speed and motion into campus life, avoiding likely problems. While urban space is formed by these two phenomena, the university campus-planning concept should be interrogated for these preset conditions. As Virilio says, we live in speed-space (quoted by Armitage, 2000: 70). In this space, spatial limitations and boundaries are redefined by the effect of new technologies. With regard to METU, similarly in cities, new transportation technology may be shifted to the spatial boundaries of the campus and start a reconstruction process in architectural space.

5.2 Spatial Structure of Middle East Technical University

The Middle East Technical University campus is located in an area to the west of Ankara, and is surrounded by two main highways. These are Ankara-Eskişehir highway on one side and Ankara-Konya highway on the other. The main design aims of the campus were set out in 1961 by Behruz and Altuğ Çinici. The campus comprises three zones according to main functions: the teaching area, with its central pedestrian circulation; the residential zone; and the newly added technopolis (teknokent) zone. In the teaching area, the social, administrative and faculty buildings are arranged on a major axis (a pedestrian alley). In this settlement, the academic buildings are located to the west of the pedestrian alley and the administrative and social buildings are placed on the other. The second axis, which connects with the major one, extends to the residential and recreational zone. There are dormitories, housing units for academicians, shopping units and outdoor and indoor sport areas. The third zone, which has recently enlarged near the A7 gate, is the Techno-park, primary and high school area. Today, the campus structure is enlarging through this new zone, but this development has introduced many problems. The newly added building is breaking away from the old axis development and campus accessibility has become gradually more difficult.

As a result of this extension, the campus structure is going through a crucial transformation process. Both the new buildings and the metro, which will serve both main gates, necessitate the reconsideration of future structure of the campus in the context of speed. On this basis, the existing current structure of the campus should be examined in the light of alterations that occurred in the past up to the present.

In this thesis, as a consequence of these diagnoses an alternative transportation technology responding to future demand of flexibility will be proposed. This project will provide a redefinition of architectural space, creating overlapping, tension and threshold point, and also building façades. Therefore, the existing transportation structure, population and traffic flow of the campus is studied in the following sections.

5.2.1 Transportation in Campus

The transportation network system of METU was designed in 1960s to the "*redburn"* system (Erpi, 1999: 158). The architectural form of the campus is composed of separated pedestrian walkways and a service ring surrounding the campus area. In the campus, the automobiles reach the faculties' parking lots through "*cul de-sacs*" connected to the service ring. In this way, a pedestrian can walk around the campus without being hindered by any obstacles (Erpi, 1999: 158). In the main pedestrian roads, or alleys, gives a social and cultural place for campus life. Presently, the desultory relations of the new added facilities and the significantly accelerating number of automobiles inside the campus, makes the pedestrian movement without facing any obstacles that Erpi mentions, difficult.

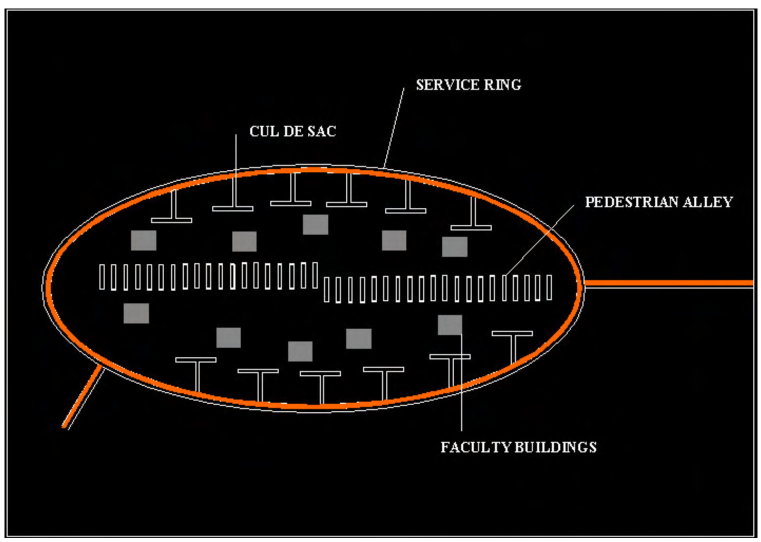


Figure 5. 5 The original transportation structure of METU.

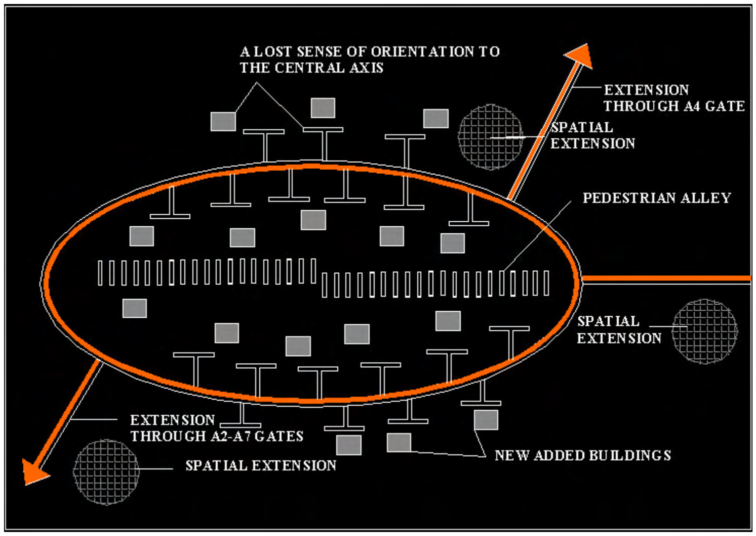


Figure 5. 6 Today, main principle of campus' transportation structure is distorted with extensions.

Today, the present transportation from the city to campus is provided by dolmuş, buses, personnel services, private cars and taxis. In addition to these, inside the campus, bus routes are used for inner circulation. Figure 5.7 displays the stop distribution of these transportation vehicles. In the distribution of these stops, the proximity to activity zones and density spaces are taken into account. As the expansion inside the campus is considered, the number of stops of the mass (public) transportation vehicles has been increased. However, the stop points being placed nearby the activity spaces results in bottlenecks in these places at certain hours of the day, for instance, the long queues occurring for the personnel rings at rush hour.

Figure 5. 7 Campus Public Transportation Circulation.

In Turkey, the ownership of private cars has been increasing tremendously compared to the development in public transportation. METU is not an exception. In the campus there has been a considerable increase in the use of the automobile compared to the use of public transportation. In the research carried out in the 2003 academic semester, the ratio of different transportation choices is compared relative to each other. In this diagram, although the percentage of bus covers the biggest part, it has to be considered that this diagram is based on the number of passengers, and therefore in fact the number of cars which enter the campus is more than the number of the buses. When this ratio is compared to the1996 and 1985 researches, a significant increase is observed in car use. According to a research done in METU, the automobile usage ratio was stated as 7% in 1985. This ratio reached 24% in 1996 and 39% in 2003 (See Figure 5.8 and 5.9).

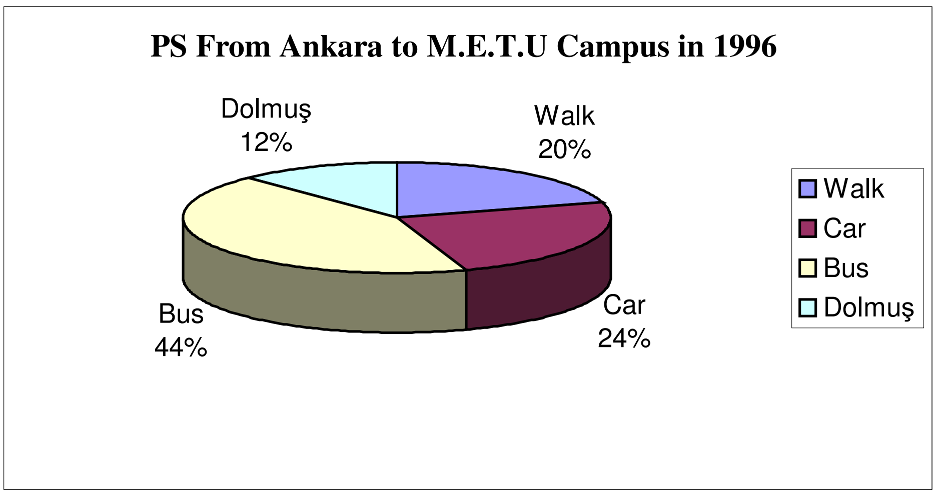


Figure 5. 8 Passenger (PS) From Ankara to M.E.T.U Campus in 1996.

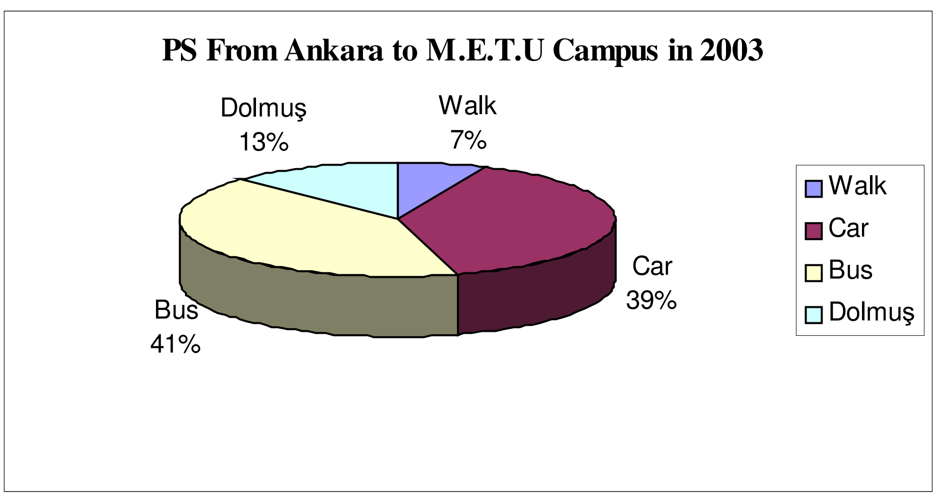


Figure 5. 9 Passenger (PS) From Ankara to M.E.T.U Campus in 2003.

Besides this study, the quantity of entrance cards (sticker) measured in the research carried out on 10th December, 2002 is another indicator of the increase in private cars.

Table 5. 1 Total entrance card number in METU campus.

ENTRANCE CARD TYPES (Sticker)	TOTAL NUMBER
Permanent users	1998
Users subject to renewal (each years)	1000
Permanent administrative users	1350
Administrative users subject to renewal	60
Graduates	500
Guests	1000
High school users	500
Teknokent users	250
Student entrance card	2250
Vakıf users (Güdaş)	500

As a result of this study provided from the presidency office, it is determined that the total number of entrance card users was 9,408, 3000 of which were academic users. If number of cars that entered the university campus without any entrance card were to be considered, the total number would be more than this result.

Finally, campus-wide vehicular traffic and density on each entrance has been studied. This study, which was completed in November/December 2003, is compared with the researches of the Civil Engineering Transportation Department of METU studies, completed in 2000. An important increase is observed in both public transportation and private vehicles. During the peak-hour (8.00-9:00), the 564 vehicles at the A1 entrance in 2000 have increased to 1,111 in 2003. Moreover, in 2000, 400 vehicles entered through the A4 entrance in the peak-hour, this number reached 814 in 2003 (See Table 5.2 – 5.3 and 5.4 – 5.5).

The estimated enormous increase in the number of people entering the university campus in peak-hours in 2015 is shown in Figure 5.12. The above study clearly supports this estimate made by EGO in 1985 (see Figure 5.10).

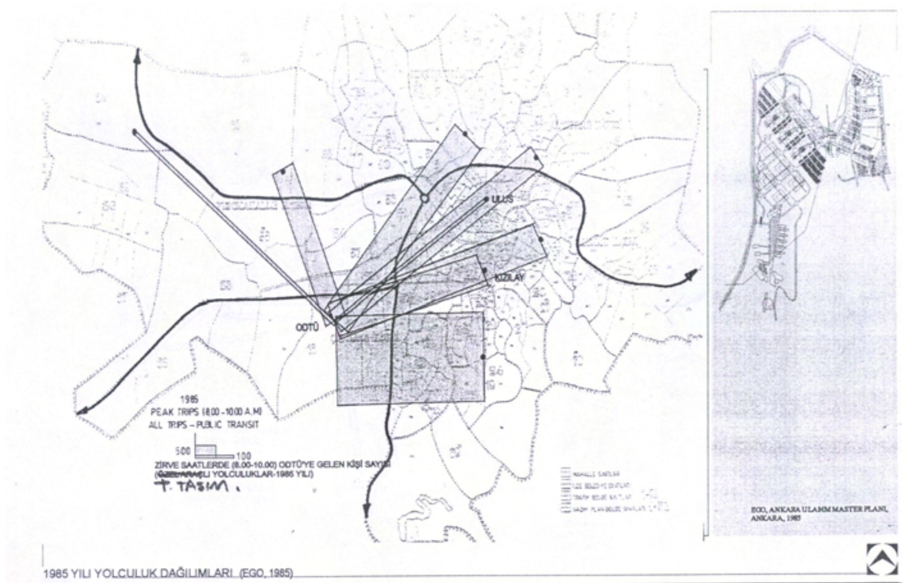


Figure 5. 10 Passenger distribution in 1985.

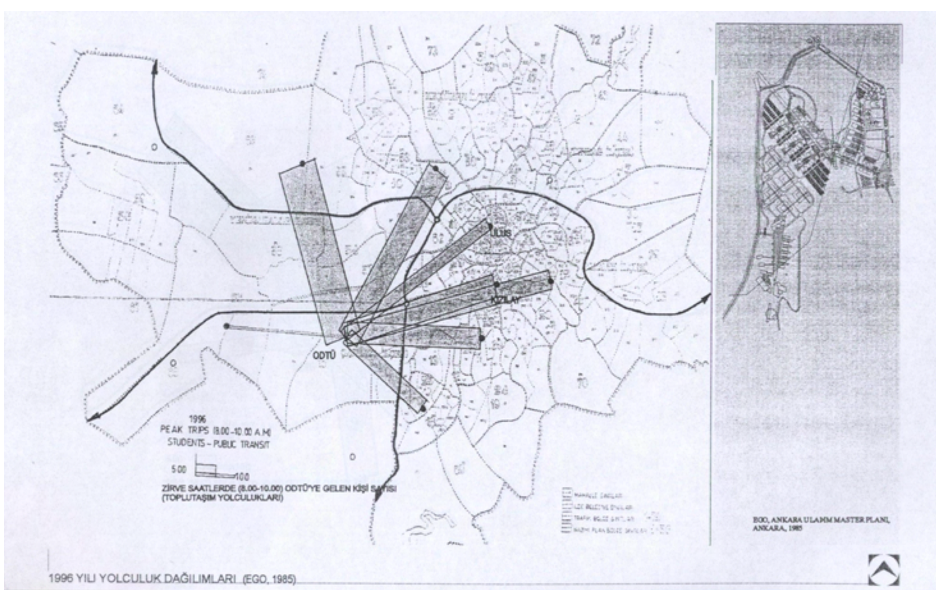


Figure 5. 11 Passenger distribution in 1996.

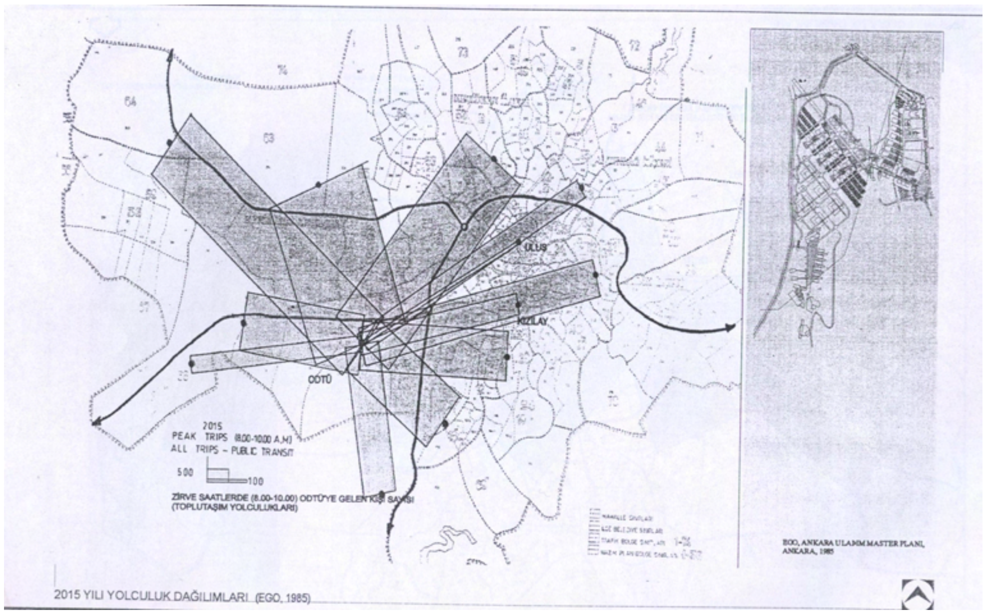


Figure 5. 12 Approximate passenger distribution in 2015.

Table 5. 2 Vehicles Enter Through A1 Entrance in 2003.

TIME	TYPE OF VEHICLE									TOTAL (VEHICLE)
	DOLMUŞ (KIZILAY)	DOLMUŞ (ULUS)	DOLMUŞ (BALGAT)	SERVICE	BUS	TAXI	CAR (STICKER)	CAR	PEDES.	
8:00-9:00	25	5	4	19	7	56	750	245	400	1111
9:00-10:00	20	2	4	2	7	48	470	160	205	713
10:00-11:00	25	2	4	1	5	21	300	130	125	488
11:00-12:00	21	1	3		4	16	170	126	120	341
12:00-13:00	20	2	3		4	20	160	110	96	319
13:00-14:00	20	2	3		4	15	180	115	85	339
14:00-15:00	22	1	3		4	15	85	90	67	220
15:00-16:00	23	1	3		4	12	80	70	20	193
16:00-17:00	20	1	3		4	7	55	35	22	125
TOTAL	196	17	30	22	43	210	2250	1081	1140	3849

Table 5. 3 Vehicles Enter Through A1 Entrance in 16-05-2000.

TIME	TOTAL (VEHICLE)
8:00-9:00	564
9:00-10:00	359
10:00-11:00	
11:00-12:00	423
12:00-13:00	269
13:00-14:00	
14:00-15:00	
15:00-16:00	
16:00-17:00	74

Table 5. 4 Vehicles Enter Through A4 Entrance in 2003.

TIME	TYPE OF VEHICLE								TOTAL (VEHICLE)
	DOLMUŞ (AYRANCI)	BUS ULUS	BUS TERMINAL	BUS KIZILAY	TAXI	CAR (STICKER)	CAR	PEDES.	
8:00-9:00	7	3	4	2	43	675	80	425	814
9:00-10:00	7	6	7	3	45	340	56	135	464
10:00-11:00	7	5	5	1	21	180	42	125	261
11:00-12:00	7	2	4	1	19	160	40	119	233
12:00-13:00	5	4	5	1	28	155	39	93	237
13:00-14:00	6	5	5	1	12	172	50	99	251
14:00-15:00	5	4	5	1	10	90	45	50	160
15:00-16:00	5	4	5	1	5	75	37	21	132
16:00-17:00	5	4	5	1	5	42	28	15	90
TOTAL	54	37	45	12	188	1889	417	1082	2642

Table 5. 5 Vehicles Enter Through A4 Entrance in 16-05-2000.

TIME	**TOTAL** (VEHICLE)
8:00-9:00	400
9:00-10:00	458
10:00-11:00	
11:00-12:00	381
12:00-13:00	434
13:00-14:00	
14:00-15:00	
15:00-16:00	
16:00-17:00	74
TOTAL	

5.2.1.1 The Increase in the Number of Parking Spaces in the Campus Area

Insufficient parking spaces reflect another problem raised by the rapid development of the campus and the continuing increase in the number of vehicles. While this problem is tried to be reduced with the help of a paid entrance card, it is obvious that they will continue to be insufficient, considering the gradually increasing number of private vehicles. It looks like this; the metro is going to decrease the number of private vehicles on the city-campus transit. However, private vehicles will still be preferred because of the large distances between the spaces within the campus area, and the problem will continue. As a consequence, a sustainable solution should be a connection to another public transit system within the campus.

The numbers of parking spaces in the campus are shown in Table 5.6. Comparing these numbers with the population of parking lots' service area, it can be observed as far from sufficient. Middlebrook mentioned in his book (1957) that the ratio of campus population to parking space is 2.2 to 1. Similarly, Caudill (1959) said that the ratio of registered cars on campus to the number of persons eligible to have registered cars 1:3.8. With regard to METU, the ratio of registered cars on campus is more than the number of persons. Especially on special days when cultural activities are taking place, this problem is seen with the overflowing of cars to into main streets.

Table 5. 6 Car Capabilities of parking Areas at METU Campus.

Social Sciences	20
Computer Center	75
Trade Center	25
Faculty of Education	100
Dep. of Electrical and Electronic Eng.	115
Faculty of Natural and Applied Science	110
Dep. of Physics	50
School of Foreign Language	262
Laboratory of Hydraulic	50
Faculty of Eco. and Administrative Sciences	114
Primary school	200
Dep. Of Geological Engineering	86
Cafeteria	70
Swimming Pools	45
Dep. Of Chemical Engineering	35
Tennis Courts	60
Cultural& Conventional Center	240
Library	202
Dep. Of Mining Engineering	6
Dep. Of Mechanical Engineering	210
Dep. Of Mathematics	25

Engineering Building	55
Small Mosque	10
Vocational School of Higher Education	10
Dep. Of Metallurgical and Mat. Engineering	97
Faculty of Architecture	110
Guest House	20
Post Office and Bank	25
Prof. House	75
Presidency-Student Affairs	60
Health Care and Rehabilitation Center	40
Social building	20
Sport Center	70
Dormitories	65
TOTAL	2757

5.2.2 Campus Population

Because of the increase in car ownership, architectural spaces are subject to a great distortion. Another reason of this distortion is the growing campus population. The capacity of the faculties has increased, new buildings have been added and new activity spaces have been created. This development in the campus has created a basis to a rapidly growing population, which can be seen in the comparison of the master thesis of Serdar Özbay in 1999 and the number of campus inhabitants taken from the presidency office in 2003 (See Figure 5.13 and 5.14).

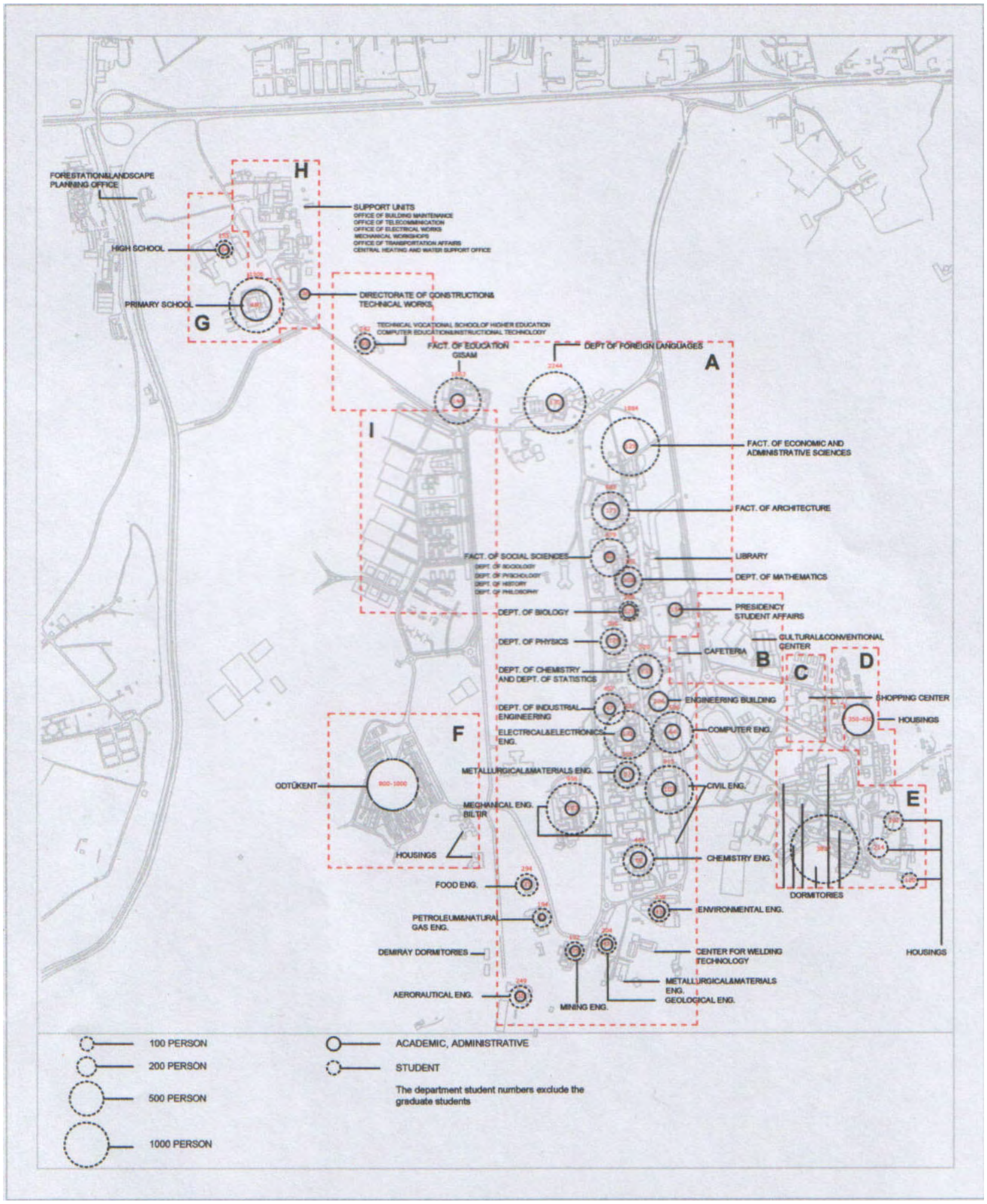


Figure 5. 13 The Population of METU in 2002.

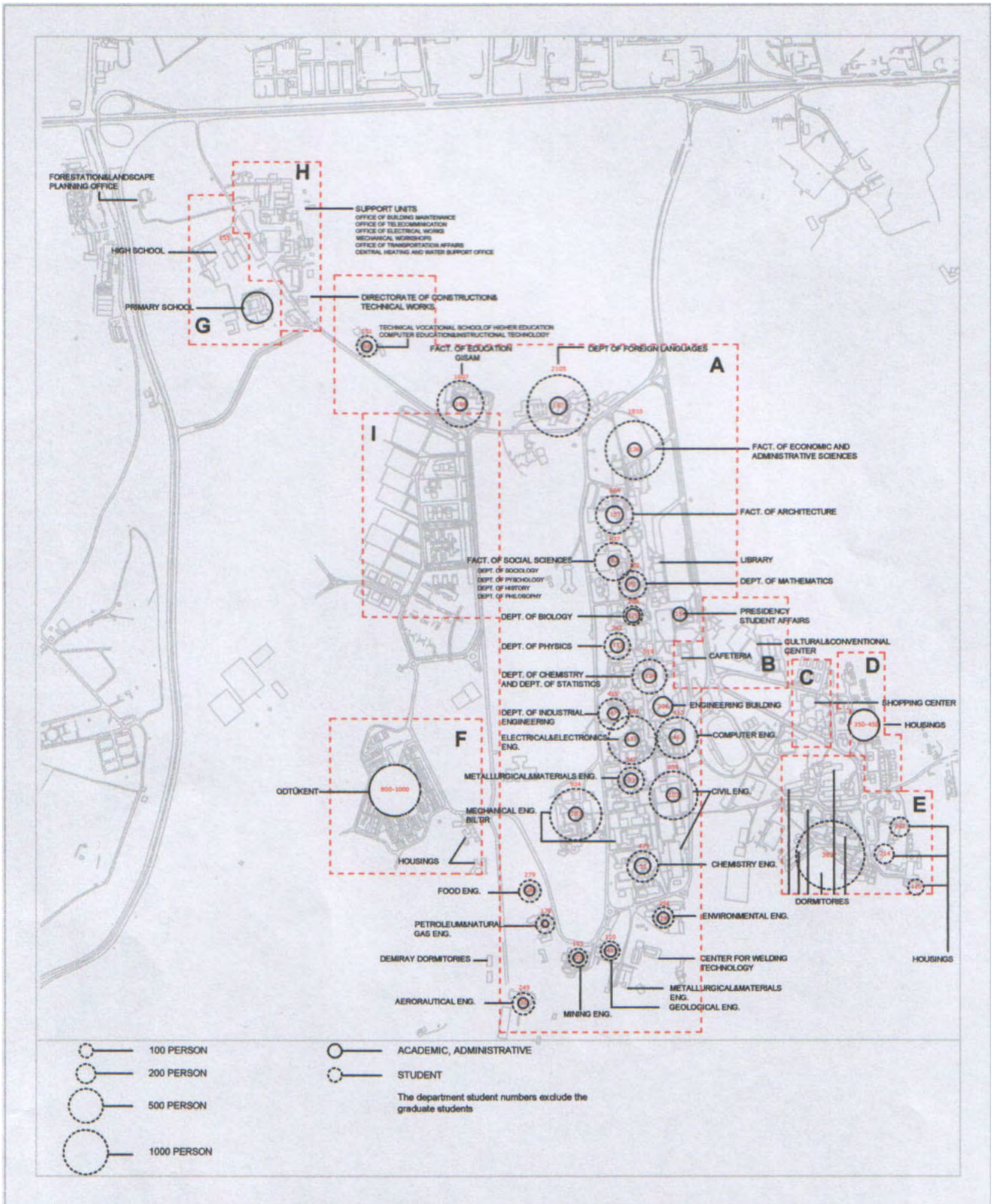


Figure 5. 14 The Population of METU in 1999.

Both studies divided the whole campus into nine zones. In these figures, faculty buildings are located along the so-called zone A-central alley. The population of the most dense zone A has increased from 15,681 in 1997 to 17,157 in 2003. Examining these two studies, in consideration of the temporarily dense areas, such as Congress Center, Stadium, it is seen that the population is concentrated mostly in the area where the Faculty of Physic and the Presidency Office are located.

As a result, the increasing campus population is the important factor behind the need for a reconstructing process. As stated by Kortan (1981), when a campus is designed for 5,000 people, the diameter would be 500m and the area about 80 ha. According to this solution, the area of the campus should be in a circle, with a diameter of around 800 m, and permit walking from one end to the other optimum in 12 minutes, maximum in 15 minutes. He also suggests that the population of a campus should be 5,000 to 20,000 people. With regard to METU, all these show us that the existing transit means are insufficient due to the increasing population reaching 30,000 inhabitants.

5.2.3 Building Heights and Façade

While studying METU, which can be considered as a small-scale city, this situation should be taken into account. An architectural solution proposed for the campus transportation will cause new readings as it does in the cities. Each sequence of campus structure - open spaces, facades and even roofs - will face a major transformation according to the different speed of transportation modes. The conception of façade may be altered by the fact that the proposed monorail will run on an elevated road. As was examined in the previous chapters, incoming speed and motion to the campus will cause these façades to be perceived in a "*cinemotografic*" [2] way.

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[2] This terminology is used by Paul Virilio.

By taking all these alterations into account, first the existing situation of the buildings in the campus should be defined. To do this, all the building heights are studied in following part.

Another important study is made in an observation of the location of buildings, which is often the key to shaping campus transportation patterns. The buildings in the campus are grouped as follows:

- Academic buildings
- Administrative buildings
- Academic and administrative buildings
- Dormitories for the students.
- Housing units for academic and other personnel of the University.
- Social buildings.
- Shopping buildings.
- Sports buildings.
- Teknokent and High school buildings
- Buildings which are under construction.

While academic and administrative buildings are arranged along the center axis of the campus, the social, sports and shopping buildings, along with dormitories and housing units, extend to the A4 gate. Another extension is enlarging to the A2 gates with new added buildings.

5.2.4 Campus Topography

An analysis of campus topography is an important aspect in the proposal of a new transportation system. The METU campus has a sloping topography, and for this reason the application of some transportation technologies, such as light rail or tram, may not be economical or flexible. Monorail technology that can especially run in an elevated way is the best solution for campus transportation due to the topography. In this context, the slope map of METU is analyzed to support this study. In Figure 5.17, the different percentages of slopes are demonstrated with different colors.

Figure 5. 15 Campus topography drawn with GIS.

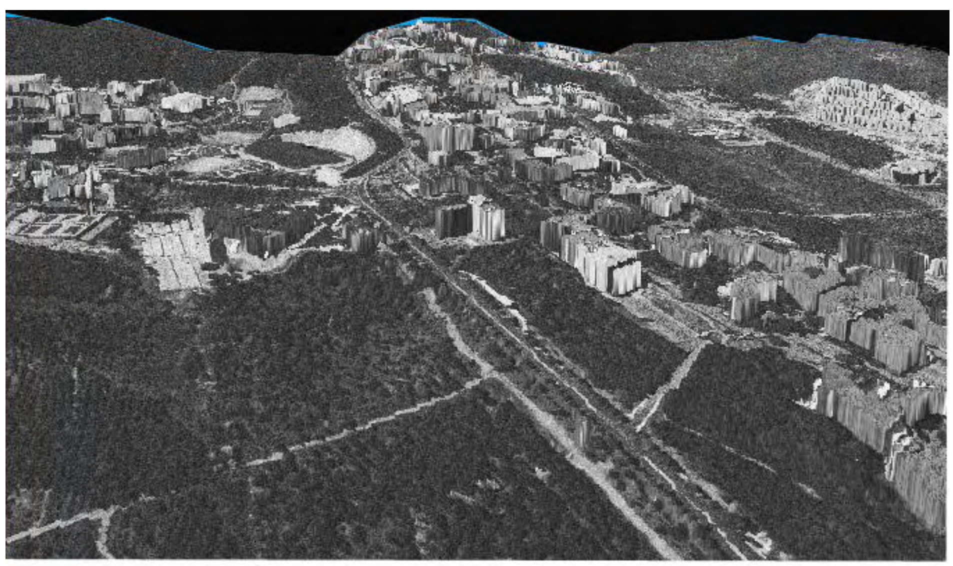

Figure 5. 16 Campus Topography drawn with GIS.

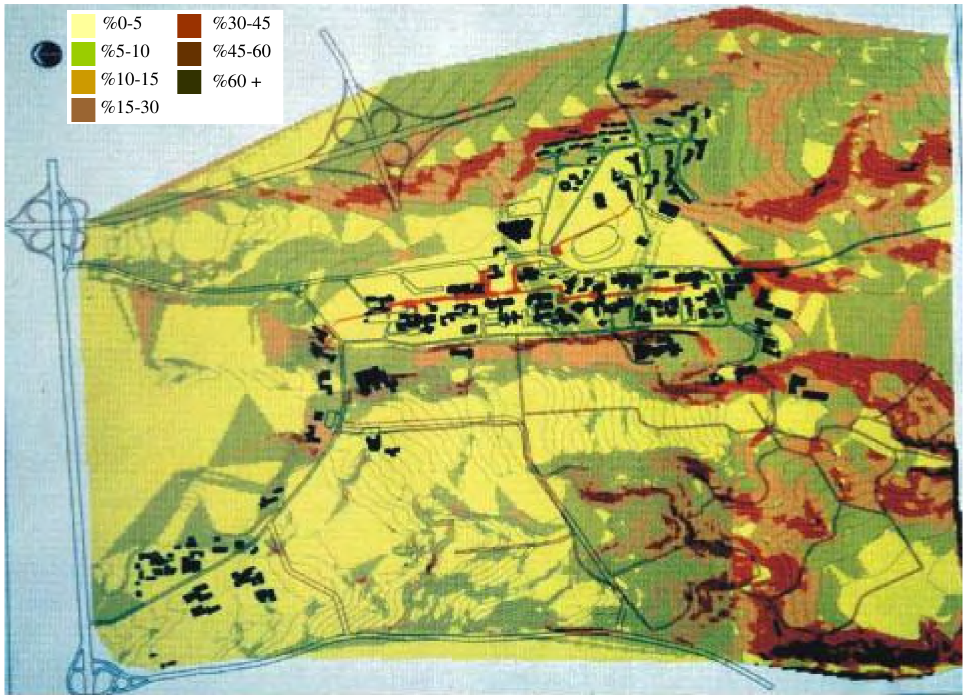

Figure 5. 17 Campus Topography.

5.2.5 Open Spaces, Building Material

Open spaces are arranged in front of each faculty and related alley. Some square and rectangular forms are unified in building shapes. It is an organic architecture, and architects influenced from brutalism have applied the brut concrete system successfully. The materials used are brick and concrete, this application of brutalism is a pioneer example in Turkey.

In this part of the thesis, structural analyses are made in order to search for new transportation solutions in METU. The results of all these analyses show that the current transportation system should be restructured. This restructuring can be reanalyzed with either renovation of the old system or by building a new technology. In this thesis, a new technology is proposed to overcome the transportation problem founded as a result of structural studies. These studies cover the whole METU area, including all structural demographic, social and cultural activities. Six types of analyses are made and the results are transformed into digital format. With the use of geographical information system (GIS) technology, all these different results are overlapped in one environment, which has made a general overview of the situation possible.

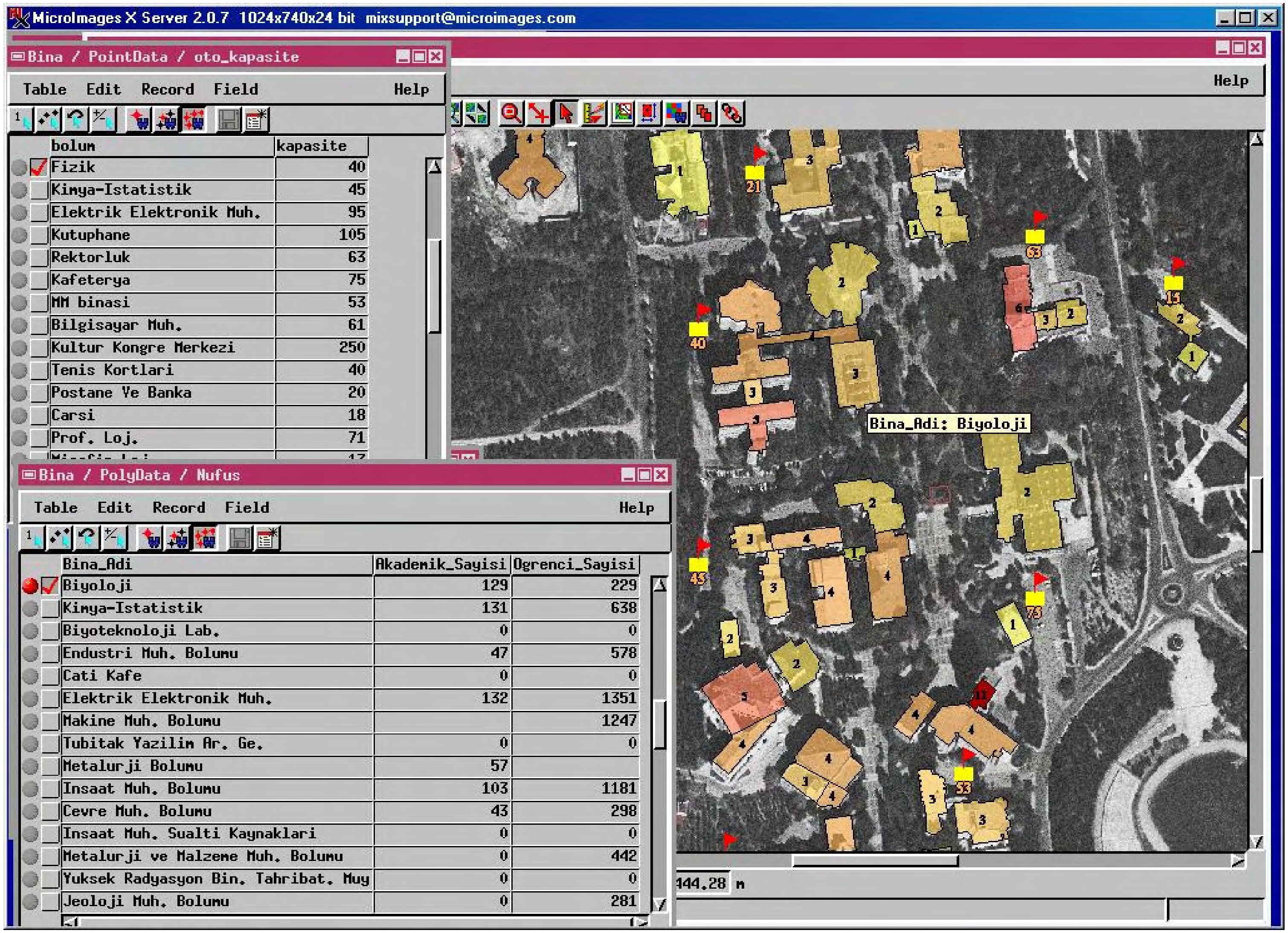

Figure 5. 18 Campus' data (populations, parking spaces capacities and building heights) is overlapped with GIS.

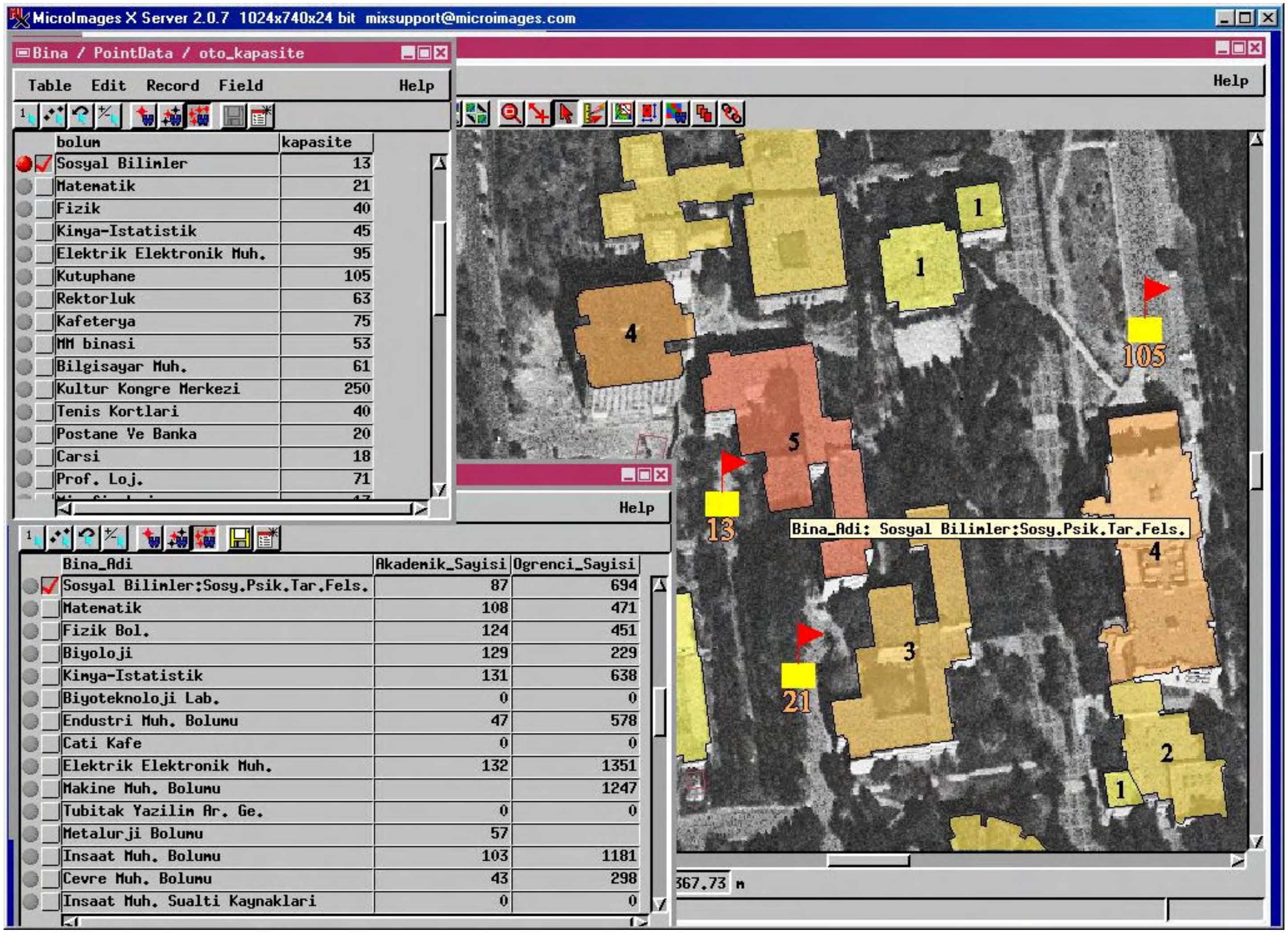

Figure 5. 19 Campus' data (populations, parking spaces capacities and building heights) is overlapped with GIS.

5.3 A Proposal for METU Transportation: Monorail Technology

The aim of this thesis is to discuss the proposals of new transportation technologies for METU and how they affect the transformation of architectural space, especially in the field of architecture. After studying and comparing new technologies according to technical characteristics in appendices, this thesis is limited to the study of a proposal attained from all technical and architectural findings. This will light the way for how the different systems that will be proposed in the future will transform the architectural space, and which criterion should be taken into account in design. It is emphasized how the proposed solution in this thesis in the context of these criterions will build the architectural space and lead what kind of new readings and perceptual metamorphosis.

In the chapter four, in the concern of technical properties, that is to say, since it moves ahead an elevated plane it is faster, much more secure and flexible, enabling different developments and non-polluting, it is thought that "monorail technology" will bring a new speed to campus transportation. This system, from an architectural point of view, with its elevated structure, will not cause obstacles to pedestrian traffic, as in the original campus plan. At the same time, this new and fast technology will provide possibilities for changes and new readings in both the horizontal structure and vertical plane of the campus. The designed stations providing the perception of previously unseen façades and roofs at a different speed through an elevated system will provide the constitution of new architectural spaces and activities in it's the station areas. In this respect, all these arguments are certainly an important step towards transforming architectural space with new proposed systems.

Architecturally, the approach to design is formulated in three levels of inquires. The first is to propose a new technology taking into account the properties of architectural space. Secondly, an effort will be made to determine the design criterion to be followed in the process of the integration of this technology into this space. Third and lastly, to re-examine the proposed system in the context of spatial experiences relative to speed and movement.

Considering the architecture of the campus and the architectural arguments handled in the previous chapters, the principles of the design have been revealed as:

- Designing the appropriateness of the "plainness" of the proposed system and the architecture of station points of this system in relation to the architecture typology and style of the campus.
- Designing the proposed system not ruining the pedestrian and vehicular traffic discrimination of the campus previously designed by Çinici.
- Designing the proposed line as an preferred technology compared the current public transportation, bus and dolmuş. Choosing a system that is safe, faster, environment friendly and not causing traffic jams and noise.
- Designing the line, in a way friendly to the campus landscape.
- Designing the stations being in contact with buildings, population and other public transportation, as well as the activity spaces and parking lots.
- Designing the stations within walking limits, and approximately the same distance to buildings and parking lots.
- Designing the distances between stations so as not to reduce monorail speed.
- Designing the stations and line, considering the previously examined theoretical framework.

Within the perspective of above principles, new technology will possibly change the existing campus structure. Contrary to this constant form, the new monorail technology will constitute a more extensive communications structure. The campus area will be experienced with the sequencing movement. It will explore the coexistence of different movements, such as train and pedestrian. The study is an interaction between different movements on campus, especially, conceptual and perceptual analyses in the formation of architectural judgments in this concept.

Today, the newly added buildings have caused a lost sense of orientation to the central axis. Therefore, the existing campus area suffers from a lack of pedestrian experience. In addition to these problems, the new extended structure has created a time problem in campus transportation. With the monorail project passing from the main pedestrian alley, the above-mentioned problems may be solved synchronously. In such a scenario, the monorail system may provide a perception of the whole campus region, and at the same time provide efficient travel within the campus.

Technically, the new monorail technology considered for the campus was proposed in order to connect the expanding campus area, control campus sprawl and solve the time problem for students moving between buildings to different faculties. In addition, it is considered that a monorail system may be preferred to the current bus and dolmuş system, being safer, faster, combining easily with pedestrian and vehicular traffic, environmentally friendly and totally accessible.

In this project, the nodes of monorail stations are proposed to be elevated, a heavy emphasis must be placed on designing the line independent of ground and topography. Another factor in the selection of the elevated system is the capability to pass through narrow corridors. For this reason, while giving new speed to campus life, the preferred monorail technology will not hinder pedestrian movement, but will provide for a close interaction within the campus.

Furthermore, another important reason for the selection of this elevated technology is its being appropriate for the future changes in the campus land-use patterns. Based on this, projections should be made of the anticipated future changes in the land-use pattern.

5.3.1 Selecting Monorail Route and Station Points

The first crucial step in the monorail design process is deciding on the route. In order to determine the route of the monorail, it is proposed to consider which design criteria will determine the structure of the monorail line. In this context, where the monorail is to pass will be decided according to a third parameter:

- High-density zone (population, settlements and parking and activity points)
- Spatial extensions
- Spatial boundaries

Considering all the above criteria, some alternatives have been produced for the monorail line with Assoc. Prof. Dr. Baykan Günay and research assistant Fikret Zorlu from the Department of City and Regional Planning in METU. At the end of this study, five alternative circulation networks have been determined; being convex polygon (CVP)*, one-way ring (OWR)*, nested loop (NL)*, binary tree (BT)* and spine line*. A suitable alternative should be effective in terms of volume and capacity and be flexible for possible future growth. Nested loop - with two ways rings - covers all the above criteria and it seems economically more feasible when compared to other alternatives. Another important criterion of choosing this system is that it is more flexible than the others according to future development. In this way, the system will consist of two loops. While the first loop serves to the currently most populated regions of the campus, that is the faculties, library, Presidency Office on the main alley and the dormitories, congress center and recreational areas, the other loop will serve the alternative progress of the current campus structure. According to this, the first loop will pass through the

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* convex polygon is a robust and compliant circulation system with various junction configurations (Zorlu, Fikret, 1999:101).

* one way ring is neither a robust nor a well-compliant circulation system, and in this system travel distance is much more than others (Zorlu, Fikret, 1999:131).

* nested loop is one of the most applicable and convenient circulation systems separated as radio-concentric, the grid and hexagonal loops (Zorlu, Fikret, 1999:123).

* binary tree requires extreme hierarchical arrangement and this circulation system is arranged to serve especially for interbase trips (Zorlu, Fikret, 1999:136).

* spine line is one of the most applicable circulation systems separated as the radio-centric, the grid and hexagonal spine.

current settlement of the High and Elementary School regions, the School of Foreign Language, the Faculty of Education and the Technopolis regions.

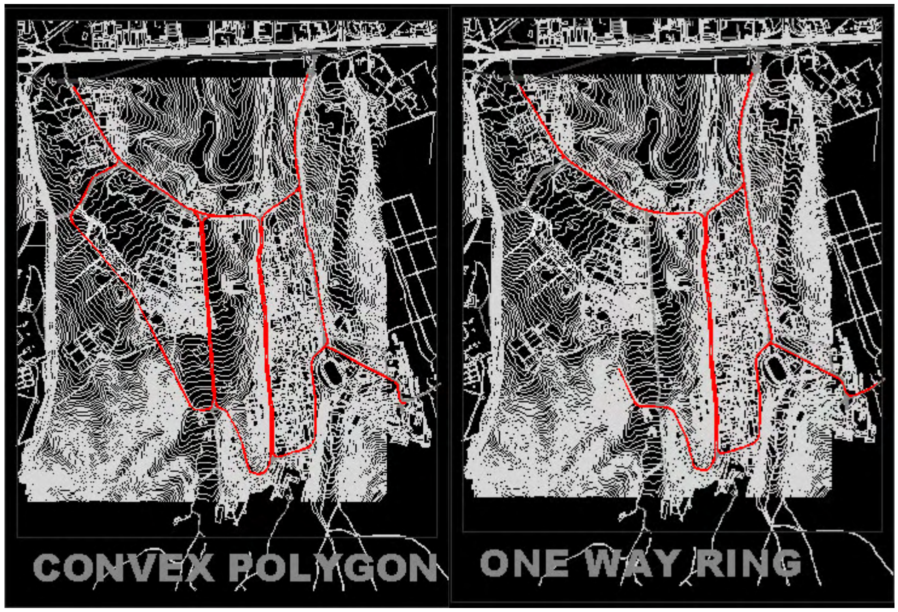


Figure 5. 20 Convex Polygon and One Way Ring Solutions.

Figure 5. 21 Spine Line and Binary Tree Solutions.

Figure 5. 22 Nested Loop Solution.

The second important step is deciding on the departure stops. The reason for the selection of A1 and A2 gates as departure stops is that they will connect with the station stops of the metro line, which will pass through these regions in the future. The waiting period, compared to other areas, will be longer at the new parking lot, which will be constructed by the A2 gate, parallel with this progress and at the station points to be built near to the parking lots at the A1 and A2 gates.

The third step of the design process is the proposal of station zones. In this project, the station zones are selected according to the activity, population and density points. Inevitably, the new system must respond to the changing spatiality and complexity of the enlarging campus. The new line will develop alternative facilities and create new programs. The station zones will create a new density of spatial relationships and uses.

5.3.2 Technological Features of Proposed Monorail Mode

It is claimed that the monorail has special attributes, which render people more able to attract trips to public transport than the alternatives. With regard to METU, in campus transportation, private vehicles – automobiles - are the preferred mode when compared to public vehicles-bus loop. Each of the approximately 6 km monorail loops is proposed as an alternative to buses. Such a system will permit easy and quick access to all parts of campus, regardless of a person's physical ability.

According to this project, the train would be composed of three 30-foot cars, capable of carrying approximately 20 passenger and several bicycles. Its speed will be between 15 and 35 mph. Furthermore, monorail vehicles would run elevated and mix with other vehicles on and through campus traffic routes, but at the same time be given priority. In addition to vehicular traffic, the elevated monorail system in campus has minimal interventions on the landscape.

In an urban context, this flexible structure will provide for a horizontally expanding campus. This technology acts first as a new movement system in campus. For easy access, the station consists of several rectangular planes and ramps to create both multiple use and accessibility to station.

It would even be possible to build the stations of this system attached to existing buildings. Interface between the façades and the stations will be important in the enhancement of the architectural spaces. Programmatic and spatial transformation is the basis of this project's intension. The concept of a campus network not only allows for transformations of buildings façades, but also for new spatial links between faculties and recreational areas.

Another crucial point in the design is the intersection points with other transportation systems. In this respect, each station makes use of intersection points in transition to bus and dolmuş transportation. The transition points of two loops are located close to the current gravity center of the campus.

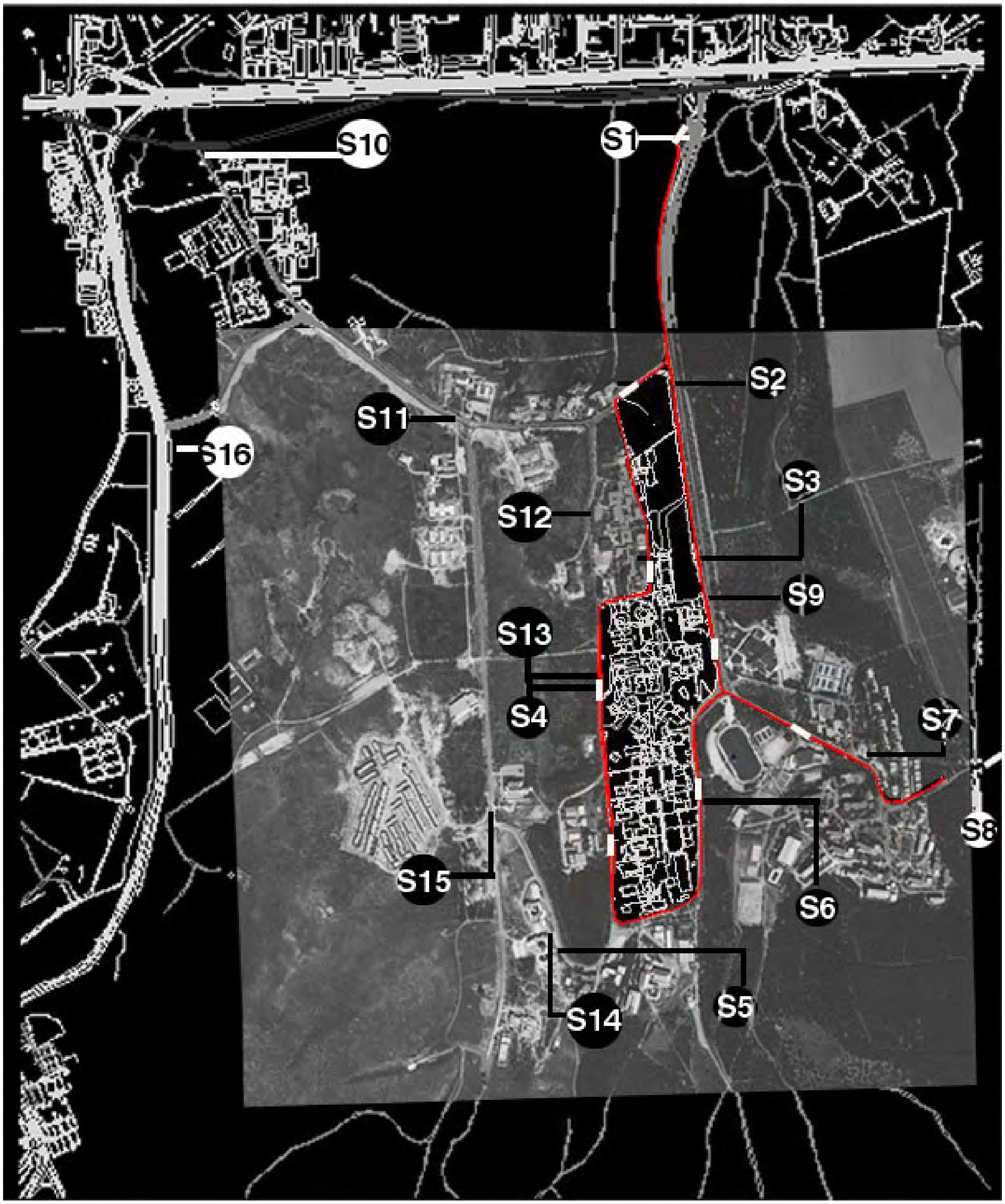


Figure 5. 23 The proposal of first loop.

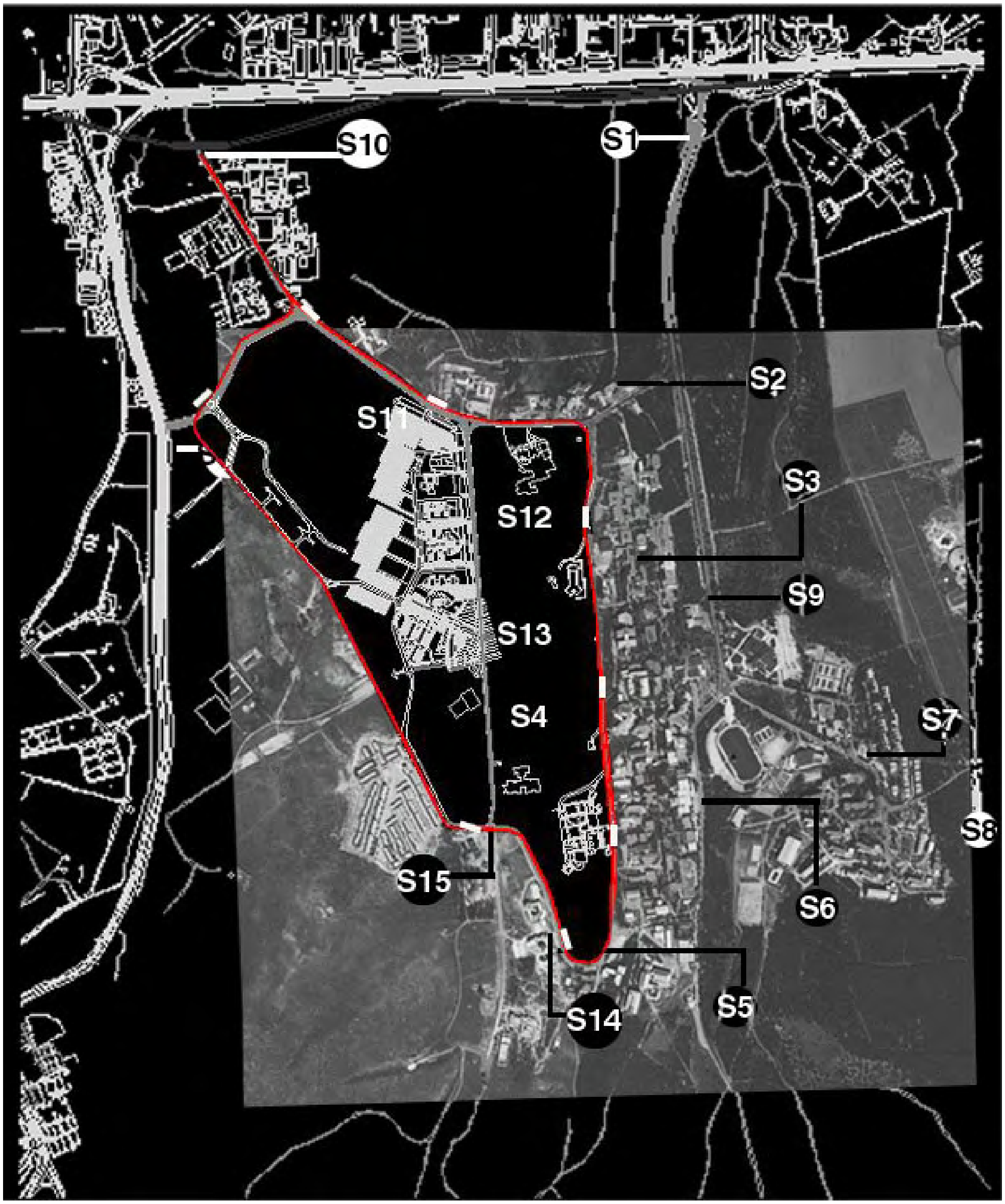


Figure 5. 24 The proposal of second loop.

Figure 5. 25 Monorail in Main Gate (S1).

Figure 5. 26 Monorail in Campus (S2).

Figure 5. 27 Monorail in Campus (between S1-S2).

Figure 5. 28 Monorail in Campus (S2).

Figure 5. 29 Monorail in Alley (S3).

Figure 5. 30 Monorail in Alley (S3).

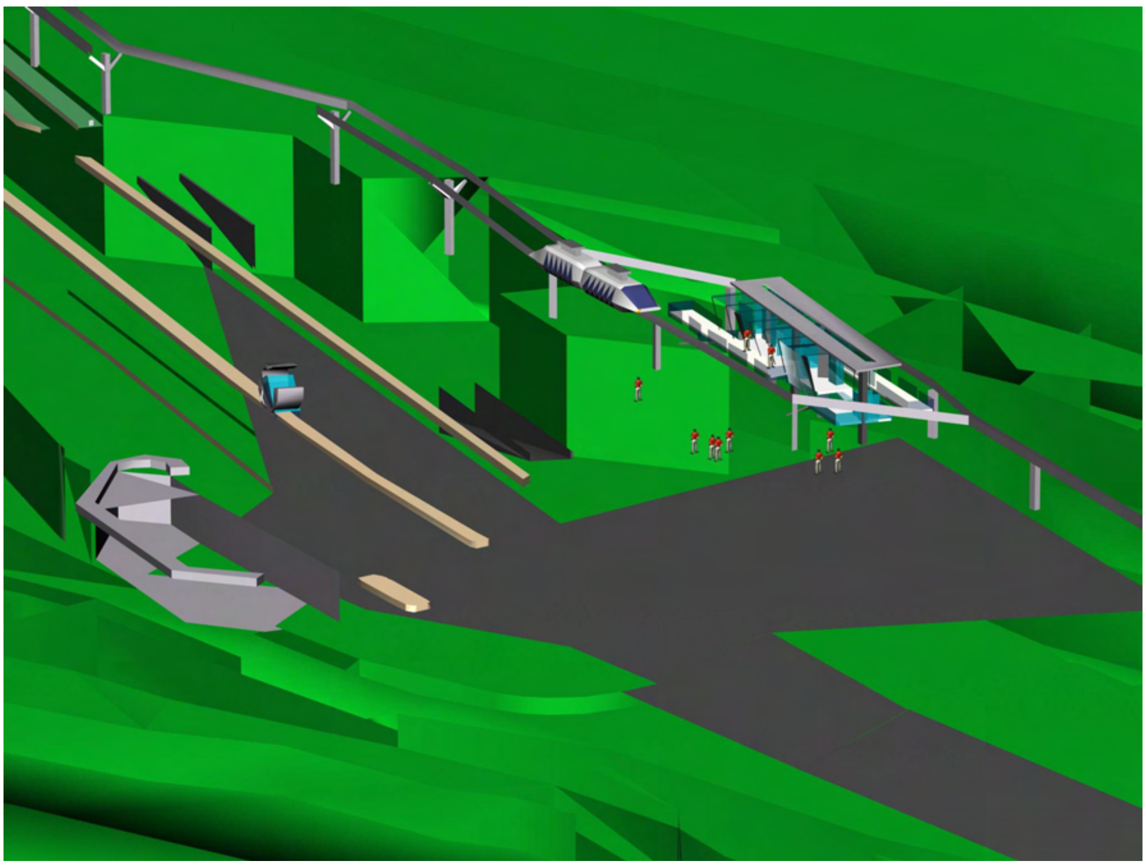


Figure 5. 31 Monorail Station Design.

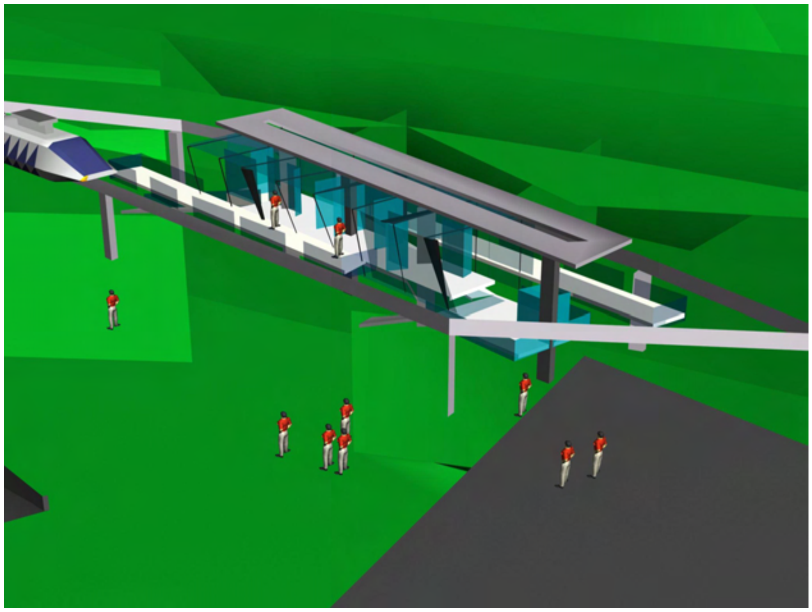


Figure 5. 32 Monorail Station Design.

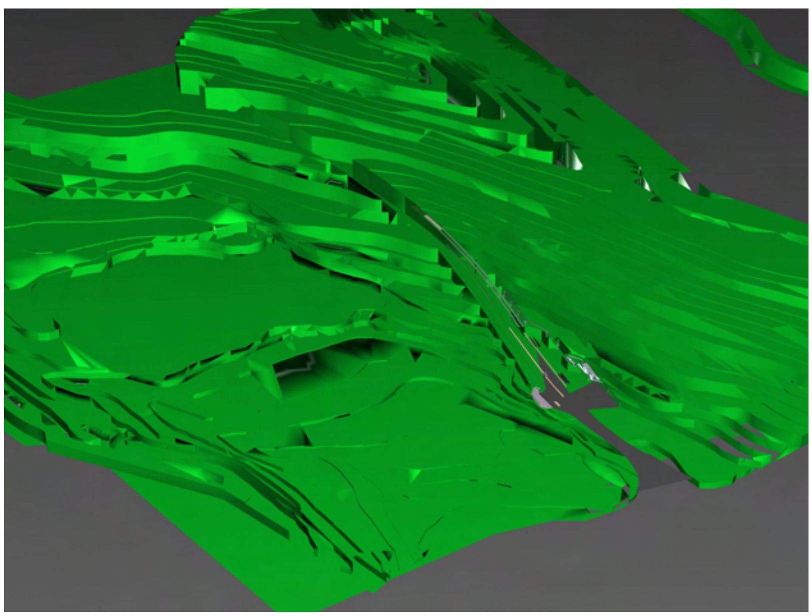


Figure 5. 33 3D Campus Topography.

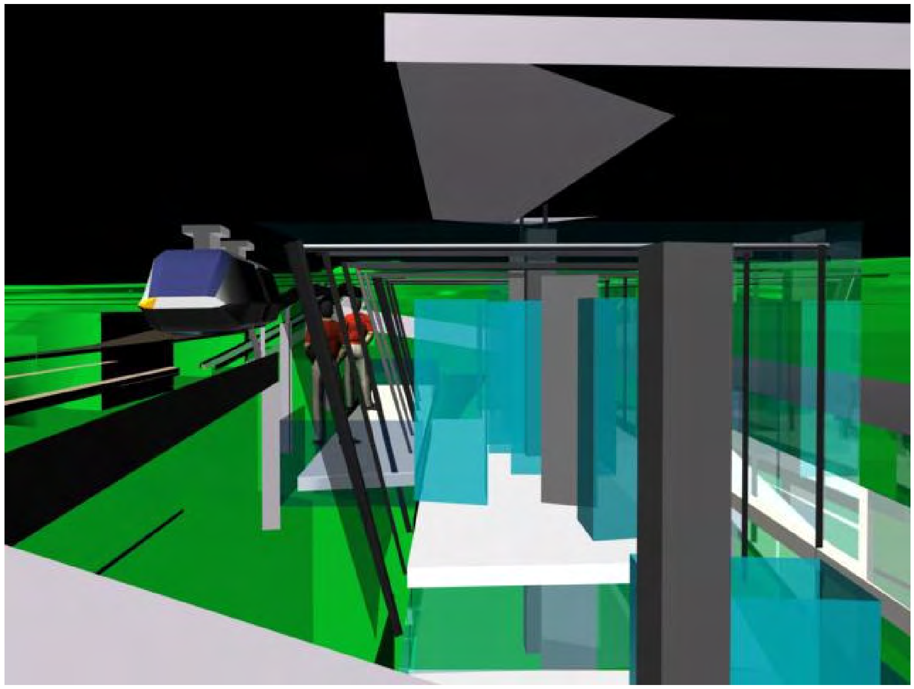


Figure 5. 34 Reflective Glass Structure at Main Station.

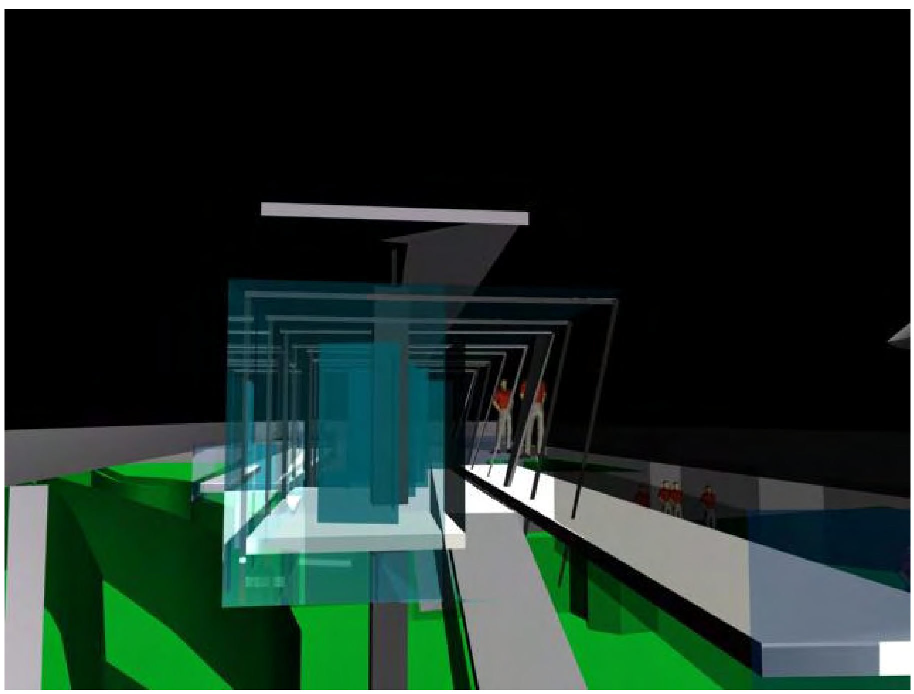


Figure 5. 35 Reflective Glass Structure at Main Station.

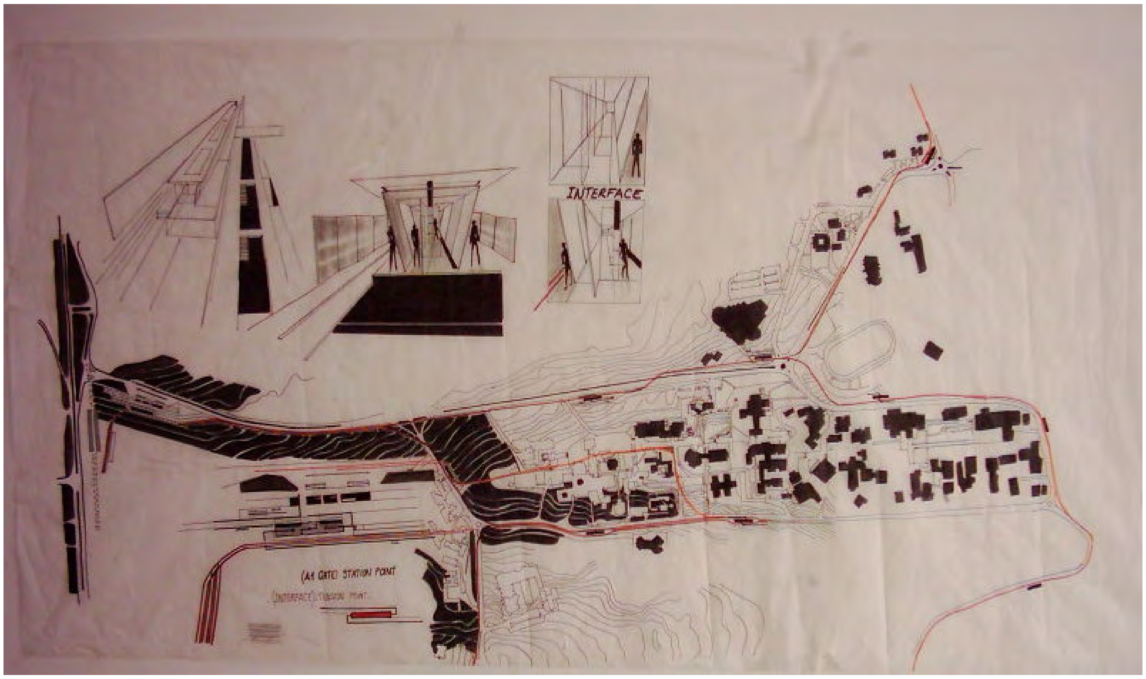


Figure 5. 36 Preliminary Sketch of Design.

5.3.3. Architectural Features of the Monorail Project and its Transformational Effects

The ongoing transformation in architectural space is leading to the need for a re-definition of the phenomena that constitute these alterations, in connection to the architectural project. For some, these alterations have been associated with the impact of transportation technology, implying a radical transformation of our perceptions and experiences in the city. Today, as an effect of this technology, the mental structure of space and perception of distance is not clearly defined.

Moreover, the use of different transport modes is associated with different experiences of space. All these factors are relevant to understanding the proposal of a new monorail project; a new mode, which would provide a new experience and perception in campus as an alternative to current transportations.

Firstly, the design of the monorail project in the campus is an exercise in the way time and movement relate to human experience. How humans perceive spatial elements is dependent on the speed in which they move. In the METU campus, architectural space legibility will be changed by the adding of many different scenarios of movement. Experiential activities will be diversified as walking, cycling, moving by car and moving by train, etc. Paul Virilio, on many occasions, compared the driving of a car with a cinematographic experience (quoted by Eeckhout and Jacobs, 1999: 129). During the monorail design, the new spatial experience of the metropolitan city will be taken into consideration.

In our day, speed has distorted the visual perception of discontinuous structure of perceived phenomena. In this context, Moholy-Nagy said that motion, accelerated to high speed, changes the appearance of objects and makes it impossible to grasp their details. There is a clearly recognizable difference between the visual experience of a pedestrian and a driver in viewing objects. The motorcar driver or airplane pilot can bring distant and unrelated landmarks into spatial relationships unknown to the pedestrian. The difference is produced by the changed perception caused by the various speeds, vision in motion" (quoted by Wenz). Along with reducing distance in the campus area, this new technology will expand the visual perception of spectator traveling by monorail.

Much of the design is concentrated on the introduction of new spatial relations and new readings in campus. The new station's zones create a new density of spatial relationships and uses. Each station structure is composed of reflective glass panels, which are set at different angles. Reflective walls rise up around the monorail station and the walkway. They curve over the station and walkway, like shells. It's like a screen that reflects each mode of motion and speed.

Also in station design, integrated speed and human perception within the programmatic context of monorail stations via reflective structure are emphasized. Thanks to this reflective structure, perceivers at different speeds - such as walking, waiting at the station, traveling by train - will perceive an image in different ways. Gyorgy Kepes (1944), in "Language of Vision", mentions that the visual image has gone through a metamorphosis and its definition change as a language of space. According to him, with this new language people can perceive space-time relationships never recognized before. The architectural expression of the station structure is derived from the surrounding influences of speed and motion. Sliding forms in reflective surfaces place the visitor in a world of motion.

"Geometry gives order to places, it sets out axis, scales, rhythms" (Roncayolo, 1998: 24), it is also a language of space. The language of design in monorail stations is its structure, composed of three elements: ramps, interfaces and waiting platform. The ramps are used to connect different levels in the station and also transition one level to another.

> Today, stations have to organize the passage and exchanges that take place between numerous transport networks in restricted space. They accommodate a multitude of commercial activities and have therefore become extremely complex amenities (Roncayolo, 1998: 24).

The station points are designed for various social activities, as well as different types of communication. Scenes placed on the glass walls that surround the stations are there for these purposes. In these scenes, flowing news and advertisements about campus activities are used as communication interfaces. Under these circumstances, the monorail line and station point can be used as communication and activity places besides exchange and transfer points.

On a city scale, the zones selected to pass the monorail line and station points create new constitutions and activity spaces. Lefebvre mentions that "a social transformation, to be truly revolutionary in character, must manifest a creative capacity in its effects on daily life, on language, and on space" (Lefebvre, 1991: 54). In this project, the new line will probably affect campus social life and architectural space.

Besides being used as transition and exchange spaces, stations can also be used as communication and activity spaces. This structure should allow possible future constructions and transformations just like the monorail passing areas. At this point, a solution open to be adapted to future alternative lines and transformations that could be experienced in the campus as a whole is very crucial. From this point of view, an elevated system proposal, not dependent on ground is the important issue.

Consequently, it can be said that the university campuses, similarly to the city, are increasingly differentiated from previous architectural forms by their extensive boundaries. Unlike the previous structure, today METU campus settlements are gradually expanding with new buildings. For this reason, the new character of campus space needs new transportation solutions for the enlarged structure. In this project, the proposal is to move away from the traditional interpretation of the campus planning process and to adopt a new system. This thesis emerged from three interests: first, the way people's understanding of the spatial environment influences, and is influenced by, transport infrastructure and movement in space; second, the role of an individual's perceptions and attitudes in making choices about transport modes; and third, the importance of the social context in which these decisions are made.

CHAPTER 6

CONCLUSION

It is understood that rapid advances in transportation technology have changed the morphological structure of the cities. Without any doubt, this fact will continue to reconstruct future cities. These ongoing spatial reconstructions are inevitably leading us to scrutinize the influences of these technologies on the architectural space and readings. Although many studies have been made, since transportation technologies inevitably affect our lives, never ending renewal in technology in order to conquer distance and reduce the time factor makes it necessary to reconsider the new coming influences in architectural discourse.

These influences of transportation technologies within the context of architecture, such as changes in space-time, speed-movement and distance-boundaries concepts, are handled thoroughly in this thesis. The ways in which these concepts are reconceptualized is explored with the contemporary urban transformations. As a consequence of this study, fundamental elements of the contemporary city are determined. In this respect, the spread of new transportation technologies coerce the limits of space and time.

Conceived in this way, these new technologies have brought all points in the world closer, have shrunk the distance and have blurred the architectural boundaries. It can be said that our current spatial definition and experience is in a distortion process. Speed and movement have become the inevitable component of this process. With these transforming dynamics of urban phenomena, architectural space is in process of progression. As Arata Isozaki asserts, “the process itself is always and in any case, the construction; thus, in this sense, everything in the world is under construction.” (1999: 84). Today, “we live in the realm of mobility and emancipation” (Virilio, 2001: 31) and therefore cities are always under construction like Isozaki states.

In our day, the notion of speed and movement has started profound shifts in urban perception and experiences. One reason for this is the inevitably accelerating speed of transportation technologies. The production of airplanes and high-speed trains has reshaped people’s perceptions of distance, the meaning of boundaries and the connections of different cities within a global system. Revision of architectural design and planning strategies with the new accelerating machines (high speed train, airplane and also computer) is necessary for city development in the 21st century.

While increased mobility makes the world more accessible, it causes congestion and density problem in the modern metropolis. Although the notions of congestion and density have fundamentally shaped the image of the modern metropolis, these problems were never really resolved completely. One notable preventive measure in the solution to this problem is to increase public transportation instead of automobile usage in the cities.

In the world, especially in Europe and America, cities are being reconstructed with this necessity. The TGV, reaching 200-300 km per hour in intercity transportation, monorail, light rail and sky train renewing technologies and gradually increasing speed in cities, began to spread all through the cities. Whereas, in our country, in spite of new metro lines built in big cities, railroad networks are still so inadequate. Moreover, the main transportation networks are composed of highway transportation in Turkey.

While in the world the transformations as a consequence of the renewal technologies in architectural discourse are in discussion, Turkey shouldn't stay out of these revolutions and discussions. The aim in studying this thesis originates from the alteration of the structure of the METU campus as a part of city, which is captured by automobiles, just like the city, and the deterioration of transportation inside the campus. In this respect, both theoretical and practical analyses –which are grounded on architecture, are tried to be made in order to find a proper solution for METU campus transportation.

So to conclude, the main objectives of this thesis are:

- To scrutinize the reconsideration of METU's gradually changing spatial structure with new transportation technology and open this issue to discussion.

- To study the latest debates in architecture erupting with new technologies – such as the capture of our daily lives by speed and mobility and changes in space and time concepts - and to explore their reflections on METU campus life.

- As the world experiences a shift from automobile transportation to public transportation and faster, more secure, environmental friendly systems are being solved in railway technologies, our country still tries to improve the highway network staying out of this revolution. To provide METU as one of the biggest universities of Turkey with a leading role in following these technologies, considering its own structural alterations.

- To integrate the new speed coming to campus life appropriate to campus structure with other systems.

- As a consequence of the comparison of monorail systems with other similar systems in the technological researches made, such as light rail, sky train and cable car, the monorail is found to be a faster more secure and more environmentally friendly system. In this context, besides being more appropriate to campus life, it is independent of campus topography as an elevated system. It does not contradict the current structure of the campus, in which pedestrians and vehicles are separated. Its ability to pass through narrow corridors makes it possible to plan the system through pedestrian alleys and the stations can better integrate with campus life. However, this system shouldn't be conceived as the only means of campus transportation; considerations of how it will integrate with other proposed systems, such as cycle routes inside the campus, should be studied.

While the new developments in railway technologies have contributed to the expansion and realignment of the urban space, this thesis has aimed to investigate new railway transportation in METU and the impact that the proposed system will have on spatial transformations in an architectural context. In the light of this study, it can be said that a new monorail technology will probably change spatial definitions, such as façade and boundaries in the campus and affect the perception of architectural space. All these transformations will possibly change social life in the campus.

In this way, this thesis studied synchronized concepts of space-time and speed-movement in practice of architectural design. The theoretical researches asserted in the first four chapters are practical reflections of the design process in chapter five. So to say, the theoretical and practical analyzes studied in order to reveal a solution proposal, provides the problem to be discussed on the ground of architecture.

REFERENCES

Albertsen, Niels and Diken Bülent (2001) “Mobility, Justification, and the City”, in http://www.comp.lancs.ac.uk/sociology/soc082bd.html (10 April 2003)

Alkışer, Yasemin (2000) “Karanlıkla Aydınlığın Buluşması: Metro”, Yapı, Vol.227, p.63, İstanbul: Yem Yayın.

Allen, Stan (1999) Points+Lines: Diagrams and Projects for the City, New York Princeton Architectural Press.

Andreu, Paul (1999) ‘Border and Borderers’, Architectural Design, No.69, pp.57-61, London: Academy Editions.

Armitage, John (2000) “Paul Virilio Hypermodern”, in http://csf.colorado.edu/mail/ipe/2000/msg02072.html (9 April 2003)

Armitage, John (2001) Virilio Live: Selected Interviews, London and Thousand Oaks: Sage Publications.

Babalık, Ela (2000) Urban Rail Systems: A Planning Framework to Increase Their Success, unpublished Ph.D thesis submitted to University of London, London.

Barnett, Jonathan (1995) The Fractured Metropolis: Improving the New City, Restoring the Old City, Reshaping the Region, New York: Icon Editions.

Benedikt, Michael (1993) "Cityspace, Cyberspace, and the Spatiology of Information" in http://www.utexas.edu/architecture/center/benedikt_articles/cityspace3.html (20 March 2003)

Benli, Ayşen (1998) A Comparative Study For University Campus Planning, unpublished master thesis submitted to Dokuz Eylül Üniversitesi, Ankara.

Black, Allan (1995) Urban Mass Transportation Planning, London: McGraw-Hill.

Bouman, Ole and Van Toorn, Roemer (1994) The Invisible in Architecture, London: Academy Editions.

Canter, David and Tagg, Stephen (1975) "Distance estimation in cities", Environment and Behavior, Vol.7, No.1, pp.59-79

Caudill, Rowlett Scott (1959) Campus Planning Study For The Ohio State University: Phase 1: Alternative Basic Schemes, Texas: Planning Consultants for the Ohio State University.

Cossons, Neil (1997) "An agenda for the railway heritage", in Burman, Peter and Stratton, Michael, ed., Conserving the Railway Heritage, London: E&FN SPON.

Çinici, Behruz (1999) Improvisation: Mimarlıkta Doğaçlama ve Behruz Çinici, in Tanyeli, Uğur, ed., İstanbul: Boyut Kitapları.

Davey, Peter (2003) "Surface Travel", The Architectural Review, Vol.1274, pp.42-43.

David, Catling, McIntosh, Scott, Stefanovic, Gradimir and Von Rohr, Joachim (2002) "A UITP Light Rail Committee Project", Guidelines for Selecting and Planning a New Light Rail System, in CD format, Brussels: UITP Publics.

De Cauter, Lieven (1999) “The Flight Forward of Rem Koolhaas” in GUST, ed., The Urban Condition: Space, Community and Self in the Contemporary Metropolis, Rotterdam:010 Publishers.

Dethier, Jean (1981) All Stations, A Journey Through 150 Years, London: Science Museum.

Dober, Richard P. (1992) Campus Design, New York: John Willey&Sons, Inc.

Dunphy, Robert T. (1996) ‘New Developments in Light Rail’, Urban Land, No.37, p.87.

Duthilleul, Jean-Marie and Tricaud Etienne (1998) “Dynamic Urbanism” in AREP,ed., Agence des Gares, Paris: Diagonale.

Edwards, Brian (1997) The Modern Station: New Approaches to Railway Architecture, Oxford: Alden Press.

Eeckhout, Bart and Jacobs, Steven (1999) “The Virtualization of the Metropolis” in GUST, ed., The Urban Condition: Space, Community and Self in the Contemporary Metropolis, Rotterdam:010 Publishers.

Eeckhout, Bart and Jacobs, Steven (1999) “Contemporary Variations on a Theme: The Bodily Experience of Urban Space” in GUST, ed., The Urban Condition: Space, Community and Self in the Contemporary Metropolis, Rotterdam:010 Publishers.

Eisenman, Peter (1999) Diagram Diaries, New York: Universe.

Erkal, Namık G. (1995) Constantinopolis: A Study on the City of Constantinople as the artifice of Constantine the Great's Imperial Project, unpublished thesis submitted to Middle East Technical University, Ankara.

Erpi, Feyyaz (1999) Mimari Üzerine Söyleşiler, Ankara: Mimarlar Derneği.

Fishman, Robert (1987) Bourgeois Utopias: The Rise and Fall of Suburbia, New York: Basic Books.

Forester, John (1994), Bicycle Transportation, London: MIT Press.

Fortier, Bruno (1998) "Station Stops", in AREP, ed., Agence des Gares, Paris: Diagonale.

Gerkan, Meinhard Von (2002) "The Design of Transportation Structures-1", Tasarım, Vol.121, p.50, İstanbul: Tasarım Yayın Grubu.

Gleik, James (2000) "Times Goes Standard", in http://fasterbook.com/cgi-bin/faster/fchapter.pl?5 (1 July 2003)

Golledge, Reginald and Stimson, Robert (1997) Spatial Behavior: A Geographic Perspective, New York: Guilford Press.

Görgülü, Güventürk (14 September 1997a) "TCDD'ye Hayat Öpücüğü", Gazete Pazar, p.60.

Görgülü, Güventürk, (14 September 1997b) "Trenden Korkma, Geç Kalmaktan Kork!", Gazete Pazar, p.67.

Hadid, Zaha (2000) “Transport Junction”, L’arca Plus, Vol.25, pp.68-69, Milano: L’arca Edizioni spa.

Harvey, David (1989) The Condition of Postmodernity, Cambridge, MA: Basil Blackwell.

Holl, Steven (1996) Intertwining, New York: Princeton Architectural Press.

Ibelings, Hans (1998) Supermodernism: Architecture in the Age of Globalization, Rotterdam: NAI.

Ingenhoven, Overdiek (2000) “Stuttgart Central Station”, L’arca Plus, Vol.25, p.32, Milano: L’arca Edizioni spa.

Isozaki, Arata (1999) “Simulated Origin, Simulated End”, Any Time, New York: Anyone Corporation.

Jameson, Fredric (1991) Postmodernism, or, The Cultural Logic of Capitalism, London: Verso.

Juintow, Lin (2000) “ Shaping Time and Movement” in www.juintow.com/portfolio.pdf (15 April 2003).

Knight, Robert L. (1979) ‘Environmental Impacts of Transit System’, in Gray, George and Hoel, Lester, ed., Public Transportation: Planning, Operations and Management, USA: Prentice Hall.

Koolhaas, Rem and Mau, Bruce (1998) Small, Medium, Large, Extra-Large, in Sigler, Jennifer, New York: Monacelli Press.

Kortan, Enis (1981) Çağdaş Üniversite Kampüsleri Tasarımı, Ankara: O.D.T.Ü. Mimarlık Fakültesi.

Laszlo, Moholy-Nagy (1961) Vision in Motion, Chicago: Paul Theobald and Company.F

Lefebvre, Henri (1991) The Production of Space, Cambridge, MA: Blackwell Publishers.

Lefebvre, Henri (1998) Modern Dünyada Gündelik Hayat, İstanbul: Metis.

Lowe, Marcia D. (1994) "The Global Rail Revival", Society, Vol.31, pp.51-56, Available: Academic Search FullTEXT Elite Database from EbscoHOST, in http://www.epnet.com/

Lynch, Kevin (1972) What Time is this Place?, Cambridge, MA: MIT Press.

Lynch, Kevin (1981) Good City Form, Cambridge: MIT. Press.

Lynn, Greg (1998) 'Geometry in time', Anyhow, New York: Anyone Corporation.

Marcus Binney (1995) Architecture of Rail: The Way Ahead, London: Academy Editions.

Markowitz, Frank and Estralle, Alex (1998) "Campus Transportation", in http://bap.ucsb.edu/planning/1.background.stuff/campus%20moves/campus.moves.html (20 April 2003)

Matthews, Anne (2002) " End of an Error", in www.nationaltrust.org/magazine/archives/arc_mag/pennstation.htm (21 April 2003)

McLuhan, Marshall (1964) Understanding Media, New York: McGraw-Hill book Company.

Meeks, Caroll (1956) "The Railroad Station, an Architectural History", New Haven: Yale University Press.

Middlebrook, Robert David (1957) An Introduction to Junction Theory, New York: Wiley.

Mumford, Lewis (1934) Technics and Civilization, New York: Harcourt Brace.

Municipality of Greater Ankara General Directorate of EGO (1987) Ankara Urban Transportation Study, Ankara: Ajans İletim.

Municipality of Greater Ankara General Directorate of EGO (1995a) ANKARAY: Ankara Light Rail Transit System, Ankara: EGO Department of Transportation Planning and Rail System.

Municipality of Greater Ankara General Directorate of EGO (1995b) Ankara Ulaşım Ana Planı: Araştırma Raporu, Ankara: EGO Department of Transportation Planning and Rail System.

Özbay, Serdar (1999) Sustainable Solid Waste Management in Campus: METU Campus as a Case Study, unpublished thesis submitted to Middle East Technical University, Ankara.

Pocock, Douglas Charles David and Hudson, Ray (1978) Images of the Urban Environment, London: Macmillan.

Pawley, Martin (1998) "Terminal Architecture", Architectural Design, Vol.68, No.1/2, pp.86, USA and Canada: John Wiley&Sons,Inc.

Powell, Kenneth (2000) City Transformed: Urban Architecture at the Beginning of the 21st Century, London: Laurence King Publishing an imprint of Calmann&King Ltd.

Rachman, John (1999) 'Time Out', Any Time, New York : Anyone Corporation.

Richards, Brian, 1990, Transport in Cities, "Transport and the City", London: Architecture Design and Techno.

Richards, Brian (1966) New Movement in Cities, London: Studio Vista.

Ringen, Jonathan (2001) "Station to Station" in http://www.metropolismag.com/html/content_1201/tra/ (2 June 2002)

Robbins, Edward (June 2000) "The Station not the Airport", The Architectural Review, p.45, New York: E.W. Godwin.

Roncayolo, Marcel (1998) "Mobility and Urban Territories", in AREP, ed., Agence des Gares, Paris: Diagonale.

Rubenstein, Harvey (1992) Pedestrian Malls, Streetscapes, and Urban Spaces, New York: John Wiley&Sons.

Sargın, Güven A. (April 2001) "Consuming Politically the Urban Space: on Violence, Resistance, and Transformation", Arredamento Mimarlık, pp.70-75, İstanbul: Boyut Yayıncılık

Sennet, Richards (1994) Flesh and Stone: The Body and the City in Western Civilization, New York: W.W.Norton.

Tekeli, İlhan (1981) Dolmuşun Öyküsü, Ankara: ODTÜ Mimarlık Fakültesi Yayını.

Webber, Melvin (1964) Explorations into Urban Structure, Philadelphia: University of Pennsylvania.

Wendell, Cox (1996) "Urban Transport: From Theory to Reality" in http://www.publicpurpose.com/pp-nz91.htm (7 April 2003)

Wenz, Karin "Dispersion" in http://www.uni-kassel.de/fb8/privat/wenz/space/dispersion.html (15 June2003)

Wheeler, Stephen (2001) "Technology and Planning: A Note of Caution" in http://dcrp.ced.berkeley.edu/bpj/pdf/15-Wheeler1.pdf (20 June 2003)

White, Peter R. (1976) Planning for Public Transport, England: The Anchor Press.

Wolfgang, Meyer (2002) "Intelligent Transport Mode Worldwide Success", 6th International Light Rail Conference: Developing Successful Light Rail, in CD format, Brussels: UITP Publics.

Vermandel, Frank (1996) "Eurolille-Project for a City", in Croise, Espace, ed., Euralille: Making of a New City Center, Boston and Berlin: Birkhauser Basel.

Virilio, Paul (1991) The Aesthetics of Disappearance, New York: Autonomedia.

Virilio, Paul (1993) The Third Interval a Critical Transition: In Re-thinking Technologies Minneapolis, University of Minnesota Press.

Virilio, Paul (1995) The Art of the Motor, Minneapolis, MN: University of Minnesota.

Virilio, Paul (1997) Open Sky, London and New York: Verso.

Virilio, Paul (2000) A Landscape of Events, Cambridge, Massachusetts: MIT Press.

Vuchic, Vukan R. (1981) Urban Public Transportation: Systems and Technology, London: Prentice-Hall.

Vuchic, Vukan R. (1979) 'Urban Passenger Transport Modes', in Gray, G., Hoel, L. (ed.), Public Transportation: Planning, Operations and Management, USA: Prentice Hall.

Vuchic,Vukan R. (1994) "The Role of Rail Transit in Contemporary Cities", The City as an Human Environment.

Yaprak, Renda (1996), "Şehir ve Ulaşım", Bilim Teknik, Vol.349, pp.21-23, Ankara: Pro-Mat Basım Yayın A.Ş.

Zengel, Rengin (1998) An Evolution of Settlement Patterns in Campus Panning with Regard to the Criteria of Accessibility, unpublished Ph.D thesis submitted to Dokuz Eylül University, Ankara.

Zorlu, Fikret (1999) The Role Traffic Network Design in Circulation Systems and in the Formation of Urban Patterns, unpublished master thesis submitted to Middle East Technical University, Ankara.

Zupan, J., Pushkarev, B. (1977) Public Transportation and Land Use Policy, London: Indiana University Press.

APPENDIX-1

PLANNING TRANSPORTATION SYSTEMS

> Moving around in cities is becoming increasingly difficult. As the pressure for homes and working spaces grows, too does the demand for roads and other transport (Richards, 1990:1).

Movement and accessibility illustrate the role of circulation in the formation of urban space. Transportation networks are one of the circulation systems of the urban form. In the past, transportation routes played a major role in the sitting of cities, and today the transportation system affects where and how urban areas grow. Also, transportation networks affect formation of urban pattern. Lynch states that the urban pattern could be seen as a network (Lynch, 1981: 357).

In this section of the study, technical researches can be found -under the subtitles of “Movement Systems”, “Planning Railroad Networks” and “Decision Criteria of Choosing Transportation Technology”.

1.1 Movement Systems

There are as many urban structures as there are urban areas, with all of the features associated with this process of urbanization interacting with the very different pace of development of movement systems. As mentioned by Brian Richards, movement system in cities can be categorized as first and secondary movement system. He states that,

> In the future, points within the central area will be for the loading and unloading of express bus services, and rapid rail transport, which will both enter on elevated tracks, running through buildings and above streets, the views over the city giving a new dimension to travel, to be enjoyed daily and bringing the large peak flow of commuters into the central areas at their main pedestrian levels, where the secondary movement system also travel (Richards, 1966:13).

He points out that four systems of secondary movement would be necessary to handle efficiently the patterns of day-to-day movement around the city.

1. A non-stop open 'Carveyor' system for general movement
2. Pedestrian conveyors serving points of peak intensity, and changes of travel
3. Minirail system for external use
4. Mini-car hire or taxi systems for personal use (Richards, 1966:15-16).

He said that all these systems would connect all bus and rail stations (Richards, 1966:16). The other movement system, he mentioned, can be categorized according to technological differences. In 1981, Vukan Vuchic stated that transit modes could be distinguished on at least three dimensions: technology, right-of-way, and type of service. There are three general families of transit modes: rail, bus, and paratransit. Rail and bus modes operate on fixed routes and fixed schedules. Paratransit has a variable route and schedule (Black, 1995, p. 95).

1.2 Planning Railroad Networks

The major advantage of a rail line is its impact on land-use development. Hence, the design of the route network and choice of specific locations for routes and stops are very important for transportation planning.

The relationship to rail routes to land use is particularly important. As Black mentions, there is a symbiotic relationship between rail transportation and a particular form of urban development; the two support each other and need each other (1995: 222). Transit functions most efficiently in cities that have high population densities and are compact and highly centralized. Such cities are relatively dependent on transit and have rider ship levels much greater than those of dispersed, low-density cities (Black, 1995: 222).

The planning of transit routes changes from city to city, depending on the size, density, and settlement pattern of the city. Black (1995) enumerated four steps in the process of transit planning:

1. **System Planning:** this is long-range planning for the entire urban area. It involves examining alternative systems at a general level, evaluating their potential cost-effectiveness, and identifying a priority corridor for the next major improvement,
2. **Alternatives Analysis:** This study is a detailed comparison of several alternatives for the priority corridor, including a base case or null alternative. It results in selection of a preferred alternative,
3. **Preliminary Engineering**: This work on the preferred alternative determines technical feasibility; establishes specific alignments, grades, and station locations; and makes detailed cost estimates,
4. **Final Design:** Architectures and planners prepare the final plans and specifications that will be used by contractors.

1.3 Decision Criteria of Choosing Transportation Technology

Transportation technologies form integral building blocks for a contemporary society. As stated by White, “efficient and safe movement of people and goods ensures a thriving economy and provides for an improved quality of life (1976: 74). Furthermore, transportation technologies affect the environment through physical construction and operation of transportation facilities, and through the travel behaviors they encourage. The study of transportation therefore must not only focus on efficient and safe design but also on the relation between urban structure and environmental quality.

1.3.1 Environmental Quality

The decisions made on how we move around the city affect the overall quality of life in the city. As sated by Robert Knight, "environmental impacts occur in a chainlike manner, with initial impacts leading the others". According to him, an initial alteration in the environment creates a set of emissions that lead to some direct impacts on various aspects of the physical environment, which may in turn generate indirect ones (Knight, 1979: 529).

Physical environment is affected by air pollution and noise. Motor vehicles are major sources of carbon monoxide and ozone, the two most common pollutants. Public transportation vehicles have the capacity to cause less air pollution per passenger, and a large shift of motorist to transit would improve the air quality. The other major environmental impacts usually involve noise and aesthetics. In the past few years, monorail has become the preferred option for railway investment in the world. This is because has lower environmental impacts.

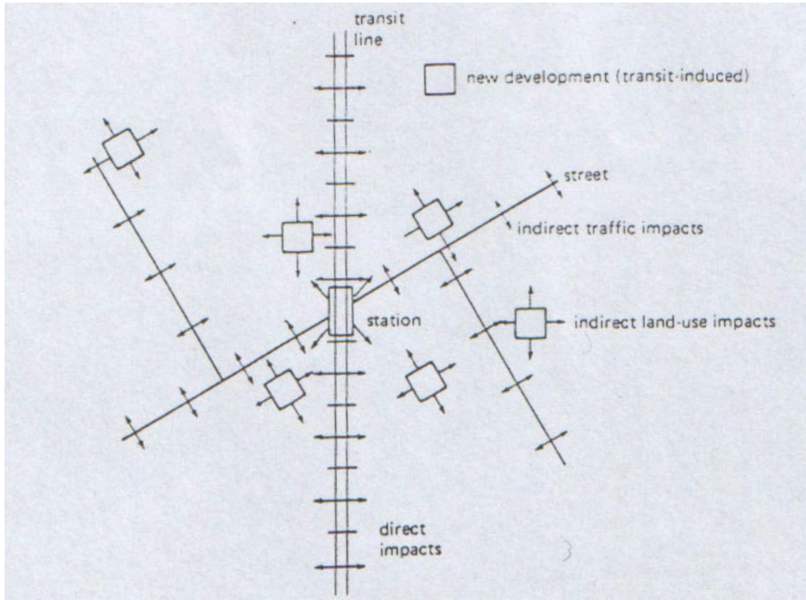


Figure App.1. 1 Direct and indirect environmental impacts.

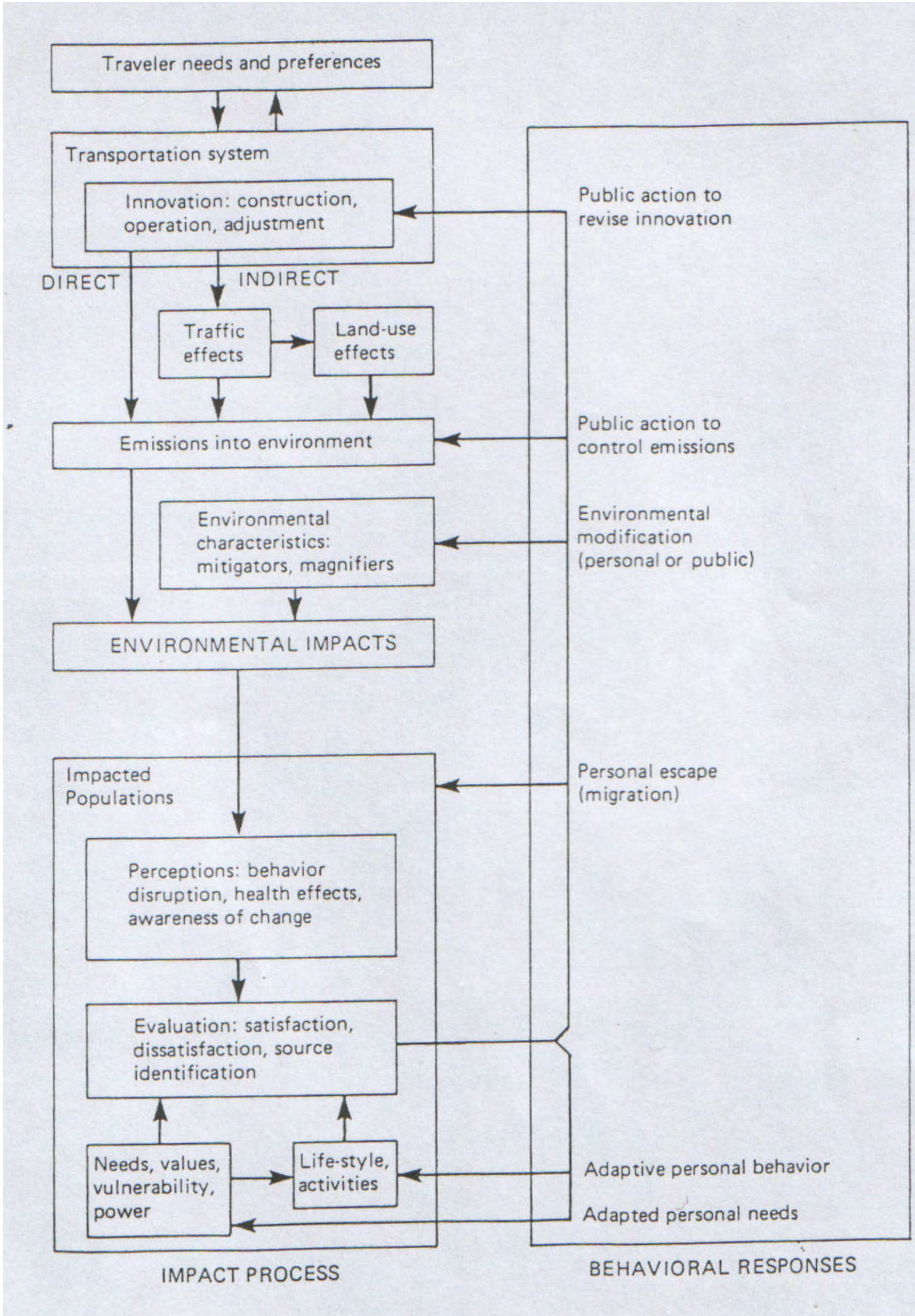


Figure App.1. 2 Socio-environmental impacts of transportations.

1.3.2 Speed

Since a rail line has a separate right of way, trains are not bothered by traffic congestion and supposedly compete better with the automobile in speed. Buses running in mixed traffic are slow, and they get slower as the highway becomes more crowded (Black, 1995: 120).

Alan Black (1995) stated that there are three different measures of speed in a transit system: maximum speed, average vehicle speed and door-to-door speed. The one that gets the most publicity is the maximum speed that vehicles are able to attain. Technology does not limit the maximum speed of either trains or buses. It is a matter of design objectives. Any vehicles design for a certain top speed. Modern railcars run with 70 to 80 miles per hour, but buses most run with the speed limit, which is no more than 50 miles per hour in urban areas (Black, 1995: 120).

The average vehicle speed is based on the total time and takes a vehicle to cover a route from end to end (Black, 1995: 121). Black revealed that the critical factor is not the technology but the spacing of stops. Close spacing stops means slow speed for both rail and bus. Rail systems potentially have higher average speed (Black, 1995: 121).

The door-to-door speed is the average speed for travel from origin to destination, including time spent walking and waiting for a transit vehicle. This is the most important measure because it is believed that most travelers base their modal choice on door-to-door time (Black, 1995: 122). Rail has less advantage over bus by this measure because the access distance tends to be great.

Thanks to their high performance, monorail vehicles accelerate quickly. Together with good design features such as an elevated way these will result in a good average commercial speed (between 20 and 30 km/ h) and thus short journey times. Measures to reduce dwell times at stops increase speed and regularity and also improve the accessibility of the system.

Table App.1 1 Comparing public transport system according to average speed and distance between stations.

System Name	Average Speed (km/h)	Distance Between Stations (m)
Rapid Transit or Metro	30	1000-2000
Light Rail Transit	20	350-800
Advanced Light Rail	35	500-1000
Guided Bus	25	350-800
Monorail	20	350-800

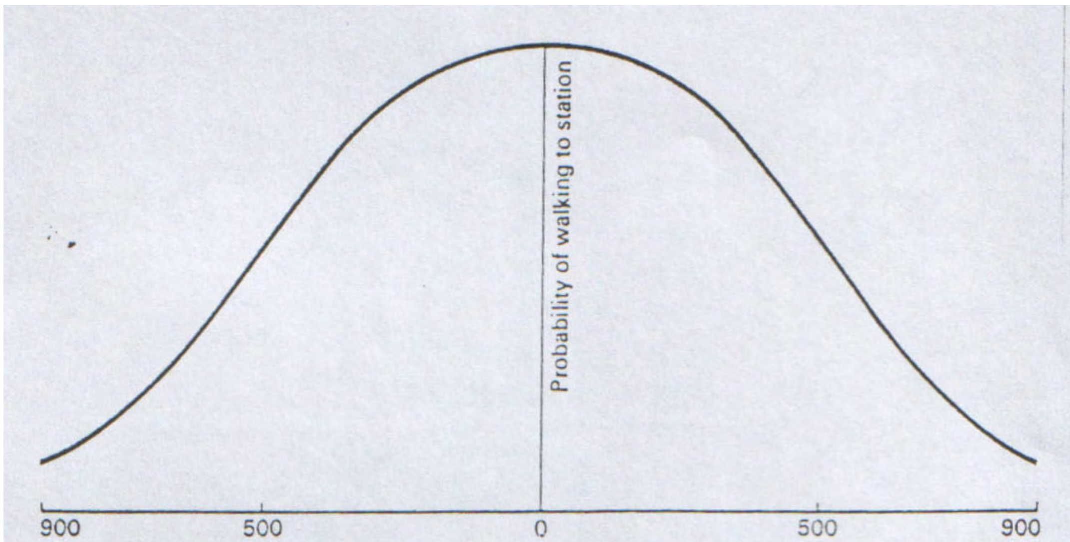
1.3.3 Easy Access

Alan Black said that the transportation problem is actually bundled of interrelated problems. They can be grouped in three major categories: congestion, mobility and ancillary impacts.

Mobility

The second aspect of the transportation problem is usually labeled mobility, or accessibility. Walking distance through station is very important for mobility. Experience of transport operators, together with some theoretical work in the Runcorn New Master Plan suggested that about 500 meters is the maximum distance over which most passengers are prepared to walk to a bus stop (White, 1976: 101). This is equivalent to about five minutes' walk for the average adult, but can be up to Twice as long for a woman with a pram, or an elderly person.

German research suggested a gauss distribution of probability of walking to a station. The probability of walking falls gradually to a range of 500 meter than rapidly down to about zero at 900 meters (White, 1976: 102).



Distance from station (meters)

Figure App.1. 3 Probability of passengers walking to a station.

1.3.4 Visual Effects

Rail transportation lines built at elevated level usually have little visual impact on the urban landscape. In addition, many people consider the newer elevated structures to be a positive addition to the visual environment. Many subway stations are virtually invisible at street level, but some do have buildings that form a noticeable part of the built environment. While most of stations are simple and functional, a few have received special treatment. Urban transport by monorail contributes positively to the social dimension of a city, improves the quality of visual architectural space.

APPENDIX-2

EXAMPLES OF RAIL TRANSPORTATOIN TECHNOLOGIES

2.1 Light Rail Transit

Light Rail transit *is a metropolitan-electric railway system characterized by its ability to operate in a variety of environments such as streets, subways, or elevated structures. It is a modern version of the electric streetcar. In 1983, UITP' International Light Rail Commission issued the following definition; light rail is a rail-borne form of transport which can be developed in tages from a modern tramway to a rapid transit system operated on its own right- of- way, underground, at ground level or elevated (Wolfgang, 2002). Since Light Rail systems can operate on streets with other traffic, they typically use an overhead source for their electrical power and boardings take place from the street or platforms. According to a transportation consultant, because Light Rail systems operate in both exclusive and shared right-of-way environments, they have stricter limits on their length and the frequency of service than heavy rail systems.

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*UITP (Union International des Transports) organized "6th UITP Light Rail Conference: Developing Successful Light Rail Systems" conference in Nantes, 13-14 June 2002.

Figure App.2. 1 A computer-generated image of the Tacoma Light Rail.

Light Rail systems gained popularity as a lower-cost option to heavy rail systems, and a number of cities have constructed Light Rail projects over the past 20 years (Babalık, 2000: 18). From the late 1960s, Light Rail has proved suited to fill the gap between the classic street tramway and the high-capacity heavy metro or suburban rail networks (Wolfgang, 2002). There are now over 400 LRT and tram networks in 50 countries and more than 100 new Light Rail systems are being planned world-wide. It is flexible enough to be integrated in existing or planned urban structures and developments, and can be built and operated in a cost-efficient way. Since the mid-1970s new networks have been developed for example, North America, the Asia-Pacific region and the United Kingdom but France is the most important one. In U.S.A., since 1980, Light Rail systems have opened in 13 metropolitan areas: Baltimore, Buffalo, Dallas, Denver, Northern New Jersey (Hudson and Bergen counties), Los Angeles, Pittsburgh, Portland, Sacramento, San Diego, San Jose, St. Louis, and Salt Lake City. Several other cities, including Minneapolis and Seattle, are in the process of planning Light Rail systems. Examples of France will be examined as more detail in following section.

According to a transportation consultant, system speeds generally depend on characteristics such as the distance between stops, fare-collection methods, and the degree to which the tracks or roadway are exclusive to transit vehicles or share right-of-way with cars and other vehicular traffic, as both buses and Light Rail lines typically do in downtown areas.

The name of the 'Light' is come from the passenger capacity compared with heavy rail. Light Rail is ideal for flows of 3 000 to 8 000 passengers/h in each direction. Metros and heavy rail have a higher capacity. High performance light rail vehicles (LRVs) on dedicated rights-of-way can offer a commercial speed of between 22 and 35 km/h.

Table App.2 1 Light Rail Systems' Planning Principle.

Slope of Line	1%
Radius	max 300-400m
Length of station	80-125m
Wideness of station	3,5-4,5m

Some of the advantages are claimed for light rail:

1. It is safer than heavy rail because the electricity comes from an overhead wire instead of a third rail. There is no need fence the track, and it can operate in street.
2. It offers more flexibility of location than heavy rail. Where land is expensive (as in a downtown area), it can be put in street and passengers can board and alight from the sidewalk. Right-of-way acquisition and construction can be cheaper than for heavy rail.
3. Hence it is viable in situations with a lower level of demand than that needed to justify costly heavy rail projects. This might include medium-sized cities where the only alternative is bus service.
4. If most of route is on separate right-of-way, average speeds are higher than for buses in mixed traffic.
5. It is widely considered flexible in operation, and environmental friendly (Edwards, 1997: 50)

6. It has a technical capability of running in narrow corridors, without necessarily requiring underground construction or segregation from the rest of the traffic (Edwards, 1997: 51).

7. Light rail systems are flexible in that they can be designed to have street-running segments to penetrate the city centre, and fully- segregated sections outside the city centre to provide services with higher speeds and higher degrees of reliability (Dunphy, 1996: 87).

Light Rail schemes are not just about transport, but are also city projects. This contributes to the regeneration and modernization of urban centers and to the development of new areas. The long-term commitment of a rail mode encourages commercial development such as new housing, offices and shopping centers along its route. It also increases the value of existing property as well. At the same time, by encouraging higher-density developments on the core corridors, Light Rail encourages more compact towns and cities, avoiding unnecessary and inefficient urban sprawl (Wolfgang, 2002).

Experience shows that customers respond more enthusiastically to Light Rail than improved bus services (Wolfgang, 2002). This enables a modal shift from the car, which can help reduce congestion in road space and parking. Light Rail makes a positive contribution to the social dimension of a city and improves the quality of life significantly. In optimum performance, Light Rail routes give easy access to the city center, which means fitting into existing or planned urban areas. Although various solutions have been developed over the years, further innovations will be needed if the mode is to be better perceived as an integrated component of urban living (Wolfgang, 2002).

Light Rail can operate in every possible urban and suburban environment - at ground level, underground or elevated. It is ideal for pedestrianised areas, as the vehicle path is unvarying and instantly apparent. But beyond the city limits, “several cities have shown successfully that LRVs can run on railway track, mixed with heavy rail traffic” (Wolfgang, 2002).

2.1.1 Station Design

Brian Edwards mentions that “suburban stops are frequently raised above ground level, approached by ramp so that cars are level with platforms for easy and quick loading, even by disabled people. Alternatively, loading is necessary from streets level, and special fold down steps are used” (Edwards, 1997: 120-123).

2.2 Examples of Light Rail Projects

2.2.1 Bangkok-Thailand

In Bangkok, new light rail system was opened at the end of 1999. It was heralded as a turning point in the fortunes of the capital of Thailand, which is crippled by appalling road traffic congestion that stifles business life and causes some of the world’s worst air pollution. A massive 82% of the city's journeys during the early 1990s were by bus, car motorbike or taxi. In an effort to provide a long-term solution to road congestion, Bangkok Metropolitan Administration (BMA) initiated three separate mass transit system schemes. One of them is the new light rail network comprises two lines, extending to a total of 23.1 km. Trains run on 9 m wide and 12 m above the road level viaduct. Siemens-Italian Thai took on building and operating the line.*

* See in http:// www.railway_technology.com

Figure App.2. 2 Trains run on the viaduct.

2.2.2 Barcelona-Spain

Barcelona and Madrid capital city of the Spain share a number of common obstacles to their economic growth - chief among these being the growth in the number of cars, and consequent clogging up of the city's main roads. So both cities decided developing a new light rail system, as a central plank of moves to tackle the growing congestion. Barcelona's authorities wanted to develop a system, which would truly bring new heart to their city, so the route chosen follows one of the city's main arteries, and serves the main square. In Barcelona's case, city planners are looking to bring the new light rail system right into the heart of the city by laying new tracks along one of the city's main arteries and the city’s symbolic heart, the Placa Reina Maria Cristina. The centrepiece of Barcelona's new metro system is a new fleet of the elegant Eurotrams, the design devised by Adtranz. The total of the project cost is £ 85 million, 11 km route is estimated £65 million and equipment and rolling stock is approximately £20 million.*

* See in http:// www.railway_technology.com

Figure App.2. 3 Eurotrams in Barcelona.

2.2.3 Bremen-Germany

The modern city of Bremen is 50 km from the North Sea coastline. Today, the operator of the city's light rail system, Bremer Strassenbahn AG (BSAG) operates eight tram routes, extending to a total of 77 route kilometers. In 1990, the governing authority considered importance of trams in the city's infrastructure. Eight years later, the first tangible signs of the plan appeared, with the opening of a revamped Line four, complete with a 3.4km extension to a new northern terminus. 1.6km extension of Line six to reach the city airport. . Line six also serves the main “city university”, following the opening of a 2.2km extension. In the city, trams share the road with other vehicles. The light rail vehicles were provided by constructor MAN.*

Figure App.2. 4 Bremen light rail vehicle provided by MAN.

* See in http:// www.railway_technology.com

2.2.4 Bristol-United Kingdom

In Bristol, planners believe that the new line will drastically reduce traffic congestion in some of the busiest areas of the city. In their opinion, the light rail system will also have the potential to enhance the economic competitiveness of the North Bristol corridor as well as introducing protected green areas and reducing pollution. The project was submitted for Government approval under the Public/Private Partnership Project (PPPP) in 1998. The construction, according to project schedule, should be completed by 2002. The line should be fully operational by the year 2003.*

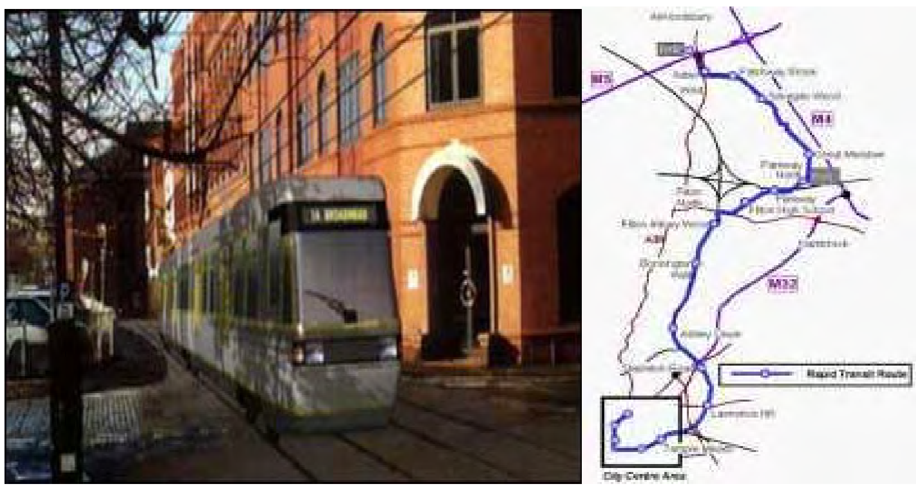

Figure App.2. 5 In Bristol, the new light rail line will operate in 2003.

2.2.5 Cologne-Germany

The German city of Cologne (Köln), 200km north of Frankfurt, is cut in two by the River Rhine. Over a series of wide boulevards, which comprise the 'ring' running for five kilometers around the edge of the city, three tram routes form a semi-circle. In Cologne,

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* See in http:// www.railway_technology.com

Modernization of such an extensive tram network has been ongoing, having first begun in 1956. During the 1960s, the city's articulated trams benefited from large-scale investment, and the pace of modernization has remained fast ever since. City tram routes and interurban routes were amalgamated in 1968, and the vast, 15-route tram system upgraded. Eight tram routes have been upgraded to light rail standards in the programme begun in the 1970s. These all have 900mm-high station platforms and use tunnels and/or surface tracks laid on reserved alignments. A novel system of operation is used on two lines, Lines 16 and 18, which link the conurbations of north Köln and south Bonn. The 34 km Route line is now the network' s longest line, and its third busiest, used by 67,000 passengers a day. The lines was built and designed by Siemens*.

Figure App.2. 6 Light rail station in Cologne.

2.2.6 Croydon-United Kingdom

The major commuter and commercial town of Croydon, 15 miles south of the UK capital, London, has grown tremendously during the latter part of the 20th century. With

* See in http:// www.railway_technology.com

a population of 320,000, it is the most populous London borough, the equivalent of Britain's seventh largest city. This has led to roads across the borough becoming choked with traffic, and to the adoption of light rail as a solution to the resulting problems. The idea to bring trams back to London for the first time in 50 years emerged from discussions between London Transport and the former British Rail in the 1980s. Improvements to the existing rail network were originally suggested, and the main target identified as improvements to east-west links through the area. The new system is 28km (18miles) long.

The winners of eight firms which bid for the concession to design, build, finance and operate the system were Tramtrack Croydon Limited (TCL), comprising Bombardier Transportation, CentreWest Limited, Sir Robert McAlpine Limited, Amey Construction and the Royal Bank of Scotland. The cost of the project is £200million.*

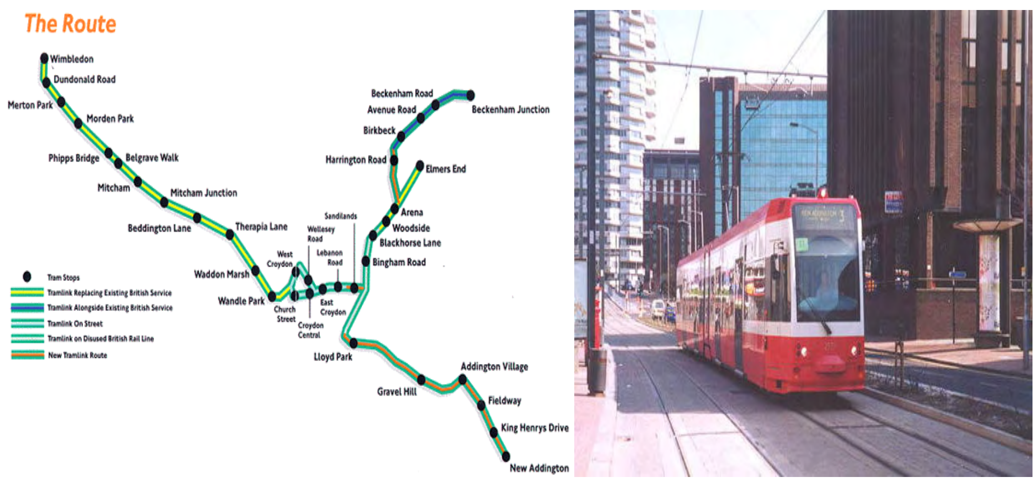

Figure App.2. 7 Street running trains.

* See in http:// www.railway_technology.com

2.2.7 Docklands-United Kingdom

Since opening in 1987, the Docklands Light Railway has been central in the regeneration of east London, UK. The system consists of two main 'arms', running north-south and east-west, intersecting in the suburb of Poplar. The planner believed that the system would regenerate of the area south of the River.Serco Docklands, DLR Ltd. and part of the new Transport for London (TfL) holds the operating system, vehicles built by bombardier. The system' long is 2.6 miles, approximately 0.7 miles is in bored tunnel, 1 mile at near ground level and half a mile on viaduct. The system cost is approximately £77million*.

Figure App.2. 8 DLR is unique in the UK as its trains run without drivers.

Figure App.2. 9 A DLR train at East India Station on the Beckton Extension.

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* See in www.railway_technology.com

2.2.8 Dublin-Ireland

Dublin is by far the largest city in Ireland with over 1m inhabitants. However, its transport infrastructure has not developed to cope with the extra demands and the city suffers from serious road congestion. A light rail network was proposed in 1990 with one line. All of the constructions were completed in 2001.

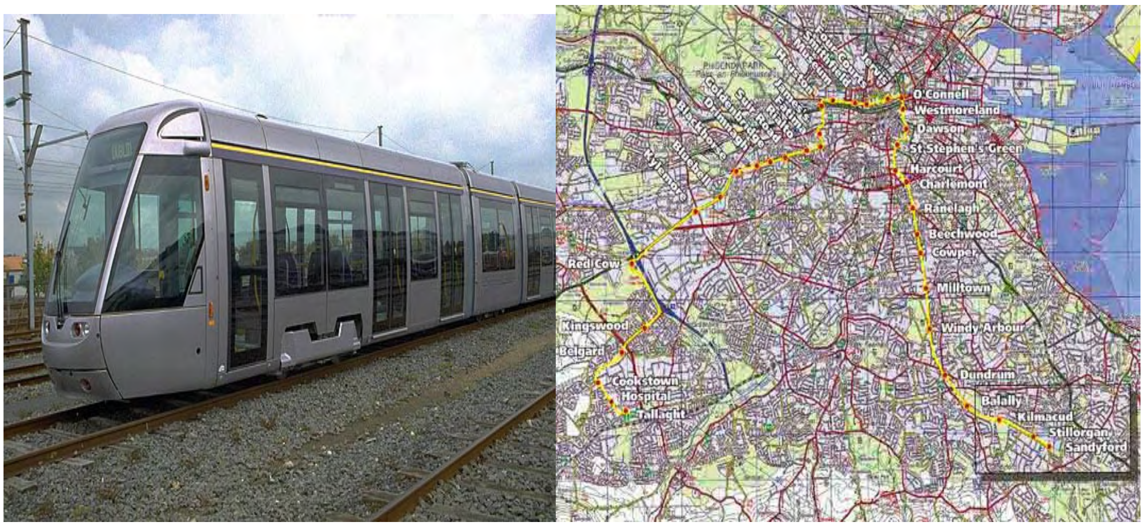

Figure App.2. 10 Dublin Light rail system.

2.2.9 Grenoble-France

In Grenoble, Light rail tramway system is widely seen as an excellent example of the marriage of modern technology with urban renewal of an historic city. The city received extensive environmental improvement in 1987 when the new tramline was built. The network played an integral part in redevelopment of the whole city, which also included pedestrianisation, buildings renovation and landscaping.

Despite being situated in Europe's most mountainous country, Grenoble itself is relatively flat. The total length of the line is 20km (12 miles). A further 13.5km (8.4 miles) line will open at the end of 2005. The line extends hospital complex and "university campus", which has lent it the name "the students' tramway". The network is served with 53 trams built by GEC Alstham*.

Figure App.2. 11 LRT in Grenoble.

2.2.10 Houston-USA

The proposed light-rail project is expected to provide a higher level of transit in the city of Houston, Texas (USA). The light rail will link downtown with other major venues, but it is also believed to have the potential to become the cornerstone of a regional rail system. The project is also believed to support and enhance ongoing economic development and redevelopment within the corridor. It is hoped that the light-rail link will encourage investors in building new shopping areas and other entertainment around the busiest stations. Any potential environmental hazard will be mitigated through

* See in http:// www.railway_technology.com

design to prevent negative impact. The construction will be managed to reduce or avoid disruption or inconvenience to the usual mobility. The system will carry its first passengers in early-2004. The system's trains will be built by Siemens*.

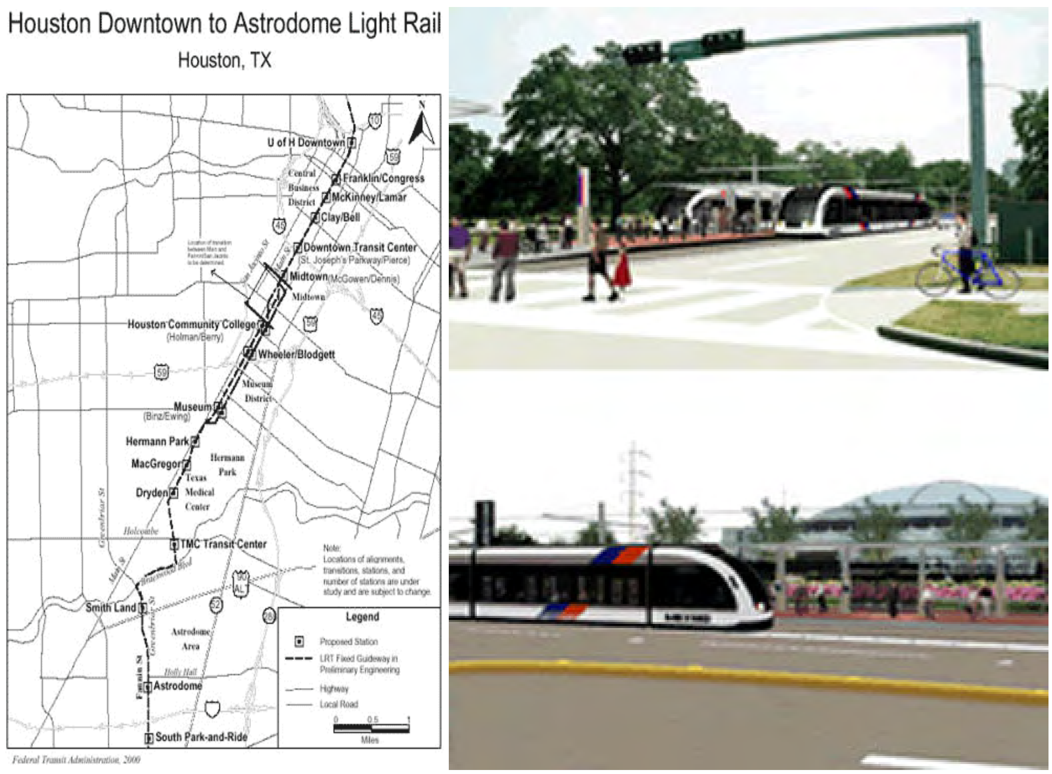

Figure App.2. 12 Houston's proposed light rail system.

2.2.11 Karlsruhe-Germany

The German city of Karlsruhe was the first in Europe to investigate the possibility of track-sharing for light and heavy rail vehicles. It is now considered the model for similar developments worldwide. The city was keen to link urban and rural areas, enabling passengers to travel into and out of the city centre without having to change vehicles. A

* See in www.railway_technology.com

combined light/heavy rail system was seen as the most viable solution to meeting increasing demand. The system's engineering company is Siemens. Karlsruhe's new modern tramway system has been built at relatively low cost. Light rail adaptations were completed by deutsche mark 45 million (£15 million) worth of modifications, including building eight new stations*.

Figure App.2. 13 Karlsruhe Light rail system.

2.2.12 Milano-Italy

Milano, Italy's second largest city, boasts one of the best-developed light-rail/metro systems in mainland Europe. The system opened its first line in 1964, and over the next 30 years it grew to comprise three lines, to serve 84 stations. Construction and maintenance is in the hands of the privately-owned The mass of tram routes criss-crossing the city are gradually being superseded by the more technologically-advanced light rail, in a rolling program, which will eventually see the elimination of the 420-strong tram fleet, which has an average age of more than 50 years. Early in the 1990s, city leaders realized that they would not be able to afford - either financially, or in terms

* See in Source: http:// www.railway_technology.com

of the likely disruption to traffic and business - substantial further tunneling or other works involved in developing new light rail alignments*.

Figure App.2. 14 Milano Light rail.

2.2.13 Montpellier-France

The choice of a modern tram, or light rail system, was largely determined by the city leaders' desire for a system with its own dedicated alignments. Bus lanes, often open to abuse by car drivers, were not seen as a viable solution, and as existing bus routes were already at, or near, capacity, a new high-capacity articulated tram system, similar to those which had already proved popular and successful in many other growing central European cities, was seen as the ideal solution. Public transport accounts for a relatively high 17% of all journeys into and out of the city center, but the tramway's introduction is

* See in www.railway-technology.com

seen as a major contributor to the achievement of strict new EU standards on air quality. In December 2001, a second line was approved. The line with 15.2 km length extends major centers of activity, hospital, university, and exhibition center and rail terminus with 75,000 people living within five minutes walk of a tram stop. The tramway is seen as the final piece in the jigsaw of urban regeneration, which has already seen the university, hospital and railway station upgraded. As much of the tramway as possible is laid on grassed tracks on reserved alignments separated from existing roads. In addition, Montpellier was the first city to order Alstom's sleek, modern Citadis tram design. Each tram accommodates 220 passengers*.

Figure App.2. 15 LRT in Montpellier.

2.2.14 Nantes-France

In the French city of Nantes, new light rail system was opened in 2000 with 27 km. Nantes claims to be the city which invented public transport, when in 1826, it saw the first public hackney cab. Since then, however, the city has become a thriving port, its prosperity built mainly on massive traffic in timber imports. Like many other cities, it eventually adopted the tram, but then abandoned them quickly in the 1950s when the bus was seen as a more flexible alternative. In the ensuing half-century, growing road traffic

* See in www.railway-technology.com

has seen this view proved a fallacy, and in the early 1980s, Nantes signaled a return to trams - although this time in their new-generation form.

A five-year plan for development of the transport network was drawn up in 1989, covering restructuring of the city's buses to act as feeders for the light rail system. A decade later, many bus routes served at least one tram stop. The trains built by Adtranz have 76 passengers capacity with 23 low-floor vehicles. Nantes is being closely watched by other European cities, and is particularly seen as a model for the light-rail system planned for Nottingham, UK - the two cities are of almost identical size, and have seen similar growth in population and transport needs in the latter part of the 20th century*.

Figure App.2. 16 LRT in Nantes.

2.2.15 Singapore-Singapore

Singapore, one of the most densely populated islands in the world, boasts an excellent modern light rail network. The system is run by Singapore Mass Rapid Transit (MRT). Until late 1997, MRT was a basic network of four lines, giving a total route mileage of

* See in www.railway-technology.com

83km (50 miles). Of this, just over 60km (40 miles) is above ground, 19km (12.5 miles) underground, and 3.8km (2.2 miles) at street level. Before the extensions were inaugurated, the network had 48 stations, two-thirds at above-ground sections. In1997, The line is extent to Airport. The Airport station will be directly linked to Terminals via escalators and lifts, while the airport's Skytrain system will take passengers to Terminal*.

Figure App.2. 17 Singapore LRT.

2.2.16 Strasbourg-France

As a major city at the hub of the European Economic Community, Strasbourg began moves early in the 1990s to give the city a public transport system which would justify its position at the hub of the continent. The resulting system is one of the most distinctive anywhere in the world.

* See in www.railway-technology.com.

Figure App.2. 18 Postdam LRT.

2.3 Sky Train

2.3.1 Mandalay Bay-USA

A number of the main tourist attractions around the major destination of Las Vegas, Nevada, USA are linked by a unique form of rapid transit system, which its developers hope will become an attraction in itself. Drawing on the latest cable-drawn transport technology, the system is, in effect, a rail-borne ski-lift, which is fully automated, thereby reducing staff and operating costs, compared with a conventional light rail or tram system. Private operator Circus Enterprises claims the Cable Liner offers a suitably unique mode of transport along what is 'the most famous casino mile in the world'. The construction of the system was taken on by Dopplemayr Cable Car of Wolfurt, Austria (that country's division of Siemens Transportation) and CCEI. The twin-track tram system is fully automated, and operates via a cable, linking the principal Las Vegas' Boulevard intersection with the prestigious hotel complex at Mandalay Bay. In an area where wealth is reflected in the high percentage of vehicle ownership, the cable liner claims to offer a radical alternative to the problems of road congestion, at the same time as providing a solution in keeping with the unique character of the area it serves[*].

Figure App.2. 19 Sky train in Mandalay.

2.4 Cabin Car

The cable car has a dedicated guideway, which can run either overhead or underground. Passengers are transported in a number of cars continuously traveling along the line on a regular interval basis. The terminals are equipped with turntables to turn the cars round for the return trip. The cars are designed to carry 33 passengers each (at 4 persons per square meter) at a line speed of 6 - 8 m/s (21.6 - 28.8 km/h). A typical configuration comprises two terminals and up two five stations along the line. The system is very flexible and can accommodate gradients of up to 10% without any difficulty. The cable liner can also negotiate tight bends, which is always a problem with conventional systems.

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[*] See www.railway.com

Figure App.2. 20 Cable car.

One of the big attractions of the cable liner is the small footprint. The highly flexible design of the cars and guideway is the key to full integration into existing structures and the urban environment. The modular design of the system and the variety of solutions available make for an optimum fit in any location as well as short construction times.

Figure App.2. 21 Cable car.

2.5 Monobeam

Monobeam is an elevated transit technology, which is unique in that two-way travel is possible riding along both sides of the monobeam via a unique cantilevered suspension configuration. The system is a major break through which should significantly influence the transit market in the 21st century. Its capacity of more than 20,000 passengers/ hour/ direction is possible using 28-foot, 52-passenger vehicles in varying train lengths (1-10 cars), operating at as little as 90 second headways. Initial maximum speed is 70 mph, with later development leading to speeds of 100 mph or more. Proven, modern train control technology will regulate the movement of trains, either under automated or operator-assisted scenarios. A minimum turning radius of 90-feet horizontal and 300-feet vertical give. Vehicle speed is initially 70 mph; later versions may reach 100 mph.

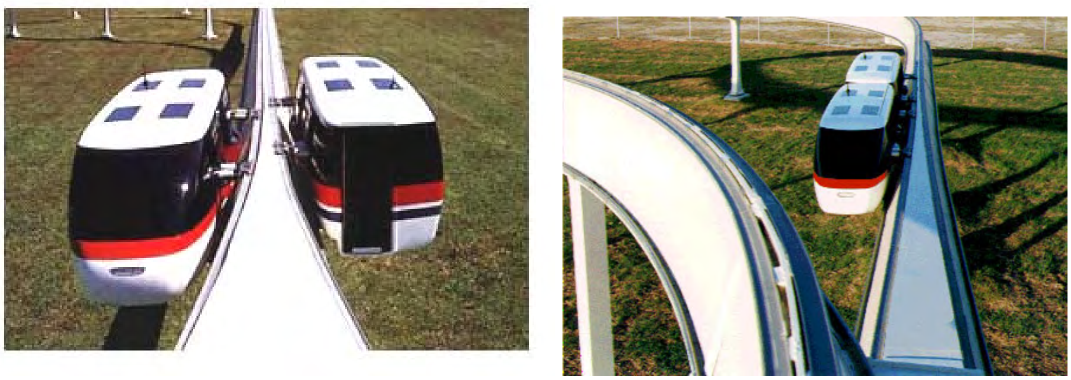

Figure App.2. 22 Monobeam Examples.

2.6 Sky Tran

This system is only a proposal for new-elevated technology. According to sky train designers such a system would provide all-time, no-wait, non-stop, transfer-free passenger service at speeds up to100 mph in urban areas, and between 100-150 mph for inter-city, suburban and rural regions. The system would feature small, streamlined two-passenger vehicles with tandem seating.

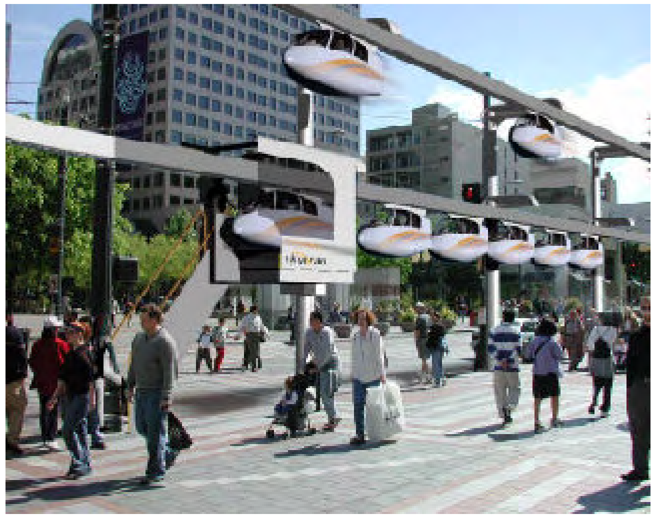

Figure App.2. 23 Proposal of Sky Tran.

APPENDIX-3

MONORAIL VEHICLES RUNNING TIME AND TECHNOLOGY

3.1 Vehicles Running Time and Dwell Time

As part of the initial comparison of possible alternative public transport modes it is necessary to have approximate indicative run times for two reasons:

- to enter journey times of the various options into the transport demand model and assess the effect on patronage and revenue,
- to estimate the number of vehicles and crews required to provide a given service frequency, to input to the capital and operating costs estimates (David, 2002).

3.2 Monorail Dwell Time

1. Minimum dwell time - unloaded direction 10 seconds,
2. Standard station - loaded direction 15 seconds,
3. Station in central area 20 seconds,
4. Station with significant interchanges 30 seconds,
5. Maximum interchange with large railway stations 40 seconds (David, 2002).

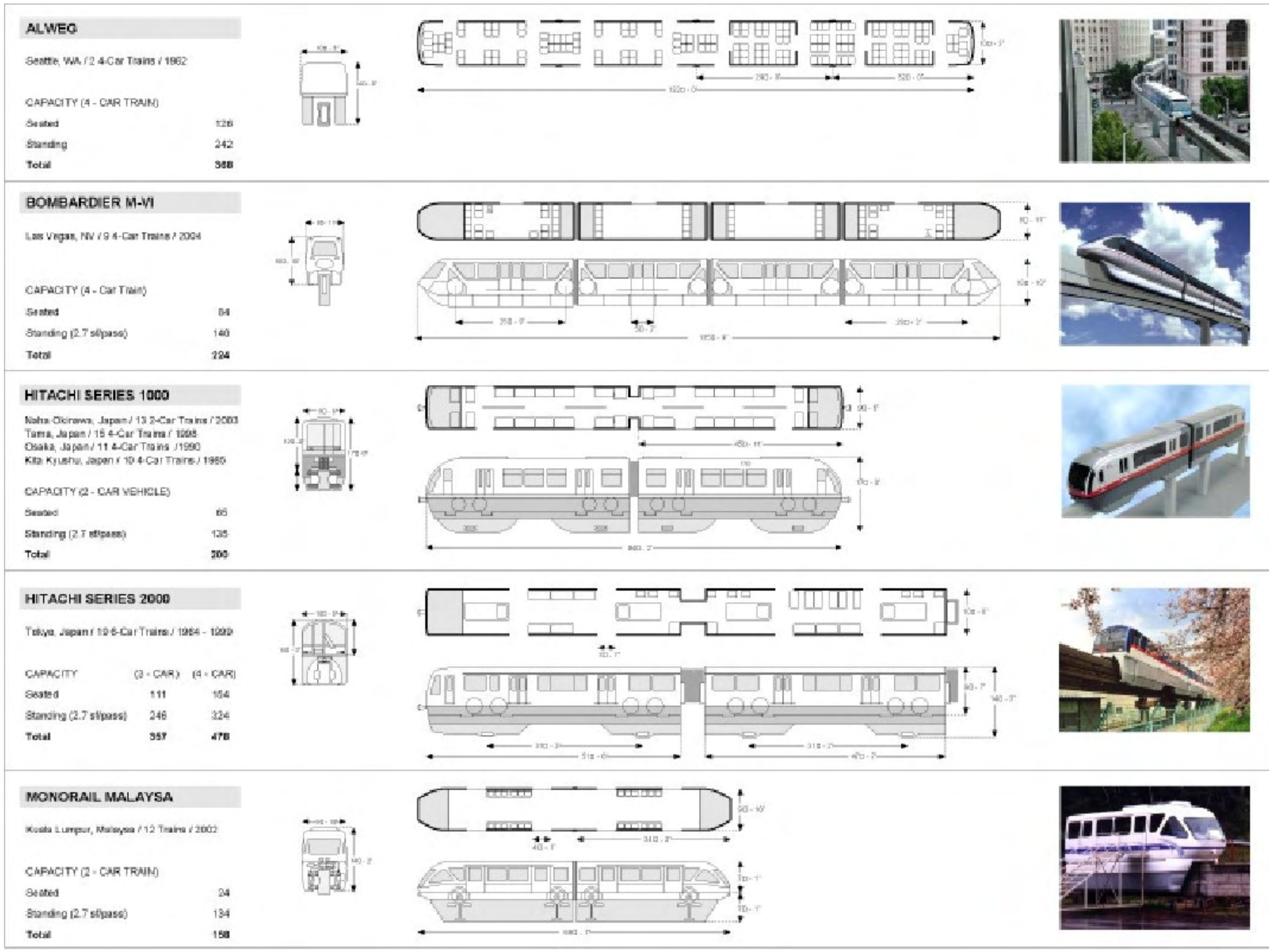

Figure App.3. 1 Alternative vehicles technology.